PV TECH POWER

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MONO IS THE FUTURE

About LERRI Solar

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LERRI Solar is a world leading manufacturer of high-efficiency mono-crystalline solar cells and modules. The company was founded in 2007 and later on acquired by Longi Group in 2014. Longi Group (SH601012) is the largest supplier of mono-crystalline silicon wafers in the world, with total assets above $1.7 billion. (2016)

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Cover illustration by Leonard Dickinson

Introduction

This time last year the great and the good of the US solar industry were gathering in Anaheim for Solar Power International 2015 and the fate of the investment tax credit (ITC) was by far the hottest topic. No one then would have dared to believe that three short months later a three-year extension to the policy followed by a stepped reduction would be approved in DC.

The Christmas time announcement was predictably called the best present the industry could have hoped for. There has, however, been some cause for concern during this period of adjustment. There can be no doubt that the US solar industry will benefit hugely from the extension but in the near term, efforts to mitigate the 2016 expiry, (front-loaded pipelines, bridge PPAs to build 2019 capacity in time to benefit) are no longer necessary. A few gaps have opened up in some big players' plans with First Solar among those taking steps to deal with the shifting distribution of project completions.

These gaps can be filled however. In this issue of *PV Tech Power* we look at the state of the US solar sector in 2016 (p.20) and identify some of the new emerging opportunities. One is undoubtedly community solar (p.32), which has the ability to create demand for smaller utility-scale projects serving customers previously without access to solar. The cumulative installed capacity in the US could almost double this year and tracker manufacturers are likely to be among the beneficiaries as low-maintenance, yield-boosting technologies become hard to ignore (p.64).

Financial innovation, the build-up to a secondary market in the US and the search for tax equity partners present other challenges, and opportunities, for the US industry (p.28). Meanwhile, hard to ignore is the onward march of the energy storage sector, which is finally proving itself to be the critical part of the future energy system that many have long believed it to be (p.25).

As always, *PV Tech Power* mixes insightful analysis of the latest market developments with cutting-edge explorations of the latest technology trends. Highlights in this issue include an in-depth piece from the US National Renewable Energy Laboratory on how the market is understanding and dealing with the issue of potential-induced degradation in modules. We also feature an exclusive paper from the EU-funded Solar Bankability Project on its work to develop a methodology for assessing the economic impact of technical failures in PV power plants.

This is our biggest edition of *PV Tech Power* to date and the second anniversary issue of the journal. The team would like to thank you for your continued support and look forward to meeting you at Solar Power International.

John Parnell
Head of content

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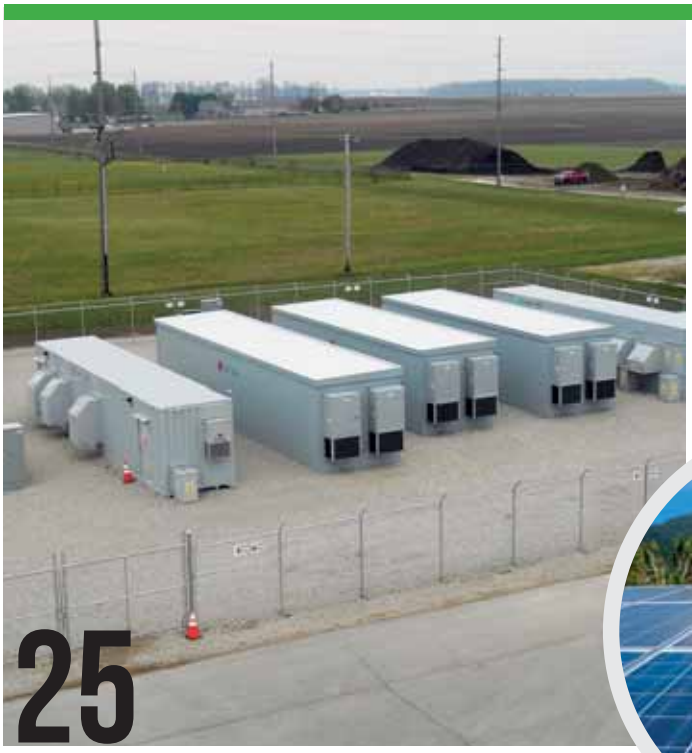

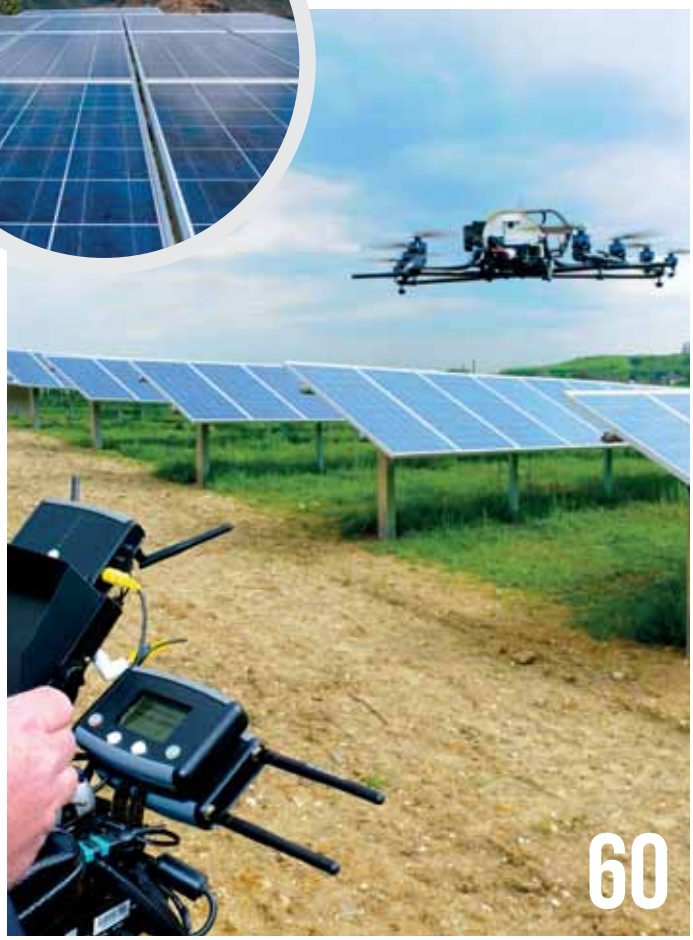

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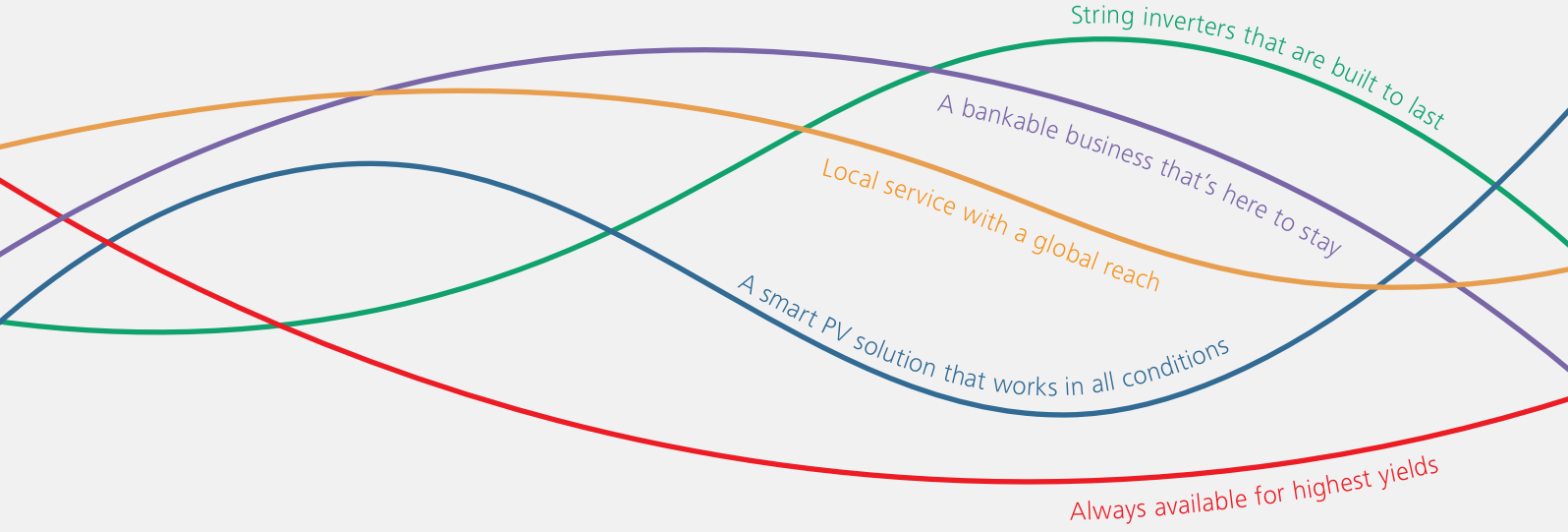

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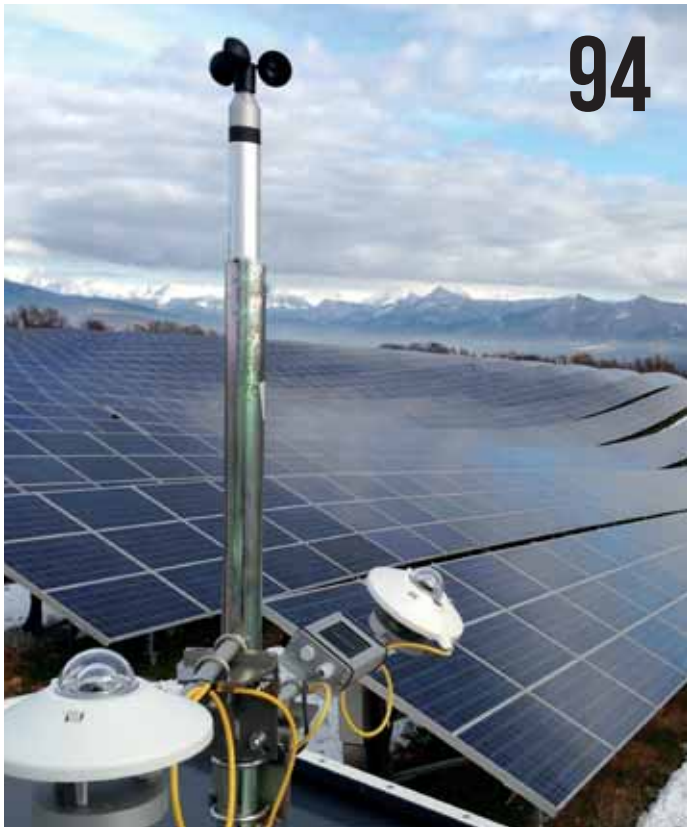

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EUROPE

Brexit

UK shakes up energy department in wake of Brexit

The new, post-Brexit, UK prime minister dissolved the country's energy and climate change department. Energy will be part of a business, energy and industrial strategy department in a move that split opin-ion. Some welcomed the appointment of the new secretary of state Greg Clark and the integration of energy and industrial policy but there were concerns that carbon reduction policies were being side-lined. The government insisted it was not downgrading climate change as an issue saying, that it would be a consideration for all departments.

Credit: Flickr/Olbac

UK energy policy is at a crossroads.

Finance

Brexit to impact European energy investment

The European investment market for power generation assets is likely to be severely hit by the continuing impacts of the UK's Brexit vote, 'Big Four' consultancy EY warned. However clean energy assets backed by long-term power purchase agreements (PPAs) will remain of particular interest due to their ability to provide stable, long-term returns. The sentiments were raised in EY's latest power transactions and trends report, updated for Q2 2016. Within it, the consultancy has warned that until the UK's energy policy and position in the EU energy market becomes clearer, investors could be put off acquiring utility-scale energy generation assets, particularly those in the UK. Since the British public voted to leave the European Union on 23 June there has been substantial uncertainty over how the country will engage with continental Europe and the wider European energy market.

Blackrock closes €650m renewables fund for Europe

The world's biggest asset manager BlackRock Real Assets has secured €650 million (US$726 million) from more than 25 institutional investors in Europe and Asia for its Renewable Income Europe fund. It exceeded the initial fund target size of €500 million, reflecting strong investor demand for long-term income from the renewable power asset class, according to BlackRock. Since the Renewable Income Europe fund's first close in February this year, it has invested in nine wind and solar projects across the UK and Ireland with a long-term aim to build a diversified portfolio of European wind and solar projects, expected to be primarily in Western Europe.

Markets

Spain may step from solar wilderness with 3GW tender

Spain is considering a 3GW renewable energy auction including solar PV, however, the policy is uncertain while the country awaits the formation of a government. The Institute for the Diversification and Saving of Energy (IDAE) has announced the tender plans, which were then confirmed by the general secretary of energy. The Energy Ministry had organised a renewables bidding option in January, which only applied to wind energy and biomass, Spanish solar association (UNEF) general director José Donoso told PV Tech. However, a new option is being considered which is most likely to focus on wind and solar PV, with intentions to procure around 3GW capacity. Importantly, the intention is to have no technological discrimination.

Portuguese renewable energy agency questions 'unsubsidised' PV contracts

Following a Portuguese government announcement approving 180MW of unsubsidised solar PV capacity, the country's renewables association has said solar cannot work without financial support in current market conditions. José Manuel Medeiros Pinto, general secretary of Portuguese Renewable Energy Association (APREN) told PV Tech the arrangement between the government and the developers of these 180MW of solar is unclear – adding: "We think this is quite impossible to construct PV power plants in the energy market without any kind of rule or support or something that can make PV comparable with other thermal resources." Pinto said the market price next year is expected to be around €40/MWh on average, which would make it "impossible for a PV producer to survive".

Trade

Brussels sends Beijing solar trade deal warning

The European Commission has warned China that it will reassess the future of the minimum import price (MIP) if a pattern of breaches continues. A further three Chinese manufacturers, Osda, Linuo and Qixin, were removed from the price undertaking agreement between the EU and China. All three had been found to be importing into the EU to related companies and then selling within the EU at rates below those stipulated by the price undertaking. The European Commission wrote to the Chinese Chamber of Commerce Import and Export of Machinery and Electronic Products (CCCME) informing it that if the same pattern of breaches continued it "… might re-assess the overall practicability of the undertaking". Previous notices have simply stated that individual breaches did not represent "systematic" failure of the undertaking.

AMERICAS

US

Solar-style ITC for energy storage under new US Bill

US senators introduced a new Bill for energy storage that brings in investment tax credits (ITC) for both grid-scale and residential energy storage systems. The 'Energy Storage Tax Incentive and Deployment Act', a bipartisan bill co-sponsored by seven senators and introduced in Congress in late May, uses the current ITC for solar energy as its model in a bid to open up competitive storage markets. For commercial applications of storage, all energy storage technologies qualify for the ITC, but the system must have a storage capacity of at least 5kWh.

M&A

Tesla confirms US$2.6 billion all-stock purchase of SolarCity

Tesla Motors sealed its acquisition of leading US residential PV installer SolarCity with an all-stock transaction valued at around US$2.6 billion. SolarCity was granted a 45-day timeline to potentially seek alternative buyers. However, SolarCity saw continued market demand weakness through the first half of 2016 that would result in lower than expected full year installations. Following this, its co-founders Lyndon and Peter Rive, CEO and CTO, respectively agreed to waive their salaries and receive a token US$1.0 in annual pay as the company plans an unspecified number of job cuts. The major acquisition came shortly after Elon Musk revealed his Tesla 'Master Plan: Part Deux' highlighting a range of sustainable projects, not least the plan to put solar on every roof and a battery in every garage.

Credit: Dan Taylor/Heisenburg Media

Shareholder appoval is the last major hurdle for Elon Musk's Tesla-SolarCity deal.

Nevada utility movements favour solar

Nevada's largest utility, NV Energy, has requested regulators for permission to retire a utility-owned coal plant 10 months early, as well as for approval of a new 100MW solar plant. It also made a filing with the Nevada Public Utilities Commission to return existing rooftop solar consumers to the previous, more favourable net metering rates for the next 20 years. NV Energy urged regulators to approve the filing in order to end controversy around net metering and eliminate the uncertainty that surrounded many of NV Energy's private solar customers.

NRG plans to buy 2.1GW of SunEdison assets

US firm NRG Energy, looked set to bid US$144 million to buy 2.1GW of wind and solar projects from bankrupt renewables firm SunEdison, which is seeking bankruptcy court approval to sell a number of its North American assets as part of its restructuring plan. The development of asset sales continued with independent energy retailer Crius Solar, which has also proposed the acquisition of certain SunEdison assets for US$1.5 million.

292MW

Enel starts construction of largest PV plant in Latin America, the US$300 million Nova Olinda with a capacity of 292MW

Chile

Lowest ever solar tariff in Chile's largest ever power auction

Solar developers won at least 720GWh (6%) of capacity awarded in Chile's largest ever power auction. Wind power dominated the 12,430GWh of power on offer with at least 5,781.6GWh. Solarpack came through with a record breaking low tariff for PV of US$29.1/MWh, having been awarded the 120MW Maria Elena solar PV project in the Tarapaca region. Endesa, a majority-owned subsidiary of Enel won about 47% of the tender with an offer that is not tied to specific projects, so it is not clear how much solar will be included.

Chile passes major transmission law after solar curtailment

Solar power firms and some wind developers have experienced curtailment of their energy production in the north central regions of Chile since October 2015, with rates reaching above 2% in December. This was partly due to a high concentration of solar plants in the Atacama desert region. Commentators said that developers are continuing to build in expectation of improved transmission infrastructure. Chile then passed a major transmission law, which will establish a new national interconnected power system to be established alongside a new independent operator.

Brazil

Brazil cancels 2016's first solar auction and delays second

Solar has been removed from participating in Brazil's first renewables auction this year while the second auction has been delayed to 16 December. Brazil's Ministry of Mines and Energy (MME) announced that now only hydroelectric projects can be submitted to its 1st Reserve Energy Auction. Meanwhile, the 2nd Reserve Energy Auction, originally scheduled for October, will now be held in December for both wind and solar participants. Around 13.4GW of solar projects have now been accredited. The solar and wind projects in the second auction will still have to supply energy for 20 years, starting from 1 July 2019.

El Salvador

Solar and wind to compete in 170MW El Salvador tender

Solar and wind will compete in a 170MW tender process in El Salvador. SIGET, the department responsible for electricity and telecoms, will oversee the process with 20-year contracts starting in 2019. The auction is open to interested parties immediately with final offers to be submitted to the government by 20 October. Winning projects will be required to invest 3% of their annual sales into projects for the local communities where the installs are sited. The country is targeting a 13.4% share of renewables in its energy mix by 2019.

MIDDLE EAST & AFRICA

Sub-Saharan Africa

Nigeria signs first ever solar PPA

Federal government-owned public liability, the Nigerian Bulk Electricity Trading (NBET), has signed Nigeria's first ever solar power purchase agreement (PPA) with more than ten project developers, totalling 975MW of utility-scale solar. Nigeria had, until now, stayed relatively quiet in its solar energy ventures. The first official project to be implemented under the 20-year PPA is a 75MW solar plant in Katsina state, to be developed by European and Nigerian utility-scale investor and developer Pan Africa Solar, in collaboration with JCM Capital, an Ontario-based developer.

No matter where you are...
We've got your back.

Due Diligence and Risk Management of Photovoltaic Projects

Who should be interested in due diligence and why?

Competent due diligence can reduce financial risk. Whether planning, construction, safety, logistic or technology issues: All of them can result in financial risks. When building large-scale photovoltaic power plants it is essential for stakeholders to leverage due diligence to minimize risks and secure funding.

- Investors
- Owners
- Lenders
- Governments
- NGOs
- EPCs

Why TÜV Rheinland?

TÜV Rheinland, as Third Party, has been working with the financial industry, investors and operators worldwide for decades. Well known for component and module certification and applied R&D, TUV Rheinland has the experience to guide a PV plant from inception, planning, construction, commissioning, to O&M and re-sale.

Our services span the gamut from owners/lenders engineering, tender development, site feasibility, production estimates, component and vendor qualification, buyer services, contract review, on-site receiving inspections, construction oversight, financial sensitivity analysis, periodic & warranty inspections, performance optimization to asset value assessments.

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Big lows

Another record-low tariff in Dubai

Masdar and FRV won Dubai's 800MW tender process after offering an initial bid below US$0.0299/kWh, which for a short time was once again the lowest ever solar tariff worldwide until Solarpack's recent bid in Chile. The consortium, which also includes Spanish firm GranSolar, will operate as an independent power provider. The Mohammed Bin Rashid Al Maktoum Solar Park has already commissioned a 13MW first phase and work on a second round of 200MW is underway. The tender rules are likely to give the Dubai Electricity and Water Authority (DEWA) 51% ownership and the Masdar-led entity 49%, as per previous tender rounds. UAE minister of state and chairman of Masdar, Abu Dhabi Future Energy Company, Dr. Sultan Ahmed Al Jaber said: "The significant scale and competitive cost of this project are a clear signal that solar energy is a reliable and commercially viable technology."

Credit: First Solar

The was briefly the lowest solar tariff worldwide.

Africa

IFC Zambia PV auction sees record-low 6¢ price

Zambia set a new benchmark for low-cost solar power in Africa with a competitive auction under the 'Scaling Solar' programme, which saw winning bids as low as US$0.0602/kWh. The winners of the auction were France's Neoen and American PV manufacturer First Solar. Italian power firm Enel also won capacity with a bid of US$0.0784/kWh. First Solar won a 47.5MWac project that is scheduled to be completed by mid-2017. Energy generated by the plant will be sold to state-owned utility ZESCO under a 25-year PPA. Meanwhile, Enel will build a 28MW plant.

World Bank backs US$1.1 billion of projects in northern Kenya

The World Bank will finance various energy, water and infrastructure projects in northern Kenya under its US$1.1 billion North-eastern Kenya Development Initiative. The Initiative will encompass an off-grid solar access project, which aims to provide power to households and public institutions in 14 counties across northern Kenya. In conjunction, the World Bank is also financing the development of five micro-grids in the counties of Tana River, Turkana and Marsabit, which are expected to be completed by August 2017. The micro-grids are to be powered mostly by hybrid solar-diesel generators.

Middle East

TBEA to build two 500MW PV power plants in Egypt

China-based major EPC firm TBEA Sunoasis has signed a memorandum of understanding with two Egyptian government agencies to build two 500MW PV power plants in the country. The MOU was said to support the local production of polysilicon through to PV modules and provide ongoing training in the construction of major solar power plants. No timelines for the projects and further developments on a domestic PV manufacturing sector were provided.

Developers renegotiating Egypt PPAs

A group of developers, including Scatec Solar, are renegotiating the terms of their power purchase agreements with the Egyptian government in an effort to keep them on the existing timetable. Enel Green Power had previously confirmed its operations in the country were on hold. A second consortium that won capacity in Egypt's oversubscribed solar tender was also reported to be ready to walk away. Talks between investors, developers and authorities have sought to address concerns. The main objection is the use of local arbitration, which investors want to be moved overseas.

Saudi's 9.5GW of renewables by 2023 target now possible due to government reshuffle

A Saudi Arabian government reshuffle reaffirmed its 9.5GW renewable energy target by 2023. Oil minister Al-Naimi was replaced by Khalid Al-Falih, who was made the head of the new ministry of energy, industry and mineral resources. It had been assumed that 9.5GW of clean energy would be attained by 2030, because no explicit timeline was provided in the 'Vision 2030' policy paper. However, a 2023 target was announced in May. This new target would propel Saudi to the forefront of renewable energy deployment in the MENA region.

Palestine licenses its first solar power plant in West Bank

The Palestine Energy Ministry has granted licensing and permits for its first large-scale solar power plant near the city of Hebron. To develop the 5.7MW PV project, US-owned, Holland-based solar firm Gigawatt Global formed a joint venture with Jordan and Palestine-based energy engineering and technology solutions company Rack Tech. The Palestine firm has plans for another three projects with a combined total capacity of 35MW. The first project requires investment of US$10 million with the US Government's Overseas Private Investment Corporation (OPIC) lined up to supply around 70% of the financing.

German firm wins 100MW project in Iran

German solar company Planet in Green has won a 100MW project in Iran. The firm has already begun to prepare the site with work to begin in earnest this autumn. It has agreed a 20-year power purchase agreement (PPA) with the Iranian renewable energy organisation (SUNA). The PPA tariff is set at IRR3200/kWh (US$0.105kWh). The firm plans more projects of 10-20MW in size and is working with local firms to develop O&M teams and has pledged to integrate local expertise with its international supply chain partners.

ASIA-PACIFIC

Southeast Asia

Indonesia solar FiT makes Java-Bali and Sumatra attractive for projects

Indonesia's first ever feed-in tariff (FiT) for 250MW of solar PV projects should generate attractive project returns in Java-Bali and Sumatra, according to Bloomberg New Energy Finance (BNEF). Both regions have better grid infrastructure and potential project sites than others and are expected to have rates of return of around 14-18.8%. Projects will have 20-year power purchase agreements and the tariff rates will range between US$0.145-0.25/kWh depending on project location. Java has been allocated the highest capacity of 150MW, but also the lowest tariff.

India

India surpasses 8GW solar PV deployment

India has surpassed 8GW of installed solar PV capacity, having added 257MW in July. Bridge to India said around 75% of all India's solar capacity additions in the last 12 months have been in southern states. Capacity grew by 80% over the latest 12 month period, with 2.7GW out of 3.6GW added in the South. Meanwhile, the southern state of Tamil Nadu became the country's largest solar state by adding more than 1.2GW. This was partly down to developers taking advantage of a generous feed-in tariff of INR7.01/kWh (US$0.104/kWh).

India sanctions plans for 10 'Solar Zones' and doubles Solar Parks plan

India has sanctioned plans to implement 10 'Solar Zones' each consisting of at least 10,000 hectares of land to encourage solar PV project developers, manufacturers and investors to help achieve the country's massive 100GW by 2022 solar targets. The unprecedented scheme, which will run for five years from 2016/17 to 2020/21 using government or privately-owned wasteland, uncultivable land or fallow land, will receive INR440 million (US$6.5 million) of central government funding. Meanwhile, India is also expected to approve a doubling of its solar parks policy to reach 40GW capacity by 2020.

'Path breaking' Indian tax overhaul could raise solar costs

India has passed a ground-breaking tax bill that seeks to bring the country under one uniform tax regime, but which is likely to increase costs for solar developers. While the Goods and Service Tax (GST) Bill will not be enforced until 1 April 2017 at the earliest, Jai Sharda, managing partner of research firm Equitorials, said: "Currently capital goods and services used in electricity generation value chain get various tax exemptions. These exemptions will now get eliminated under GST. Accordingly, GST would increase the capital and O&M expenses for the renewable energy players."

Indian solar facing first curtailments in Tamil Nadu

Developers have experienced curtailment of solar power in the Indian state of Tamil Nadu for the first time in India, sometimes in the range of 50-100% during peak generation periods. Wind developers, who faced curtailment previously were given some level of relief by the utility Tamil Nadu Generation and Distribution Corporation (Tangedco), so there is hope for solar developers looking for the same. Later, India's energy ministry asked the power regulator, the Central Electricity Regulatory Commission, to favour solar generation over thermal power in response to curtailments.

Pakistan

EnerTech plans 500MW of solar PV projects in Pakistan

Kuwait government-owned developer EnerTech signed a bilateral agreement with the government of Pakistan to set up 500MW of solar plants in Balochistan Province. The capacity near the city of Quetta will mainly be made up of solar PV. Pakistan's National Electric Power Regulatory Authority (NEPRA) also published proposed revisions to its feed-in tariffs (FiTs) for solar energy projects of between 1-100MW capacity. NEPRA also received an application for a 20MW solar PV plant at the Shaheed Benazirabad District from Benazirabad Solar Power.

US$1 BILLION

Value of World Bank loan for Indian solar push in 2017

Rush or red herring

China's PV grid connections hit 22GW in H1 2016

A massive 22GW of grid-connected solar projects were logged in China's official register for the first half of 2016, including 11.3GW in June alone. However, the numbers do not directly represent the market's end-demand with a number of factors skewing Beijing's data. Yvonne Liu, Bloomberg New Energy Finance's (BNEF) Chinese solar market analyst, said: "We expected about 18GW of grid connections in H1 2016. The National Energy Administration (NEA) believes there may still be some duplicate records in their data; they describe it as 'over 20GW'. The NEA estimates that about 1-2GW will be removed from the 22GW in the final number." The news led to some commentators forecasting a lack of demand from China in H2, which could benefit solar developers in India looking for cheaper equipment prices. Only two months earlier China had set its 2016 solar installation cap at 18.1GW and took significant steps to address curtailment and encourage market consolidation.

Credit: United PV

22GW of grid-connected solar projects were logged in China's register in H1 2016.

Australia

Campaigns against Australian RET 'ramp up' in wake of election

Conservative groups and power industry bodies have made fresh calls to hinder Australia's Renewable Energy Target (RET) in the wake of the federal election. They pushed the merits of gas power and questioned the effectiveness of renewable technologies and many blamed a recent peak in electricity prices in the state of South Australia on renewables. However, Australia's newly appointed energy minister Josh Frydenburg said the extreme fluctuations in South Australia's electricity tariffs should be blamed on a number of factors not just renewables, including the Heywood Interconnector being down for maintenance, increased power demand due to a cold snap and increased spot prices for gas.

QIC in AU$1 billion renewable energy partnership with AGL in Australia

Australian investment manager QIC is to invest AU$800 million (US$598 million) and power firm AGL is to provide AU$200 million of cornerstone equity for a major partnership in the development of large-scale renewable energy infrastructure in Australia. The investment will go towards the Powering Australian Renewables Fund (PARF), which aims to fulfil a significant part of Australia's Renewable Energy Target (RET) for 2020. PARF aims to own AU$2-3 billion worth of large-scale renewable energy projects totalling more than 1GW in combined capacity. This will account for around 10% of Australia's renewable energy capacity once fully invested.

Product reviews

Trackers — Array Technologies DuraTrack HZ v3 provides single-bolt per module clamping

Product Outline: Array Technologies has launched it next-generation DuraTrack HZ v3 solar tracking system for utility-scale power plants. This new version is designed to deliver a variety of efficiencies allowing faster installation times, elimination of scheduled maintenance costs and maximum power plant uptime to deliver optimum levelised cost of electricity.

Problem: Solar module tracking systems need to constantly keep up with demands for greater reliability and faster installation of modules, while being flexible in a wide variety of ground conditions that support the lowest capital cost and LCOE.

Solution: The DuraTrack HZ v3 has a high power density, due to a reduction in

module-to-module gaps to 1/4" coupled with elimination of the gear box dead-space that has resulted in a 6% density advantage over its closest competitor system, according to the company. Greater reliability is provided by improved driveline design efficiencies that have allowed for 50% fewer motors and controllers per MW, with each motor driving 650-750kW. Motor assemblies are now located on the east or west edge of the tracker blocks, facilitating easy access. Zero scheduled maintenance is achieved with the drive train sealed and lubricated for life. The new system features passive wind management which does not require active wind stowing, or an uninterrupted power source (UPS). Additionally, v3 self-calibrates each row twice daily to ensure optimal performance.

Applications: Utility-scale PV power plants.

Platform: DuraTrack HZ v3 tracker rows are connected by a flexible rotary drive shaft. The rows can accommodate north-south slopes of up to 15% and angles of up to 40 degrees in the east-west direction.

Availability: Currently available.

Modules — Hanwha Q CELLS introduces 72-cell module in 1,500V configuration

Product Outline: Hanwha Q CELLS is launching a 72-cell solar module, the 'Q.PLUS L-G4.2,' which is specifically optimised for large-scale deployment with power classes of up to 340W. The utility-scale module incorporates Hanwha Q CELLS' proprietary Q.ANTUM technology.

Problem: Providing high voltage PV modules up to 1,500 VDC is claimed to lower system costs by reducing component count requirements. The higher maximum system voltage is said to reduce resistive losses, increasing overall energy yield. Modules need to be of high quality and reliability so as to operate in harsh environments with minimal lifetime degradation.

Solution: The 72-cell polycrystalline solar module Q.PLUS L-G4.2 helps US utilities optimise system performance and cost structure by reducing system costs in large-scale solar power plants. Q.ANTUM technology pushes module power classes up to 340 watts, making it one of the most powerful polycrystalline solar modules in the market today, and is both UL and IEC 1500V certified for the US market.

Applications: Large utility-scale deployments.

Platform: The Q.ANTUM proprietary cell architecture is based on a rear-side passivation of the solar cell and includes many additional technological features for maximum energy yield under harsh conditions. Q.ANTUM improves power output, low-light and temperature behaviour, while at the same time offering all of Q CELLS' VDE-certified quality standards such as anti-PID protection, Hot-spot protect, and Tra.Q laser marking. The module retains an aluminum frame and backsheet, rather than a glass/glass configuration.

Availability: Already available in the US market.

Products in Brief

TÜV Rheinland highlighting expanded product testing programmes

TÜV Rheinland is expanding its testing programme for the quality assurance of components used in PV power plants that goes beyond the minimum requirements established in typical certification and safety standards. TÜV Rheinland has developed a comprehensive examination programme for PV system components to developers, operators, insurers, investors and manufacturers. An important aspect is the location of the plant and the resulting demands on components. The program also provides for an assessment of the components before the end of a typical warranty period. This review is carried out by on-site examinations and laboratory tests.

BizLink launches new 'Sunbolts' DC branch fuse holder

BizLink's new 'Sunbolts' DC Branch Fuse Holder is intended to streamline in-field installation and maintenance with easily replaceable fuse connectors on each branch. Sunbolts DC Branch Fuse Holder consists of an over-molded, hermetically-sealed branch connection with a Sunbolts fuse-connector terminating each of PV cable ends. With strong over current protection this RoHS compliant and UL-recognised connector simplifies in-field module installations and maintenance with the easily replaceable fuse. Low-resistant, IP67 branch cables reduce stripping and crimping to make branch connections, reducing labour cost and improving workmanship.

Ginlong launches 'Solis' 36K-40K three-phase inverters

Ginlong Technologies is increasing its focus on the US commercial and utility-scale markets with the launch of its 'Solis' 36K-40K three-phase inverters, which feature a 4 MPPT design and high-frequency switching technology. The 'Solis' 36K-40K inverter also features fan-less natural convection for higher reliability. The inverter offers 97.8% peak efficiency and 97% CEC efficiency. It is UL 1741 certified and compliant with 2014 NEC 690.12.

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Inverter | KACO's blueplanet 1000 TL3 bi-directional battery inverter works for grid stability and peak shaving

Product Outline: KACO new energy is launching the blueplanet gridsave 1000 TL3: a storage solution in the megawatt-class. The unit assists utility companies, distribution grid operators, EPCs and large companies to balance energy generation and consumption on the power grid.

Problem: PV power plant systems when combined with energy storage can provide improved resiliency to the electricity distribution system and most grid types in general. However, PV systems and energy storage solutions must be designed to meet static and dynamic grid support.

Solution: The blueplanet gridsave 1000 TL3 is a bidirectional battery inverter

with a rated power of 1,000kVA. By charging and discharging batteries it provides static and dynamic grid support in order to regulate the frequency. It thus contributes to keep the grid operating reliably at every second. The system also offers a 'fault ride through' function that contributes to the stability of a grid. The size of the storage system can be scaled to requirements. The inverter is suitable for large-scale peak shaving and is compatible with conventional energy sources, just as it is with wind and PV.

Applications: The blueplanet gridsave 1000 TL3 is compatible with all common battery technologies as well wind and solar PV and grid types.

Platform: The blueplanet gridsave 1000 TL3 communicates via Modbus and Sunspec. These widespread, non-proprietary protocols and languages enable the use of a large number of control systems to regulate the battery inverter. Individual storage system requirements are available.

Availability: The system will be launched in the USA in the second half of 2016, followed by Europe.

Racking | TerraSmart 'TF2' fixed-tilt ground mount rack tackles difficult soil conditions

Product Outline: TerraSmart's TF2 fixed-tilt ground-mount racking system is claimed to offer faster installation times with 66% less hardware than TerraSmart's previous racking system.

Problem: Tackling a wide range of ground conditions can lead to PV project delays as selection of the correct foundation and mounting system has to be assessed. Extra costs can be incurred with pre-construction civil work. Having a foundation system and mounting system that can accommodate any ground conditions reduces selection time and de-risks projects.

Solution: The TF2 racking system combines with the widely deployed 'TerraSmart' ground-screw foundation, making it suitable for difficult soil conditions. In addition, the new solution offers installers an additional 30% in cost reductions on foundation installations, according to the company. With slope capability up to 36%, the TF2 significantly reduces pre-construction civil work and potential unknown delays and costs due to subsurface obstructions uncovered during construction.

Applications: Foundation and racking system for a wide range of ground conditions for PV power plants.

Platform: The TF2 has passed the UL 2703 Edition 1, complies with the NEC and has undergone wind-tunnel tests. The TF2's lighter yet stiffer components make it safer and easier to handle onsite as well as more economical to ship. An integrated wire management system accommodates cables to provide hassle-free wire management. Threaded inserts and two-part hardware stacks make connecting TF2 components easier and quicker than previous versions.

Availability: Currently available.

Products in Brief

HellermannTyton adds improved wire management products to PV installation catalogue

HellermannTyton's ratchet 'P Clamp' is an adjustable, releasable clamp that bolts on to racking. Its one-piece, PA66 nylon solid body and stamped metal mounting plate creates a lightweight, durable alternative to traditional products for managing free-air conductors within a PV array. The Ratchet P Clamp reduces the number of fixing points required to safely secure wires and bundles, and is also releasable. The new Low Profile Metal Edge Clip is designed to fit solar racking products and is engineered to stand up to wind, rain, snow and UV exposure.

Skytron energy's 'PVGuard' gains integrated controls for PV power plant monitoring

Skytron energy has released version 2.3 of its 'PVGuard' Supervision Platform. The updated platform features a new integrated control function, allowing operators to directly connect to a plant via a customised dashboard, activating and deactivating individual inverters, sections or the entire plant. This direct connection to the PV plant allows selected data to be displayed live on the dashboard and makes the effects of switching operations visible in real-time. The new version allows operators to store high-resolution data from the example network analyser or system controller for up to six months in the database.

Valentin Software simulation software upgrades reduce PV system design times

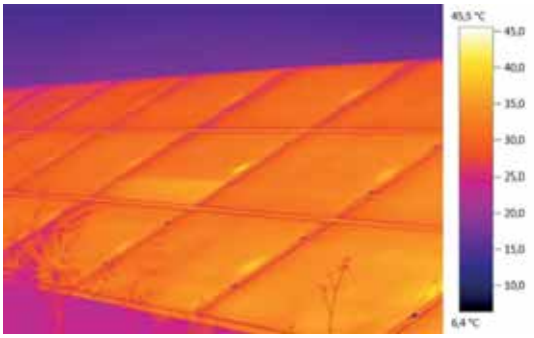
Valentin Software's updated simulation software PV*SOL premium 2016 offers the possibility of importing floor plans, cadastral maps and screenshots from web-based satellite maps directly into the 3D visualisation and then including them in users' projects to scale. The dimensions, orientation and the mutual distances of 3D objects (buildings, trees) can therefore be determined easily and without an on-site appointment. By tracing a floor plan, the program can automatically detect and create the standard 3D objects.

Product reviews

O&M PI Berlin offers in situ lab quality power measurements of PV power plants

Product Outline: Photovoltaik-Institut Berlin (PI Berlin) now has the capability to troubleshoot faults in PV power plants using a precision LED solar simulator. This device is the first of its kind to allow laboratory standard solar module power measurements to be taken in the field without the need to dismantle modules, according to the company.

Problem: If a solar power plant fails to deliver the expected yield, this may be caused by a variety of factors. Power losses can often be traced back to the smallest of faults in PV modules, which aren't recognisd at first glance – for instance micro-cracks in solar cells. To return a power plant to full productivity as rapidly as possible, faults and their relevance must be quickly pinpointed. With mobile labs out in the field you first need to dismantle several PV modules, which can take time and can also result in further damage to the modules.



Solution: The LED solar simulator is set on the module substructure at the site, so there is no need to remove modules and the output measurements are quicker and cheaper. The precision LED sun simulator replicates sunlight so realistically that engineers are able to test module power output with extreme accuracy at any time of the day or year. Testing at night has the added advantage for operators that there is no plant downtime.

Applications: In situ PV power plant power measurements.

Platform: The Class AAA LED solar simulator was developed in collaboration with the innovative high-tech start-up Wavelabs and Zurich University of Applied Sciences (ZHAW). The device not only meets the current IEC 60904-9 standard but also satisfies the more rigorous forthcoming specifications.

Availability: Currently available.

Racking Quick Mount PV provides easy replacement tile mount for rooftop PV installs

Product Outline: Quick Mount PV has introduced the 'Tile Replacement Mount' for US rooftop solar installations, providing a fast and easy way to install solar on tile roofs while protecting against water intrusion.

Problem: Installing solar on tile roofs can be difficult and time-consuming and a simple and efficient method to mount solar on tiles without compromising waterproofing or code requirements is required. Tiled roofs often require tile grinding or cutting and waterproofing.

Solution: Quick Mount's Tile Replacement Mount eliminates messy and time-consuming tile grinding and cutting to significantly reduce installation time and labour costs.

The new mount works with all standard curved and flat tile roofs, as well as all standard rail-based racking systems. The Tile Replacement Mount is fully engineered to meet code requirements and industry best practices, and features Quick Mount's patented Elevated Water Seal technology for superior waterproofing.

Applications: Works with all standard curved and flat tile roofs, and all standard rail-based racking systems.

Platform: The Tile Replacement Mount features a universal base mount, which works with all three flashing profiles: flat tile, S-shaped, and W-shaped curved tiles. To offer installers and distributors cost-effective stocking and packaging flexibility, the universal base mount is sold separately from the flashings and posts. The Tile Replacement Mount is 100% IBC compliant and comes with a 20-year warranty.

Availability: Currently available.

Products in Brief

Ingeteam launches 1,500V central PV inverters

Ingeteam has introduced a new range of 1,500V DC central PV inverters for utility-scale PV power plants. The INGECON SUN PowerMax B series are able to supply up to a maximum power of 1,640kVA in a single unit (2,800 x 885 x 2,010 mm). The inverter features a 'smart cooling system' which makes it possible to optimise and reduce the auxiliary services consumption. The system can be installed indoors (IP50) and outdoors (IP56), and can deliver its rated power up to an ambient temperature of 50ºC.

Advanced communications and compact size data logger added to the Tigo's 'Smart Platform'

Tigo has developed 'Cloud Connect Advanced' (CCA), a powerful communications hub for its smart modules. The CCA is fully compatible and configurable with 'Tigo SMART' mobile app, allowing, commissioning, configuration, O&M and monitoring to be performed by any mobile phone without setting changes. 'Tigo Smart' OS enables third parties to develop and deploy apps to the Cloud Connect Advanced through the Tigo app store. The Tigo platform is supported by all of the major inverter and module manufacturers world-wide.

Sungrow launches 1,500V SG3000HV-MV turnkey container solution

Sungrow has entered the emerging 1,500V market with its SG3000HV-MV turnkey container solution. The system enables more modules to be connected, reducing system costs and power generating losses. Its active power is said to be adjustable ranging from 0 to 100% and its reactive power control with power factor can be adjusted from 0.8 leading to 0.8 lagging. The system also has night-time reactive power compensation capability and intelligent control which is compatible with multiple regional utility standards.

Inverter — SMA Solar's new 'Medium Voltage Block' pairs seamlessly with its new line of central inverters

Product Outline: SMA Solar has revamped its 'Medium Voltage Block' in a second-generation design intended to be an integral part of the utility power system. The new system is claimed to seamlessly integrate with SMA's new line of central inverters: the Sunny Central 1850-US, 2200-US and 2500-EV-US.

Problem: PV project developers, EPCs and owners increasingly demand greater risk reduction, cost optimisation, simplicity and convenience when constructing PV power plants and have adopted a number of modular technologies to achieve this goal. Providing seamless integration of a medium voltage block with central inverters is required.

Solution: The Medium Voltage Block is designed for the unique requirements of a PV application. It is a simplified solution mechanically, with low-voltage connections positioned horizontally in plane with the output bus bars of the inverter. To enable this shorter connection scheme, the low-voltage connections have been relocated to the side of the medium-voltage transformer. This offers simplified field integration, requiring as little as one man hour, while eliminating the need for skid solutions that increase the total installed system cost and logistical complexity.

Applications: PV power plants.

Platform: The Medium Voltage Block has been fully type tested and validated to meet the needs of PV applications with a 25-year service life. Its space-optimised design with a 22% smaller footprint reduces shipping costs while fewer components and easy access maximise serviceability. Transformer monitoring, communicated through the inverter MODBUS registries, reports the health of the transformer, including analogue values for temperature and pressure, which enables trend-based predictive maintenance that can considerably reduce O&M complexity.

Availability: Currently available.

Balance of system — Telergon's S6000N DC switch disconnector is designed for 1,500VDC PV systems

Product Outline: Telergon's S6000N DC switch disconnector from distributor Switchtec has been introduced to meet the demand for this type of product as a result of the increased usage of 1,500VDC generation in utility PV systems.

Problem: The migration to 1,500VDC PV systems is designed to improve system efficiency. Using 1,500VDC rather than lower voltages enables the PV installer to save costs as higher-voltage systems enable longer strings, which means fewer combiner boxes, less wiring and trenching, and therefore less labour, resulting in lower total ownership costs and LCOE.

Solution: Aimed at photovoltaic installers and panel builders in PV systems and control panels, and designed to switch up to 1,500VDC, the Telergon S6000N DC switch disconnector is available with different terminal configurations to suit the installation's specific requirements and needs. The switch can be supplied with its input and output terminals at the top of the switch, at the bottom, or one at the top and one at the bottom – all options are covered.

Applications: 1,500VDC PV systems.

Platform: The S6000N DC is constructed from two, type S6000 switches mounted back to back with built in, internal bridging links that enable the switch to be rated at 1,500V DC and also to enable quicker installation. Available in either 315A or 400A 1,500V DC ratings, the switch consists of a sandwich type contact arrangement with self-cleaning blade contacts and pre-arc zones to ensure long-term, fault-free energy transmission.

Availability: Currently available.

Products in Brief

Pika Energy's 'B Link' battery converter provides flexibility in solar-plus-storage

Pika Energy will offer bidirectional smart battery converters to enable breakthrough integrated solar and energy storage solutions in the first quarter of 2017 with the availability of its 'B Link' battery converter, which is said to open up a new segment of the energy storage market by enabling solar equipment suppliers and installers to connect currently-available battery technology to next-generation inverters. B Link has already begun attracting OEM partners who will use B Link to assemble smart batteries, energy storage systems.

ET Solar launches 'EliTe' monocrystalline module worldwide

ET Solar has launched its new generation monocrystalline module, 'EliTe Mono', worldwide. By utilising passivated emitter rear cell (PERC) technology to optimise module design, improve performance and reliability, ET Solar's monocrystalline modules are claimed to offer higher performance, with module conversion efficiency up to 18.75%. All ET Solar's monocrystalline modules are certificated by VDE and ETL, and have passed the strict tests under the standards of the International Electrotechnical Commission (IEC) and Underwriters Laboratories (UL).

AUO's new 'SunVivo' P-type monocrystalline module applies light capturing technology

AU Optronics Corp (AUO) (previously BenQ Solar) has launched its SunVivo p-type mono-crystalline module that applies an advanced light capturing technology with enhanced material design to reach a power output of 314.8W, gaining at least 2% more power than conventional p-type counterparts. The new module is said to meet AUO's own Diamond-Level Test Conditions, which ask for solar modules to withstand as many as 1,000 hours of PID resistance testing at 85°C and 85% relative humidity.

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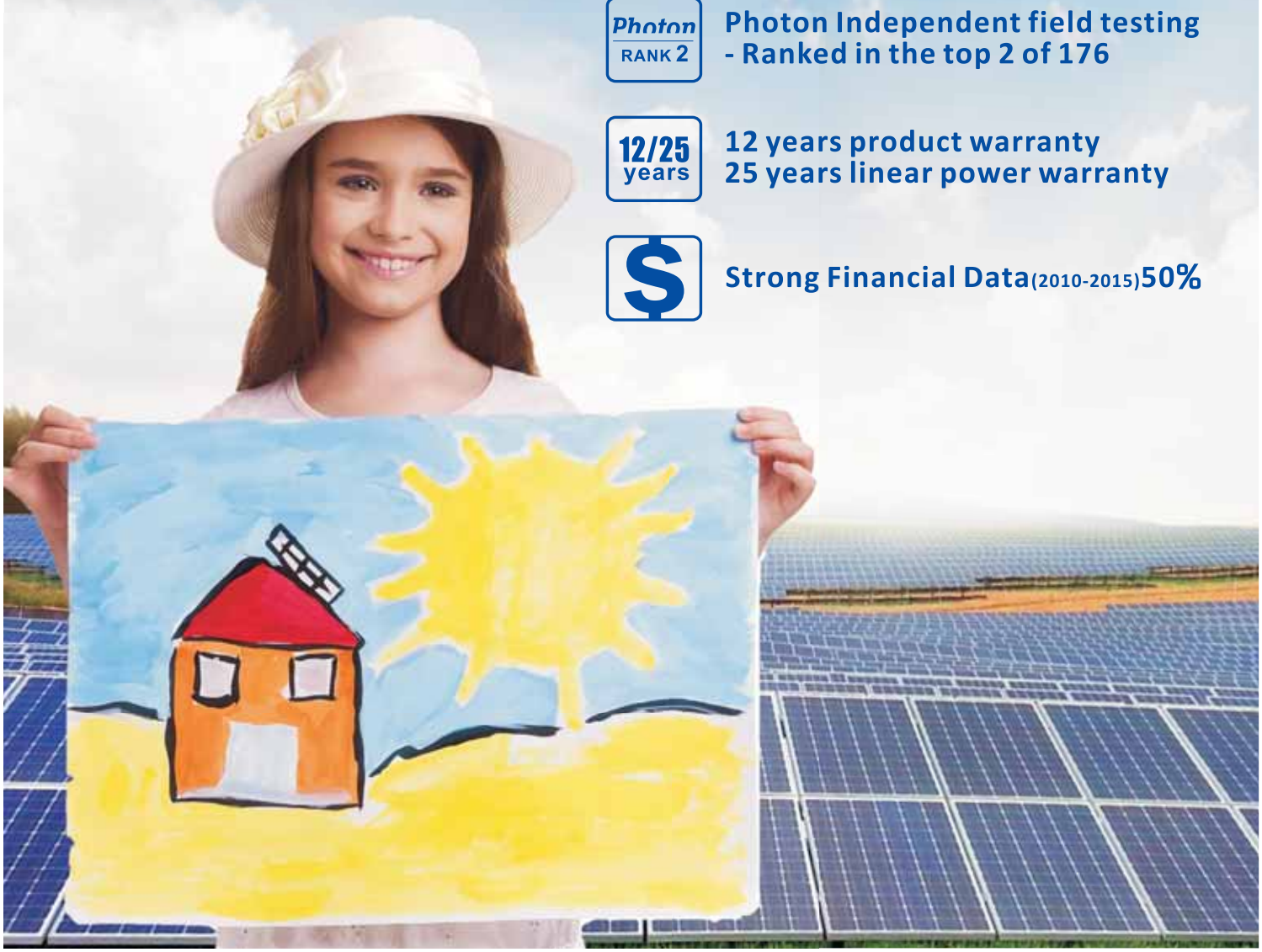

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Product reviews

Modules | SolarWorld's 'Sunmodule Bisun' system boosts free-field and flat roof power generation

Product Outline: SolarWorld has launched a new era of modules for free-field and flat-roof systems. The new 'Sunmodule Bisun' is a solar module active on both sides (bifacial) that converts light from all directions into electricity. This ensures up to 25% more yield per installed kWp. SolarWorld has also developed a new racking system for flat roofs that is optimised for the bifacial technology.

Problem: Conventional modules cannot take advantage of reflected light from a roof or ground surface to provide higher performance.

Solution: The double-sided light sensitivity of the modules, the so-called bifaciality, is based on the further development of PERC

technology. If the solar module is used on surfaces such as light-coloured concrete or white membrane, more light is reflected into the module and the energy yield increases further. However, the bifacial module also produces more output than comparable standard modules on non-optimised surfaces such as grass, sand or trapezoidal sheeting. The Sunmodule Bisun also has a long lifespan through the use of glass on the front and rear sides of the module. This glass/glass technology also ensures high mechanical durability and improved degradation behaviour offering at least 86.85 % output after 30 years.

Applications: Ground-mounted systems and flat roofs.

Platform: 'Sunfix Bisun' mounts the module at a distance of 30 cm from the roof surface optimising light capture for energy harvest without sacrificing the performance of the racking system. The racking system is fixed to the roof through ballast. Roof bolts can be integrated into the system if required. Sunfix Bisun can be attached to flat roofs with a roof-tilt of up to five degrees. It is suitable for various rooftop covers such as bitumen, gravel, foil or green roofs.

Availability: Already available.

O&M | meteocontrol refines SCADA Center and VCOM monitoring solutions for PV power plants

Product Outline: meteocontrol, a subsidiary of Shunfeng International Clean has launched several new features and refinement to its SCADA Center and VCOM monitoring solutions for PV power plants, as well as its 'Pit Stop' service for existing systems.

Problem: PV power plant owners continue to demand greater services and increased accuracy and response to maximise plant operations. Greater clarity on plant issues and alerts as well as the ability to react better to the needs of grid operators are required.

Solution: The new Pit Stop service provides a professional system check for a fixed price, comprises an expert inspection of components and a valid report that outlines

faults and recommends solutions. The service is helpful for investors on the secondary market. Risks can be minimised and profits maximised when buying or selling systems. Meteocontrol is also further refining its VCOM (Virtual Control Room). Functions such as the heat-map diagram, keyboard shortcuts for faster operation and analysis diagrams for ticket evaluation underscore the company's commitment to providing an effective monitoring platform. The improved alarm system with user-defined alarm rules is another highlight. Improved usability is found, for example, in a new feature that optimises the further processing of incoming alarms by filtering and prioritising them on a system-specific basis.

Applications: Operation and maintenance of PV power plants.

Platform: Because this system does not depend on having a stable internet connection and features a flexible user interface, it can be used anywhere and adapted to suit local requirements. Data is stored on a high-performance industry server and available on location for analyses. High-resolution live values allow errors to be located quickly and easily.

Availability: Currently available.

Products in Brief

Advanced communications and compact size data logger added to the Tigo's 'Smart Platform'
Tigo has developed 'Cloud Connect Advanced' (CCA), a powerful communications hub for its smart modules. The CCA is fully compatible and configurable with 'Tigo SMART' mobile app, allowing, commissioning, configuration, O&M and monitoring to be performed by any mobile phone without setting changes. 'Tigo Smart' OS enables third parties to develop and deploy apps to the Cloud Connect Advanced through the Tigo app store. The Tigo platform is supported by all of the major inverter and module manufacturers world-wide.

Ginlong's Rapid Shutdown Device offers low-profile design for compact installation
Ginlong Technologies (Solis) has introduced a low-profile NEMA 4X 'Solis Rapid Shutdown Device' for mounting directly to the PV rack under the panels, ensuring compliance with NEC 690.12, as well as contributing an aesthetic appearance. When AC power is cut, the RSD device forces the PV array to be shut down automatically and safely. The system is available in either single-channel output or dual-channel output to align with the number of MPPT channels in the inverter system.

PV Racking launches clamp-free racking line
PV Racking offers a completely clamp-free racking line for pitched roof and ground-mounted solar systems. Its rails incorporate a guided channel that allows solar modules to slide into, as opposed to individually fastening modules with clamps. By sliding the panels into place, the installation time is significantly reduced, according to the company. In turn, hidden soft costs on labour are eliminated. The system also allows for a more stable and secure solar array than traditional clamp systems.

POWER PVTECH

SPECIAL REPORT

The state of play in US solar and storage

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US solar's bright young thing, p.32

Market watch
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Solar finance
Three talking points from the finance frontline, p.28

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The rise and rise of energy storage, p.25

A nice problem to have

Market update | The US solar market finds itself with the bizarre, but welcome, problem of having to "manage" a boom. Danielle Ola examines the impact of the ITC extension, alternative drivers of US solar and debunks the supply crunch myth

Getty/AndrewKravchenko

More solar panels have been mounted on the roofs of American homes this year than ever before. The US recently celebrated 1 million solar installations, well and truly confirming the technology as a mainstream and affordable resource, and banishing the idea that solar was something exclusive to the wealthy or the eco-warrior. Nascent no more, the US solar industry is incrementally emerging as a consolidated market with leaders surfacing.

A global decline in PV prices, manufacturing overcapacity, strong consumer demand and financial incentives have culminated to drive a booming US solar market. The extension of the investment tax credit (ITC) in December provided the industry with long-anticipated economic stability – even if the price of that is a curtailment of short-term installations now that the pre-deadline rush is over.

In the first quarter of this year alone, the US installed 1,665MW of solar PV to reach 29.3GW of total installed capacity. This was a 24% increase over Q1 2015 and the largest non-Q4 in the entire history of US solar. With more than 1 million individual solar installations nationwide, the industry is on track to grow 94% in 2016, according to data by the Solar Energy Industries Association (SEIA) and GTM Research.

The future for US solar is looking increasingly less reliant on politics, more diverse in terms of drivers and geographies, and backed by an increasingly persuasive economic argument.

ITC extension

The five-year extension of the 30% ITC is one of the key drivers and most critical federal policy mechanisms to support US solar deployment to date. "The ITC is an important economic benefit to the industry, and makes solar possible for many more customers than would otherwise be possible," says Thomas Plagemann, executive vice president and head of capital markets at Vivint Solar. The extension was critical in maintaining economics across our current markets while we continue to focus on reducing cost per watt and extend the reach of those markets. Not only does it provide the ability to continue to efficiently finance our self-owned systems through our tax equity partnerships, but it also provides an important economic benefit to homeowners."

Solar deployment in the US has settled down to a pattern of steady growth since the extension of the ITC

In the residential and commercial segments, the ITC has driven installation growth by more than 1,600% since its initial implementation in 2006, according to the SEIA, at a compound annual growth rate of over 76%.

"Hopefully over the next few years we can move into a post-ITC world," says Kevin Prince, senior director, business development at NRG Energy. Whilst it is undeniable that a lot of the procurement in the commercial sector is driven by the ITC extension, which not only gives consumers the certainty to pursue projects but also the opportunity to realise immediate savings on their energy bill and hit sustainability targets, it was never intended a sustainable driver in the first place. And whilst the extension certainly prolonged the lead-time on a number of projects that were stampeding to a close prior to an end-2016 expiration, once that pressure was off, the market settled back into regular deal cycles. Therefore, the tax credit extension turned out not to be the main event and bumper 2016 deployment will be a little more measured.

> "The ITC extension was critical in maintaining economics across our current markets while we continue to focus on reducing cost per watt and extend the reach of those markets"

The ITC extension may have provided an initial boost for project developers, but second quarter results of the biggest solar companies reveal a delay as the tax credit was only extended at the end of the year when developers had already decided to hold back on some projects. GTM

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Research had originally forecast 16GW of installations for 2016, but the readjusted figure was evident in Q1 with 2GW of planned projects dropped.

Instead, other happenings among the solar super-majors are dictating the direction of travel of the market: SunEdison went bankrupt; Tesla bought SolarCity in a move considered the pinnacle of vertical integration; and SunPower laid off 1,200 employees. What is really moving the market is not the ITC, but the fight for quality, according to Alan Russo, senior vice president of sales and marketing at REC Solar. "Customers are starting to think about counterparty quality in a way they never did before. That's the main event: the ITC has sort of passed as a talking point for our customers and our network."

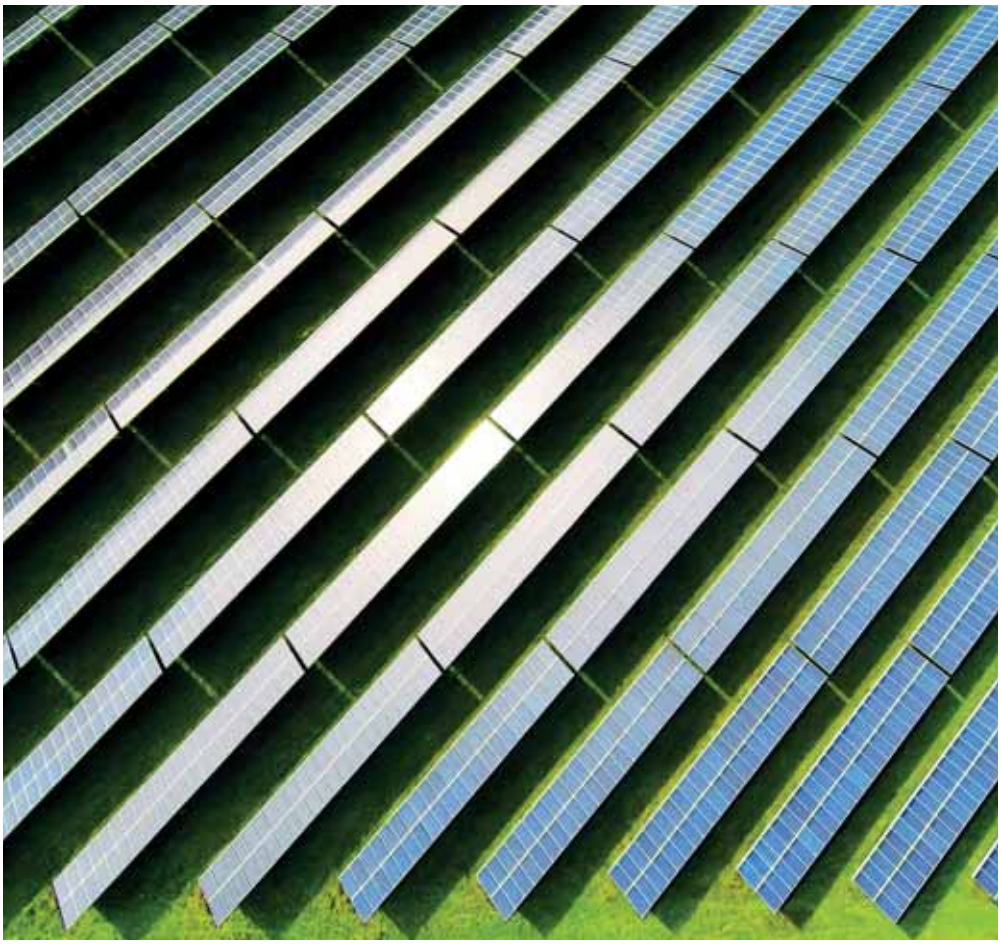
State incentives and regulatory frameworks

Solar deployment has also been spurred by solar renewable energy credits (SREC), particularly in the north-east. These incentives, which too will ratchet down over time, are instrumental in getting projects online, but are slowly being phased out. "It is very market specific, but we see that if a project generates savings today, customers are willing to purchase those, regardless of the runway of the ITC," adds NRG's senior director of business development, John Woody.

Furthermore, state renewable portfolio standards (RPS) are a key driver of solar procurement, requiring utility companies to source a certain amount of generation from solar, wind and other renewables. In Hawaii, for example, there is the ambitious goal of 100% renewables by 2045. Vermont has set itself the goal of 75% renewables by 2032. California also has a strong RPS, at 50% by 2030, closely followed by Maine's pledge at 40% by 2017.

An RPS can drive utility prices up in places like California where the burden on the utility is deemed to be a driver of future utility rate escalation, according to REC Solar's Russo. This utility rate escalation in turn makes onsite generation economic models look better because of the spread between what electricity can be generated onsite versus what is paid today and in the future. If the RPS drives the perception that utility rates are going to be higher, that creates an environment for onsite generation of all sorts.

"In terms of the utility side, I do think the RPS in states is definitely driving procurement but we are also seeing utilities that are not subject to RPS provisions procuring renewables given the cost. You see some procuring solar and that is partly due to customer demand and customer requirements effectively," explains Woody. "Despite some regulations around RPS goals we do see a lot of utility renewable procurement outside of those regulatory frameworks."



Credit: Getty Images

Utility -scale solar deployment is increasingly happening outside of state renewable portfolio standards

In addition to RPS, states across the nation have been adopting Integrated Resource Plans (IRPs) that follow a simple mantra: less coal and more renewables. Georgia, a particularly low-cost market, initiated a 20-year IRP this year to add renewable energy, predominantly solar to the state. Georgia Power recently added 525MW of renewables under its latest IRP programme.

Signal not a driver

Separate to any state incentives or utility rebates, demand for solar power is a driver unto itself as consumers and energy providers are realising the worth in a clean and increasingly cheap source of energy. "We are seeing customer demand increasing pretty rapidly – customers are definitely driving energy and technology trends, most frequently in the renewable space. Most of those customers have significant renewable energy goals and they are demanding change," says NRG's Prince.

"In our business today, especially on the utility-side, I would say we are not really an incentive-driven business, we are more of a market-driven business. Where market fundamentals are good is where the electricity market properly values what solar provides to the electricity grid," explains Brian O'Hara, senior vice president of strategy and government affairs at EPC Strata Solar. "Incentives like RPS in the states that we are operating in now are as much a signal to the market as they are an actual market driver; the RPS is not fundamentally what is driving the growth of solar, it is really the economics. Since we are in the south-east, many of those states don't have a RPS and yet we still have a fairly robust solar market there."

In addition to that, the cost to install solar has dropped more than 70% over the last 10 years. "We continue to see really significant drops in component pricing and I think what that is doing is continuing to drive down the levelised cost of solar and open market potential up," says O'Hara, who also adds that a further driver propelling solar as a whole is increasing recognition by utilities that

solar is an integral part of their portfolio. In future, when solar is fully amortised, it will be even more attractive in its ability to produce power at low operational costs in the absence of fuel cost inputs.

Supply and demand

Over the last 10 years US manufacturing has been on the relative decrease with strong competition from Asian module and inverter manufacturers. Despite the ITC extension causing a hangover in the first and earlier part of the second quarter, particularly in the utility space, US manufacturing is facing a bigger problem: China. With vendors such as Trina Solar and JA Solar forecasting more shipments to the US in Q2, there is more pressure for US panel manufacturers to sell at lower prices.

The punitive tariffs on Chinese firms have meant there is a trend for factories being added in Malaysia, Thailand and Vietnam over the last 18 months, so supply is not a problem. In fact, the 14.5GW of installations GTM and SEIA forecast for 2016 should confidently be met despite the duties squeezing out some Chinese supply

A substantial amount of that 14.5GW has potential to come from US manufacturers, with the rest having to be imported. Hanwha Q CELLS, which manufactures in South Korea and Malaysia, has a shipment contract for 1.5GW for 2016 and imported 500MW into the US last year. In addition, Trina Solar, Jinko Solar and REC Group all manufacture in Singapore, and around 60% of their sales last year came from the US. With all of that said, that 14.5GW should easily be supplied, even in spite of the tariffs.

"I think there's a tremendous amount of talk of overcapacity in the media. When it gets down to actual buying behaviour though we still see a real urgency from people to buy," says Matt Card, executive vice president of commercial operations at US module firm, Suniva. "There may be overcapacity in the more commoditised multi products, and a tremendous amount of supply and demand there, but in higher powered, higher quality mono products demand is still the driver more than an oversupply situation."

SunEdison founder and clean-tech investor Jigar Shah echoes this sentiment: "I think what you're finding is that the solar industry just simply can't help itself. And so even though there is supposed to be a pull-in of manufacturing capacity, people are so desperate to build more capacity that it just seems like manufacturers cannot produce a shortage of product, even if their life depended on it. Everyone keeps predicting a shortage of product and then you look at the market and you realise there is no shortage of product."

There is in fact a general increase in demand for high-efficiency modules, which allow the number of modules needed to power a system to be cut to generate the same kilowatt hours, which reduces upfront costs and even requires fewer or smaller inverters. This is particularly attractive in the US where there are significantly higher irradiation levels than generally found in the northern hemisphere, for example.

"We are seeing an increased premium being placed on power density. Part of the reason for that is that people are understanding that the more power you can generate off a rooftop, the better off your application is going to be," explains Card. "But also, quite frankly, most of our more developed regions, the really easy to develop pieces of land are becoming fewer and far between; the perfectly

square, no trees, all flat, sitting right next door to a substation land is all gone. And so now you are getting land where more compromises have to be made. As land becomes less optimal, the need for power density goes up because the cost of developing the land is more expensive. We've seen great uptake of high-power products in that micro-utility space and certainly the commercial and industrial space."

Due to net metering rates or space constraints, it is becoming increasingly important to maximise the amount of energy that can be produced in any square foot of land. A maturing market is a good thing for high-power, high-efficiency providers because such markets understand it is not just a question of price per watt but it is a question of the value ratio between price and power – and high-power certainly drives that value ratio up.

"It is a market that is driven by real economics that exist regardless of administration"

An unquantifiable spanner in the works for US manufacturers and developers is uncertainty over the presidential election. Some industry experts take the opinion that financial markets are hugely sensitive to any unknowns, and if they do not know something, they sit back and wait until certainty is restored. Suniva's Card however does not feel that this will have a significantly detrimental effect on the market: "The market has great momentum in the US and it seems to have matured to the point that this is not just a decision of a market that is driven by political view point. It is a market that is driven by real economics that exist regardless of administration. So that's a great sign for the US; it has moved passed the case of being totally driven by political or subsidised considerations – more to the notion that the economics simply work."

But with 76 of the 115 companies in the NYSE's Bloomberg Global Solar Energy Index down, and the index itself at a negative 26.57% return in the past year, investors will most likely be taking a seat, for now. ■

Swing states

Credit: Getty/FernandoAH

The US solar industry is changing. The drivers, the scale, the cost, they are all in flux. With all these conditions changed, it is to be expected that the geographic distribution of solar would also be altered. State-led renewable portfolio standards gave way to the federal tax credit as the main driver of solar; now pure economics is becoming an increasing influence and further diluting geographic discrepancies.

2015	2016-2020(e)
California	California
North Carolina	Texas
Nevada	North Carolina
Massachusetts	New York
Arizona	Arizona

Top five states by deployment. Source: GTM Research/SEIA

California has historically been way out ahead of all other US states in the solar deployment stakes. In 2015, Arizona deployed 258MW of solar. That was enough to earn it a place in the top five, according to data from GTM Research and the SEIA. During the next five years Arizona will retain its fifth spot compared to other states during the same period. To do so, it will install 2.5GW, or an average of 500MW per year. This is a pattern replicated across the country. Healthy but unspectacular markets will increase in size. Some with tiny demand now will grow rapidly – Connecticut, for example, had around 230MW installed as of 2015 but will pass the 1.3GW mark at the end of 2020, according to GTM's data. Texas is the only state that will experience transformative growth. Around 4.5GW of additions in the next five years, averaging out at 900MW a year, is a major increase on the 212MW installed in 2015. It is the state that everyone has been waiting to pop, but there are rich pickings available elsewhere too.

Florida

While the fate of Florida's rooftop market looks set to go to the polls, utility-scale solar is now beginning to make its mark. In the last year the state's major power providers, Florida Light & Power and Duke Energy have started work on a total of 725MW of solar farms. More than 2GW has been forecast to be added in the next five years as the Sunshine State's energy mix finally starts to live up to the name.

Minnesota

Minnesota will also add more than 1GW in the next five years and is likely to do much of this via its well-established community solar programme (see p.32 for more on community solar). The state has spent the last three years refining a system with the utilities to enable those without access to a roof or the necessary cash for an install to invest in a portion of a larger centralised system in return for reduced bills. Xcel, the largest utility on the state could install 200MW this year and more than that in 2017.

Oregon

With 73% of its power from hydro, solar deployment hasn't been a huge priority for Oregon, even with so much PV manufacturing encamped there. That said, its renewable portfolio standard is not washed out as its requirements specify that targets must be met from new-build renewable generation. There is competition from established wind, expanding geothermal and well-stocked biomass generation, but solar is still expected to top 1.5GW by the end of 2020. Just 30MW was installed in 2015.

New York

Governor Andrew Cuomo has spearheaded a series of solar-friendly schemes including NY Sun Initiative with a 50% renewables mandate the latest positive indicator for solar. Silevo/SolarCity and 1366 Technologies will add a significant manufacturing presence to the state on top of the expected burst of deployment. It currently has around 716MW of installed solar but the GTM/SEIA forecast expects close to 3GW of new solar capacity during the next five years.

South Carolina

While all eyes are on North Carolina, there is significant opportunity in neighbouring South Carolina. The state didn't introduce its renewable portfolio standard until 2014. As such, it currently has 17MW of solar installed. But it should prove to be a fertile hunting ground for developers as it looks to meet a modest 2% renewable generate capacity target by 2021. GTM/SEIA forecast 765MW in the next five years. The RPS however, does not include projects over 10MW.

By John Parnell

The rise and rise of US storage

Storage | Energy storage in the US is being propelled forward by falling costs and increasingly favourable markets and policy. But for the full value of storage to be realised, numerous regulatory and fiscal barriers must still be surmounted, writes Matt Roberts

Credit: S&C Electric

Increased deployment is proving the value of storage in the US across a wide range of use cases

Energy storage in the United States is going through a meteoric rise, fuelled by a combination of increasing value and market access, enhanced regulatory structures and plummeting system costs.

This ascent is taking different forms across the country. Last month, Massachusetts became the third state in the US to pass energy storage procurement goals, following a trend born on the West Coast. California is pursuing a goal of 1.325GW of energy storage by 2020 for its public utilities and Oregon has followed suit with its own targets.

Also in California, anticipated gas shortages, underpinned by the largest ever natural gas leak in the US, have propelled utilities to rapidly procure energy storage to prevent system capacity shortfalls. New Jersey is seeking storage to ensure system reliability in the face of increasingly intense superstorms, and to enable customers to have backup power and consume their own solar energy even when the grid is down. In New York, Con Edison is procuring storage to defer the cost of a major substation upgrade, while Indianapolis Power & Light just completed the installation of 20MW of storage to help balance the grid and provide black start capabilities in the state.

At the federal level, the White House convened the "Summit on Scaling Renewable Energy and Storage with Smart Markets" earlier this summer. The summit resulted in new executive actions, and 33 government and private sector commitments representing nearly $1 billion of new investments and 1.3GW of additional new deployments. Congress has introduced bipartisan legislation supporting storage advancement, the IRS is revising its guidance on storage and the Investment Tax Credit, and the Federal Energy Regulatory Commission (FERC) is reviewing treatment and qualification of storage systems across the ISO/RTO markets.

What this confluence signals is critically important: the energy storage industry, after decades of work and hundreds of successful and reliable deployments, is being accepted as a critical facet in securing the nation's energy future and modernising the grid. But while these milestones are momentous to the industry, there is critical work to be done to establish fair, competitive markets that capitalise on the value of energy storage.

What storage is today

Our electric grid is one of the longest supply chains in the world with very little storage capacity built in. We stockpile fossil fuel, and some of our advanced hydroelectric facilities even run water uphill and back down again – but once energy is generated our ability to do anything other than consume it is very limited. Since the advent of the electric grid we have known the inherent value of stored energy and sought to deploy it – even Edison's Pearl Street Station incorporated battery storage in the 1880s to help ensure reliable electricity supply for his first 82 customers.

The term energy storage defines a suite of technologies – batteries, flywheels, compressed air, thermal, flow batteries and more. While each of these systems may operate differently on the inside, their fundamental value is the ability to store energy when it is plentiful and utilise it when it is needed or most valuable to the grid.

Energy storage systems make a more reliable electric grid possible, creating flexible, decentralised reserves of energy that can be tapped in to on demand. Faster-responding storage allows us to operate the grid more efficiently, instantly balancing our ever-fluctuating supply and increasingly dynamic demand. These systems are also used to defer or avoid costly investments in excess capacity and infrastructure currently needed to serve our nation's growing peak loads.

Customer-sited energy storage enables homeowners and businesses to drastically lower their consumption while avoiding more expensive demand charges and time-of-use rates. Storage provides backup power and enables solar customers to generate on-site and consume their own energy even when the grid is down. High-tech industries with exacting power specifications can use storage for reliable,

unvarying supplies of energy.

Through these various applications energy storage enables end-users to be partners in creating a more reliable and affordable electric grid, and means that utilities can deliver more sustainable energy from a more resilient system while adapting to the changing needs of businesses and homeowners.

What storage is not

The oft made analogy is that energy storage resembles the solar industry circa 2005. Though from my seat – sitting at the nexus of technology, policy and markets at the Energy Storage Association – the road ahead looks very different than that of the past decade for renewables.

According to the 'U.S. Energy Storage Monitor' [1], in 2015 we saw more than 250% growth in system deployments – doubling the entire US installed capacity. In just the last quarter of the year there was more energy storage deployed than all of 2013 and 2014 combined. By the beginning of next decade, more than 6.5GW of energy storage will already be deployed (Figure 1).

In just the past 18 months, energy storage system costs have declined more than 70% [2] and the balance-of-system costs are projected to decline another 41% [3] before 2020. Ramped up manufacturing and production supported by expanded market access will depress prices for storage technologies even further, and the ES Monitor projects more than 25% in additional cost declines before 2018.

While these trends may closely mirror the acceleration in solar, they also mirror the advancement of nearly any energy technology – higher value coupled with lowering costs equals industry success, Economics 101. For energy storage though, the drivers of that success and the challenges ahead are markedly different from the growth in solar.

Energy storage has a fundamentally distinct value proposition when compared to renewable generation, and benefits the grid in very different ways. Storage is, in effect, an energy service; the valuable utilisation of energy when and where it is needed most. It doesn't fit neatly into traditional asset classes like generation, transmission, or load; it can perform as any one of them or all three, adapting to the changing needs of the system in real time.

Additionally, energy storage is often held up as the saviour of renewables, here to address intermittent generation – this is an oversimplification. Intermittency hasn't 'broken' the grid as some proclaim; rather dynamic generation has shown that our current electric grid is insufficient and outmoded.

Energy storage can rapidly balance *all types* of generation and load, allowing fossil plants to run more efficiently and maximising renewable output. Variable generation and mutable loads combine to produce an ever-fluctuating system that energy storage addresses, helping us operate the grid more reliably and affordably. Energy storage has a critical role to play, regardless of how our generation mix and customer behaviour evolve in the future.

Applications and value of storage systems today

Today, the majority of energy storage systems being deployed are in front of the meter, connected directly to the grid and serving in various roles and applications. But customer-sited storage is catching up quickly and the market for these distributed systems is expected to eclipse grid installations before the end of the decade [4].

In wholesale markets storage is designated as an 'Exempt Wholesale Generator' by FERC –meaning that it can provide capacity, energy and ancillary services in ISO/RTO markets. Energy storage has notably been active for many years in PJM and NY-ISO providing ancillary services, and is quickly being adopted by the remaining wholesale markets as well.

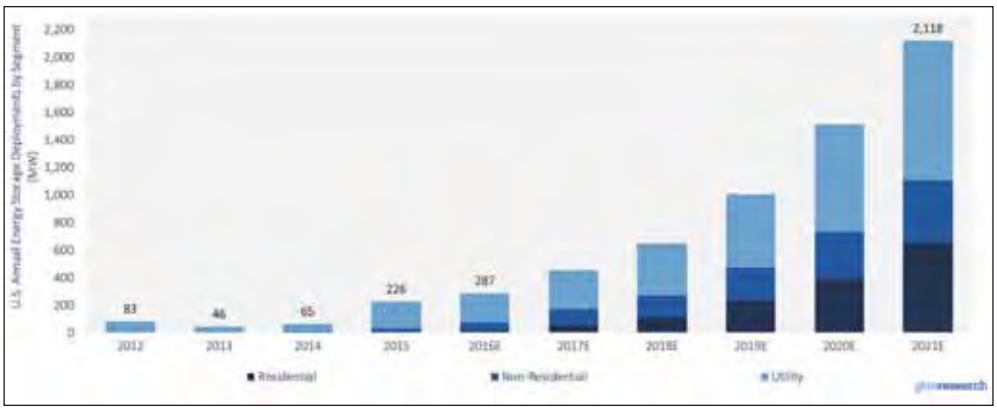
In PJM in particular, this required market changes that separated resources such as fossil fuel plants, which follow a traditional, slower grid signal (RegA) from energy storage systems and other technologies that can follow a quicker, faster-responding grid signal (RegD). The RegD signal is able to meet the dynamic needs of grid operators much more efficiently, reducing energy consumption across the multi-state region through increased performance while saving millions of dollars.

When utilities weigh storage side by side with other solutions, it proves to be a cost-effective replacement for traditional fossil assets like local capacity or 'peaker' plants. Under the guidance of the California procurement targets, when utility Southern California Edison examined energy storage against traditional solutions for local capacity requirements, it decided to procure nearly 264MW of storage in one fell swoop, more than five times what was required – on both sides of the meter.

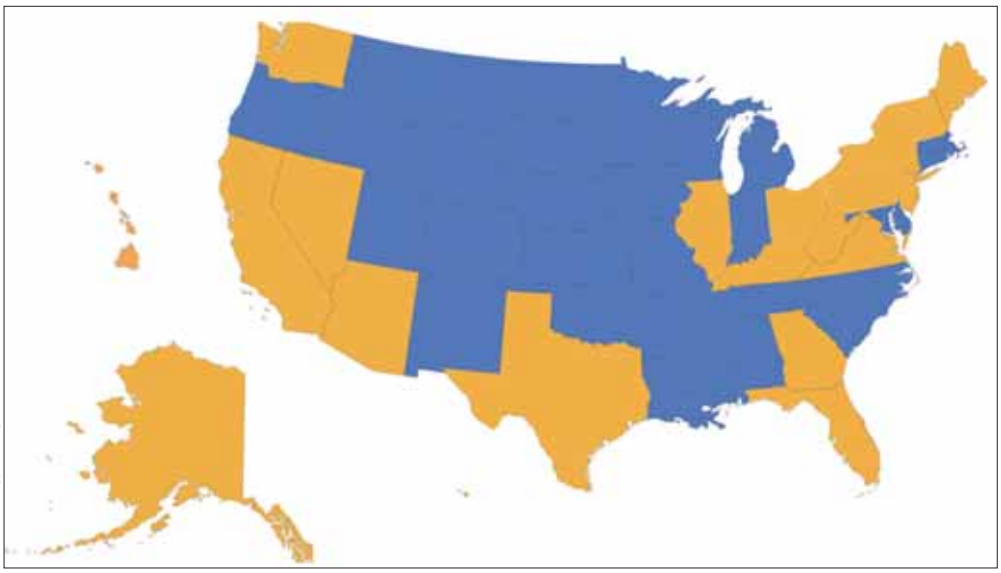
In customer-sited systems, energy storage is helping to defray the cost of demand charges for businesses and helping customers avoid time-of-use rates and consume more of their own on-site energy. Project developers are even building aggregated storage systems and virtual power plants that tie multiple installations together, working in concert to address system needs and creating an entirely new distributed tool for grid operators to call upon. These types of applications empower homeowners and businesses to be active participants in the grid – helping improve system performance, efficiency and reliability along with the utilities.

In 2015, 20 states installed energy storage systems in 2015, signalling that these opportunities are widespread and economically attractive in multiple applications and environments (Figure 2). In front of the meter, PJM and California are the two markets with the most deployments in the last three years, followed by states like New York, New Jersey and Hawaii that are starting to accelerate. On the customer side of the meter, California has led the industry on deployed storage systems in recent years, followed closely by Hawaii and then a collection of states experiencing their first waves of installations.

Figure 1. The US energy storage market will grow nine-fold from 226MW in 2015 to 2.1GW by 2021



Source: GTM Research



Source: Energy Storage Association.

Figure 2. In 2015, 20 US states installed energy storage systems

These systems have proven themselves a cost-effective solution in many roles in wholesale, competitive and vertically integrated markets across the country. And while this convergence of factors is driving immediate success, there are changes to regulatory and market structures that are needed to ensure that we can access and utilise the full value of these innovative energy systems.

What barriers exist for energy storage?

While the US electric grid is becoming increasingly outdated and is in need of substantial improvements, we are burdened with archaic regulations and practices that govern the system and hinder our ability to capitalise on advances in technology.

When energy storage is interconnected in wholesale markets it is defined as a generator – even though a storage system does not 'generate' any new electrons. This constrains the system's potential to perform specified functions and contribute to certain markets, and can limit which entities are allowed to own and operate storage systems on the grid.

Within utility resource planning, energy storage is markedly undervalued by current methodologies and modelling and therefore often not even considered alongside other options. Given the limited role that energy storage has played on the grid historically, most of the traditional utility planning models were not designed to assess energy storage alternatives. And as storage defies simple classifications, it's often difficult if not impossible for the generation, infrastructure and load forecasting segments within a utility to determine how to appropriately quantify the value of storage under current planning methodologies.

In our energy tax code, energy storage is not listed as a qualifying energy property under the rules of the Investment Tax Credit. While storage can be included as part of the equipment within a qualifying renewable energy installation, owners are not able to invest in energy storage alone under the same terms. This is despite its ability to lower electric bills, enhance renewables penetration and improve system reliability.

These types of challenges and market nuances exist throughout the US, with differing federal, state and local policies and regulations governing the energy industry. While numerous best practices and precedents are in place, there is still a need to adopt regulations that ensure we are properly valuing, integrating and operating energy storage systems for maximum benefit. In short, it is imperative that regulations keep pace with advances in technology or else we are working against ourselves in the pursuit of grid modernisation.

What lies ahead?

The energy storage industry is not just about what traditional assets can be displaced, it is also about how we create new markets and drivers that capitalise on the performance of advanced energy systems. With the right competitive markets and deployment goals, we can ensure affordable and reliable energy for everyone – and achieve the nation's clean energy and resiliency objectives.

We are no longer debating if energy storage systems are reliable, or if they are cost-effective, or if they can perform various applications – hundreds of installations operating for multiple years have shown this to be true. Still to be determined though is exactly how markets will adapt and which states will follow the lead of California, New York, Massachusetts and Hawaii and benefit from the economic activity and job growth that is enabled by creating vibrant storage sectors.

By restructuring markets to reward system performance and delivered value while providing the same tax credits that other clean energy technologies are afforded, we can hasten efforts to create truly integrated resource planning that prioritises innovative solutions over the status quo. Additionally, enabling more opportunities for utilities, businesses and residences to own energy storage will ensure that markets are open and competitive while keeping electricity costs affordable for everyone.

The Energy Storage Association is excited to work with so many pioneering states and markets leaders to implement policies that accelerate energy storage adoption. In 2015 we saw 20 state and four regional markets, as well as the federal government, deploy energy storage. Led by the innovative work of our more than 200 members across the globe we are reshaping the way that energy is generated, distributed and consumed, and are paving the way for the meteoric rise of energy storage systems deployed on the grid. ■

Author

Matt Roberts is the executive director of the Energy Storage Association, overseeing operations and strategic initiatives for the industry's trade association. Based in Washington, DC, he has more than 12 years of experience in clean energy policy and market development, with a recognised expertise in storage, renewables and sustainable infrastructure. Matt also serves on the board of directors of the Global Energy Storage Alliance (GESA), as a co-founder and communications officer on the executive committee.

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US solar finance: three talking points

Credit: SolarCity

Finance | Over the past 12 months, the US solar business has been on a rollercoaster ride, with the high-profile bankruptcy of SunEdison and the merger of SolarCity and Tesla stealing the headlines. Danielle Ola talks to the experts about some of the key trends shaping the world of solar finance and investment in the US

Market consolidation

After several years of consolidation in US solar, particularly in the residential space, 2016 looks set to be the year that trend changes.

"This is the first year that we have reversed the trend of consolidation," says Jigar Shah, founder of SunEdison and clean energy entrepreneur. "For the past five years the residential marketplace has been consolidating into five players, and this year that will reverse. The top five players will lose market share this year. So a lot of the smaller players who have been 'slow and steady wins the race' are continuing to grow at 20% a year. In the past this has not been rewarded because the top five were growing at 50% a year."

This can be attributed to a decrease in appetite for rooftop solar panels, as evidenced by California's rooftop solar applications, which were down over 20% year-over-year in May. As California is the single biggest solar market, it is a clear indicator of the future of rooftop demand. This is also further seen in SolarCity's second quarter results and lowered full-year guidance. But the good news is that this opens up the market for a new type of competition; as smaller players may have a chance at a larger market share.

Key deals

Despite a less than stellar performance overall, some key transactions were seen this year. The biggest transaction so far was undoubtedly the all-stock US$2.6 billion Tesla-SolarCity deal, with Shah suggesting the opportunity for both brands to cross-sell products was a significant motivation.

"The two technologies in the clean energy space that have some sex appeal to them are solar and electric vehicles. So for all the people that are attracted by electric vehicles Tesla can now sell them solar, and for all the people that are attracted by solar, SolarCity can now sell them EVs. If you've got Tesla having 300,000 pre-orders for Model 3s, they can really substantially increase the sales of SolarCity. And vice versa. A lot of those people who bought SolarCity systems could go out and buy Teslas."

Opinion is divided on whether the merger of SolarCity and Tesla signifies a broader long-term trend in the US

Markets and market watchers responded less favourably than Shah, with share prices tumbling 4.14% and 1.92% for SolarCity and Tesla respectively since announcement of the deal. There is agreement among industry experts that the deal was driven more by internal dynamics than any other external force; the two companies are intertwined by family ties, as well as sharing many of the same investors. It is a good opportunity for the residential installer, which will now get access to Tesla's fairly large balance sheet, better access to the public market and of course access to energy storage.

"It basically consolidates even further the vertical integration they had," says Santosh Raikar, managing director, renewable energy

investments at State Street Bank. "Batteries will play a much larger role in residential solar in the future and there are some integrated residential solar battery players that are being implemented in the market."

The deal is arguably a better value proposition for SolarCity than Tesla, with some characterising the deal as more of a bailout than an acquisition, comparing it to the Total acquisition of then embattled SunPower. Regardless of a less than welcoming investor reception, it is evident that the deal propels both companies into a space not yet seen in the solar industry.

"It's pretty atypical to everything else in the solar industry," says Stacey Hughes, CEO at SunLight General Capital. "Tesla and SolarCity have done something really different which is to incorporate high-end consumer products. It probably does allow for a really sophisticated and well-funded R&D approach and positions them to do things differently than all the other energy market participants." For example, the two companies are talking about a push to create rooftops with solar embedded.

A sign of things to come?

Despite its eye-catching nature, the general feeling is that the deal in isolation does little to signify the shape of US solar consolidation to come. "I don't believe that that is an indicator of a larger trend," says David Giordano, managing director and member of the Renewable Power Group at Blackrock Alternative Investors. "I think there is a very specific synergy that exists between those two companies, and it was a fairly unique partnership that was able to facilitate that merger."

What it does signify is that the solar market is a challenged space, with only so many investment dollars and only so many projects that work. Perhaps it is an indicator to those that wish to have a serious market share and scale that more internal diversification is needed to remain competitive.

But Edmeé Kelsey, CEO of asset management specialist 3megawatt believes the Tesla-SolarCity deal is indicative of a specific trend of business models merging: "We see three things: utilities, car companies and solar companies all trying to blend their business models. The significance of the SolarCity deal is just that you see these three types of companies all of sudden merging into a defining business model for the future." Indeed, Mercedes-Benz last year began offering its own brand lithium-ion batteries through German automaker Daimler AG. BMW recently entered the energy service business, and utilities also are now buying storage companies.

Yieldcos

Recent events do not paint the yieldco model in a positive light. Still contractually shackled to a bankrupt sponsor, SunEdison, both TerraForm Power and TerraForm Global depend on the developer for administrative and supportive services. Both yieldcos have delayed filing their second quarter 2016 results, the third successive quarter without financial filings from the pair. This can be attributed in part to the bankruptcy of their parent firm, as previous results were delayed due to "material weaknesses" identified by SunEdison management.

It would not be surprising if investors now tread with trepidation when it comes to the yieldco model. The general consensus is that in and of itself, the yieldco can be a very effective financing mechanism that allows retail investors to access mature and stable cash-flow asset classes. However, the challenge comes in broader market conditions that make it difficult to access that capital. Having a healthy pipeline of projects on the developer side to deliver projects to the yieldco is pivotal, and this is where SunEdison failed.

Most will agree that it is a challenge to raise new capital during periods of growth in the public markets, but opinion is divided on whether the SunEdison fiasco merely tainted the model, or whether it is inherently flawed. "In theory it is a perfectly good financial model," says Hughes. "The problem is if you isolate it to make investments in solar or even only in wind where there are not enough new projects to deliver the economies of scale. To the extent they are very general, project finance yieldcos can work fine. To the extent it is limited to solar, I think it is probably an unrealistic approach and I don't think the yield that they are delivering is sufficient for either the risk they were taking or the capital they were putting up."

Investor view

But what do the investors think? Some reckon that yieldcos draw most interest from institutional investors like hedge funds, which tend to be more opportunistic. Other investors, who are looking for a wider array of projects with higher yield, might not be as interested in yieldcos. "Overall I think companies are trying to isolate the SunEdison incident as a one-off and look at yieldcos as something separate," says Mercom Capital Group's CEO, Raj Prabhu.

There are still a lot of yieldcos out there and there are a lot of investors that favour them. It can only be a good thing to have a quoted entity that holds solar assets, particularly in the US, where one has to be a credited investor in order to buy solar projects. So the yieldco model is essentially the only way that as a private investor you can invest directly into solar projects and that is very appealing.

Positives for yieldcos

It is a huge selling point that yieldcos are one of the only ways to gain access to a class of investment that was not available for small investors in the past. It still remains fairly difficult for your average mutual fund or individual investor to invest in a project finance deal – as this is usually the domain of large equity investors and commercial banks. "They give you a nice combination of growth and yield that is difficult to find elsewhere in the economy at this point in time," says Berger. "It is a long-term promising model that is viable and clearly I think is coming back."

Indeed, the SunEdison yieldcos are much more valuable than what was thought by the market even a few weeks ago. In addition, some feel that they may be rebounding after the SunEdison hit. Two other yieldcos, NRG Yield and 8point3 Energy, are seeing some improvement in stock prices, which could be a signal of better days to come.

"I think yieldcos were in a bit of trouble last year, but they have rebounded nicely," says Shah. "This is a big deal and a good thing, and gives people more licence for traditional innovation. In fact, I think the yieldco model has become stronger than ever. There were a lot of people questioning the yieldco market last year but I think with the rebound of 8point3 Energy and NextEra and some of these others, you are seeing a tremendous resurgence in the yieldco market right now."

Secondary PV market

The secondary PV market – where solar assets are sold to new investors – has yet to get going properly in the US, as it has in Europe. This is largely due to investors making the most of tax equity benefits bestowed on PV projects under the federal investment tax credit.

According to Shah, the fact that the secondary market has yet to kick off is the "biggest casualty" of the SunEdison yieldco debacle. "The secondary market is still not liquid and that is because TerraForm Global and TerraForm Power were the main

Credit: SunEdison

provider of liquidity to the first donors of solar PV. Now that they have exited the market, here has been very little interest on the part of other yieldcos."

Sunnova's Berger believes the secondary market is not only being held back by tax equity, but by a lack of companies that have sound balance sheets and are able to be sponsors to asset sales to financial and other players. "The industry has to become profitable and reduce leverage, which are related, to proliferate," he explains. "That is clearly taking place and as investors see those positive things, then I think that more participants and more competitors will show up and other investors will see that and want to invest. As they build asset bases, that will mean that there will be more participants that can trade secondary assets."

Market drivers

To build real scale in the secondary market would take an outside force, for example, a meaningfully higher asset price, because most of the projects are already operating in an acceptable yield, and to sell them, the owner would have to either take a haircut on that or the buyer would purchase it at a much lower yield. In addition, one of the main barriers of the secondary market is the fact that there is no good due diligence methodology. Therefore, a real driver for this latent market will be standardisation. "Once someone figures out how to due diligence these assets for 90% less cost, you will see a boom in these purchases," Shah says.

Until that happens, the fundamentals of the power portfolio mix themselves will continue to create opportunities for new projects to get built, and as they get built there will be opportunities to sell them in the secondary market to investors who are seeking more mature assets and not just new builds. "You also have adjustments where you have utilities enhancing the environment for new project development, as the demand is increased for end-users for access to renewable power," adds Giordano. "That combined with an increase in demand will really drive growth."

Companies can also engage in tactical or opportunistic strategies to ensure a place in the secondary market. For example, some projects may be financed with an intention to taking them public at some point – either through a yieldco or an IPO. Due to lack of access to capital market activity, such projects can be sold to an alternate investor with a view to releasing the capital so they can recirculate.

Market obstacles

It is apparent that cracking this market, in the current tax equity climate, is difficult. Another problem that may arise is the quality of early projects. "The current owners of the solar projects, particularly in the US, are generally fairly unsophisticated," says Shah. "Their paperwork etc. is not in order. Many of them have not been audited before and so it's just very difficult to trust the numbers that they have."

The bankruptcy of SunEdison capped a difficult year for solar yieldcos

On an even more basic level, owning assets directly could be an initial challenge for investors. There are, after all, only so many projects already built, and there are depreciating assets. Notwithstanding a fragmented secondary PV market, Berger is assured that everything that is going on now is healthy for the industry: "We were strongly cautioning that the industry was about to go to a capital market that was going to be rather difficult. We've obviously experienced that. I think the capital market is cleaning up and saying specifically, spend less money on overhead, don't buy overpaid assets, basically have good returns and don't over lever, and as that market discipline is in place in the industry, the assets themselves are performing very well. Right now, as opposed to say a year ago, the underlying fundamentals of the business, which is really what matters in the industry, are extremely strong. I think in the next year or so we'll be in a very strong position, but that will be because the industry has bought financial discipline to play. It's healthy, and it happens in every market." ■

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Community solar | Community solar is emerging as a promising new source of demand in the US, opening up access to solar among previously excluded groups. John Parnell reports on the prospects for a new market segment whose time seems to have come

It's a claim that residential solar markets as disparate as the UK and the US have both faced: middle class; people with big houses and money to spare, perhaps motivated towards solar by smug superiority. This is a common line of attack from utilities in the net metering debate in the US. It is part of UK critics' argument that solar drives up the cost of bills, which is most keenly felt by the poor.

Residential solar has certainly had greater initial take up among medium- and high-income households but social housing schemes, local authorities and other non-profits have also found ways to expand access.

The most compelling – and market-driven – means of expanding solar's reach among all income groups is arguably community solar, or community solar gardens (CSG) as they are sometimes dubbed. Closer inspection reveals that US community solar is now at the inflection point from pilot schemes to substantial deployment as more and more states develop the necessary frameworks.

"It's basically a state market," explains Jason Coughlin, senior research analyst at the National Renewable Energy Laboratory (NREL), who adds that the first movers are Colorado, Minnesota and Massachusetts and "hopefully California in the near future".

In the US, community solar has a slightly different definition than elsewhere. It is not about direct project investment by a local community or about direct supply to households via a private supply agreement. Instead, customers sign up for a certain amount of solar capacity, often at a level lower than would be economical as a rooftop install. They are billed as normal but the utility will then credit their account based on what their share of the install generated. Coughlin refers to it this approach as "virtual net metering".

"We're seeing real uptake in the projects. A number of colleagues here at the lab that are members of community solar gardens," he says. "I think it's a real market segment and here to stay."

NREL has previously put the size of the community solar market at 11GW by 2020. With standard utility projects easing up with the removal of the ITC crunch, that's a sizeable, and well-timed, new source of demand for projects.

Community solar gardens offer access to solar to customers without the opportunity to install their own system

Utility buy-in

Once a state has passed the necessary legislation it is over to the public utilities commission (PUC) and the utilities themselves to create an offering that is attractive. Minnesota, as Coughlin mentions, was a pioneer in this aspect. Martin Morud, founder of the installer and developer TruNorth Solar, was one of those responsible for pushing the development of a community solar proposition.

"Consumer choice for clean energy is absolutely critical to our future, and the community solar programme provides that," says Morud. "I believe that if we're going to have sustainable, clean energy in the future you have to work with utilities not against them and so I wanted to be a voice of the PUC that said, 'You know what, let's work this out'."

Morud says this approach has aimed to develop a productive, 50-year relationship with the state's largest utility, Xcel, rather than an antagonistic one that doesn't survive one project cycle. While not perfect, as Morud admits, the scheme with Xcel does achieve several of the big asks: it has opened up the solar market for consumers, it is sufficiently attractive to consumers and it steers clear of the scale of controversy that sets the bar for approval of the policy that bit higher.

"It's designed to not be an incentive or a disincentive, it's meant to be equal with whatever they're currently paying. So if rates go up, the CSG bill credit rates go up. If rates go down, the CSG bill credit goes down. So there isn't a whole lot of certainty with the investment, it's just an opportunity to offset a consumed kilowatt hour with a different energy recipe," explains Morud.

Asked whether the additional benefits of solar should also be reflected in the price, he was unconvinced of the benefits, for now at least: "My personal and professional thought is I don't care whether it's applicable retail rate or CSG bill credit rate or value of solar net metering, none of that matters to me. What I care is whether clean energy infrastructure is built. If we clean up our energy recipe then we've won no matter what the policy is and that's my message to the state agencies."

Access

This sentiment is a common vein running through all community solar champions it would seem.

Hannah Masterjohn is the director of policy and new markets at Clean Energy Collective, one of the largest community

solar developers in the US. She also serves as the chair of the Coalition for Community Solar Access.

"We need to expand access to solar to all customers; 80% currently have no access and we think that needs to change and can change quickly," she says.

"Around 80% of people can't put solar on their own roof; they might not own it or have the rights to it. It could be shading or that it is facing the wrong direction or you have folks who are thinking about moving so they are not going to make a big investment in their property. Or maybe they don't want contractors interfering with their roof.

"Everyone paying their taxes contributes to the ITC. Bill payers are also paying into various state incentive programmes and they ought to be able to take advantage of that. Access is really the number one [issue]," adds Masterjohn.

Financing: who and how

TruNorth's Morud claims there is more demand than supply for community solar in Minnesota right now with his company one of a group working hard to get projects online. He expects Xcel to roll out around 200MW of solar gardens in 2016 and more than that next year.

Demand is high and an increasing number of states – Maryland is next – are creating the right policy and regulatory conditions for community solar. But with all the will in the world, this is not enough without the financial backing to get projects of the ground.

The structure of the finance will depend on the model being used for the community project. Some utilities are sponsoring their own projects and offering customers what is in effect a power purchase agreement that sets the price slightly higher than the current retail rate but protects the customer against future rises. The bill credit model brings together the patchwork of investments from each subscriber but that is insufficient in the development stage.

Marissa Alcala, partner with the law firm Chadbourne Parke says that while it is still emerging as an asset class, it is taking on a familiar form.

"Community solar bridges the best of the residential sector and the commercial and industrial space, or perhaps the small utility-scale space," Alcala says. "You have flexibilities for replacing customers but at the same time you've got the opportunity to evaluate the credit of your customers, you have the opportunity to have a project that is going to be on a site, it doesn't have to move if you need to change your customer base, you have consistency of subscription agreements for the different customers who are signing on to a project but you have a scale that's obviously much bigger than anything one could ever dream of in the residential scale. It's much more like C&I or small utility-scale."

One area of additional complication is the state-by-state shape of community solar regulations.

"The biggest issue is the diversity in the regulatory framework across states, which just increases the transacting costs for people who are looking to develop projects in different states," Alcala explains.

"So if you're looking to do financing for a portfolio that crosses different states, there are still growing pains. There are still inefficiency concerns about how people fit deals into financing structures because of the need for tax equity or debt providers to become comfortable enough with the programmatic requirements and frameworks in different states.

"Even when tax equity investors or lenders have gotten comfortable with community solar as a structure for building and developing projects, and selling power and generating revenue, they still need to get comfortable with the different programmatic requirements and programme structure in every state," she adds.

Customer acquisition

While sales-related soft costs are a major consideration for residential solar installers, who have become experts at sourcing and closing leads, community solar can be a far simpler process. In most cases, attracting and securing subscribers is akin to utilities' signing up new customers than it is to cold-calling or doorstep sales of solar systems and leases.

"It's definitely different from the process for signing up residential consumers. The product is so different in terms of the expertise that you would use for selling it," says Alcala. "I think the sales process is much more efficient for community solar."

This, in addition to the financing similarities, offers another advantage to installers and developers that have had some experience in the commercial PV sector. It also opens up the opportunity to have some commercial clients as anchor subscribers for the projects.

"The interesting thing about community solar is that you have projects with those individual consumers and subscribers and community solar projects with commercial or industrial subscribers. Some community solar farms have a combined subscriber base," says Alcala.

The process of signing up customers is one of the differentiators that has seen Masterjohn's Clean Energy Collective develop 100 projects in 12 states. Masterjohn explains that the sign-up facility is now entirely operated with customers able to join via their iPhone if they want to. It also offers the software services required for utilities to offer their own community solar programmes.

"When you have tens of thousands of people using community solar you need the software interface, it's part of how we are going to make this happen. Lots of US utilities are literally using 30 or even 40-year-old billing systems. Some have even been manually handling rooftop net metering customers on Excel spreadsheets, that's just not going to work," she adds.

The market

Estimates vary but what is clear is that well in excess of 20,000 people will be community solar customers by the end of the year served by several hundred megawatts of capacity, Masterjohn says. Minnesota's largest utility will by the end of next year have 400MW just by itself. California's scheme is a work in progress but has huge potential. Colorado and Massachusetts will continue to enjoy success. Maryland will be joining the fray too.

For customers, it's a route to solar's benefits that doesn't rely on the authorities to have solved the net metering conundrum, and it resolves the issue of access. Utility companies can be seen to be offering the benefits of solar beyond those select households that have or will install their own system. In contrast to the polarising net metering approach, community solar is an inclusive offering with fewer (powerful) critics.

For developers, it is a source of demand for the sluggish C&I sector and the small utility-scale sector. Deployment by utility and independent power producing players is slowing as capacity they needed by the latter portion of the decade is no longer being rushed through to capture the end of the ITC. A new source of demand on the 11GW scale seen by NREL is a meaningful opportunity to tighten up some of that new slack in development pipelines. ■

America's corporate clean energy trailblazers

Commercial solar | Through its Corporate Clean Energy Universe, market researcher Clean Edge is tracking the 37 US corporations leading the way on low-carbon and renewable energy adoption. Its managing director, Ron Pernick, tells Ben Willis of his hopes that a second wave of smaller companies will follow their lead as new green energy business models hit the mainstream

The corporations in your latest index are showing a clear commitment to renewable energy, and especially solar. What are the key drivers behind this?

First and foremost, there is an economic driver here. Power purchase agreement (PPA) prices are is coming down. To me this economic story of the defining cost has a great deal to do with corporate uptake. The other thing that is driving this this is energy stability pricing – so a long-term hedge. Most of these are five, 10, 20 year agreements. So they're locking in pricing for a very long period of time.

What are the renewables of choice for companies looking to embrace clean energy?

If you're going to do on site, solar is your choice. So companies that are looking to place clean energy on rooftops are going to go primarily with solar. And I think that follows the general industry, where five to 10 years ago wind was where a lot of the electrons were coming from, and solar was a small portion. And now solar is contributing an increasingly significant portion of total clean energy deployment. I think we'll definitely see that in the corporate realm as well. And especially if they want something close to their operations. The other big innovation that we expect we'll see in next three to five years is solar plus storage. So that's the Holy Grail, and would mean you'd see an uptick in solar.

How do you find larger corporations have most commonly been procuring low-carbon energy?

Most corporates now don't want to do it through RECs [renewable energy certificates], and if they're using RECs they're looking for ways to transition; we see corporates coming out of the gate and saying we're going to get a high penetration of renewables via RECs but then transitioning over time. And so RECs enable them to meet their targeted goal quickly, but then they are transitioning. Because everyone is looking at the market and, say, having on-site renewables, doing a PPA via a third party or doing a green energy tariff with your utility if you can. And even this concept of community solar, which traditionally you might think would be used by individuals, could potentially be used by corporations.

Your Corporate Clean Energy Universe tracks some of the largest corporations in the US, but what about smaller ones? To what extent are we seeing them embrace low-carbon energy?

You have these companies that are willing to go out there, stake a claim and even pay a bit of a premium [for renewables; that's always a small percentage of individuals or companies. Now you've got an incredibly large number of these Fortune 1000/500 corporates that are embracing this. And as they develop the models for the PPAs, for the green tariffs, for the community solar if we see that to start playing out in the C&I space for on site, then I think you see the next wave coming from smaller commercial and industrial players, as long as it's economical, as long as they save or break even over time.

What are some of the innovations in finance and business models that are opening up the way to smaller companies?

There's the virtual PPA model that has certainly been getting honed quite a bit. Green energy tariffs are certainly a way for utilities to participate in this, if the utility is interested and the regulators are also willing, so we've seen green energy tariffs sprouting up in a handful of places. I think the community solar regime is interesting; we've seen it primarily to date playing out with individual people buying into a community solar array. But you can imagine in a city where you've got certain types of businesses that a number of smaller companies might come together and say we're acquiring green power from this solar facility.

Are there any specific policies or innovations you'd pick out that could ease the growing pains for corporations making the transition to low carbon energy?

I wish that were the case. Unfortunately in the US there are about 3,000 operating utilities, there are 30 holding companies that represent about 60% of them; then those companies operate multiple utilities and those utilities are operating in any number of PUCs and districts. So it's a bit of a puzzle. But I do think there's general agreement around the valuing of clean energy resources and around market access. And corporations are creating mandates and goals to reach 100% renewables or significant redeployment. Of the 37 companies that make it through our screening process, 25 of them have a 100% renewable energy goal. When I have a 100% goal I'm going to do whatever it takes to get there. So that's the pain point for the utilities – because if the utilities don't do it, the corporations are going to go wherever they need to go to get it. So that's the big conundrum now.

Further information on the Corporate Clean Energy Leaders Universe is available at http://cleanedge.com/indexes/Corporate-Clean-Energy-Leaders-Universe

Clean Edge's Ron Pernick

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Solar finance in India feels the squeeze

Finance | Cutthroat pricing in India's booming solar market is causing headaches for developers. Tom Kenning reports on some of the looming pinch points for solar finance in a country where the cost of capital remains persistently high

Credit: IBC Solar

Solar tenders are flying out rapidly across India and a formidable pipeline of more than 20GW of PV marks a thriving utility-scale sector. However, raising finance for solar projects remains an area of concern as lenders ruminate over low tariffs and tight margins, while developers face up to the high cost of capital from domestic banks.

At the recent Green Infrastructure and Investment Coalition (GIIC) event in London, the first secretary of the High Commission of India, Ajungla Jamir claimed: "India is now the most open economy in the world in terms of foreign direct investment."

It is a strong sentiment, but a question mark remains over whether the country will be able to attract the US$100 billion necessary to achieve its solar goals by 2022. Even Tarun Kapoor, joint secretary of the Ministry of New and Renewable Energy (MNRE), says that one of the major challenges is getting finance in this sector, not to mention the added expense of a multi-billion dollar upgrade of the country's transmission network. The southern state of Tamil Nadu recently became the first state to experience curtailment of electricity from solar sources due to inadequate grid capacity and comparatively high solar tariffs. Therefore, overlooking the transmission sector would only be to the detriment of the PV industry.

The World Bank's recent announcement of a US$1 billion loan for Indian solar in the financial year 2017 – the bank's largest ever solar loan – was a significant boon. However, several major power firms with deep pockets have already entered the Indian market over the last year. It is the equity capital being invested by these global outfits such as Fortum, Energie, EDF EN, Enel, Skypower, Hanwha, Foxconn and Softbank, that will really leverage the World Bank's commitment into the US$100 billion that India needs, claims Tim Buckley, director of energy finance studies, Australasia, at the Institute of Energy Economics and Financial Analysis (IEEFA).

To date, around half the capital investment has come from Indian firms, adds Buckley, with bulky solar investments from utility NTPC, Coal India, India Railways, Tata Group, Adani Group, Reliance Power and Renew Power among others.

India's highly competitive solar market is putting pressure on developers to finance projects

Sub-5 rupee tariffs

Nonetheless, lenders are still stalling over the continuation of aggressive bidding in the solar auctions, with tariffs often well below the INR5/kWh (US$0.074) mark.

Consultancy firm Mercom Capital Group's latest quarterly India solar market report said: "Some banks are comfortable lending at INR4.5-5 (~US$0.066-0.074) tariff levels as long as they are confident in developers' experience, capacity to execute and ability to repay debt."

This would support speculation within the Indian solar industry that an overseas investor has now successfully financed a project won with a sub-5 rupee tariff and is moving forward. This development would have been recent, since consultancy firm Bridge to India reported in April that no project with a tariff under five rupees had yet obtained financing.

Even so, the bidding makes it tough for smaller firms to get a foot in the door, particularly with the aggressive timetable to reach commissioning after PPAs have been signed.

"As long as we are seeing these record drops [in tariffs], it makes it very hard for a new developer to come into the market," says Brian O'Hanlon, director of business development, renewable and clean energy group, Overseas Private Investment Corporation (OPIC). "You really have to back these bids with a large balance sheet or some very deep and low-cost sources of financing, which not everyone is going to be able to have. As a developer you face either a choice of being overly ambitious and not being able to meet those commitments or just not being able to compete."

Margins

Such low tariffs also means incredibly tight margins, which has led to Mercom reporting that banks are concerned about developers not disclosing actual margins to lenders. In a telling figure, Mercom found a difference of INR5-10 million (~US$0.07-0.15 million) between project cost estimates from banks and those of developers. Banks clearly feel developers are being too optimistic and they want to witness successful financial closings for these low-bid projects before venturing in. On the other hand, according to Mercom, developers see the banks as out of touch with realities on the ground.

Some commentators are also suspicious over what such low tariffs are driven by. O'Hanlon says: "Pricing is really going to be driven by your cost of EPC and your cost of financing, so I don't know if there is some

secret source that some of these players have found that is going to be able to achieve financing."

"If you talk about all these low bids, they have come from big players; they have not come from small players. They are rich in equities and have access to different types of capital," adds Sunil Singh, chief executive of Indian energy firm OPG Power. "I believe in India they must be facing problems but the project timeline is 18 months from time of bid. So there is lot of pushing in terms of price reduction. But yes, being a small player you could run into problems with low bids."

Many bids are based on an anticipated drop in module prices over time, adds Singh, but if the module prices remain static then the developer is caught out and the banks become more sceptical. However, new technologies such as trackers, which can increase energy output by roughly 20% while only increasing costs by just 10%, may come to aid developers in this respect, adds Singh.

Moreover, expectations of an oversupply of Chinese-made modules in the second half of 2016 will also come as welcome news to aggressive bidders. In a rush to add capacity ahead of feed-in tariff changes on 30 June, China added 7GW in the first half of the year, leaving a hole in Chinese demand for the rest of 2016.

> "As long as we are seeing these record drops in tariffs, it makes it very hard for a new developer to come into the market"

As a result, Bridge to India expects tier-one module prices to fall to INR27.50/Wp (US$0.41) for shipments in Q1 2017, a significant decline of almost 10% in less than a year. It so happens that the first quarter of 2017 is also expected see India's largest ever capacity additions of roughly 2GW.

But again, some of the bigger firms have access to financing that may reduce the importance of such price fluctuations. For example, recent media reports quoted a director of Finnish company Fortum claiming that the firm will be self-financing the 70MW of solar it won at a price of just INR4.34/kWh in Rajasthan in a move that sidesteps the need to convince domestic banks over adequate project returns.

Non-performing assets

The major concerns from an investment perspective can be split into three, says Abid Kazim, UK managing director of investment and asset management firm NextEnergy Capital. The first and largest concern is "the hype" where all players start running in the same direction with ill-thought-out bids. This is directly followed by the second concern, which is the potential poor quality of assets on the back of this hype.

"The third thing is behaviour – the so-called 'race to the bottom' to build at the lowest PPA," adds Kazim. "This then leads to 30% of assets being non-performing and this is where equity has to take a backseat. India is not a unique model. Every country needs international global equity; India is no exception."

Several commentators agreed that instances of non-performing assets (NPAs) makes banks immediately become more risk averse, so it is in the best interests of the industry to avoid any such instances.

India's banks

Indian banking at large is experiencing certain challenges, which could make borrowing more difficult in the short term,

Source: Mercom Capital

Table 1. Western PV developers are not used to the high costs of capital seen in the Indian market

says the Mercom report. Banks are hesitant to take on any debt considered risky, especially with the low solar bids.

A key challenge for the Indian solar sector is that the banking system is not as well developed as in other countries, particularly Europe where many players are used to operating, says Bob Smith, executive vice president and head of asset management at Mytrah Energy. The Indian banking system is often slower and can be risk averse to the point where it won't lend such large chunks of cash to individual projects as perhaps developers are used to in Europe. Thus developers end up with much more syndicated debt, which is more complicated to put together and again takes longer.

Smith says it pays to have spent time in India already and treating solar forays as long-term and local ventures in order to start receiving more innovative financing solutions. It is even possible to get "quite impressive debt structures" if the developer has been in India for some time.

Cost of capital

Perhaps the first issue confronting anyone looking to raise finance within India is the cost of capital, which at around the 11-12% mark still remains staggeringly high compared to established European banking systems (see Table 1).

"While getting investment into the country is a challenge, getting it at the right cost is the real challenge because renewable energy is totally capital intensive," says Tarun Kapoor. "If we are able to reduce the cost of capital we can reduce the tariffs and we can make it close to grid parity."

As part of the MNRE, Kapoor is clearly focusing on offering the best scenario to the consumer, which is the lowest price of electricity possible and grid parity. Whereas developers have to battle with tight margins and these steep interest rates in any scenario so as to generate a sustainable return from their projects.

There has been an increase in asset finance debt and equity coming into India's renewable projects during 2015, according to Bloomberg New Energy Finance (BNEF) figures:

"We are on a positive trajectory, and now dollars yield a much greater capacity of megawatts than five years ago," says Ashish Sethia, regional head, South and Southeast Asia, BNEF. India has one of the lowest capital costs in the world for building solar projects, in fact even slightly lower than China as far as we are concerned and power yield is fairly high, but the issue is our cost of financing still is extremely high."

A second issue, quite unique to India, is the ailing financial health of its distribution companies (Discoms), which can compromise the security of payments coming to solar developers. First instances of minor delays in payments have hit Rajasthan of late and this threat needs to be diminished to attract foreign investment. The government's UDAY scheme is in the process of trying to alleviate the ballooning debts of the Discoms.

"Banks are still waiting to see the impact of UDAY," says the Mercom report. "They recognise that it may solve short-term liquidity issues, but are unsure if Discoms will start accumulating debt again."

Meanwhile O'Hanlon says that if there was one thing to fix that would offer a major boon in financing the whole sector, it would be the Discom's own financial health.

The challenges are many, but reports of certain projects with sub-five rupee tariffs moving ahead will give confidence to bullish developers. Bankrupt SunEdison's Indian projects remain in limbo at the time of writing, although its demise cannot be blamed on its India tactics but rather on its wider global strategy. If the Indian solar sector can ride those particular choppy waters and still deliver most of its other projects won in aggressive auctions in the coming year, then the finance community will surely look favourably upon the region's massive solar endeavours. ■

Year	Solar debt and equity finance, US$ (billion)
2011	12.5
2012	7.5
2013	6.1
2014	6.8
2015	8.6

Source: BNEF

Table 2. Renewables investment in India is rising again

The World Bank's largest ever solar loan

The World Bank announced a ground-breaking US$1 billion loan for Indian solar in June. This includes US$625 million for solar rooftop and US$200 million for supporting internal infrastructure in solar parks. Another US$200 million will be available for large-scale solar projects and innovation with wind and storage hybrids to be implemented by the Solar Energy Corporation of India (SECI). Another loan will be for state-owned transmission and utilities firm Power Grid Corporation to help support transmission from solar parks.

IEEFA's Tim Buckley explains the loan: "In India's case, private corporate capital has been moving rapidly already over the last 18 to 24 months, so this World Bank move is another endorsement and follow-on to help upscale the solar efforts and maintain momentum.

"Renewable investments require significant upfront debt and equity capital, so there is also a role in recycling capital for early movers and solar project developers once a project has been de-risked. By on-selling the finished and operating projects, this not only allows the developer to redeploy their limited capital to new projects, but it also validates the value creation process and encourages the banks who witness the development of a secondary capital market."

GST Bill

One concern hovering over Indian solar developers is the impending Goods and Services Tax Bill (GST). The GST, which has been in discussion in parliament for a protracted period, seeks to address the issue of complex indirect tax discrepancies between central and state government and to stop issues such as tax on tax for all kinds of industries.

However, minister of power, coal, new and renewable energy and mines Piyush Goyal (pictured) reportedly does not want to exempt renewable energy imports from the GST, in a bid to support domestic manufacturers. This comes in spite of an MNRE report, which found that the implementation of the tax would increase the levelised tariff and the cost of setting up and operating grid-connected solar PV projects by between 12-16% and increase costs for off-grid solar by 16-20%.

With some developers waiting for module prices to come down, this will only add to their and the banking community's worries.

harsha abakus solar

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IN INDIA

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Opportunity knocks for Brazilian PV

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Market update | Several rounds of auctions for large-scale projects and a favourable policy environment for distributed systems have helped create the right conditions for PV to flourish in Brazil. Rodrigo Sauaia and Juliana Vasconcelos explore the biggest areas of opportunity for foreign firms looking to access this promising new market

As the one of the 10 largest economies on the planet and the largest electricity market in Latin America, Brazil stands out as one of the world's most promising emerging PV markets for several reasons. The country ranks as one of the best in the world in terms of its solar resource, with irradiation levels ranging from 1,500kWh/m^2 per year in the least sunny regions of the south to over 2,500kWh/m^2 per year in large areas of the sunny north-eastern region, with a national average above 1,800kWh/m^2 per year. This is approximately twice as much as the average irradiation level of a typical temperate-climate European country, such as Germany or the UK. Additionally, Brazil is the fifth largest country in the world in terms of total landmass area, meaning there are vast strips of land available for the deployment of large-scale PV projects.

So far, only about 50MW of cumulative grid-connected PV capacity has been installed in Brazil, but this number is poised for substantial growth in the coming years. Regarding large-scale PV projects, until 2018, more than 3,200MW of already contracted PV systems are expected to come online. Additionally, PV deployment is set to increase significantly in the coming decade in response to the government pledging to contract more than 7GW of large-scale PV by 2024 (doubling its previous plan of 3.5GW by 2023).

In terms of regulatory and legislative drivers, a range of supportive policies and incentives has been developed for the PV sector in Brazil. Reserve Energy Auctions (or LER in Portuguese) establish a reliable pipeline for large-scale PV growth out over the coming years. These auctions are based on low-risk, guaranteed, 20-year PPAs. In the first state solar auction of the country, in 2013, 92MW of PV were contracted over five projects, some of which are already operational. In the 2014 national solar auction, over 1GW of PV was contracted through 30 projects and in 2015 more than 2GW of large-scale PV projects were auctioned.

A healthy development pipeline and new distributed PV policies have put Brazil's emerging solar market in a strong position

In relation to PV distributed generation (PVDG), the recent revision of the Brazilian Electricity Regulation Agency's (ANEEL) net-metering regulation represents a key upgrade in supporting the growth of the PV market in the country. The revision incorporates several of the international best practices recommended for net-metering regulations, therefore establishing Brazil as a reference in terms of positive policies to fast-track the adoption of small- and medium-scale PVDG. The main strategic improvements of this so-called Normative Resolution nº 687/2015, in effect since March 2016, are summarised in the box below.

Apart from these market and regulatory drivers, favourable financing conditions are available through the Brazilian Development Bank (BNDES) and from

New net-metering policies in Brazil

- Establishment of a nationwide "virtual net-metering" mechanism
- Establishment of a nationwide "community net-metering" mechanism
- Increase in maximum net-metering system installed capacity from 1MW to 5MW
- Nationwide standardisation of subscription forms and basic procedures for new net-metering connection requests throughout all distribution companies
- Reduction of deadlines for distribution companies to approve and connect new net-metering customers
- Meter equipment used in small-scale net metering provided directly by the distribution company
- Net-metering electricity credits (surplus electricity injected into the grid that can be used to compensate future electricity consumption) now valid for five years compared to only three years previously
- From 2017, all Brazilian distribution companies must offer an online process for receiving and following up new net-metering connection requests from consumers

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foreign capital sources (especially given the current devaluation of the Brazilian real, which makes the country very attractive for international investors). Numerous tax breaks and statewide incentives act to attract global suppliers and PV project developers to Brazil.

In terms of taxation, in 2015 the states established a national agreement that exempts the electricity from net-metering systems from paying ICMS, a value added tax. Since then, ABSOLAR has worked tirelessly to mobilise states to adopt this exemption. Currently, a total of 20 out of the 27 Brazilian states have already adopted this exemption.

In terms of local funding for small-scale PV projects, in April 2016 the Northeast Regional Bank (BNB) created a specific financing product named FNE SOL ("sol" means "sun" in Portuguese) to support PVDG projects, which can finance full PV systems, including the project, PV equipment and installation. The BNB financing can be paid in up to 12 years with a grace period of one year and competitive local interest rates.

Based on this scenario, the government is expecting PVDG to develop into a 1.5GW to 5GW market by 2024, resulting in between BRL12 and 40 billion (US$3.7-12.5 billion) in cumulative investments by that period. This market development trajectory creates a huge opportunity for new and established PV companies, local and international. When we consider the total market potential, the country has a total of 66 million residential consumers, 5.7 million industrial consumers and 5.5 million commercial consumers who could still benefit from PV.

In summary, both the present and the future hold great opportunities for PV in Brazil. According to this year's forecasts from Bloomberg New Energy Finance (BNEF), when considering the contributions from small-, medium- and large-scale PV in Brazil, the share of PV in Brazil's electricity matrix is projected to increase from 0.01% in 2015 to more than 30% in 2040.

What are the opportunities?

There are strategic opportunities in different segments of the PV sector in Brazil, as well as for companies with different business models and profiles.

On the one hand, due to the market projections and governmental plans for large-scale PV projects in the country, there are untapped opportunities for companies working with solar resource assessment, as well as project developers, engineering, procurement and construction companies, service and insurance providers and consulting companies, amongst others. Additionally, project developers will require new components and equipment to bring auctioned projects online. This creates a large potential for the local manufacturing of PV components and equipment in Brazil, as well as for the sourcing of bankable goods from international markets. Currently, there are local content requirements to obtain access to financing from the BNDES. This serves as an additional incentive for new investments in the establishment of local manufacturing operations by foreign companies already experienced in the fabrication of PV modules, inverters, mounting structures, tracking systems, string boxes, as well as other balance-of-system BOS components. Additionally, the government is also interested in attracting the fabrication of PV solar cells to the country to supply the local manufacturing of PV modules.

> "By the end of 2018 it is expected a pipeline of between 3 and 6GW of of auctioned PV projects will be built in the following year. These numbers will position Brazil as a young but promsing and evolving PV market"

In fact, some of the leading PV component and equipment manufacturers, both national and international, have already announced or started manufacturing operations in Brazil and new companies are expected to take advantage of this opportunity in the near future.

On the other hand, due to the high electricity prices in Brazil and falling PV system costs, distributed PV has started to reach grid parity through the national net-metering regulation. The new regulatory framework is enabling new business models, such as third-party ownership and PV electricity as service, spurring a new wave of entrepreneurs and investors searching for the best business models for growth, scalability and profitability. This environment is fostering new opportunities for companies working throughout the distributed generation segment, such as installers, engineering companies, financial institutions, legal offices specialised in contract drafting, equipment distributors and retailers, service providers in sales, marketing, customer support and many more.

Foreign investors could see a high rate of return when investing in PV projects in Brazil. National interest rates are relatively high and BNDES loans can cover up to 70% of a PV project's total investment – driving PV project developers to source the remaining capital from alternative sources, locally or overseas. Private equity funds can benefit from this opportunity.

Due to the establishment of a local manufacturing base, which is currently under progress, there are also opportunities for the development of R&D centres and projects in Brazil, especially those aiming to transfer state-of-the-art PV technology to the country, adapting it to the local climate and electricity grid characteristics.

What are the risks and setbacks?

Financing in Brazil can be challenging, due to the high local interest rates. This has been a difficulty not only for the PV sector, but in fact for many infrastructure projects in Brazil, from power plants, to ports, airports and roads. The favourable conditions offered by BNDES goes some way to solving this, though companies are often still left with the need to find additional external funding from other sources to complete the project funding. Large-scale PV investors especially are usually limited to approximately 70% of their project funding through BNDES.

Brazil's currency has also devalued in the last two years, increasing local costs of developing and deploying PV projects, as the prices of PV raw materials, components and equipment coming from abroad are frequently linked to foreign currency. The possibility of additional currency fluctuations in the future represents a risk for foreign investors in Brazil, which is both hard to predict and complex to value.

Having said that, the local currency devaluation also means that investing

in Brazil is currently cheaper for investors with foreign capital, with PV assets acquired in the country in the short term likely to gain value in the medium and long term, when the local economy and currency recover.

Though the Brazilian government has demonstrated its determination to support PV growth, the political instability observed in recent times has brought additional complexity to the local economy. However, the new leading decision makers of the Ministry of Mines and Energy of the interim government have clearly signalled their support for continued solar PV development by guaranteeing the execution of a Reserve Energy Auction for PV in 2016, announced for 16 December 2016.

On behalf of the Brazilian PV sector, ABSOLAR has also brought forward technical, legislative, regulatory and market recommendations for the minister of mines and energy and his team.

Near-term development of the Brazilian PV market

In relation to the large-scale PV segment, we expect new large-scale PV auctions in 2017 and 2018, with between 1 and 2GW of new contracts auctioned every year. By 2018, the large-scale PV market is expected to surpass the 2GW mark in terms of total cumulative installed capacity, as a result of projects from 2014 and 2015 being realised. Additionally, by the end of 2018 it is expected a pipeline of between 3 and 6GW of auctioned PV projects will be built in the following years. These numbers will position Brazil as a young but promising and evolving PV market.

In regards to the distributed generation PV segment, we expect this year's market to continue its exponential growth in the number of installed systems throughout the country, with an annual growth rate above 400% in 2016, compared to more than 300% in 2015. So far, the market has been strongly based on small residential and commercial installations, which account for more than 90% of all net-metering PV installations. Nevertheless, this may soon evolve to new business models, once the advantages of virtual net-metering and community net-metering mechanisms are successfully incorporated into the market status quo. ■

The Brazilian Trade and Investment Promotion Agency (Apex-Brasil), ABSOLAR, the Brazilian Ministry of External Relations and the Consulate General of the United States of America in Sao Paulo are hosting an event on solar opportunities in Brazil in Las Vegas on 14 September 2016. For further information, email apexbrasil@apexbrasil.com.br.

Authors

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MARKET WATCH

Back from the brink

Commercial solar | After a series of hammer blows, and against the backdrop of Brexit uncertainty, the UK solar industry appears to have found some joy offering long-term contracts and self-consumption systems to commercial clients, a sector it had previously found hardest to crack, writes John Parnell

Credit: Lyreco

Commercial solar is one of the few bright spots in the UK's beleaguered solar PV market

In its heyday, the UK solar industry employed more than 25,000 people. A generous feed-in tariff (FiT) created a residential market that remained steady, even after a series of cuts. Likewise, the Renewable Obligation, a certificate based scheme, was gradually closed to solar, first for projects over 5GW, with the last sites to be completed under the system next year.

The market segment that never quite got going was commercial-scale solar. This is despite a promise from the then energy minister Greg Barker, oft-quoted in our UK sister publications, to put "rocket boosters" under it. A few regulatory hurdles were cleared, the red-tape was reduced, but the shrinking subsidy support had appeared to kill the sector dead even before it had got going. Rumours of its death were, it seems, premature.

The commercial-scale market is now the most vibrant in the UK with three distinct models offering customers compelling reasons to pursue solar. Installers looking to scale up, and developers looking to scale down, are now competing for capacity and adjusting to the new conditions.

Businesses in the UK, like consumers, have faced rising electricity bills. The per-unit cost of electricity for business customers has risen 37% in five years. Meanwhile, National Grid's assessment of the amount of spare generating capacity on the network has been consistently shrinking. Fears over the security of supply are either very real or totally overblown depending on who you ask. But the fact the question is being asked is sufficient to make some nervous.

The UK's domestic climate policies, not affected by Brexit, also mean that decarbonisation is being encouraged via a number of taxes and other obligations placed on businesses and new infrastructure. Blue ticket British brands like Rolls Royce, Marks & Spencer, Bentley, Sainsbury's, Jaguar-Land Rover and British Telecom have already turned to solar as part of wider decarbonisation efforts.

This has all helped to create a receptive marketplace for businesses looking to reduce cost, risk and carbon.

The third-party finance approach

Office equipment retailer Lyreco decided to install solar, largely swayed by the green credentials that come with it. Jordan Mawbey of UK installer EvoEnergy, which delivered the system, explains the client's motivation.

"They have a carbon emissions target that they're trying to hit, and this is something they were looking at to satisfy that strategy," he says. "I think the electricity savings were a part of it, but it was more about however many tonnes of carbon the company were going to save during a given period of time. It was about who could give them the best solution to help them meet their targets. The PV solution alone isn't going to do that, but it's going to have a significant reduction."

The client didn't want to fund the system upfront and was, from the beginning, looking for a power purchase agreement (PPA) model.

"PPAs are starting to take off and get a bit of traction within the industry," Mawbey says. "When the cuts happened the external businesses thought it was technically dead and I think some people turned their back on solar for a little while. I think it was also a case of making the PPAs work with the funding companies. They had to almost remodel how a PPA could work. Prior to the FiT cuts, you could almost save 50% on people's current rate, but now you're lucky if it's even half a penny less than what they're paying, but that makes a massive difference."

"I think the market still needs to be educated on PPAs, and I think there are still a lot of people that aren't aware of them," he adds citing a recent experience at a trade show for the logistics industry where even some very large corporations were unaware of what a PPA could offer them.

Mawbey points out the use of a third-party finance partner means additionally stringent technical requirements. "They are very strict and very demanding on the type of technology we use. It's very important that we do use quality suppliers in all these installations."

Private wire

For those with larger energy consumption, a variation on the PPA model can offer further reductions in the unit cost of energy. A private wire project linking a larger ground-mounted project directly to the source of demand can offer more capacity than a rooftop can, literally, support. It also reduces losses through transmission and, in most cases, cuts down grid connection costs. The connection is done at the point of the customer's grid connection meaning they are typically responsible for its maintenance. UK

MARKET WATCH

grid connection charges for greenfield solar projects can hit seven figures and ultimately prove to be a limiting factor.

The crucial component is limiting the distance between the customer and the project. In 2014, a British Telecom research centre supplemented its own on-site array with a 20-year deal to acquire all the power from an 8MW solar farm just a stone's throw away.

Belfast Airport has a 25-year PPA that sees it take all the power from a nearby 4.83MW system. The developer and financer behind that project, Lightsource Renewable Energy, is aggressively pursuing opportunities in this space. Former energy minister Lord Barker has also been supportive saying that private-wire projects offer a unique opportunity in the absence of subsidy support. Lightsource has gone one further saying that it is the only way it can finance utility-scale solar in the UK under the new policies making it less a choice and more a necessity.

Self-consumption

In the absence of a compelling feed-in tariff and reduced export tariffs, the incentive to consume as much power on-site, instead of paying the going rate, is increased. With an upfront investment from the site owner and a responsible installer that can match their demand with the right system, attractive returns can be achieved.

The site's huge energy demand (it's a 1km-long warehouse with around 300 conveyor belts) is higher during the night. Designing a system based only on total consumption, and not time of demand, would have resulted in much of the electricity generated during the day being exported. The local grid operator, however, said it would need to severely curtail export.

"We used the positioning of the modules, allocated them optimally, to make sure we weren't overloading the model, and to provide constant electricity," says Nick Spicer, COO of Your Group. "So actually you've probably got a split of between 50% of the system being on the southerly aspect, and we used all aspects of the building to enable them to generate throughout the day. Rather than having a peak power time such as a solar farm, where in the middle of the day it's optimally producing, you're drawn to dissipate the generation throughout the day to offset as much electricity as possible. And that's how – through the design – we got to 97% on-site consumption."

The reduction in carbon contributes to the client's obligations under UK carbon reduction regulations. The return on investment is estimated at just over 13%.

Outlook

While the uncertainty created by the UK's vote to leave the European Union has done nothing for the appetite for renewable energy investment, assets backed by longer-term contracts are being viewed more favourably.

'Big Four' consultancy EY issued a bleak forecast for renewables investment in the wake of Brexit but said that the growing number of assets backed by long-term PPAs, which by their nature are stable, had buoyed the market.

Falling wholesale energy prices mean that PPAs can offer asset owners a better return than the market while end users, who tend not to have those whole price reductions passed down to them, can undercut traditional suppliers with a long-term solar deal.

The apparent ability of the PPA model to survive such uncertainty in a country offering negligible support should provide encouragement to other markets looking for a means to kick start business directly with commercial customers of all stripes. ■

The opportunities in the UK commercial solar sector will be one of the key themes of Clean Energy Live 2016 on 4-6 October in Birmingham, England. Organised by PV Tech Power's publisher Solar Media, the event is the new face of Solar Energy UK, the largest and longest running solar trade expo for the UK market. Further information on the event is available from cleanenergylive.co.uk

Inside Lightsource's Belfast Airport PPA

Credit: Lightsource Renewable Energy

Lightsource maintains direct PPAs such as its one with Belfast Airport is now the only route to market for large-scale PV in the UK

Speaking to PV Tech Power's UK sister website, Solar Power Portal, Nick Boyle, CEO of Lightsource Renewable Energy, explained the scale of the changes on his business. The company had been putting in place a commercial & industrial solar division but the UK subsidy cuts gutted the business model.

"We have laid off everyone in the C&I sector, simply because it doesn't work financially. If we can't get it to work it, because of our buying power and our market position, it would be a gutsy assumption to think that any, or many, other entities can get it to work," he said.

The company had grown off the back of its utility solar business but had been building both residential and commercial units at the time of the cuts.

"Our skillset is clearly in large-scale solar: the finding of, developing and building of large-scale solar. With no tariff [there is] an absolute inability to get a financial arrangement to work where we just plug it into the grid," he added.

Boyle was quoted by the government as having said on the record that utility-scale solar could work without the tariff.

"Despite the government quoting me as saying that, what I actually said is that hard-wiring large-scale projects behind the meter is doable for large, bankable counterparties where we can go and raise the finance to allow us to do that. The finance has to be at a competitive rate so the counterparty is important. How large that market is, is dictated by how many large, bankable counterparties there are and how many of them have large fields adjacent to their operations. It's a fairly small market," he explained.

Boyle also points out the additional complexity of negotiating each individual deal with each counterparty versus the more straightforward process of developing a site, connecting to the grid and claiming the applicable revenue and subsidies.

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By Tom Kenning

EMERGING MARKETS BRIEFING

The latest developments from solar's newest markets

Nigeria signs first ever solar PPAs

The solar industry has often decried lengthy delays in the West African market. Time periods for signing power purchase agreements (PPAs) can stretch into years and this only makes financing more difficult with extortionate costs of capital from domestic lenders. However, July saw a cornerstone moment when state-owned power body, the Nigerian Bulk Electricity Trading (NBET), signed Nigeria's first ever solar PPAs. This was no minor accomplishment given that they related to just under 1GW of solar PV projects to be implemented by at least 10 developers. There may also be more projects in the pipeline.

Nigeria has the largest solar targets of any country in West Africa by some distance, but until now large-scale projects had been thwarted by lack of movement on both PPAs and financing.

The 975MW of projects now signed, which would account for more than 20% of the country's current total electricity generation, have a tariff of US$0.11/kWh.

Omotayo Dairo, founder and chief executive of Nigeria-based wind and renewable energy firm Quintas Renewable Energy Solutions, says: "This is significant because prior to this signing of agreements, prospective investors in solar electricity in Nigeria had said that a tariff of US$0.18/kWh – an NBET offer – was unprofitable for solar electricity generation."

The first official project to be implemented under a 20-year PPA is a 75MW solar plant worth US$146 million in Katsina state, to be developed by European and Nigerian utility-scale investor and developer Pan Africa Solar, in collaboration with JCM Capital, an Ontario-based private equity firm. The project has been under development since 2011 so the PPA signing marks a significant breakthrough following years of stagnation.

Among other projects, NBET also signed for an 80MW plant to be developed by Canadian energy company Nova Scotia Power Development Limited (NSPDL) and partner CDIL, a fellow Canadian renewable energy company with projects focused on Africa.

The President of Nigeria gave a Voluntary Renewable Energy Portfolio Standard (VRPS) commitment of 20% on behalf of the nation at COP21 in Paris in 2015. As a result, successful execution of these PPAs could put Nigeria on a comfortable position to meet this national VRPS commitment on renewable energy from solar electricity generation alone.

Credit Flickr, canonim

Delays in PPAs had stalled solar in Nigeria until now

"Our concern for now is that this tariff is denominated in US dollars while electricity consumption charges will be collected in Naira," says Dairo. "The volatile fluctuations in exchange rate in Nigeria may create some problems during the implementation of tariff collection. When the agreements were signed, the naira was exchanging for NGN197 to US$1. The exchange rate has now gone up by over 160% since the signing of the PPAs."

A skills gap in the local labour market is also a major challenge, adds Dairo. Investors will have to build the capacity of their local staff to deliver their services efficiently.

While the PPA signing is a positive move forward, it remains to be seen whether developers will be able to secure financing.

"Local financing for renewable energy service providers in Nigeria is non-existent," says Dairo. "One presumes that the promoters of the solar power plants have already secured foreign finances for their businesses. Reliance on local financial support may be a mirage."

The steep drop in solar module prices worldwide will have helped the signings at these low tariffs. This may spur growth in renewable energy given that Nigeria saw a 100% electricity rate hike in January as it – like many countries in Africa – starts to make the transition to consumers paying for electricity rather than relying on only hydro or other technologies.

Lowest ever African solar tariffs in Zambia

Zambia set a new benchmark for low-cost solar power in Sub-Saharan Africa in June with a competitive auction, which saw winning bids as low as US$0.0602/kWh.

The auction came under the 'Scaling Solar' programme, formed by a partnership between IFC and the World Bank.

The winners of the auction were France-based developer Neoen and American integrated PV firm First Solar, who jointly bid at just US$0.0602/kWh, and Italian company Enel, which bid US$0.0784/kWh.

"This auction could be a game changer as it shows what a renewable IPP requires to have a competitive bid in Africa," says Romain Desrousseaux, deputy chief executive of Neoen. "Under such conditions, solar is more competitive than most conventional solutions and can be deployed very quickly. But it requires political will to set up a quality framework."

First Solar bid for a 47.5MW AC project that is scheduled to be completed by mid-2017. The power plant, named after Zambia's West Lunga National Park, will cover an area of just over 52 hectares. The plant will be located in the Lusaka Multi-Facility Economic Zone, with the International Data Corporation (IDC) retaining a 20% stake in the project.

Energy generated by the plant will be sold to state-owned utility ZESCO under a 25-year PPA. The facility will be powered by around 450,000 First Solar modules, which offer up to 6% more energy in Zambia than conventional crystalline silicon modules, due to a superior temperature coefficient, according to a First Solar spokesperson.

On the other hand, Enel will build a 28MW plant. The new facilities are expected to expand the country's generating capacity by 5%.

"The Scaling Solar tenders have been organised by the World Bank in order to avoid some of the most critical issues with solar tenders," says Desrousseaux.

The benefits included well-designed legal documentation, World Bank guarantees and pre-approved documentation, and permit the reaching of a quick financial close. The project sizes were also significant for Sub-Saharan Africa at nearly 50MW, combined with a good tax regime and a strong PPA in US dollars.

Indonesia introduces first solar feed-in tariff

Indonesia has seen very few support mechanisms for solar except for a half-baked solar auction process for 140MW in 2013, which only saw 14MW awarded. As of 2015, Indonesia had just 84MW of utility-scale solar capacity deployed.

However, the Ministry of Energy and Mineral Resources (MEMR) introduced the country's first ever feed-in tariff (FiT) for solar in July this year to help kick-start the development 250MW of PV.

The original auctions were stopped in 2014 after being declared unconstitutional by the Supreme Court, says Maggie Kuang, analyst at Bloomberg New Energy Finance (BNEF). The Indonesian Solar Module Manufacturer Association (APAMSI) filed a lawsuit against auctions arguing that solar developers were not using enough local content; therefore violating Industry Ministry regulations. The criteria for the auctions also lacked clarity and were ineffective in attracting good project developers, adds Kuang.

Under the new decree, projects will have 20-year power purchase agreements (PPAs) and the tariff rates will range between US$0.145-0.25/kWh depending on project location. Java has been allocated the highest capacity of 150MW, but also the lowest tariff, with individual project sizes capped at 20MW.

A Bloomberg New Energy Finance (BNEF) report said that the new FiT for solar should generate attractive project returns of around 14-18.8% in the two regions Java-Bali and Sumatra. Both have better grid infrastructure and potential project sites than other districts, where developers may struggle to obtain such attractive rates.

At a wider level, Kuang says if the developers in the far eastern part of Indonesia can keep project capex at around US$1.3 million/MW, they will be able to generate returns of more than 10%. However, some project developers believe they will not be able to achieve such returns due to the quality of infrastructure in Indonesia at present.

Developers will need to complete <10MW projects within 12 months and >10MW plants within 24 months to avoid triggering penalties of between 3-8% in the first year of delay.

To qualify for the FiT, developers will also need to have 43.85% of their solar project content sourced from domestic manufacturers and service providers based on the current Industry Ministry regulation.

However, it is not clear how local content will be precisely measured and to what extent it will prevent developers from using imported solar modules and inverters, adds Kuang. After further clarification, if the local content rule will suppress imports, domestic capacity will need to be ramped up over the coming year as there is just 90MW of domestic manufacturing capacity at present, equal to just 36% of the FiT capacity quota.

Flickr, Bart Speelman

Java-Bali and Sumatra are the most attractive regions

Nevertheless, the time leading up to construction is expected to be at least 16 months from the day that registration opens, so there is time to generate this capacity, according to BNEF.

Kuang says that the FiT rates will be proportional to the amount of local content in the project. For example, if a project has half the required percentage of local content, then its FiT will also be reduced by half.

BNEF calculates the levelised cost of energy (LCOE) for PV in Indonesia to range from US$0.89/kWh to US$0.229/kWh.

"In terms of future capacity forecasts, it is very hard to say at this stage because the policy is not implemented yet," adds Kuang. "Assuming the policy implementation starts from end-2016 or early-2017, around 200MW in Java, Bali and Sumatra are likely to be built over the following three years as the project economics in those regions support."

Not long after the decree was announced, Indonesia's energy and mining minister Arcandra Tahar was dismissed after reports that he had dual citizenship for the US and Indonesia. However, Kuang says: "It will have little impact on the direction that Indonesia is taking on developing renewables."

"Furthermore, the IFC has proposed concessional debt for the project, which allows developers to have a very competitive cost of funds," adds Desrousseaux.

The development of solar energy has been a priority for the Zambian government, he adds. Furthermore, a "very positive" move has been to start with defining the optimal set-up for a PV investment, working with the World Bank. Under their Scaling-Solar scheme, the pricing can be much more aggressive than under a less robust legal solution where more risks remain with the investor.

Other qualities of Zambia as a solar market are its strong irradiation levels and the absence of any kind of local content requirement, which prevents price and quality distortions, adds Desrousseaux.

"We believe Zambia can be a strong market if it continues to operate under efficient guidelines such as the one defined by Scaling Solar. The fundamentals are good: it has good solar resources, the grid can absorb more solar and the country needs energy."

Credit: First Solar

Zambia's government has prioritised solar energy

Argentina confirms 300MW solar auction

Argentina made this section in the previous edition of *PV Tech Power* after a series of big solar announcements in Q1, which although lacking in substance, were a welcome signal from a country that had had negligible movement on solar to date. However in the quarter just gone by, the energy ministry has confirmed a 1GW renewable energy auction and a significant 300MW set-aside for solar PV.

The initial announcement was followed by news of a slight two-week delay in the date for publishing results to 12 October this year. Bids will be accepted until 5 September.

There is potential for problems to arise considering the issues seen in the recent Mexico solar auction where there were issues with results due to a faulty internal algorithm.

"It's entirely possible that something happens like that," says Manan Parikh, analyst at GTM Research. "They have already pushed back the publish dates and built in a little bit of a buffer, but I don't think we are going to see anything as drastic as Brazil in terms of cancellation."

The signals remain positive in terms of policy structure and progress, adds Parikh, however successful developers will only have a two-year timeframe to complete their projects.

"That is really ambitious for a country that doesn't have much renewables on the ground as it is," says Parikh. "They have a supply deficit that they are trying to cover and their currency is still attempting to rebound – granted they have paid back a lot of their creditors in terms of their existing debt."

Countries with Argentina's experience can be expected take a little more time to get projects off the ground even if driven by a renewable energy target of 8% by 2018. "While those are great targets to have, I think developers may run into problems such as securing financing," adds Parikh.

Developers will have access to tax benefits under the Renewable Energy Development Program as well as World Bank guarantees. Nevertheless, Parikh says project completion dates are still likely to be pushed back to late 2018 or early 2019. Delays are less likely to happen if a major developer that is well established in the region takes the whole capacity. Parikh cites Italian energy giant Enel as a possibility given its strong progress in Brazil and other Latin American markets. He claims that if the capacity is shared out between five or six developers then delays are highly likely.

Wind, biomass and small hydro power technologies will also be represented at the auction. The new policy complements Argentina's first movements in Q1, when a renewables policy was introduced and new president Mauricio Macri revealed plans to establish 3GW of solar in Northern Argentina. There were also early signs of a 700MW development in La Rioja. ■

Credit Flickr: NASA Goddard Space Flight Center

Developers will only have a two-year timeframe to complete their projects

Technical failures in PV projects

Risk assessment | The aim of the Solar Bankability project is to establish a common practice for professional risk assessment, which will serve to reduce the risks associated with investments in PV projects. In this article the project team discusses a key aspect of this work: the development of a methodology for the assessment of the economic impact of failures occurring during operation but which might have originated in previous phases

Historical performance data for PV systems on which to base technical risk assessments and investment decisions are not easily accessible by some market players, such as investors, PV plant owners, EPC contractors and insurance companies. The reasons for this difficulty are that most PV systems have been operational for only a few years (GW-level cumulative installations in many countries were only reached after 2010), and that there is a tendency among system operators and component manufacturers to keep available performance data confidential. In addition, performance data are in most cases not available for PV plants with low nominal power (e.g. residential/commercial market segments up to 250kWp), as the cost of monitoring is still perceived as an added cost. Finally, although the description of failure and corrective measures is common practice in the field of operation and maintenance (at least in paper form), this is not often carried out with a sufficient level of detail in order to derive meaningful statistical analysis because of missing cost information and the lack of a common approach in the assignment of failures to a specific category. For the PV industry to reach a mature market level, a better understanding of technical risks, risk management practices and the related economic impact is thus essential to ensure investor confidence.

One objective of solar bankability is to improve the current understanding of several key aspects of risk management during the project life cycle, from the identification of technical risks and their economic impact, through the process of mitigating and allocating those risks among project parties, to transferring those risks through insurance, warranties, preventive maintenance, etc. To achieve this, the Solar Bankability project team has started building upon existing studies and collecting available statistical data of failures with the following aims: 1) to suggest a guideline for the categorisation of failures; 2) to introduce a framework for the calculation of uncertainties in PV project planning and how this is linked to financial figures; and 3) to develop a methodology for the assessment of the economic impact of failures occurring during operation but which might have originated in previous phases. The focus of this article will mainly be on the third aspect.

Failures of PV system components

A description of the typical failures at the PV module level was the subject of extensive studies within the first phase of the IEA PVPS Task 13 "Performance and Reliability", and the results were presented in the deliverable review of PV module failures [1]. In that document the most common failures of PV modules are described along with the measurement methods in order to assess the impact on performance and safety, with a particular emphasis on visual inspection. Other studies [2] have found that the typical reasons for module returns are linked to problems with laminate cell/ribbon/solder failures (primarily cell interconnections), and to problems with the backsheet or encapsulant (e.g. delamination). Thus, the vast majority of the returns are associated with failures that can usually be identified visually.

> "A better understanding of technical risks, risk management practices and the related economic impact is essential to ensure investor confidence"

Modules that have failed and been returned to the manufacturers are not the only factor to be considered; modules are usually observed to degrade slowly in the field. The literature on the subject of degradation rates for crystalline silicon modules shows that the degradation is dominated by a loss of short-circuit current [3,4]. In most cases this decrease in short-circuit current is associated with discoloration and/or delamination of the encapsulant material. Thus, statistics that relate both to returns of modules and to slow degradation appear to be correlated to mechanisms that can be observed visually. The systematic use of visual inspection would enable the collection of a large dataset of failures. However, other types of failure with low detectability by visual inspection (e.g. hotspots, cracked cells, PID, etc.) might then be under-represented, leading to biased conclusions.

The failure modes that mostly affect PV inverters are related to units that have been exposed to high thermal and electrical stress, as well as to the thermal management system itself [5]. Electronic components – such as bus capacitors, electronic switches and printed circuit boards – have been found to be responsible for the majority of PV inverter failures reported in the literature. Furthermore, maximum power point tracking (MPPT) schemes have also been identified as an important factor impacting the overall reliability of PV inverters. A fan failure could cause the inverter to overheat, affecting its overall lifetime and reliability. Nevertheless, it has been reported in the literature that even under extreme operating conditions, state-of-the-art fans used in PV inverters may work without failing over a period of more than ten years. The typical estimated life expectancy of integrated circuits and optical components is around ten years; however, this will to a large extent depend on the quality of the materials used and on the design topology.

The examples of failures detected in the field as described above only relate to modules and inverters, but each component of a PV system can be affected by failures. Within the Solar Bankability project (a project funded by the EC under the H2020 scheme), typical technical risks for all components of a PV plant and for

		I	II	III	IV	V
	Components / Project phase	Product testing	PV plant planning / development	Installation / Transportation	Operation / Maintenance	Decommissioning
A	Modules					
B	Inverter					
C	Mounting structure					
D	Connection & Distribution boxes					
E	Cabling					
F	Potential equalisation & Grounding, LPS					
G	Weather station & Communication & Monitoring					
H	Transformer station & MV/HV					
I	Infrastructure & Environmental influence					
J	Storage system					
K	Miscellaneous					

Figure 1. The risk matrix as implemented in the Solar Bankability project

various project phases (e.g. product testing, planning, transportation/installation, O&M, decommissioning) have been included in a risk matrix (Fig. 1), and a methodology has been developed to assess the economic impact of failures on the calculation of the levelised cost of electricity (LCOE) and on business models. This represents an initial attempt to apply a cost-based failure modes and effects analysis (FMEA) as an important step towards increased confidence in the operation of PV systems based on a large-scale failure analysis. More-detailed results of this work are presented in the Solar Bankability's public project report "Technical risks in PV projects" [6].

Assessment of the economic impact of technical risks: CPN methodology

The typical approach in risk analysis for technical projects is to apply a classic FMEA in which the various risks, associated with a certain phase and component, can be prioritised through their risk priority number (RPN). In the FMEA each identified risk is evaluated for its severity (S), occurrence (O) and detectability (D); numbers are used to score each of these evaluation parameters. The RPN is then usually obtained by multiplying these three factors.

The classic FMEA with RPNs, although important, is incomplete and needs to be enhanced to include a method for assessing the cost impact of each risk. A classic FMEA is thus deemed inadequate for this specific objective when the technical risk analysis needs to provide a framework for the calculation of the economic impact.

Regarding the application of cost priority FMEA to other fields, many studies have been reported that involve the introduction of a special coefficient called the *cost priority number* (CPN). To the best of the authors' knowledge, there has not been any analysis documented in the literature relating to photovoltaic plants.

A CPN ranking prioritises risks which have a higher economic impact; however, this might not be applicable to each type of risk. To this extent, technical risks were first listed in the risk matrix. The inclusion of the risks in a risk matrix is considered a fundamental step to allow the possibility of failure data, based on an agreed nomenclature and definition, being shared by all the different stakeholders. For the calculation of the economic impact of risks, which are likely to occur during the implementation phase (i.e. during operation and maintenance), it is important to separate this into loss of income due to downtime, and the costs related to fixing the failure (e.g. repairing or replacing a component).

Loss of income due to downtime

For the calculation of the missing income due to downtime, the occurrence and severity were calculated following a well-defined procedure. This procedure is designed to allow generalisation and flexibility in order to maximise the use of the methodology. The severity, S, is defined as the total plant(s) production over one year in the absence of failures. The occurrence, O, is calculated on the basis of the downtime of a specific failure, normalised over the number of components and the total hours.

For the calculation of the costs due to downtime, it is important to consider the lost income as a result of reduced energy production. This can be related to feed-in tariffs (FiTs), to the missing income from power purchasing agreements (PPA), or to the missing savings generated by PV plants installed on roofs/facades which are linked, for example, to the retail cost of electricity. Specifically, the downtime costs are calculated considering the time to detection of the failure, the time leading to the repair/replacement, and the time to fix the problem.

Costs related to fixing the failure

The costs related to fixing the failure derive from the sum of the costs of repair/replacement, detection, staff, transport and labour; the calculation is carried out for failures affecting various components. The overall sum of this type of cost is then equal to the cost of monitoring/detection and corrective maintenance. Preventive maintenance can be included as a detection cost, and its impact can be assessed using the methodology, as it effectively reduces the time to detection.

As a final step, the calculation of the CPN is then given by the sum of the costs due to downtime and the costs due to fixing the failure.

Results from the CPN analysis

The division into the various categories allows the calculation of CPNs for very

Figure 2. Database used in the Solar Bankability project

	Total no. plants	Total power [kWp]	Average no. years
Total	772	441676	2.7
Components	**No. tickets**	**No. cases**	**No. components**
Modules	473	678801	2058721
Inverters	476	2548	11967
Mounting structures	420	15809	43057
Connection & Distribution boxes	221	12343	20372
Cabling	614	367724	238546
Transformer station & MV/HV	53	220	558
Total	**2257**	**1077445**	**2373222**

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Multi-Contact: 120GW PV power installed worldwide – a figure that speaks for itself

Over a billion connectors from the Multi-Contact Solarline range have been providing reliable connections all over the world since 1996. This represents a PV output of over 120GW – almost impossible to believe. Matthias Mack, head of photovoltaics at Multi-Contact, explains how this important milestone was achieved in a highly volatile market environment.

Matthias Mack, a total of 120GW PV power has been installed worldwide to date with PV connectors from Multi-Contact. What does this figure mean for the company?

We are extremely proud of it, naturally. This figure is simply staggering and unique. At the end of 2015, global solar power amounted to around 230GW – over half of which came from systems with original Multi-Contact connectors. For us, however, the aspect of longevity is also key: PV systems with our connectors are intended not only to produce this fantastic result of 120GW today, but also to provide constant power for years to come. Our products could be described as the backbone of the system, and if they are not in perfect working order, the system's performance can deteriorate dramatically within a very short space of time. While photovoltaics are currently being strongly promoted worldwide, there is not much point installing ever bigger PV systems if they go on to provide only 60 to 70% of their maximum power because second-rate products have been used. Photovoltaics are an extremely important ally when it comes to achieving climate targets all over the world, and we should not weaken their effect if it can be avoided.

The PV power we have achieved is therefore in principle a confirmation of our customers' trust in our company and in our products: they see us as a market leader with the greatest wealth of experience, a pioneer since the early 1990s. We have achieved this outstanding result within the space of two decades – the best evidence of the longevity and flawless performance of our products, some of which have been in use for 20 years. Evidence such as this from the field tells us so much more than any laboratory test ever could.

What does this figure mean for the industry?

It is truly unique. As a comparison, the biggest module manufacturers are currently at around 15GW. We are thus making an important contribution to positioning solar energy as an alternative renewable energy source, and over the longer term as the central source. At the same time, however, we are aware that cabling (connectors, junction boxes, and cables) is just a small piece in the puzzle of a large PV system and accounts for less than one percent of overall initial costs. That said, the most effective solar panels in the world are no good if top-quality cabling is not used to transport the power to where it is needed. When it comes to evaluating the risks associated with the return on investment (ROI), this is still often considerably underestimated. So much can happen: increased contact resistance leads to less power and more heat, components and strings provide less output, they can fail, or a fire can even occur, resulting in increased costs for maintenance and spare parts. If we factor in these aspects over an operational period of 10 to 20 years, it becomes clear that in the long term, quality prevails.

These are also the key criteria when it comes to securing financing for a big PV system: low risk and the highest possible ROI. This calls for reliable partners and products, not least in financial terms – and there is no better argument for underlining the bankability of our products than this 120GW power achieved using our connectors.

How have you managed to reach such a figure? Which partners have you been working with?

One reason is undoubtedly our focus on first-class contact with partners and customers. On top of this, we can also boast over 50 years of core competence with MULTILAM. We identify trends at an early stage and have a systematic problem-solving approach. As a Swiss company, we naturally focus on quality, and see ourselves as a true solution provider. We also have our outstanding workforce all over the world to thank for the successful global presence of Multi-Contact. The cumulative effect of all of these factors has enabled us to set the standard – or benchmark – in the industry. Back in 1996, for example, came the development of the first industrially produced connector designed specifically to meet the needs of a PV system. Initially, the leading manufacturers were from Japan and Germany, volumes were low and technical requirements were high. Later came collaboration with top players from throughout the industry and with research institutes, targeted partnerships, and further development of products. We invested in regional and international capacity expansion at an early stage with a view to building up a global presence. Backed up by this solid foundation, we experienced the dynamic transformation of the industry – both from a technical and a geographical perspective – with the best possible results. Today we have a broad customer base in over 67 countries worldwide, ranging from module manufacturers through power inverter producers, EPC or developers to installers and resellers to whom we sell both our standard products and our customer-specific solutions.

When did the development away from a niche product and toward a mass product become clear to Multi-Contact, and what were the challenges involved?

Trends in this direction were identified back in the early 2000s, and then there was some extremely strong growth in the second half of the decade. The challenges included the trend toward standardisation, the evolving global markets, and the significant price pressure combined with high technical requirements. It was also interesting to observe how the market shifted from Europe to Asia and brought new business partners as a result. We had to keep pace with this growth and maintain control over investments. Notable aspects included the transformation into a commodity market, the drive toward design-to-cost and toward lower costs combined with enhanced features. It was a logical consequence, then, that against the backdrop of this competition and price pressure, the focus was often no longer on top quality but on the principle of "good enough". At the same time, however, it can also be said that even if copycat products are unfortunately often of lower quality, photovoltaics have really established their place in public perception, thanks not least to cultural developments, the creation of local opportunities for production, and the significant increase in the number of local competitors.

Which particular factors have contributed to this development?

Environmental issues have played a major role. Public awareness has increased considerably, with most people agreeing that alternative energy

sources need to be used. Financial factors – local incentive schemes, subsidies and the decline in cost for components – have also had an impact, as have the technical enhancement and efficiency of the systems. The good results in terms of LCOE and grid parity are also attracting increasing numbers of investors. This positive dynamic is unstoppable, and photovoltaics will clearly play a very significant role in the future of energy.

What can you say about the quality and the longevity of your connectors? And what are the possible impacts on these two?

We are the only manufacturer with our own internal production facilities for PV connectors, which enables us to guarantee consistent material composition and standardised processes. In addition to this, we also use our own production tools. The technical data concerning contact resistance and longevity go a lot further than what is required for certification. We assess the longevity of our products under enhanced test conditions that go beyond the standard, also studying influences such as ammonia and carrying out salt spray tests. Today's market requirements have evolved on the basis of environmental issues and geographical diversity, but here too, experiences in the field are much more meaningful than laboratory results. And do not forget: 120GW worldwide in the last 20 years! Our products can be found in every corner of the earth – and in some very different, sometimes extremely tough, environmental conditions. Our products have extremely low failure rates (PPM).

Problems can occur as a result of low-quality or recycled materials, for example, and as a result of poor contact quality. While this is ruled out in our manufacturing process, our products can of course be affected by external influences, including incorrect or poor assembly (especially when crimping) or a crossover connection. A crossover connection is one in which our connector is combined with one from a different manufacturer. A large number of studies and a great deal of experience in the field in recent years have shown clearly that these different connectors are not compatible. TÜV Rheinland has stated, for the purpose of clarification, that the use of two different connectors invalidates the certification of the individual products. This is not only dangerous (the increased contact resistance leads to a loss of power and in the worst case to heat build-up and fire), but also means that the product guarantees no longer apply and insurance companies may refuse to cover any damage. In addition to this, the legal uncertainty when it comes to liability has a direct negative impact on the overall project bankability and the ROI calculation.

What are Multi-Contact's strengths, and where does the company stand in an international comparison?

Our connectors make us the undisputed "best in class" – the benchmark. We make no compromises on quality and offer enormous expertise based on over 50 years in contact technology and 20 years in the PV market. What we also offer, is the best value for money over the long term, combined with the benefits of consistently available production capacity and the financial strength we enjoy as part of the Stäubli Group. Our customers value our innovative solutions, the service orientation of our sales team, and our strong and enduring partnerships in the PV industry throughout the entire value chain. We also attach great importance to a sustainable approach, and have high standards when it comes to our own intercultural understanding. Another clear benefit is our presence in the installation markets and in over 20 different countries with our own subsidiaries. These arguments make us an exceptionally reliable partner in the PV industry, both from a technological and a financial perspective.

Looking ahead, which developments or trends do you see approaching, and what is Multi-Contact doing to maintain its role as market leader?

We expect to see increased segmentation in the future, with standard modules for various areas of application and doubtlessly a large market for building-integrated photovoltaics, while classic PV will gradually merge with storage applications. We anticipate continued strong growth in the USA, China, Japan, and India, in particular, and attractive growth markets also exist in the MENA region, South America, and Southeast Asia. The central issues include cost optimization and further development of products – not least because of the increasing numbers of lenders and investors entering the industry and insisting on high quality, sustainable returns, and low risk. We need to stay on the ball, focus on quality issues, and respond to the increasing importance of operational and maintenance services. We can continue to consolidate our pioneering role through our work on expert committees and advisory panels. Also on the customer side, however, we will need to set ourselves apart from our competitors by means of training opportunities and excellent service, for example. This will also enable us to increase the innovation rate over the long term

Where do you see the PV industry and the technology in 10 years' time?

The industry will continue to develop positively based on its growth, and photovoltaics will become an increasingly important part of everyday life. Whether through integration in buildings, large centralized and decentralised PV power stations, or amalgamation with storage solutions – photovoltaics offers smart renewable energy. PV is in the process of consolidating its role as a fixed component of primary energy production, and will soon have established an even clearer role worldwide as a technology of the future. Global big players will advance into the industry and high-quality components will win out in markets driven by ROI and bankability.

Multi-Contact

MC

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ABOUT THE PRODUCT

The original MC4: Its excellent characteristics have made the MC4 (MC = Multi-Contact) the "de facto standard" for connectors throughout the world for over 12 years. The heart of every connection is the tried and tested stable MC MULTILAM technology, which guarantees consistently low performance loss throughout the service life of the connector. The MC4 meets the conditions for the IP65 and IP68 degrees of protection and is approved for use within a temperature range of –40°C to +85°C (IEC and UL, 1500 V). The impact-resistant polycarbonate housing can withstand UV radiation, salt spray, and ammonia vapours.

ABOUT THE PERSON

Matthias Mack: the expert has been working for Multi-Contact since 2006, and is currently Head of Photovoltaics and member of the senior management team.

Module failure	Failure share
Soiling	23.4%
Shading	16.8%
EVA discoloration	11.6%
Glass breakage	6.5%
PID	5.0%

Table 1. Share of specific technical risks over all failures: PV modules.

Inverter failure	Failure share
Fan failure and overheating	21.8%
Fault due to grounding issues	4.9%
Inverter firmware issue	3.8%
Burned supply cable and/or socket	2.2%
Polluted air filter	3.3%
Inverter pollution	1.5%

Table 2. Share of specific technical risks over all failures: inverters.

generic cases or for plant-specific scenarios, depending on the type of input data available (statistical analysis of failures or specific plant-related figures). The parameters used for the calculation of the CPN can also be specified as country dependent by applying country-based coefficients to take into account different FiT schemes, retail cost of electricity, annual insolation, cost of labour, etc.

CPNs are given in €/kWp or in €/kWp/year and can thus directly give an estimation of the economic impact of a technical risk. The methodology also considers the year of installation, the year of failure and the nominal power in order to be able to run analyses for different market segments and to evaluate the distribution of failure probability once the available data in the database reaches statistical relevance to this type of data granularity. The methodology also considers other statistical parameters, such as the number of affected plants and the number of components in affected plants; in this way it is possible to understand if a specific failure is PV plant dependent or if it is equally present over the entire PV plant portfolio.

The database used for the calculation of the CPN for various technical risks includes so far 772 plants, for a total of around 450MWp and with an average operating period of around three years (Fig. 2). The number of components totals 2.4 million (including 2 million modules and 12,000 inverters).

If all market segments are considered, the most important failures (in terms of occurrence) for PV modules are: soiling, shading, EVA discoloration, glass breakage and potential-induced degradation (PID) (Table 1). In the case of inverters, the failures are: fan failure and overheating, fault due to grounding issues, inverter firmware issues, burned supply cable and/or socket, polluted air filter and inverter pollution (Table 2). Overall, the occurrence per year for affected components is around 12% for PV modules (including shading and soiling) and 8% for PV inverters.

To be able to translate the information about failure occurrence into a CPN, two scenarios were established: 1) a scenario in which the failure was never detected over a one-year period; and 2) a scenario in which the failure, once identified, was fixed within a month. The sum of the CPNs calculated for the two scenarios was defined as the base-case scenario for the analysis. In terms of CPN, the most significant failures for PV modules turn out to be glass breakage followed by PID, snail tracks, defective backsheet, delamination, and hotspots, equating to total costs of €60/kW/year. The analysis also shows that it is important to consider the evolution of the impact of failures on the performance loss over the course of several years. The contribution to the overall CPN of the first scenario (no detection) alone can in fact double or triple over the years (Fig. 3).

It is important to highlight that a lower CPN value for the 'never detected' scenario (solely due to downtime) does not mean that this strategy is more cost-effective than fixing the problem. Power losses will increase over the years, and the existing or impending failure could also pose safety risks!

Another important aspect is represented by the spread of the failures over the PV plant portfolio included in the database. If only the PV plants where the failures occur are considered, the results are remarkable: the overall occurrence might be low

"A lower CPN value for the 'never detected' scenario does not mean that this strategy is more cost-effective than fixing the problem"

but when the failure occurs it can have an important economic impact on the affected plants. The costs relating to theft of modules can then increase from €0.08/kW/year when considered over the whole portfolio, to €34/kWp/year for the affected plants; similarly, the PID-related costs can increase from €6 to €114/kWp/year.

Mitigation measures

Once the base-case scenario has been defined and the overall CPN calculated, the next step is to assess the effectiveness of the combination of various mitigation measures in terms of CPN reduction, and to understand who bears the risks and who ultimately bears the costs of PV component failures.

The most significant mitigation

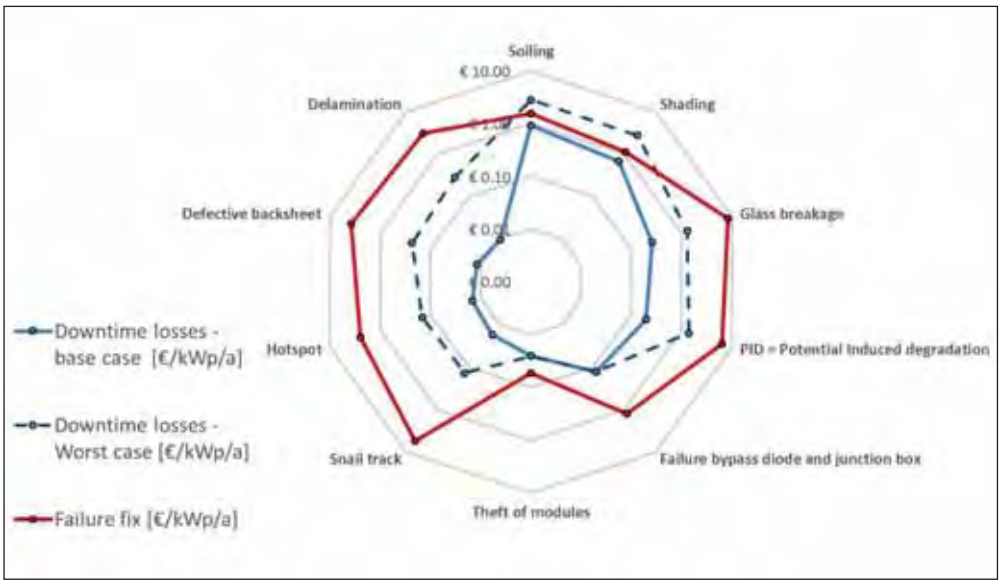

Figure 3. CPN values resulting from the statistical analysis for the top ten technical risks for PV modules. The red line represents the cost/kWp/year of fixing the specific failure. The dashed and solid blue lines represent the cost/kWp/year due to downtime in the worst and base case scenarios respectively

measures are related to component testing, design review and construction monitoring, qualification of EPC contractors, the use of basic or advanced monitoring systems, the use of visual or advanced inspection, and spare part management. Each of these mitigation measures has an associated cost and impact. Starting from a value of around €100/kWp/year as the overall CPN when all components are considered over the entire PV portfolio included in the database, the best combination of mitigation measures can reduce this value to under €20/kWp/year. This value can now be compared with the current costs of O&M in Germany, which is around €8/kWp/year.

Future development and other aspects

In the coming years, as the availability of measured data exponentially increases, it will be important to build large databases along with potentially a uniform method for increasing the confidence level of the statistical analysis and thereby reducing the perceived risks by investors. With the availability of these large databases, the necessary information (minimum requirement) can be filtered out in order to perform tailored analyses in a uniform way, i.e. using the same granularity, data and formulas. The Solar Bankability methodology based on CPNs attempts to provide such a benchmark.

This particular methodology can only be applied to the failures that have a direct economic impact on the business plan, in terms either of the reduced income due to downtime or of the costs associated with repair or replacement. The technical risks included in the risk matrix which cannot be described using a CPN are very important and have to be taken into account, as they might have an impact on the CPN value of other component failures. For example, the technical risks related to the monitoring system, spare parts, norms and documentation, insurance reaction time, O&M contract, video surveillance and detailed field inspection (IR, EL, etc.), just to name a few, can reduce or increase the time to detection or the time to repair/replacement and might have an impact on the detection costs. To other technical risks, for example during planning, it is possible to assign an uncertainty (e.g. irradiance variability, soiling, shading, etc.) in terms of impact on the initial yield assessment. These risks can have an effect on the overall uncertainty during the initial energy yield calculation and assessment. A reduced uncertainty can in fact correspond to a higher level of energy yield for a given exceedance probability value (given as P50/P75/P90/P99/etc.) and thus directly impact the business model. Typical values of the overall uncertainty for the initial energy yield lie in the range 5–10%. In the case of the scenario in which non-optimised models are used in the calculation, and the overall solar resource assessment is characterised by high uncertainty, this value can be as much as 15% or even higher. The reduction in the energy yield at P90 can be greater than 22% when the worst-case scenario is compared with the base-case scenario.

From all these considerations, the general recommendations laid out in Table 3 can be formulated in terms of PV plant design, commissioning and O&M (these recommendations were defined in the project report "Review and gap analyses of technical assumptions in PV electricity cost" [7]).

Risk	Phase/field	Identified critical technical gaps
Year 0	Procurement/product selection and testing	EPC technical specifications that are insufficient to ensure that selected components are suitable for use in the specific PV plant environment of application.
		Inadequate component testing to check for product manufacturing deviations.
		Absence of adequate independent product delivery acceptance test and criteria.
	Planning/lifetime energy yield estimation	Effect of long-term trends in the solar resource is not fully accounted for.
		Exceedance probabilities (e.g. P90) are often calculated for risk assessment under the assumption of a normal distribution for all elements contributing to the overall uncertainty.
		Incorrect assumption of degradation rate and behaviour over time in the yield estimation.
		Incorrect availability assumption in calculating the initial yield for the project investment financial model (vs. O&M plant availability guarantee).
	Transportation	Absence of standardised transportation and handling protocols.
	Installation/construction	Inadequate quality procedures in component unpacking and handling by workers during construction.
		Missing intermediate construction monitoring.
	Installation/provisional and final acceptance	Inadequate protocol or equipment for plant acceptance visual inspection.
		Missing short-term performance (e.g. performance ratio – PR) check at provisional acceptance test, including proper correction for temperature and other losses.
		Missing final performance check and guaranteed performance.
		Incorrect or missing specification for collecting data for PR or availability evaluations: incorrect measurement sensor specification, or incorrect irradiance threshold to define the time window of PV operation for PR/availability calculation.
Risks during operation	Operation	Selected monitoring system is not capable of advanced fault detection and identification.
		Inadequate or missing devices for visual inspection to catch invisible defects/faults.
		Missing guaranteed key performance indicators (PR, availability or energy yield).
		Incorrect or missing specification for collecting data for PR or availability evaluations: incorrect measurement sensor specification, or incorrect irradiance threshold to define the time window of PV operation for PR/availability calculation.
	Maintenance	Missing or inadequate maintenance of the monitoring system.
		Module cleaning absent, or cleaning too infrequent.

Table 3. General recommendations.

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Authors

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Ulrike Jahn graduated in physics and leads various research and development projects in the business area of solar energy of the TÜV Rheinland Group in Cologne, Germany. Her work focuses on characterising PV module technologies and on PV system performance analysis. She is a project manager of an international expert group examining PV system performance and module reliability of the PVPS programme of the International Energy Agency (IEA).

After 12 years' international sales and marketing experience in the chemical sector, Matthias v. Armansperg joined the PV industry in 2004 as a senior strategic advisor. In 2009 he founded ACCELIOS Solar, which offers technical, commercial and financial advisory services with an integrated perspective on solar bankability and risk management, including feasibility studies, due diligences, expert opinions and management of insurance claims.

Ioannis Thomas Theologitis has been working at SolarPower Europe Business since the beginning of 2012. As a senior advisor he has been involved in areas that are directly linked to the PV industry, market, quality, research and sustainability, with further contributions to, and involvement in, grid integration, storage and electricity market design topics. Prior to that he worked as a research engineer, investigating the impact of high penetration levels of PV on the European grid under certain technical specifications.

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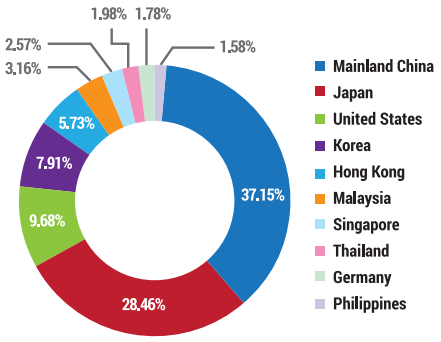

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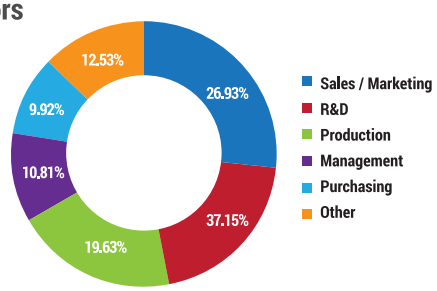

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Rubber stamping bankability

Plant certification | Certifying the quality and performance of an entire PV array has been a notable development in the past two years. Sara ver Bruggen looks at the extent to which developers, investors and insurers are turning to plant-level certification to guarantee the design, construction quality and performance of a PV system

Credit: First Solar

First Solar's Macho Springs project in New Mexico was the first to receive the VDE/Fraunhofer ISE Quality Tested certificate

Several of the top independent solar PV certification agencies now include in their offering to the industry plant- or system-level certification.

Experience gathered in the field by certification agencies, such as VDE and TÜV Rheinland Energy and their partners has shown that the quality of individual components is not enough to predicate the quality and the operational performance of the plant itself. Plant design, planning phases and installation procedures and practices also have an impact.

The perceived need for such comprehensive and holistic types of qualifications has begun to gain currency for several reasons. "In the past the risk was accepted. But as PV plants have emerged as assets, ensuring the technical as well as financial bankability of the plant over its operational lifetime requires qualification that goes further than the component-level," says Willi Vaaßen, director of the Global Competence Centre PV Power Plants, at TÜV Rheinland Energy.

TÜV Rheinland Energy has provided its comprehensive solar power plant certification for projects in Germany, other parts of Europe and Japan. More recently the agency has been promoting certification in emerging solar PV markets, such as South Africa.

The plant certification concept emerged from the findings of a study by the agency between 2012 and 2015, of a sample of PV plants from TÜV Rheinland Energy's global portfolio of 14GW of inspected PV plants. The study's sample comprised 100 separate PV plants, ranging between 100kW and 30MW in size, mostly based in Germany and Europe, but with the US, Africa, the Middle East and Latin America accounting for 20% of the sample.

The main findings of the study revealed that 30% of the plants inspected between 2014 and 2015 showed what the agency classified as "particularly serious" and "serious" defects, including safety issues. More than half of these defects were due to incorrect procedures or actions during installation. The study concluded that potential-induced degradation (PID) followed by module soiling in arid climates are two of the most common causes of failures and impacts on the performance of of PV plant operations.

Growing demand

Certification agency VDE, in partnership with testing house Fraunhofer ISE, has been offering PV plant-level certification for a couple of years. PV developer First Solar has been an early adopter, earning the Quality Tested mark from VDE and Fraunhofer ISE for a PV plant in New Mexico in the US in 2014. In 2015 First Solar's Luz del Norte 141MW solar project in Chile also earned the certification.

"In western Europe, where the level of experience is high, partly because so many projects have been developed in markets, such as Germany and the UK, there was not such a need for this level of certification," says Matthias Jäger, at Allianz Climate Solutions, the renewable energy advisory subsidiary of global insurer Allianz.

Allianz Climate Solutions joined the VDE and Fraunhofer ISE partnership in 2015 to broaden the scope of their Quality Tested qualification by ensuring that all project risks, both financial and technical, are well documented, through the risk assessment, so that they can be understood by the stakeholders.

As new markets have opened up, investors and lenders are starting to call for it. "We have been seeing demand in Turkey, Kazakhstan, the Middle East and North Africa (MENA), including Iran and Egypt, as well as Latin America. Parties such as banks and investors in these new emerging PV markets are afraid to have bad quality projects," says Jäger.

However, for First Solar, not every plant

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it builds has the certification. According to Azmat Siddiqi, senior vice president, quality and reliability at the company the sorts of projects that require the Quality Tested certification are likely to be those that will be sold on once operational. As more private wire power purchase agreement (PPA) commercial projects happen, these may also require the certification. In each case this level of certification provides assurances that the plant will operate reliably over its lifetime and will generate the income and the returns that investors expect.

"Bankability is all about return on investment. Investors want to know if, and also how well, the project was built to standard so its economic performance may be reliably predicted in the pro forma over a 20 or 25 year term," says Siddiqi.

First Solar's first plant to earn the Quality Tested mark, the 50MW Macho Springs plant in New Mexico, was sold on to a new investor, Southern Company subsidiary Southern Power and Turner Renewable Energy, in 2014 after it was built.

"First Solar has always offered module-level certification as part of our terms. The Quality Tested certification has definitely provided further, added assurance of performance at power plant level. While we cannot disclose the terms of the sale for this power plant – which was a pilot offering of the certification – let me say that it definitely enhanced the value and desirability of the asset. So we were able to 'check-off' the bankability aspect of QT certification," says Siddiqi.

As a developer, the onus is on First Solar to obtain the certification. However, different parties involved in a project can require the integrated services from VDE, Fraunhofer ISE and Allianz Climate Solutions, be it a bank or investor, an engineering, procurement and construction (EPC) firm or a future investor, or buyer.

Usually investors and banks order technical due diligence on a project. The certification can replace this technical due diligence and can even go beyond it in terms of risk assessment.

"While technical due diligence focuses on technical risks, the risk assessment also includes financial and macro economical risks. Furthermore the technical assessment includes module testing, in Fraunhofer ISE's labs," says Jäger.

Streamlining procedures

VDE does not want developers and owners to see the certification as an additional cost that increases the plant's capital expenditure.

Electrical engineers from TÜV Rheinland Energy carry out an inspection of a plant in Germany during the commissioning phase. Plant-level certification requires inspections before, during and after project construction

"Complex or large-scale power plant projects often use multiple independent engineers in the course of their project quality assurance. By having a comprehensive standard to refer to, project developers can streamline their quality assurance processes. This streamlining also potentially reduces the number of involved independent engineers, as VDE comes in and performs the quality assurance and certification, resulting in lower costs for overall quality assurance," says John Sedgwick, president of VDE Americas.

The Quality Tested portfolio can be customised on a project-by-project basis. Overall it comprises 300 individual points, or specifications. These can be added to or taken away depending on each project and the customer. There is a minimum pass requirement that must be met in order to receive the certification. Customers have the option of adding additional services that they request, and these extras are mentioned in the final test report.

But broadly, the certification spans several main areas. The first is verifying PV system design, ensuring proper planning and engineering, which includes validating of existing reports such as the energy yield prediction and structural analysis.

Next is proofing selected components for the project, including checking they meet international standards. Then the planning of each installation work package is checked, for example reviewing contracts with various sub-contractors assigned to different parts of the project, from foundation building, to module and inverter installations.

Documentation relating to the actual construction phase is also reviewed, to ensure professional workmanship throughout. The portfolio also covers lab testing of module performance based on samples.

Extensive on-site inspections are also carried out too, including visual inspections of the installation and the complete system. The safety and functionality of the PV power plant is also reviewed for compliance with latest procedures and standards, in electrical safety and other areas. The PV generation plant is tested on-site to determine the power output of the system.

"The way VDE/Fraunhofer's Quality Tested certification works is that the organisation comes in at the early stage of the project to check design, engineering and component selection, among other things. After construction, we do a site inspection and check the commissioning of the power plant. "We don't just come in after the power plant has been connected to the grid," says Sedgwick.

Educating investors

Vaaßen says it is TÜV Rheinland Energy's aim to have 100% of large-scale PV plants that are built to be evaluated to achieve power plant-level certification status. But he concedes that today the demand for this type of certification is far below the target, saying: "A big part of the challenge is that investors don't know these risks yet. But the more they come to understand these risks the more they will want to have this level of inspection and the certification that comes with it."

TÜV Rheinland Energy is trying to educate investors, as well as lenders and insurers by running workshops to discuss its various findings. "There is a need to overcome a mindset among investors that want to save costs, particularly the capital outlay costs. If they are a developer, for example, they are under pressure to deliver a project within budget and within time, so they want to save money," Vaaßen says.

In Turkey, within the last two years, Allianz Climate Solutions organised a roadshow with the country's main banks and lending institutions, in order to give presentations about the Quality Tested certification.

Other insurers are interested in adopting this certification into their own prequalification services and pre-insurance packages and they are able to compare it against their own insurance requirements. It can be used to reduce or streamline the insurer's own due diligence which they would have to do when putting together their own insurance offer.

Having the Quality Tested certification could serve as a pre-qualification and make it easier for the PV power plant to apply for insurance. VDE, Fraunhofer and Allianz Climate Solutions are working with these insurance companies to make sure that

Quality Tested certification fits their own requirements. "The goal is indeed for insurers to be able to reduce the effort needed for their due diligence," says Keith Punzalan, project manager, market research and external liaisons at VDE Institute in Germany.

There is also work to develop international standards around PV plant-level certification. Historically PV plant components have had to comply with international standards, such as the IEC 61215 standard for PV modules, as an example.

IEC Technical Committee 82 is meeting to discuss several system or installation-related standards, which VDE is contributing to.

Sedgwick thinks plant-level certification will follow on from component-level from the IEC, though exactly when is not known, as the process of designing an international standard can take between three and five years. "It will simplify the process of obtaining this type of plant-level certification as it will standardise, internationally, the procedures and requirements for it," he says.

In the meantime, plant-level certifications that are available to the industry are like a good housekeeping seal of approval in the absence of certification according to international standards.

The steps involved in PV plant-level certification

Historically PV plant components have had to comply with international standards, such as the IEC 61215 standard for PV modules, as an example. But this does not take into consideration how a large and often complex PV plant is planned, designed and constructed. Plant-level certifications cover the entire process.

According to TÜV Rheinland Energy, for a PV plant that is 40-50MW in size, the inspections and other work that will be required for the plant to receive the agency's comprehensive solar plant certification can be in the range of 50 man days. These span several days each for the reviewing of the contracts and for the yield data analysis, within the planning phase.

Credit TÜV Rheinland Energy

Drones can be used for visual and thermographic inspections of a plant during commissioning.

During the plant build, which can take three months or more, inspectors may end up visiting the project either weekly, or three to five times, each spanning one-to-two-day visits, over the course of the build.

Then, acceptance testing can require three to five people and can require a week-long visit to the plant. It is the phase that accounts for half of the man days spent.

Such thorough inspections of plants during planning and installation is becoming more important because of the number of parties involved in delivering large-scale solar plants, says Willi Vaaßen of TÜV Rheinland Energy.

Often, PV plant developers will appoint a main EPC firm, which will then often be under pressure to meet tight deadlines and to reduce the cost of the build. Aspects of the job are sub-contracted out, and often sub-contractors will also sub-contract, according to Vaaßen, all of which can increase the chances of bringing in a provider lacking in knowledge and experience in PV plant development, or avoids taking necessary steps to provide quality assurance during construction in order to save on costs.

In emerging solar markets interest in plant-level qualification is being driven by the higher perceived risks related to project development in these markets. "You could be dealing with installers that are not as experienced as one would like, and whose project development and installation procedures should be verified for completeness. Also, the lack of track record in solar in a particular market means that there is more uncertainty regarding the performance of the PV plant," says VDE Americas president John Sedgwick.

One-track mind

Credit: Array Technologies

Trackers | In a realtively short space of time, single-axis trackers have become the mounting technology of choice in utility-scale PV plants. Danielle Ola reports on the technological and economic drivers that have fuelled their meteoric rise and look set to ensure continued growth around the world for some time to come

The global demand for solar PV trackers is intensifying as prices for PV components continue to decline, paving the way for tracking to become more of a standard technology. Track-records that now extend over several years have demonstrated essential bankability by showing that trackers can be used effectively without having a detrimental effect on the operations and maintenance of projects. That upfront work over the past few years has enabled tracker products to come forward into maturity within this past year.

For large utility-scale projects, most developers globally are opting for trackers because of the increased yield they offer, that can be as much as 20-25% more energy production than fixed-tilt. In fact, it is very rare to see a large utility-scale project with fixed-tilt these days except for in the far northern latitudes such as Europe and Canada and in high-wind zones such as the Caribbean and Southeast Asia, where hurricanes, cyclones or typhoons mean fixed-tilt is still a preferable option.

Global markets

The US remains the largest market for trackers, accounting for 62% of all tracking installations globally in 2015, according to GTM Research. Forecasts for 2016 suggest 25% of utility-scale ground-mount installations globally will be built with tracking systems, up from 13% in 2015, and rising to more than 40% by the end of the decade. Trackers are now overtaking fixed-tilt in the ground-mount market by significant margins.

The North American market has certainly been a trailblazer for tracker technologies, dominated by home players such as Array Technologies and NEXTracker. This market increased by 135% year on year, reaching 5.5GW of shipments in 2015.

Latin America is taking off as a strong market base as a lot of European developers have stepped in to service those markets; Chile being one of the bigger opportunities for trackers, ranking as the second strongest market in 2015. A lot of the European suppliers are establishing a significant market share here, leveraging key partnerships and bringing along their preferred partners; utilising their technology without having to go through an extensive education process. With penetration rates in Latin America essentially similar to those in the US, this region is interesting from a competitive landscape perspective as North American and European vendors are claiming roughly an equal market share.

But interest in trackers is now global. Array Technologies is anticipating that a third of its business will be international in future, as the appetite for trackers increases in regions such the Middle East, North Africa and Australia. Despite the general consensus on the advantages of the higher energy production, paired with their cost-competitiveness, tracker deployment varies globally from market to market, according to GTM solar analyst Scott Moskowitz.

"In the US this year there is some 70% of ground-mount projects being installed with trackers relative to fixed-tilt, whereas in markets like China it's below 5%," he says. "There are reasons for that variation; in places like China and India the markets are very low-cost and it doesn't make as much

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sense for trackers as it does in a place like North America."

A lot of the variation can be attributed to how a market is structured and how solar is purchased or incentivised. Early tracker markets were mostly in Europe because of the feed-in tariffs that made it attractive to construct solar projects that had more output, rather than lower upfront cost. Now, as trackers are much lower cost, it makes more sense in other markets than it used to.

Supply and demand

The increased uptake in trackers has meant that many manufacturers have had to expand capacity to meet demand – but this has not resulted in a bottleneck. Trackers differ from module manufacturing or inverter manufacturing in that they rely on large steel manufacturers who source from multiple locations. Even with a ramp-up in steel demand, most tracking vendors, despite surges this year, will be able to meet that demand.

"We have a model where we are the tracker system designer and integrator but we are not the actual manufacturer – we subcontract all that out and have all the components drop shipped and assembled at the site," says Marco Garcia, NEXTracker's chief commercial officer. "Because of that supply-chain strategy, we've been able to scale with our demand. The other thing we've done is diversify our manufacturing geographically to minimise lead and shipping times from factory to factory to project site. We minimise time on the water by manufacturing not only in Asia but also in Europe, North America and South America."

Duel of the trackers

Tracking now is predominantly single-axis as they are cheaper, simpler systems than their dual-axis counterparts, with fewer failures, faster install times, all whilst still giving a relatively comparable performance to dual-axis trackers in terms of yield. The higher performance dual-axis gives is still not enough to overcome the increased cost relative to a single-axis tracker, in the same way that a single-axis tracker overcomes the increase cost relative to fixed-tilt.

"I think the application for dual-axis is definitely there, it's just about the price point," says Camron Barati, North America solar analyst at IHS Technology. "We don't see too much of a market for dual-axis outside of a few key projects in the US, namely in Texas, where local content preferences are a big part of that choice as well."

Trackers in action

Project name: Red Horse 3
Location: Willcox, Arizona
Size: 30MW AC
Type: Solar-wind hybrid

Credit Swinerton Renewable Energy

Swinerton Renewable Energy's recently completed 30MW Red Horse 3 project generates electricity that connects directly into the Tucson Electric Power grid. It features Array Technologies DuraTrack HZ single-axis trackers.

"We find clients are dictating trackers to get a better return on investment, as opposed to a fixed-tilt system," says Scott Stites, Swinerton's procurement manager. "We are seeing trackers deployed in areas that were predominantly fixed tilt, which is the northern part of the US – say Minnesota, for instance. We are seeing trackers being selected there when in that latitude it was predominantly fixed tilt."

Stites also mentions that it is likely Swinerton will not deploy a single fixed-tilt project in 2016. "Part of it is the higher output that you are going to get from using a tracker, but some of it is our client base as well: we have a lot of repeat clients, and those repeat clients gravitated towards a single-axis tracker for its performance benefits."

Due to the utility-scale of Swinerton's projects, they are exclusively single-axis as opposed to dual-axis. "Dual-axis trackers are significantly more expensive and don't lend themselves to projects 20MW and above," Stites says.

Apart from the price issue, technically, dual-axis technologies do not fare as well compared to single-axis, with two moving components that move east-west and north-south, causing more durability issues.

"The problem with a dual-axis tracker is that it casts a long shadow," says Bob Bellemare, chief financial officer at Array Technologies. "You do not get the power density that you do by just going east to west. Interestingly, you get more power out by area by going single-axis than dual. You have to space dual-axis trackers so that they do not shadow each other and then your power density goes down."

That being said, dual-axis trackers lend themselves more to smaller applications as the extra cost for only a small gain in yield usually will not work out in larger projects. Therefore, the dual-axis tracker at this point represents only a small percentage of the overall market, with traditional dual-axis vendors such as Sun Action Trackers in Texas transitioning to single-axis, especially now the solar market is dominated by PV; dual-axis tracking makes more sense for technologies like concentrated solar power (CSP), where that flexibility is warranted. But for utility-scale solar PV, single-axis tracking is the dominant technology.

Drivers for the global uptick

Traditionally, the main barrier to the deployment of single-axis trackers was the upfront cost. But as the global trend in declining PV components reaches tracker technologies, the premium is low enough over fixed-tilt that the increased performance gained makes the economics overwhelmingly favour trackers in most mature solar markets.

"It comes down to economics. In the US, solar has become a highly commercial market," says Bellemare. "Maybe four years ago it was little more R&D-ish, a little more demonstrational, but now it's full-on commercial and every penny counts. There is a lot of competition for jobs and if you're not using a tracker, you're probably not competitive because fixed-rack doesn't give you that power density."

The decline in costs is driven by intensified competition and increased market size, which in turn creates more buying power in the market. This can be used, for example, to buy more steel, which gives stakeholders more negotiating possibilities to diversify supply chains. As markets are growing with increased economies of scale, prices are dropping. In the confluence of all those factors, there is a positive wave for the solar industry that is filtering down into tracking.

As far as the ITC extension goes, there is mixed opinion as to how instrumental this has been in spurring market activity. On the one hand, it provides a demand market for tracking vendors for the next several years. According to Moskowitz, prior to the incentive, the US utility-scale market in particular was facing a steep impending drop-off that would have required most major US vendors to look globally in order to grow their volume year-over-year. With the extension however, tracking can rely on a much better launcher market. On the other hand, whilst it lowers the upfront cost, even without the ITC, there are ways, certainly in the US market, to finance projects due to the low-cost of capital.

Bankability

Even more influential in driving market growth than the ITC has been the steadily improving bankability of tracker technology. Tracking really captured solid investor confidence around 2008-2009 when it became a standard component in a utility-scale project. The shift from dual-axis to single-axis has ameliorated a lot of the maintenance and cost issues that initially gave tracking a bad reputation.

"It was funny because years ago we were all undergoing technical due diligence to confirm that we were serious companies with serious products," says Maria Lahuerta, marketing director at French tracker manufacturer Exosun. "Today investors are seeing the numbers, and seeing that the machines are easy to maintain."

It has been the track records of some of the major suppliers that have helped drive the market forward with confidence. Certain European firms such as Grupo Clavijo and STI Norland have been in the solar market for decades, have installed fixed-tilt and tracking projects and offer their own tracker solutions. Whilst they may not have tens of gigawatts on the ground, the companies themselves have been around a long time and are considered to be bankable. At the other end of the spectrum are the US giants like NEXTracker and Array Technologies who are both highly established brands.

Advances in technology and manufacturing

In an increasingly saturated market, it is critical to improve technologies in order to remain competitive. "Most tracking vendors are just trying to incrementally improve their technology – make them faster to install, lower part counts and reduce failure points," says Moskowitz. "From a manufacturing perspective, the primary thing that makes a company competitive is if they have a global supply chain so that they are able to meet project demand in different locations; so that they are able to be flexible in the event of rising steel prices or steel tariffs."

Flextronics buying NEXTracker last year gave the latter increased capabilities and the opportunity to produce local content, as well as reduce on shipping and logistics. "Flex is manufacturing our control, so there's a benefit with being in the same company that manufacturers airspace and automotive parts," says Alex Au, NEXTracker's chief technology officer. "We are able to learn off of these manufacturing methods."

NEXTracker also employs existing motors that have already been proven in the industry and applies them to a low-duty cycle application. Secondly, Au claims the distributed architecture of its technology means that any loss in production of a single motor is negligible in the scheme of an entire utility-scale plant. NEXTracker spearheaded this model, which Au believes helped it gain its place as a frontrunner.

Conversely, Array Technologies claims its centralised model helps it remain competitive. "We believe in simplicity, speed of install and highly reliable components," says Bellemare. "Our technology has roughly 180-190 electro-mechanical components in a 100MW project. Some other technologies will be pushing nearly 30,000 – and those are all potential failure points. Our product has zero-schedule maintenance and we are the only ones that have that," he adds.

Future developments

The global tracker market is now in a place where there is a lot of new product introduction, with an array of new players looking to capitalise on the sudden shift in preference for technologies. IHS predicts that as the market matures, there will be 20 or 30 tracker companies consolidating a place. By then, as the dust settles in 2017/2018, it will become clearer who is really winning big deals that will come to fruition at the end of the decade; and those are the ones that will become leaders in this new consolidated market. Diversification is evident as more nuanced capabilities are cropping up on the tracker landscape, with some players diverting attention from the utility-scale landscape and looking more into distributed generation solutions where there is more flexibility in terms of terrain.

Trackers are expected to have a greater share of the market in 2017 at over 70%, as more EPCs adopt tracker technology. As international interest grows, the tracker market will shift from being dominated by domestic US players to a global market. Whilst the intensification of competition will add pressure to lower single-axis costs, it should continue to drive improvement in products. "There is a real fight mainly based on prices and we also are seeing new companies entering the tracker market, so that of course is having influence on market dynamics," says Cristina Clavijo, head of strategic business development at Spain's Grupo Clavijo. "It puts a little bit of pressure on the traditional suppliers, which is good." ■

Turn to the next page for a closer look at some of the innovative single-axis tracker technologies shaping the market

Tracker technology highlights

Trackers | With competition in the tracker marketplace becoming extremely fierce, rival companies are adding new features all the time aimed at minimising installation and operation costs, and enhancing durability. Here we profile some of the single-axis trackers currently available on the market and the innovative design features they offer

Company: Array Technologies
Technology: DuraTrack HZ v3
Features: The DuraTrack HZ v3 incorporates a novel wind mitigation feature that allows the tracker to respond to and alleviate high wind loads. Trackers commonly utilise an 'active stow' approach to wind mitigation, whereby sensors move the solar field into a flat position to minimise wind forces. This requires an uninterrupted power source – something that may not be guaranteed during periods of particularly bad weather – and regular testing and maintenance to ensure they are functioning properly at all times. Rather than relying on sensors and a power source to move the entire structure into the same flat position, the DuraTrack HZ v3 has a torsion limiter built into each row, which decouples when exposed to high load forces. After decoupling, the tracker row naturally assumes a position of least resistance by the wind. Usually the position of least resistance is at or near v3's 52° range of motion limit, where redundant mechanical stops are located throughout the system to prevent over-rotation. This angle allows the wind load to be distributed evenly over the 80 module row and the mechanical stops distribute the forces across the row's multiple columns instead of compounding the forces on one central column location. The net result is that no scheduled maintenance is required on the v3, meaning the system can manage itself for the 30-year design life of the product, according to Array.

Credit: Array Technologies

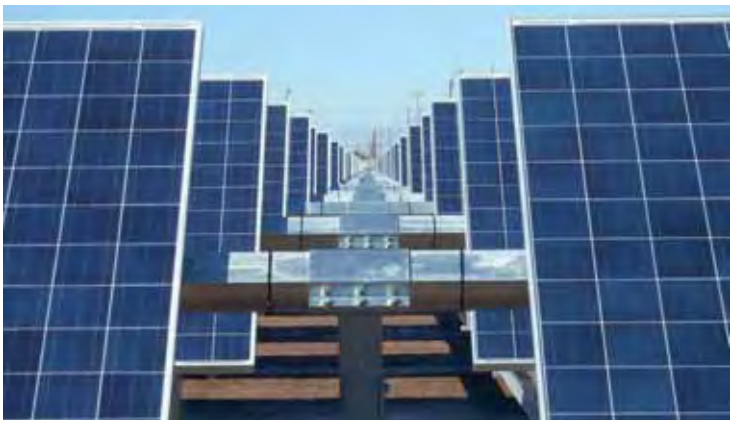
The DuraTrack HZ v3 features a unique system for handling heavy wind loads

Credit: NEXTracker

NEXTracker's NX Fusion bundles together tracker, modules and inverter in one package

Company: NEXTracker
Technology: NX Fusion
Features: The NX Fusion is a bundle of technologies that incorporates NEXTracker's NX Horizon single-axis tracker, a Huawei inverter and, if desired, modules; NEXTracker offers its own NX-405 modules or Flex's 325 modules as part of the bundle, although the system is compatible with any panels. The NX Horizon tracker itself offers various features, including a 120-degree tracking range and the ability to move rows into stowing position within two minutes. Individual rows can accommodate up to 90 panels, and the motors driving each tracker are self-powered by their own dedicated solar panel with battery backup, minimising wiring and maintenance. The NX Horizon is also compatible with bifacial modules, such as those offered by SolarWorld and LG. Overall, NEXTracker claims the NX Horizon offers 2% higher energy yields.

Company: STi Norland
Technology: STi-H1250 (multi-row); STi-H160 (mono-row)
Features: Spain-based STi Norland has over 700MW of its trackers in operation around the world. Its STi-H1250 tracks the sun on a horizontal axis oriented north-south. It is comprised of a series of torsion beams on which the PV modules rest. The beams and modules rotate, tracking the east-west movement of the sun. The 250W motor that drives the beams requires only 1.25kW per MW to operate – making it among the most efficient trackers on the market, according to STi Norland. The tracking control includes a 'backtracking' mode to prevent shadows from being generated between adjacent rows of modules, as well as a flag function to protect the structure and the modules in situations of extreme wind. The STi-H160 is a single-row option that offers greater flexibility for irregular layouts and steeper slopes.



The STi-H1250 is claimed to be one of the most efficient trackers on the market

Company: Grupo Clavijo
Technology: SP160 (single-row); SP1000 (multi-row)
Features: Spain's Grupo Clavijo is presenting the latest generation of its single-axis trackers at this year's Solar Power International. The SP160 single-row and SP1000 multi-row models are claimed to offer optimal reliability in a range of conditions, in temperatures between -5 and +50 degrees Celsius and at altitudes of up to 1,000 metres. The company has also developed a new maintenance-free spherical bearing for its trackers, which it says offers a number of benefits, including quicker assembly time by virtue of the fewer number of individual pieces involved, greater stress resistance and the capacity to absorb a working angle greater than 60 degrees with structural systems that reduce the centre of mass and decrease the energy consumption required for movement. Grupo Clavijo has around 1.2GW of its trackers installed worldwide, with production centres in Spain, the USA, Brazil, Chile and South Africa.

Credit: Grupo Clavijo

A 4.8MW PV array in Fresno, California, featuring Grupo Clavijo trackers

Company: Exosun
Technology: Exotrack HZ v2
Features: The Exotrack HZ v2 has been engineered to deliver high energy output and to minimise CAPEX and OPEX for ground-mounted solar plants, thereby offering the lowest levelised cost of energy. Exosun claims the simple design of the Exotrack HZ v2 enables an installation rate of 200 man-hours per megawatt. This is possible due to the fact that no machines are needed to assemble the structure's few and lightweight parts on site, reducing installation time. The system is also configured in short rows, meaning it accepts high land irregularities, following flowing topography without the need for land grading. Exosun says the fact the Exotrack HZ v2 requires only 51 key components needed for 10MW also minimises failure risks and reduces the need for O&M actions. Exotrack HZ v2 can be delivered with a smart module cleaning device. With reduced human intervention and its capacity to clean without water, the system offers increased cleaning performance at a low cost. More than 370MW of Exotrack HZ trackers have been installed on 35 solar plants worldwide. The Exotrack HZ v2 will be on display at Exosun's booth #3013 at SPI as well as on First Solar's booth #745 supporting the latter's S4 and S5 modules.

Credit: Exosun

The Exotrack HZ v2 has been designed to minimise the number of man hours required in installation

Company: Ideematec
Technology: safeTrack Horizon
Features: The safeTrack Horizon is claimed to use 20% less material input and 50% less foundation work than other tracking systems on the market, yet offer stability under high wind loads of up to 180 miles per hour. The tracker can be installed on gradients of up to 20 degrees in all directions; the elimination of push rods between installation on gradients of up to 20 degrees is possible without levelling work. The safeTrack Horizon's patented steel rod system minimises stress, while the absence of push rods aids maintenance by eliminating obstructions for maintenance teams.

Credit: Ideematec

Ideematec's safeTrack Horizon system in operation in Rwanda, East Africa

All about PID – testing and avoidance in the field

Module degradation | Potential-induced degradation can cause significant power loss in modules if the appropriate precautions are not taken. In the first part of a new series in *PV Tech Power* on module failure, Peter Hacke and Steve Johnston assess the current state-of-the-art in detecting, avoiding and mitigating the worst effects of PID

Potential-induced degradation (PID) in PV modules is activated by the stress of system voltage and the resulting small but continuous current transfer between ground and the cell circuit. With system voltage extending from 600V to 1,000V and 1,500V or greater, the electric field between cells within the series string of interconnected modules and ground is an increasingly stressful driving force for PID.

The term PID can imply a number of various degradation mechanisms in PV modules driven by voltage potential. These include the short-circuiting of the diode junction of the cells, which in conventional cells exists a few tenths of a micron below the front plane of the cell surface. This mechanism is referred to as PID-shunting (PID-s). It is PID-s that has garnered the most attention because it is the PID mechanism that has caused the greatest power loss, with the potential to affect most conventional crystalline and multicrystalline cell module types, which have over 80% market share today.

There are a number of reports of PID-s occurring in the field. PI Berlin has published locations where it has diagnosed PID-s around Europe [1]. These locations include the hot, generally sunny climates of Andalusia in southern Spain and the wet, rainy and cool climates of Belgium. Both elevated heat and humidity are environmental factors that increase PID rate. PID is however not only observed in extreme climates – it has also been observed in the more moderate climates of New York State, Italy and Germany. Degradation has at times been reported to be severe in these locations. For example, power loss of more than 40% of module nameplate power is not uncommon.

The PID-s mechanism occurs when the cells in the module are at negative potential with respect to ground. Positively charged sodium ions in the glass, encapsulant, or cell surface are transported by the electric field due to the system voltage potential toward the light-absorbing active layer of the cells, causing shunting of the cells where the sodium diffuses into defects in the cells (Figure 1). The electric field in the glass is enhanced by high humidity, soiling and rain, which increases surface conductivity and puts the glass face at equipotential to the grounded frame. On the other hand, higher temperature and dry conditions will usually make the module surface less conductive, but will make the packaging (glass, encapsulant) more conductive. This enhances the transport of sodium ions through the front glass near the grounded module frame or mounting points.

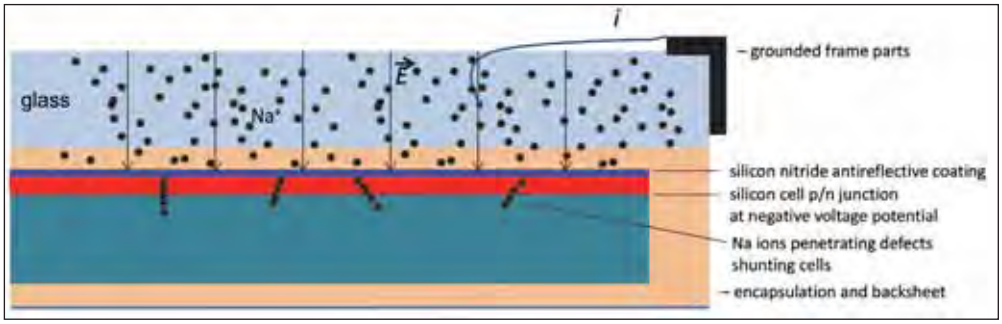


Figure 1. Schematic of module cross-section containing cells at negative voltage potential. Na+ ions are transported by the electric field between the glass face and the cell, which may eventually diffuse into defects in the cell, shunting the p/n junction, causing PID-s

System configurations where PID-s can occur include where the positive end of the module string is tied to ground or, much more frequently, in the negative potential side of module strings in ungrounded PV systems using inverters without isolation transformers. Additionally, higher than normal voltage potential stress can be exerted on the modules when the system is at open circuit; for example, when modules are mounted and connected to one another in strings, but not being maximum power-tracked. Because open circuit voltage (Voc) is higher than the maximum power voltage (Vmp), module strings in open circuit lead to greater voltage potential between ground and at least some of the modules in string than during normal operation. Also, if the modules are connected to one another into a string, but neither terminal of the string is connected to anything, then the voltage in the string may float in an uncontrolled manner, leading to the potential for higher PID stresses on the modules.

Besides PID-s, other PID mechanisms include delamination, where there is significant Na migration to the cell surface, which has been associated with reduced adhesion, and bubble formation because of gaseous products of electrochemical reactions driven by the high voltage and resulting current transfer [2]. Other cell designs and constructions (including thin-film modules types) have also exhibited various effects of system voltage, including PID-s and corrosion [3]. Another well-documented PID mechanism is polarisation, which in the past affected certain high-efficiency crystalline silicon cell types in positive strings

(where the negative terminal of a string is connected to ground) [4].

Module makers can increase module resistance to PID. Commonly implemented methods for doing so include adding layers or optimising the sodium barrier properties in the deep blue-colored antireflective coating (silicon nitride) deposited on the cells and the use of higher quality, electrically resistive, polymeric encapsulants within the module package. Higher quality glass offering higher electrical resistivity and other methods to enhance the electrical isolation of the glass face may also be employed. A combination of some of these PID-s-resistive features is frequently implemented, and is in our opinion preferable for improving resistance to various PID mechanisms.

PID testing

Testing methods to evaluate PID susceptibility have recently been developed. IEC Technical Specification 62804-1 contains standardised PID test methods for crystalline silicon modules. The protocols contained therein are for evaluating susceptibility to polarisation and PID-s, which are the mechanisms most likely to reveal themselves in the relatively short term in the field. While this IEC technical specification does not contain pass/fail criteria, the stresses and the levels contained therein were chosen to be relevant for the sensitivity of modules to these PID mechanisms in the natural environment.

IEC Technical Specification 62804-1 contains two test methods. In both cases, the module power leads are shorted together, and these connected leads are biased at the rated system voltage (Vsys) for their rated polarities (-Vsys and/or + Vsys), two samples each, for a specified duration (Figure 2). The grounding of the external surfaces differs depending on the test method. Either just the frame is connected to ground (relying on damp heat to achieve a conductive adsorbed water film on the glass), or the frame and the glass surface are grounded with a foil. The test method details are as follows:

(a) Testing in damp heat using an environmental chamber:
Module temperature: 60°C; chamber relative humidity: 85%; dwell duration: 96 hours.
Temperatures of 65°C and 85°C providing higher stress levels are given as alternatives.

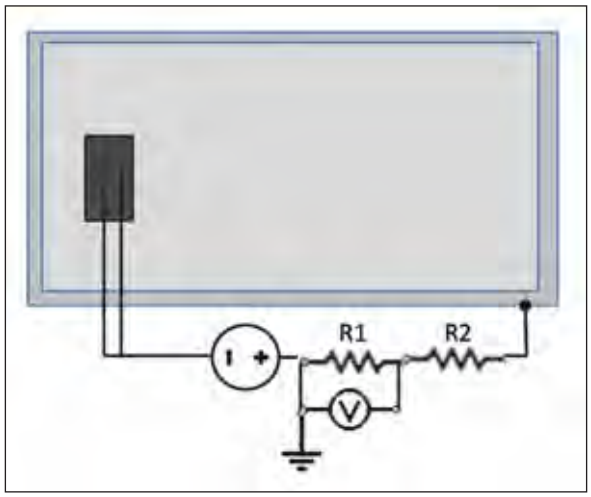


Figure 2. A configuration for testing for susceptibility to PID. The module leads are shorted together and negative voltage potential is applied to them. Current transferred to ground is measured here by sensing voltage over a resistor in a voltage divider network that is used to protect the voltage meter from high voltage

(b) Contacting the surfaces with a conductive electrode (metal foil):
Module temperature: 25°C; relative humidity: less than 60%; dwell duration: 168 hours.
Temperatures of 50°C and 60 °C providing higher stress levels are given as alternatives.

Neither stress test completely reproduces all the factors that a module would experience that influence the PID-s rate in the field; for example, the tests are performed in the dark. It has been found that light exposure prior to application of a PID stress test can make a module more susceptible to PID-s [5], whereas light exposure during application of PID stress reduces the extent of PID-s [6].

The test methods (a) and (b) each have advantages and disadvantages. Method (a) applies actual stress factors of the natural environment: heat and humidity that can diffuse through the module backsheet and encapsulant. Use of actual environmental stresses tests their direct effects on PID, usually increased bulk conductivity of the module package. Method (a) also evaluates the effect of the intrinsic conductivity of the glass surface, which can vary depending on factors such as the use of antireflective coatings. Because it depends on adsorbed humidity to increase the conductivity of the module face, it has also been found to correctly differentiate solutions used to mitigate PID such as rear insulating mounting rails instead of a module frame [7].

The Al foil method (b) has the important advantage of being simpler to implement, not requiring an environmental chamber. Also, the application of the foil on the module surfaces leads to equipotential of the surface and the grounded module frame, as would a film of precipitation or condensation on the module surface of a conventional framed module. However, unless the Al foil test is done at one of the higher temperatures above the baseline level of 25°C, the ionic conduction through the glass and encapsulant is not accelerated in this test, despite the electric field being distributed uniformly over the module face, which activates the PID more uniformly. Modules in the natural environment of course experience much higher temperatures than 25°C.

To evaluate the field-relevance of the test methods and their ability to inform which modules may degrade by PID-s in the field, we have conducted our own tests and surveyed some module manufactures, testing labs and research institutes to find modules that degraded by PID-s in the field, but did not degrade by the 62804-1 test protocols. Our surveys have not found any such cases yet, which indicates that these proposed test protocols may be sufficient to screen for PID-s susceptibility. Admittedly, our survey may not have adequately represented hot desert or hot and humid equatorial climates. Especially for such stressful climates, the test temperatures providing higher stress levels in method (a) and (b) of 62804-1 may be considered for risk reduction. It is anticipated that one or both test methods based on those found in IEC 62804-1 will be implemented into IEC 61215, the module qualification test standard. Additionally, test methods considering the dominant PID mechanisms in thin-film modules, or modules with moisture barriers and moisture sensitive cells, will be defined in another IEC technical specification, IEC TS 62804-2. Standardised tests for additional PID mechanisms for crystalline silicon modules, such as for delamination, are also anticipated in the future. Including these important PID screening tests in standard module qualification tests will reduce the number of modules entering the market that are prone to PID-s performance loss.

PID in the field

It has become apparent that a number of important module manufactures were

not giving attention to PID-s when the issue became widely published in the literature beginning in 2010 and 2011. However, our experience is that the major module manufacturers are now giving due attention to the PID-s issue at this time, and are making conscious design decisions for achieving PID-s resistance to the extent they deem appropriate for their modules. On the other hand, there are still some module makers ignoring PID-s (as are their customers), and in such cases, the modules are more likely to be susceptible to PID-s.

There is no standard for what constitutes a "PID-resistant" or a "PID-free" module. In fact, susceptibility to PID not only depends on the module but on the field use condition. Regardless of such labels, one must ask what test was applied to evaluate the PID resistance of the modules, and the results. The test conditions applied should be compared to the IEC 62804-1 stress factors and levels, and the modules preferably should not exhibit degradation through the applied tests.

Of equal importance to the PID-resistance of the module is the quality assurance protocol of the plant where the modules are produced. The same bill of materials and processes as the design that was evaluated in PID-s testing must continue to be used. It is also necessary for companies to continuously evaluate the product coming from the production line for PID-s resistance. It is however difficult for all but the largest investors and buyers to objectively evaluate what the company is doing in this regard, but one can look for module producers that have volunteered to conduct third-party inspections of their quality assurance system, encompassing consistency in the incoming materials, manufacturing process of modules and their components, and continuous testing for the durability of the product, inclusive of PID-s.

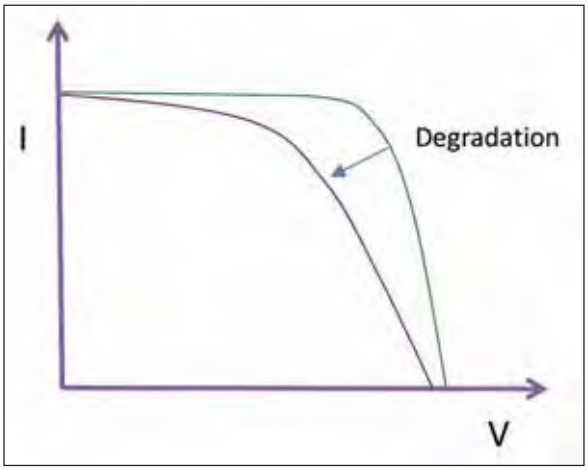


Figure 3. Degradation of a module I-V curve under standard test conditions (25 °C, 1000 W/m2) when affected by PID-s. The maximum power point Pmax degrades because of shunting of the cells, through reduction of the fill factor. Voc is less affected, and Isc is that last parameter to degrade

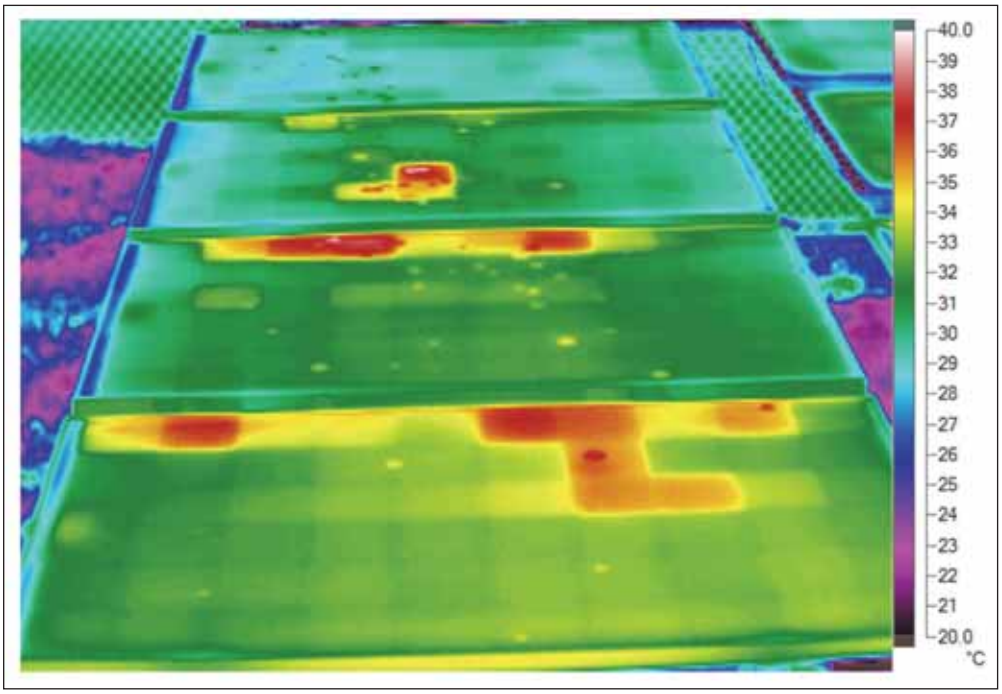


Figure 4. Imaging by thermography is a simple method to visualise PID when there is sufficient irradiance to provide contrast. Here, various modules are imaged from above at the most elevated side of the array. PID-s is seen in the hotter cells, frequently toward the lower edge of the module as seen here, where water and soiling may accumulate that facilitates conductive pathways causing the PID-s

How is one to know if the modules you have purchased are affected by PID-s? The effect on modules in systems is detectable if one knows what to look for. At standard test conditions (STC, which is 25°C and 1,000W/m^2), PID-s will first affect the maximum power point of PV modules by degradation of the fill factor (Fig. 3). Only after significant degradation will the Voc be affected. The least sensitive parameter and last to be affected is the short-circuit current (Isc). A second signature of module shunting is that the low-light (i.e. 200W/m^2) performance ratio degrades, and will be significantly more degraded than the performance ratio at 1,000W/m^2 irradiance. A newly proposed method for electrically evaluating PID-s is to track voltage versus irradiance or current under low light (Suns-Voc method), such as when the sun sets. This will also show evidence of shunting by the signature of reduced voltage under very low light conditions (where reduced voltage is a signature of PID-s), compared to unaffected modules [8].

Optical methods for detecting PID in the field or in the lab include thermography, where affected cells in all but the most degraded cells in the module appear hotter. Because of its simplicity, thermography is especially favoured for field-testing of PID-s when there is sufficient solar irradiance (for example, >700W/m^2 in the plane of array) to show contrast. PID-s-affected areas are essentially short circuited and display power dissipation at those places (Fig. 4, Fig 5(b)). Other optical methods include electroluminescence (Fig. 5(c)) and photoluminescence where affected cells display less emission because generated charges (either by optical or electrical excitation) are lost to the shunting in the cells. Lock-in methods for performing electroluminescence, photoluminescence and thermography in daylight on fielded modules also enable clear images of PID-s-degraded cells (Fig. 5(a) and (d)). Also, one can use lower cost, conventional optical equipment along with tents or dark boxes placed over the module to detect the cells exhibiting PID-s with electroluminescence [9].

Dealing with PID-s

If one has already purchased PID-s susceptible modules or if one has a power plant with cells affected by PID-s, what can a plant owner do? If warrantee returns aren't an option, one must look

航天机电 HT-SAAE

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

SUSTAINING INNOVATION SINCE THE 1960s

Milky Way Series Product: Twin Star

Existing Characteristics:

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

2016 New Characteristics:

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

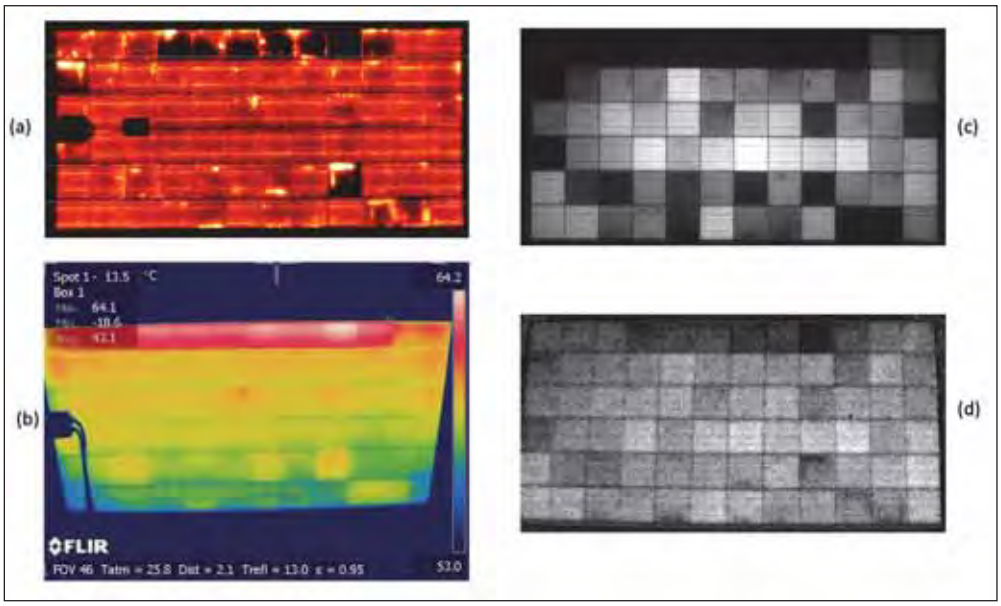


Figure 5. A module degraded by PID-s in the field imaged by four different techniques. (a), Lock-in thermography (laboratory); (b) conventional thermography (field); (c), electroluminescence (laboratory); and (d), lock-in electroluminescence, under daylight in the field

to other solutions with what one has at hand. Most (but not all) modules affected by PID-s exhibit an extent of power recoverability. That means that when the negative system voltage stress on the modules is removed, the power can recover with heat and time. The current understanding is that sodium driven into the cells can diffuse out of them. This can be further accelerated or the extent of recovery increased by reversing the string polarity—biasing the module with the system voltage in the opposite sense, positively.

In controlled conditions using an environmental chamber, PID-s-degraded modules with over 15% of initial power remaining could be recovered to an average of 97% of their initial power value by reversing the system voltage bias in otherwise the same conditions as the degradation. However, other modules with more severe power loss could only be recovered to an average value of 59% of initial power [10]. In the case of a system on a transformerless inverter having both modules in positive and negative system voltage potential, one can reverse the position (in terms of potential) of each module in the string. For example, the module at the negative terminal of the inverter is connected to the positive terminal of the inverter; the second module from the negative terminal of the inverter is placed second from the positive terminal of the inverter, etc. Of course the modules in the part of the circuit now in negative potential with respect to ground will experience PID-s stress. Therefore, this polarity switch may need to be repeated again in the future. It has however been shown that repeated cycles of PID stress and recovery can lead to an extent of stabilisation of PID-s, where increasingly more stress is required to achieve PID-s [11].

Using a similar principle, customers have requested inverter manufacturers to supply hardware that applies positive system voltage bias on modules at night, reversing the motion of sodium ions (out of the cells) and restoring power to the PID-s-affected modules. Current transfer between the module and ground has been measured to be significant when system voltage bias is applied to the module circuit at night when there is no sun to dry condensation and rain. When the system voltage stress is exerted on the modules both night and day in alternating polarities, continually active electrochemical processes increase the risk of occurrence of other PID mechanisms. At least one major inverter manufacturer that at one time sold hardware to bias modules at night no longer does so.

Choosing an inverter topology that places all modules in a positive string with respect to ground will prevent PID-s in conventional modules. Grounded systems using inverters with transformers also remains a solution, but is becoming increasingly rare due to electric code changes, and improvements in transformerless inverter performance and cost. Inverter manufacturers and third party add-ons may offer other solutions that effectively maintain the module string in positive bias with respect to ground during operation.

Microinverters applied to individual modules in operation can serve to maintain the module at a voltage no higher than that of the individual modules. While the voltage developed within an individual module is much less than that reached in series-connected module strings, PID-s has still been observed in susceptible modules biased only to this modest voltage. PID sensitivity of modules therefore cannot be completely neglected, even when considering modules for connection to microinverters.

Getting on top of PID

The outlook for getting PID under control is quite favourable. There have been improvements made in PID resistance of module encapsulant types that have been used for many years, such as ethylene vinyl acetate (EVA). Additionally polyolefin, ionomer and silicone may be used in the module laminate leading to higher electrical and PID resistance. Increasing electrical resistance of the module packaging is an overall favored solution for minimising the various PID mechanisms that exist. However, better encapsulants may be combined with solutions on the cell level that arrest the transport of the damaging sodium ion to the absorber layer of the cells, further improving the resistance to PID-s. Changes to the materials of the module packaging for the purpose of improving PID resistance tend to be introduced slowly and cautiously to verify that such changes don't lead to other, unanticipated failures. There is, however, a body of experience with many alternative encapsulants at this time.

The market has shown that moving to higher system voltages is economically favourable, so attention to PID will continue to be required. Test regimes for evaluation of PID mechanisms that manifest in the relatively short term (polarisation, shunting) exist, which may be applied to evaluate module susceptibility. The next stage will be inclusion of a pass/fail criterion in an amendment to IEC 61215, the terrestrial photovoltaic module design qualification and type approval standard. Consistency and quality of manufacturing is also important because small changes to the materials or the

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module manufacturing process can lead to changes in PID susceptibility. Many module manufacturers have PID-s under control and are making conscious decisions about making their modules durable to PID-s.

However, some manufactures and customers have not given sufficient attention to the matter and PID-s-susceptible modules can still be found on the market. Electrical and optical methods for diagnosing PID-s exist so that power plant operators can identify PID-s in their fielded systems. Cell, module and system-level solutions exist for mitigating PID-s and preventing their occurrence in the first place. The effects of PID-s can be reversed by removing or reversing the negative system voltage bias causing PID-s. Therefore solutions exist for significantly recovering the power of PID-s-affected modules. ■

Authors

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Beyond residential rooftop: module-level power electronics go large

MLPE | Microinverters and power optimisers have become increasingly common features of smaller PV systems. Sara ver Bruggen reports on the technologies' gradual transition into larger commercial and utility-scale applications

Credit: SolarEdge

Module-level power electronics (MLPE), such as microinverters and DC optimisers, have made rapid inroads into the residential solar PV market, particularly in the US.

Shipments of MLPE units reached 1.3GW in 2014 and are forecast to continue growing at an average annual growth rate of 39% through 2020, faster than any other inverter product segment, according to GTM Research, while IHS forecasts the market for MLPE technologies will reach over 9GW in 2020.

The Americas is forecast to continue to be the main market that will see most adoption to 2020 due to the concentration of MLPE suppliers and the higher awareness in the market of MLPE technology.

Microinverters are starting to see deployment in large commercial, whilst DC optimisers are finding traction in utility/ground-mount arrays, in conjunction with string inverters. The majority of MLPE suppliers – SolarEdge, Enphase and AP Systems – have tended to concentrate on the residential solar PV segment, but they are focused on new market segments. The exception is Tigo, which has focused on commercial and utility solar PV markets.

Power optimisers are likely to be used more often in larger installations, greater than a megawatt in size, as opposed to microinverters, due to the fact that they cost less and they only need to be installed on impacted modules, such as those in shadow or perimeter modules that might get dirty, according to Cormac Gilligan an analyst at IHS.

Module-level power electronics products are finding their way into ever-larger PV systems

Tigo has tens of installations over 1MW in size for its optimisers. Company founder Mauricio Ramos says: "We are experiencing increased deployment momentum in many markets, in addition to the US, including Europe, Australia and Japan. Systems as big as 8MW are using Flex MLPE with string inverters."

Seizing the India solar opportunity

By Krishan Mehta, CEO & country head for India, GCL System Integration Technology Co. Ltd.

India has set itself an ambitious target of developing 100GW of solar energy by 2022 of which 40GW is to be developed through rooftop solar projects and 60GW through ground-mounted projects and solar parks.

The government is providing a big push to the sector through several means such as increased budgetary allocation for solar energy, capital subsidies, capacity building through the "Suryamitra" scheme, low interest rate financing etc.

India already has installed more than 7GW of solar capacity with most of the capacity being built in the last year itself. Another 5GW is envisaged to be installed in the financial year 2016-2017.

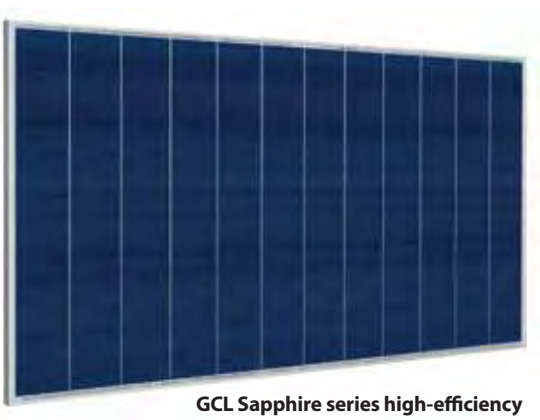
Globally solar prices are declining and recent solar tariff bids, in some places, have even fallen below coal and gas generation. While India has seen record low prices for solar projects at INR4.34/kWh, other countries too are seeing lower trends because of the falling solar equipment costs.

Technology improvement, falling raw material costs, increasingly efficient solar systems and improved global distribution supply chain are some of the key reasons for this decline in solar prices.

As a result of the above, the capital costs involved in developing solar farms in India have declined sharply by two-thirds from more than ~INR15 crore (US$2,300,000) per MW in FY10 to around INR5 crore (US$750,000) per MW in FY16. Solar tariffs in India have also significantly declined with reverse bidding, generally being awarded at tariffs below INR5 (US$0.076) per kWh.

Despite the government's push for solar powered energy, India's current domestic solar manufacturing capacity is significantly underdeveloped. The domestic solar manufacturing sector is not competitive because of lack of scale, inadequate government support and an underdeveloped domestic supply chain.

However, the government is continuously taking initiatives in an attempt to provide a boost to the sector. The Domestic Content Requirement (DCR) for solar projects was a key policy that had helped boost the domestic solar panel companies. However, with the DCR initiative being embroiled in a WTO dispute, the government has proactively started the process of coming up with a new integrated solar manufacturing-plus-generation incentive policy. This policy is being designed keeping in mind production cost subsidisation on the one hand and providing assured business both at manufacturing and generation front on the other.



GCL Sapphire series high-efficiency solar module, up to 350W output.

GCL looks at the Indian solar environment as a huge opportunity. GCL is eyeing the immense available opportunities both in the manufacturing as well as generation arenas.

GCL plans to set up an integrated manufacturing base in India covering the entire value chain from polysilicon to module manufacturing. This manufacturing base would act as a hub not only to cater for India's huge captive consumption but also GCL's business from the western part of the globe.

Without waiting for its Indian manufacturing facilities to come into production, GCL has already started offering products made at its China facilities to the leading Indian project developers.

GCL has been successful in making its mark in the Indian module market by inking contracts for more than 1GW in a short span of less than one year from the date when GCL started its India operations. Out of these, more than 250MW of modules have already been supplied and successfully installed till now.

Besides promoting its other products like single-axis trackers, battery storage systems and inverters, GCL has now started offering services as a total solution provider in the form of EPC and OEM services.

On the IPP front, GCL, which presently owns and operates more than 3GW of solar farms worldwide, looks at India as a preferred destination. In view of the fact that the downward solar tariff trend in India has now been arrested, backed with the falling component prices, GCL feels that the time is ripe.

GCL is just waiting to have a look at the much awaited incentive policy from the Indian government before it takes a plunge in the Indian IPP arena.

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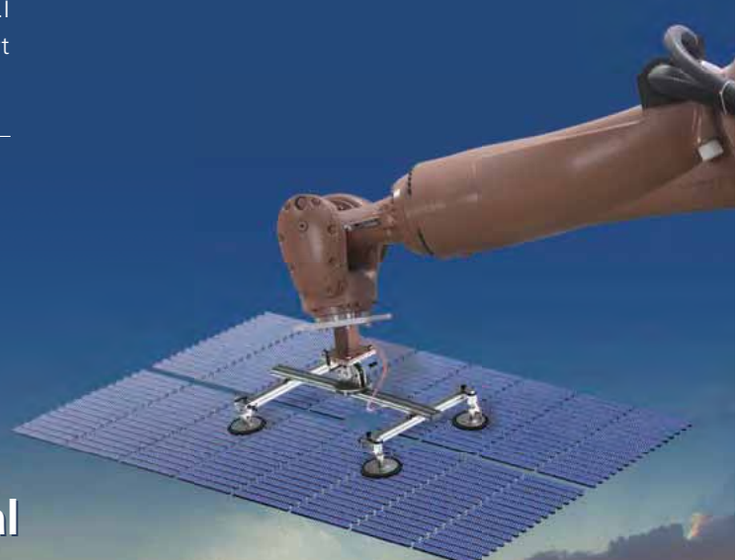

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Credit: Enphase

The company's core platform – Flex MLPE – supports selective deployment in specific locations of the solar array. The product comes either as an integrated junction box format, which is mounted on the PV module in the factory, the TS4 and a retrofit product, the TSR-4, which is mounted to the PV module frame on a rack for both existing as well as new installations.

Unlike other optimisers, Tigo's TS4 platform is modular. Customers, which range from residential installers, commercial engineering, procurement and construction (EPC) firms to utility project developers, choose the appropriate level of Flex MLPE and pay only for the needed solution. Customers can choose to have monitoring, safety, optimisation and long string options, at different price points that all work with any PV module.

Selective deployment reduces cost. "For instance, a system can include a total of 15 PV modules with 10 TS4 optimisers, with safety options and five TS4 optimisers with optimisation options. Only five PV panels need to be treated for shading. This provides the lowest cost possible," explains Ramos.

Enphase has growing demand for microinverters in large commercial and community solar projects

Meanwhile, SolarEdge's vice president of market and product strategy, and co-founder, Lior Handelsman, says the company has supplied hundreds of commercial sites around the world using its optimisers.

These include ground-mount and industrial rooftop installations in different sectors, such as agricultural, public buildings and carports. Many of these are projects larger than a megawatt and include a 5MW ground-mount installation in Turkey and a 4.2MW rooftop in the Netherlands.

Wherever system owners are interested in the long-term value of their PV system and see it as a financial investment, there is a higher demand for MLPE, according to Handelsman.

He says: "System owners who are savvier about their investments and look at the capital expenditure costs and operational expenditure costs, see the value in MLPE. This is because MLPE offers commercial systems both higher system uptime and improved PV asset management."

SolarEdge's DC-DC power optimiser places hardware on the module that manages and monitors energy production, while leaving the conversion process at the string level, helping to keep the solution scalable for large projects.

The company offers a one-power-optimiser-to-two-panel configuration to improve the scalability of its technology. "There might be a bit of a higher upfront cost for the inverter system, but there are lower balance-of-system and O&M costs, and higher lifetime revenue," says Handelsman.

Strung out

The main demand for DC optimisers in commercial projects is the increased focus on improving return on investment. This has caused a trend in recent years of moving to a decentralised inverter architecture.

According to IHS, the market share of string inverters in the global three-phase inverter market grew from 28% in 2014 to 34% in 2015, a shift prompted by the drawbacks of central inverters in these types of projects.

DC optimisers enable the trend towards decentralised inverter architecture, which favours string over central inverters, since optimisers overcome the limitations of string inverters.

To lower balance-of-system costs, central and standard string inverter manufacturers are trying to increase string length by increasing inverter input voltage to 1,500 volts. Higher voltage allows for strings up to 50% longer than strings of 1,000 volts (DC).

An alternative way to achieve longer strings is with fixed-string voltage, an advanced operating mode for string inverters. This requires power optimisers to match current level drawn from the inverter, while the inverter maintains string voltage at optimal voltage for converting DC to AC, regardless of string length or temperature.

"String length is no longer governed by voltage, but by power. This technique allows for 100% longer strings than standard string inverters, while also keeping the voltage below 1,000 volts, achieving reductions in BoS costs," says Handelsman.

GTM Research's solar analyst Scott Moscowitz says: "Though we see very little use of MLPE – when talking about microinverters – in systems larger than a megawatt in size, where DC optimisers are seeing uptake is for string optimisation, in line with increased use of string inverters in the utility solar PV segment.

He cites companies such as Colorado-headquartered Ampt, which has

developed a DC-DC converter specifically for utility-scale projects. Ampt's string optimisers put voltage and current limits on each PV string, allowing doubling of string lengths when the system is designed, while reducing the number of combiner boxes needed, as well as disconnects.

The company's technology also enables full array power at a voltage close to the PV system's maximum voltage. Inverters can narrow their operating range and deliver more power, which reduces the cost per watt of the inverter.

"However the market for DC optimisers in very large or utility-scale projects is still nascent, owing to few vendors," says Moskowitz.

Microinverter producer Enphase has completed and continues to supply large-scale commercial rooftop projects. The first of these was a 2.3MW rooftop project on a greenhouse in Ontario, which has been operational since late 2013.

In 2015, Enphase supplied My Generation Energy, a Massachusetts-based solar installer and developer with its C250 commercial microinverters for a 900kW community solar project. The company began shipping the product, developed for medium- and large-scale commercial applications, in February 2015. More recently Enphase has supplied a multi-megawatt project in Panama.

Other projects include a district in San Diego where more than 40 rooftops together make up a 2.5MW system, all of which are using microinverters.

"We are also seeing demand from big box retailers. Typically they have fleets of buildings where using microinverters enables a discreet and standardised project approach. Retailers tend to have limited space for electrical and cabling, so they can't, for example, have a central inverter in a carpark or lots of string inverters taking up a room," says Teff Reed, senior director of Enphase's microinverter solutions group.

Commercial projects in other markets are also being built using Enphase's microinverters, including a project nearly a megawatt in size in the UK as well as projects in Australia.

"In other markets, voltages are the same for whether a residential or a commercial installation, unlike in North America, so this plays to the advantage of using microinverters as there are no different requirements, which would require making variations in products. We can leverage high volumes and economies of scale to reduce costs," says Reed.

The company's technology roadmap includes increasing the efficiency of its microinverters to 97.5% then 98%, increasing power output in line with that of modules' increasing power output and shrinking the topology of its microinverters to reduce manufacturing costs.

Enphase's customers tend to be mainly rooftop solar PV installers, often installing commercial projects, but who have become familiar with using microinverters initially in residential project installations. Reed says eventually microinverters will move into the market for string inverters. "In large PV projects there is potential for losses in systems through voltage differentials. Microinverters can also simplify the installation of projects and their design."

However according to Gilligan: "The challenge for microinverters in utility markets is still price, though Enphase has communicated in its statements and roadmaps its commitment to reducing costs. We expect project sizes in the 10-100kW range to be ripe for microinverters in future."

Demand drivers

National Electrical Code (NEC) standards have also helped to drive demand for MLPE products, in residential. NEC 2017 requires rapid shutdown in large rooftop installations.

Ramos expects stronger control requirements, such as rapid shutdown, to strengthen the value proposition of MLPE and broaden adoption.

Tigo recently announced 1,500 volt certification and is also working to expand the technical specification of its product offering so that each will be able to address a wide set of parameters. "A single product will be able to provide the functionality to a very wide array of PV module specifications, reducing inventory requirements in large projects and lowering cost so it is, therefore, more attractive to commercial and utility projects."

Smart AC modules as well as demand for smart inverters and energy storage are also creating new lines of business for MLPE suppliers. Demand for smart modules will in part be driven by reduced labour costs, which in the US are higher compared with other markets. Tigo's T4 optimiser, assembled with the module in the factory, is compatible with all makes of modules and inverters.

Early next year Enphase's partners, which include SolarWorld, will release AC modules.

The first product will be a 60-cell AC module, aimed at the residential rooftop market, followed by the launch of a 72-cell AC module for commercial projects. SolarEdge recently launched a new power optimiser for AC modules that has a modular design and low profile. Manufacturers that provide smart modules optimised by SolarEdge are Canadian Solar, JA Solar, Jinko and Phono Solar.

Whether AC modules, smart inverters and energy storage demand improve the opportunities of MLPE in utility-scale PV markets in future remains to be seen. SunPower, which has made the most significant investment in AC module technology, by buying Solarbridge, is commercialising smart modules initially as a residential solution. However these are all new opportunities that providers of MLPE technologies cannot afford to ignore. ■

How MLPE technologies benefit rising demand for storage and controllable distributed energy resources

In the US, the commercial and industrial market is where demand for solar-plus-storage is concentrating. However overall it remains a smaller market, compared with solar PV.

Solaredge's Lior Handelsman says: "MLPE, as part of their standard benefits, are able to increase energy harvest, which would allow for a storage system to store more energy. However, there is more potential for DC optimised inverters. With a DC-coupled battery there is no additional conversion from AC to DC and back to AC. This allows for an overall higher storage system efficiency."

Tigo's Mauricio Ramos says PV systems coupled with storage component have the same challenges standalone PV systems have. Shading will lead to the need for optimisation, and there will still be a need for rapid shutdown if it is a rooftop. These sorts of factors will ensure PV-plus-storage systems will also benefit from MLPE.

In June Enphase announced it is supplying Californian utility Pacific Gas & Electric with smart microinverters used in distributed energy generation. PG&E will evaluate how smart microinverters used with customer sited solar are controlled and coordinated with grid management and voltage optimisation, to support increased solar penetration.

Projects such as these are important if MLPE suppliers are to prove their technology works as tougher grid requirements become the norm and solar-plus-storage becomes more mainstream.

Project briefing

SOLAR AND STORAGE AT SCALE IN WESTERN AUSTRALIA

In the heart of Western Australia, the DeGrussa Copper-Gold Mine lies 150 kilometres away from the nearest town and well beyond any hope of a grid connection to power its intensive industrial activity. The mine's reliance on vast amounts of diesel, shipped in from afar, represented a golden opportunity for clean technologies to come in and prove their off-grid advantages. Sandfire Resources, a mid-tier Australian mining company that operates the mine, called on developers to co-locate not only a solar power plant, but also a utility-scale energy storage system alongside its existing diesel power station. Showcasing the latest technological advances, the newly completed project in the Peak Hill Mineral Field has been hailed as one of the largest renewable energy systems installed at a mine anywhere in the world and certainly the largest in Australia.

The AU$40 million (US$30 million) DeGrussa Solar Power Project is owned by France-based renewable energy firm Neoen, while German solar specialist juwi Group was responsible for development, EPC and O&M.

Originally, KPS, a subsidiary of Pacific Energy, operated the 19MW diesel-fired power station as the only energy provider on the site – one of the Asia-Pacific region's premier high-grade copper mines discovered in 2009. Not only was Pacific Energy paid a capacity charge, but the mine required triple-trailer truck-loads of diesel brought in three times a week – an extremely costly endeavour. By installing a 10.6MW solar PV plant and a 6MW battery storage system, diesel consumption can be reduced throughout the day and to some extent after the sunlight begins to dwindle.

The project is set to provide significant carbon and cost reductions by cutting diesel use by 20% and minimising transport to and from the site, says Andrew Drager, managing director of juwi Renewable Energy. It will save about five million litres of diesel per annum while lowering the cost of diesel procurement. Although fuel pricing depends on the current market, Drager estimated savings of roughly AU$4 million. The inclusion of storage also provides extra benefits including the provision of ancillary services, frequency support, spinning reserves and improved power quality.

All these additions won't negate the original diesel station, which continues to provide base-load power to the DeGrussa mine so that the energy requirements of the mining process can still be met quickly and through the night. But it is estimated that the the new co-located systems will still save 12,000 tonnes of CO2 each year.

While such a hybrid project is not unique to Australia, since low-cost renewable energy is competitive with traditional fossil fuels in many off-grid and mining applications globally, the sheer scale of the project turned plenty of heads on the date of commissioning.

Project in numbers

- 10.6MW solar
- 6MW battery storage
- 19MW diesel power station
- 34,080 solar PV panels,
- 20 hectares
- 4,700 supporting posts, with NEXTracker module tracking system
- Over 70km of electric cable
- Reduction in diesel consumption by ~5,000,000 litres per year
- CO2 emissions reduced by over 12,000 tonnes

Environment and location

Environmental considerations are one of the first obstacles to most infrastructure projects, but as Meekatharra, the closest town with a population of just 800 people, is a huge distance away, there were very few complaints, says Drager. Indeed the closest major city of Perth also lies 900 kilometres to the south.

The trickiest consideration was locating the PV plant to avoid clashes with a landing strip on the mine. Developers also had to consider the high soiling losses from the PV panels due to the high levels of dust coming from the mining process.

"When it comes to the environmental side, a lot of these mines have permits for a certain amount of land," explains Drager. "So we were able to get on the mining lease and install the PV plant on the mining lease itself, which was good, but it means you also

By Tom Kenning

All images credit: juwi Renewable Energy

have to comply with special mining requirements and the special mining applications, which is very onerous to say the least."

However, there were more benefits of the mine location, because Sandfire already had plenty of information about the topography and irradiance of the land, along with detailed site images. As a result there was no need for major scrutiny of the site. Furthermore, the land was already very flat, which pertained to simple installation of the PV structures.

Layout

National surveying and infrastructure construction company OTOC built the PV plant, which comprised 34,080 individual solar panels. While the ideal location would have been in close proximity to the diesel plant in order to limit the need for cable lines, says Drager, it had to be moved roughly 1.5 kilometres away due to flora and fauna on site as well as flood zones. The solar array now covers an area of 20 hectares.

The solar panels were attached to a single-axis tracking systems from tracker firm NEXTracker mounted on 4,700 steel posts to increase the yield advantage by more than 20% on a site that has very high irradiance. The developers used a standardised block as their PV implementation model; however, they had to use above-ground cable trays.

"This was better for us because of such hard ground," says Drager. "All the poles had to be pre-drilled. It's effectively soft concrete; the whole ground."

Storage system

Installing a battery was an effective method of optimising the use and quality of the solar power during fluctuations in the weather. Battery maker Samsung provided the lithium-ion battery storage solution.

"The battery is 1.8MWh and it is a 2C solution, which means it can do 3.6MW continuous or it can do 4C for a period of time, so that is 7.4MW effectively," says Drager. "However it is limited by the battery inverters, which are limited to 6MW." Swiss electronics giant ABB supplied the inverters.

The panels are connected via an extensive network of low-voltage, high-voltage and communication cables to the battery storage facility as well as the existing diesel-fired power station.

Challenges

The remoteness of the site was clearly the main challenge, as it involved flying in and out both personnel and equipment. "Hundreds of kilometres from the next decent-sized town – it's not like you could

rely on stuff to stride in," says Drager.

There was also a range of mining-specific requirements that are not normally faced by a grid-connected PV project. The line manager of the mine had to be 100% certain that the project installer actions were safe and needed to approve every stage of action. Standard PV developers usually just answer to a utility, whose daily task involves dealing with energy, whereas the mine managers obviously had other priorities.

Thirdly, integrating utility-scale PV with utility-scale diesel posed a major challenge as the risks were far greater and it required multiple considerations compared to smaller-scale integrations. "You can't just plug it in and hope for the best," says Drager. "There's a lot more thought going into the design and commissioning."

Integration

With all three energy technologies at play, a control system is needed to balance the diesel, solar and battery systems to ensure sufficient reserve capacity is always available in the event of clouds blocking the sun. If a cloud comes over the PV panels, a part of the energy demand has to be supported by the reserve diesel capacity to make up for the shortfall in solar power. However, it takes some time to start the generators and bring them online. "When a really dark cloud comes over very quickly, the battery helps smooth it out", says Drager. "It also allows more time for a diesel engine to come online."

During the interim period, the battery is able to meet the balance of demand until the new generators are up and running. Once the cloud passes, the power station reverts back to solar power and turns off the diesel generators, which are no longer needed.

As the afternoon approaches and the amount of sunlight reduces, the diesel generators then provide a steadily increasing proportion of the mine's power needs.

During the evening when the solar no longer provides power, the battery has the ability to continue providing auxiliary services such as frequency control, power factor correction, as well as a spinning reserve, thereby increasing the overall reliability of the power station.

Finance

Project owner Neoen was responsible for providing equity for the project and securing AU$15 million in debt finance from Australia's Clean Energy Finance Corporation (CEFC), the state-run firm responsible for promoting renewable energy investment in the country. CEFC recently reported a doubling of investments in renewable energy to AU$379 million in the financial year 2015/16, up from AU$189 million in 2014/15 despite consistent attempts from the federal government to hinder its renewables support.

The Australian Renewable Energy Agency (ARENA) also provided AU$20.9 million in recoupable grant funding.

O&M

Juwi is also in charge of operations and maintenance (O&M) on both the solar plant and storage system

"Definitely a lot more consideration and time is spent managing the storage," says Drager. "You need to keep the battery temperatures constant so there are more requirements to control the environment. From an O&M perspective, it's not super difficult, but the battery is just another consideration."

Meanwhile, the cleaning of the PV plant is carried out manually.

Future

Looking ahead juwi is already eyeing up similar projects at other diesel-reliant locations.

"We've signed an alliance agreement with Pacific Energy for Australia and they own 230MW of diesel power stations in Australia on about 20 brownfield sites," adds Drager. "We are looking at those opportunities to work together on greenfield opportunities. I think we will see a few more."

Hybrid projects do pose a challenge and this particular project had only a six-year PPA term, says Drager, so the project required government funding to underwrite the back end of the PPA. As a result the whole development involved nine different law firms and four technical advisers.

"There were a lot of different entities involved and the pure hybrid complexity was not just technical but more commercial. I think that was really why we have not seen more [similar projects]. Trying to get the numbers to work on a short PPA term is always challenging with off-taker risk that is normally a bit higher than with a utility," says Drager.

Solar energy plants are being utilised near mines worldwide, from many parts of Africa to copper mines in Chile, but the Degrussa project shows not only that energy storage can be used to optimise the functionality of these renewables systems but also that scale should not hold developers back. ■

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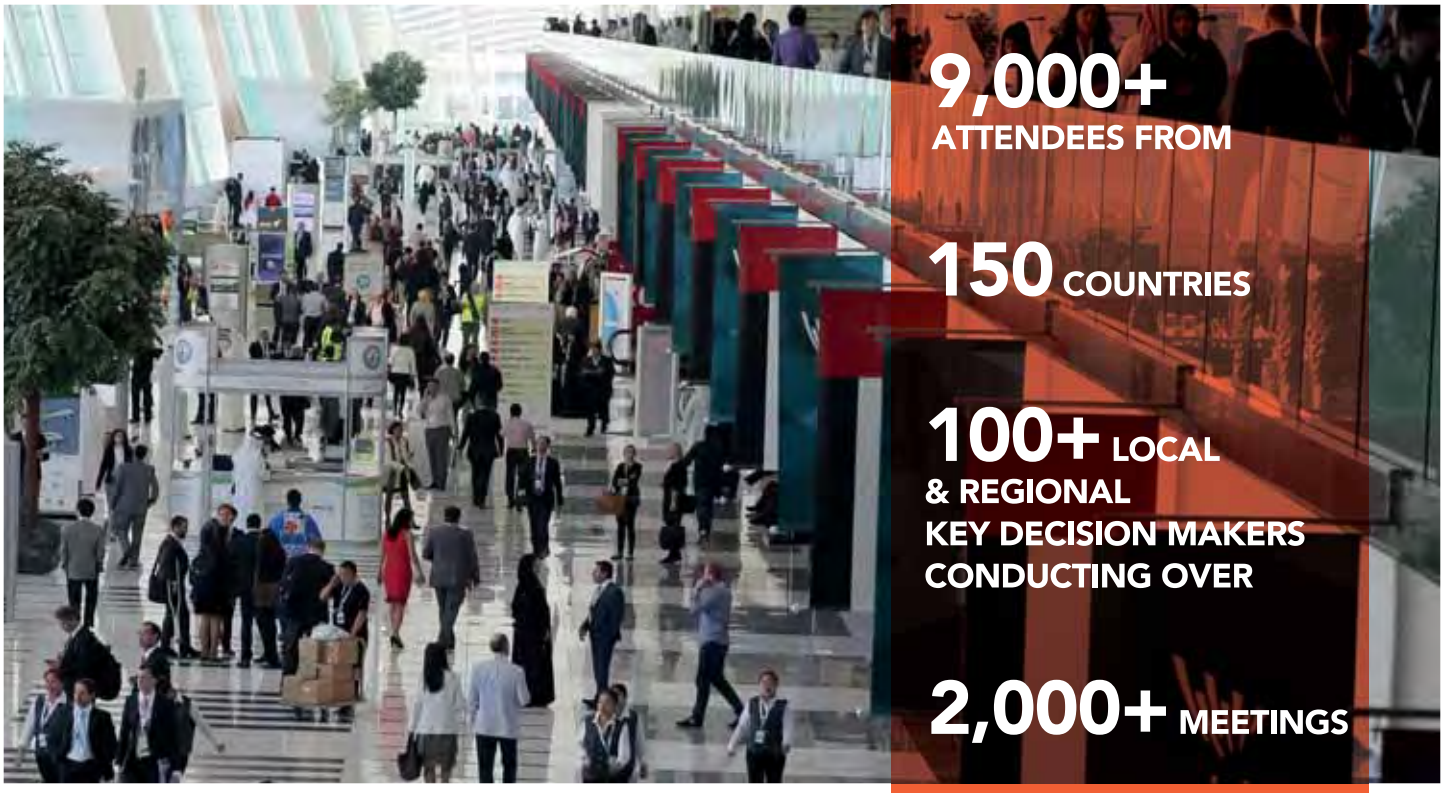

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Why standardisation in O&M is key to PV's future

Operations and maintenance | The maturing of the solar operations and maintenance business has shone a spotlight on the need for some universally accepted standards and practices across the industry. Vassilis Papaeconomou explains why such a step forward will be vital to ensuring the full value of solar assets is realised

PV technology is a rather old technology and has been around for some decades. The solar PV market started in Europe and its large-scale deployment followed a few years later primarily in Germany in the early 2000s and a series of other European countries including Italy, Spain and Greece. The early days of the market were based on feed-in tariffs (FiTs) as many countries adopted that strategy based on its successful implementation in Germany.

During the first growth phase of the market stakeholders were focused on development and construction, while long-term experience on the operation of solar PV assets was nil. Consequently, there was no clear perception of the value and importance of operations and maintenance (O&M), not only from the investors and lenders, but also on the part of the EPCs themselves.

O&M was considered as a "checkbox" to achieve financing and was initially perceived as a burden by the EPC contractors, a pure cost centre for the owners and a formal necessity from the lenders. The pipelines were rather small in megawatt (MW) size as well as plant count, geographical concentration and O&M by definition being tied to the EPC contractor.

It is obvious under these circumstances that there was no space for a pure O&M market, not only due to the above reasons, but also because O&M's value was not properly weighted to its contribution to high-performing solar assets. Much has changed since the early days of the solar PV market. Solar PV is now a booming source of renewable energy across the globe and a key solution in the nations' vision to fulfill the Paris COP21 climate change agreement.

O&M today

Now the market sees the long-term operational necessity and bankability factor in solar O&M, or better said, in some cases, the absence of it.

Solar PV plants constructed in the beginning are getting older and the lack of maintenance and/or quality design and construction are becoming evident. Such adverse effects are heavily impacting the generated revenues of solar assets and creating a lot of headaches for investors and lenders. Even in well performing PV plants, owners are struggling to decrease overall costs as the market is shifting from the FiT scheme to tender-based markets, with cutthroat pricing competition.

In the past few years we have experienced the birth of a new market segment – the independent, third-party O&M market – where O&M contractors are striving to increase the quality of services, while decreasing costs. The management of a large number of assets is becoming a challenge due to the complexity associated with that task. Most people still underestimate the challenge. The reason is the operational part of O&M activities is rarely fully understood and most discussions are based on the maintenance tasks alone, neglecting the effort needed to manage such activities (and a lot of additional ones) to a large extent.

This new market is experiencing steady growth, with more clarity related to the definitions, activities and performance-enhancing expectations related to O&M investments. Another factor is the (very often overestimated) potential of the O&M market as a business. New companies are entering the market, while others are leaving either by going out of business or by being acquired by larger groups. O&M is in a transitional phase, where finally the importance of quality O&M services is

better understood, mainly due to experiences with bad cases. But the market still lacks a significant track record, even in the older markets in Europe, let alone in emerging solar markets such as Africa, India and even Japan.

At the same time, the solar market is evolving with greater geographical dispersion of the assets and larger plants not only through new constructions, but in parallel also with new acquisitions of operational assets. Not long ago a 10MW plant in Europe was considered to be one of the larger ones, while today in India this is considered to be a small plant. The fierce competition forces stakeholders such as EPCs to focus on their core business, leaving space for independent third-party O&M providers.

A problem lies in the fact that most of these new companies have a very limited track record and bad investor experiences have created mistrust about their capabilities. Even large companies are still not providing confidence as failures such as the recent SunEdison bankruptcy show. On top of that, due to the very short history of the independent O&M market, there are huge discrepancies in the understanding of what really is part of the scope of O&M, not only between different regions (for example the USA and Europe) but also in the same country. Investors themselves have very different views and requirements of what an O&M contractor should deliver.

It is becoming very clear that a common language and evaluation criteria for O&M contractors is needed. Investors are becoming increasingly global and expanding into regions where very limited knowhow and experience of solar PV exists, while their requirements and expectations remain the same.

Future requirements of the solar PV

O&M market

The characteristics of the future O&M market can be summarised in the below four main points, which are expanded on in Figure 1:

- Global market
- Independent contractors
- Standardisation
- Plant management evolution – more emphasis on operations

Global market

The solar PV market is increasingly globalised. As costs keep dropping, new regions are showing more interest in diversifying from the classic power generation options (such as coal) and a global trend shifting into renewables is becoming very evident. Nowadays we are experiencing development of PV in areas where it was unthinkable just a few years ago. In fact, there is hardly any region in the world where some sort of development in solar PV is not seen; some regions are more advanced while some others are just starting, but the trend is really global.

Independent contractors

Together with the expansion of solar PV on a global scale, the challenges are increasing as well, while basic requirements are remaining the same. The old model of the EPC taking over the O&M is getting less relevant due to the fact that the EPC business is a project-based business while O&M is operational; two very different points of view with largely different requirements and competencies.

Standardisation

Standardisation is becoming a hot topic, while just a year ago it was not even on the agenda. There have been several initiatives mainly in the USA and Europe, but most

Global market
Solar O&M is a true global market (investment in emerging markets higher than developed markets)
Independent contractors
Established third party O&M market with track record. Track record instead of balance sheet is key
Standardisation
Best practices to increase quality of services. Clarity and consensus from all stakeholders leading to increased and healthy competition
Plant management evolution
Evolution from plant monitoring to portfolio management – high complexity more difficult to manage

Figure 1: Essential characteristics of the future global O&M market

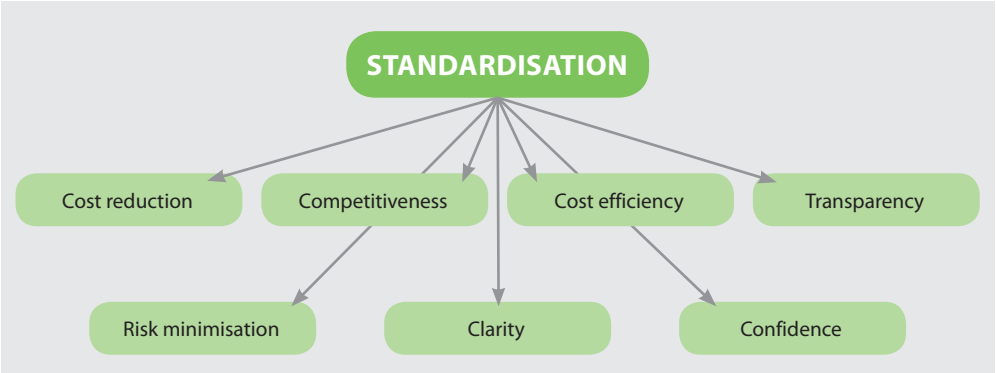

Figure 2: The benefits of greater standardisation in solar O&M practices

have focused primarily on a subset of the full O&M scope, for example, monitoring or maintenance, whereas the operational part has been neglected. Only recently we saw the first initiative from SolarPower Europe touching the subject of operations in conjunction with monitoring and maintenance and other important aspects, which provides a more complete description of what O&M is really about.

In the USA the PV O&M Working Group run by the National Renewable Energy Laboratory is in the process of drafting the PV Best Practices document and Cost Model to help bring a level of standardisation and help include realistic plant operations and plant maintenance costs into the financial models. Meanwhile, the "Orange Button" initiative funded by the US Department of Energy targets a reduction in soft costs by streamlining the collection, security, management, exchange and monetising of solar datasets across the value chain of solar.

The fact that the basic terms like 'O&M' and 'asset management', which are so often used, are not clearly defined gives enough evidence of the value of standardising the industry.

The evolution of plant management

Emphasis on the operations side of managing assets cannot be overvalued. With growing pipelines in dispersed geographies the efficient and consistent management of solar PV assets is increasingly becoming a challenge. Critical to the efficient management of dispersed assets is the evolution of software tools including the shift from simply monitoring the plants to proactively managing them. We already experienced this trend decades ago when corporate software evolved from simple accounting systems to complete Enterprise Resource Planning (ERP) solutions. We will no doubt experience the same in solar PV, where software tools will not only be dealing with one isolated aspect of a plant (monitoring, service management, asset management etc.), but also comprehensive solutions, such as the first solar ERP from Alectris called ACTIS.

Standardisation – the key to sustainable growth

As explained above, the growing pipelines of global investors, the consolidation thereof and the geographic diversity as new solar markets emerge are creating substantial complexity in operational and technical asset management. The lenders' requirements are becoming more stringent given the past experiences from more mature markets. The market is getting overpopulated by new companies, whereas we are experiencing bankruptcies from large and established players. All that is happening in an environment where cost reduction is not just an optimisation requirement, but a condition to proceed, while at the same time the industry has not yet clearly defined the terms so often used in the industry.

All of this adds up to a situation that does not seem to be sustainable for a long time. Numerous actions need to be taken, but there is a very important first step, which we consider absolutely essential, that can serve as a foundation for sustainable growth: standardisation.

Standardisation is not a new concept. We have seen this happening in many other much older and more mature markets, such as air travel or financial services. History has shown that once standardisation has been achieved, markets developed exponentially with standardisation serving as a multiplication factor in their growth. We expect standardisation to have a similar effect in the solar PV business as well, but there is a long way to go to get to this point.

Given the current circumstances, the benefits of standardisation in solar PV are very evident (see Figure 2). Most of these items are currently missing from the current solar O&M business environment.

Several initiatives that could eventually lead to standardisation in the market have already been observed in various regions, mainly in the USA by NREL and SunSpec Alliance, and in Europe by trade association, SolarPower Europe.

In the case of the USA, such initiatives focused mainly on the maintenance part of the O&M business whereas in Europe it has also included the operational aspect, which is very often neglected. In June at Intersolar in Munich, SolarPower Europe, through its O&M Task Force, published a document setting out guidelines for best O&M practices in the industry. This document is valuable in that it sets out clear definitions of commonly used terms, and schedules of critical operational and maintenance activities.

It covers a very wide range of activities, apart from maintenance, such as claim management, training, KPI definitions, environment and health and safety aspects, and many others that belong in the scope of a bankable O&M contract.

Collectively, the task force's guidelines are far from amounting to an official standards document, but is a very good first step towards standardisation. Ultimately they may evolve into a single standard for the O&M sector, but before that happens there will need to be a period of time for providers to adopt the new guidelines and engage in the debate over how their industry should be shaped. Nevertheless, through this and similar initiatives in other regions, what is emerging as a distinct business segment of the PV industry is laying the foundations for a clear set of minimum requirements that will serve as a quality benchmark for the whole industry to follow, leading to greater efficiencies and lower costs. ■

Author

Vassilis Papaeconomou is managing director of Alectris, a specialist provider of operations, maintenance and asset management services to the PV industry. He has been involved in the PV industry 2006 in various roles spanning development, construction, financing and asset care. He is a member of the SolarPower Europe O&M Task Force and a regular speaker at global solar industry events.

Turn to next page for further insights into the O&M Task Force's guidelines, including an interview with its leader, First Solar's Stefan Degener

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Solar O&M grows up

Operations and maintenance | The European solar industry has followed the lead taken by its counterparts in the US by developing best practice guidelines for the burgeoning O&M business. Stefan Degener, senior director of O&M at First Solar, who led a group to develop the guidelines, speaks to Ben Willis about their significance and aims

Credit: First Solar

The O&M task force has published the first set of best practice guidelines for the industry

As we have heard on the preceding pages, the set of activities grouped together under the O&M moniker has grown from being an afterthought normally carried out by a project's EPC contractor into something altogether more specific – and indeed vital to the long-term performance and profitability of a PV power plant.

Yet those activities have not until now been clearly defined. What's more the number of players in this emerging market has grown rapidly, resulting in a patchwork of different service offerings and standards. For project owners, lenders and other stakeholders this can create confusion and uncertainty around the minimum expectations they should have when negotiating an O&M contract.

It was against this backdrop that in 2015 SolarPower Europe formed an O&M task force, a body charged with creating a quality benchmark for the provision of operations and maintenance services. During Instersolar Europe 2016 in June, the task force published a best practice document, its first significant step towards bringing a greater level of coherence to the O&M business in Europe.

And there appears to be something in the air vis-à-vis O&M across the solar industry more generally. Last year the SunSpec Alliance, National Renewable Energy Laboratory and Sandia Lab in America joined forces to draw up a set of best practice standards for the US market, with similar aims to the SolarPower Europe venture. Other regional solar markets meanwhile have expressed an interest in following the lead taken by the US and Europe.

First Solar's Stefan Degener here offers insights into the task force's guidelines and explains why the time is right for the O&M business to grow up.

What was the thinking behind the O&M task force and why now?

The O&M market in Europe is extremely fragmented and has been undergoing a consolidation for approximately one and a half years. So following all the other segments of the solar business, O&M started this consolidation process and is still continuing. The idea was to gather interested parties from the industry and think through how we can help the stakeholders to get a better understanding of O&M best practices, with the ultimate goal of setting some kind of standard.

Why is the standardisation process necessary?

In the past we had EPCs or installers just signing pieces of paper, and the scope and content of those were very, very different. Some only understood O&M as green-keeping and looking after projects from outside of the fence, without going into very much detail. And so therefore we had the feeling it would be good to guide people a little bit around what is supposed to be a standardised scope for an O&M contract – what should be in the scope, what should be expected and what are additional services. This is what can be found in this document.

First Solar has led this group, but to what extent have others from the solar industry been involved?

It wasn't that we did this alone; it was really a joint work. So we broke it into very detailed groups, and every one of these 26 members of the task force contributed to this exercise.

Bearing in the mind fragmentation of the market, presumably that means different companies have different ways of doing things. From a practical point of view, how did you bring all of those different ways of doing things together into something that was coherent?

This is the work of 26 companies, so in a sense it's a kind of compromise setting out minimum requirements, minimum expectations a plant owner or stakeholder should have on O&M. In many cases we give a view on best practices – so how do the best performers in the industry do it – just to showcase what is possible but probably not required from every owner. The 26 companies involved represent I would say an ok average of the industry. But it can be a couple of hundred companies doing O&M right now; many have stepped out, but at the same time you see a few as well just stepping in as independent O&M partners. And that showcases that O&M is really becoming a business and not just something that is needed on the tail of construction.

Give me some examples of some of the things these guidelines have been successful in doing in terms of identifying an optimal way of carrying out a particular aspect of the O&M process.

One thing it does is provide definitions of terms that hadn't been available earlier. This is to allow people to understand what is meant when someone talks about operations when someone talks about warranty claim management and so on. This basis is important as a starter. And we took particular care of safety: in solar PV, most of the time when people work on a site in operational hours, the sites are loaded with current and that can be dangerous, so this is something we paid particular attention to. The current version of this document also outlined some kind of skill set which should be expected from someone working on a PV power plant; the idea is to develop it further and make this a kind of education document or learning document for particular PV plant maintenance personnel.

And we had a very lengthy discussion as well around the definitions as well as the application of KPIs – key performance indicators. And there are two sets of these: one is the KPIs for the power plant, which are being measured through meters and sensors. But at the same time it's important to develop KPIs for the O&M provider itself, so that the owner has a chance to benchmark or to understand the performance of the O&M provider.

Assuming the industry adopts these guidelines, what difference do you hope they could make in the long term?

The big goal is to get a kind of joint understanding about what O&M means. Today we see when talking to customers that there is a lack of understanding and education. So having these documents being understood by the stakeholders and also by the

Best practice benchmarking – key points from the O&M Task Force

DEFINITIONS

A common understanding among stakeholders of the various activities and processes involved in O&M is a key starting point for bringing a more standardised approach across the industry. This is particularly the case for operations tasks, as they have not hitherto been as clearly defined as the more technical maintenance activities. The task force guidelines provide definitions for almost 30 cornerstone O&M terms, from additional services to warranty management, and everything in between.

ENVIRONMENT HEALTH AND SAFETY

O&M providers are usually subcontracted to take on practical responsibility for the safety of personnel working in and around a PV power plant, and for the protection of the environment around it, even though the ultimate legal responsibility for those areas rests with the owner. The guidelines clarify the legal obligations of the various stakeholders and define the duties the asset owner and O&M contractor must undertake in order to remain compliant with health and safety and environmental protection regulations. Minimum requirements in terms of the qualifications of O&M personnel and the personal protective equipment used by workers are also detailed.

PERSONNEL AND TRAINING

Having the right mix of training and qualifications within an O&M team is crucial to ensuring works are performed in a safe and accountable manner. Although not overly prescriptive, this section of the document sets out some of the desired minimum skills and qualifications the technical and specialist personnel in an O&M team should have. It includes out a 'skills matrix', a table that allows companies to chart the existing, required and planned skills of personnel at different levels of an O&M team and across different disciplines.

POWER PLANT OPERATIONS

This section details the key obligations for plant owners and O&M contractors for the successful operation of a plant. It covers processes such as the correct provision and management of key documents, monitoring and data collection requirements, plant monitoring and supervision of the plant by the O&M provider, analysis of plant performance, predictive maintenance, remote plant control, power generation forecasting and reporting by the O&M provider to the asset owner. Other processes covered include ensuring the regulatory compliance of a plant, warranty management and the correct processes for handling insurance claims.

SPARE PARTS MANAGEMENT

It is the responsibility of the O&M provider to ensure spare parts are available as required in a timely manner so as to minimise system downtime. Important considerations for the O&M provider are logistics such as the optimal stocking level of parts, the location and storage of parts in terms of the proximity to the plant and security. The task force provides a sample list of spare parts and a suggested methodology for determining stocking levels, that accounts for factors such as the likelihood and impact of a certain part failing, the probability of degradation over time and the cost of a replacement.

POWER PLANT MAINTENANCE

The task force provides detail on the four main types of plant maintenance and how those should be defined in an O&M agreement:

- **Preventative maintenance:** These activities form the core element of plant maintenance, comprising regular visual and physical inspections, in line with component warranty requirements. It is up to the O&M provider to draw up a detailed maintenance plan and schedule for specific parts.
- **Corrective maintenance:** This covers activities undertaken to restore a PV plant after a failure has been detected. Key points that should be framed in an O&M agreement include a cap on the amount of corrective maintenance the O&M provider can undertake in a year and the maximum time in which the O&M provider must undertake repairs once a fault has been detected.
- **Extraordinary maintenance:** These actions are necessary following major unpredictable events that require substantial remedial work to restore a plant to operation and are generally billed separately under the O&M contract. Best practices in this area include the determination of clear rules around the right of the plant owner to invite quotations from other providers to undertake extraordinary maintenance work and the granting of a 'right to match' option for the O&M provider.
- **Additional services:** An O&M agreement can foresee services that will be carried out by the contractor at the plant owner's request, above and beyond those framed in the preventative maintenance aspect of the contract. They include activities such as module cleaning, pest control, snow removal and perimeter fencing repairs, among many others.

PV PLANT SECURITY

To keep a plant secure, recommended best practices include an additional communication line in high-risk areas. The asset owner is responsible for setting a security protocol in the event of an intrusion, while it is up to the O&M provider to ensure the correct functioning of security equipment. These activities are normally considered as part of the additional services outlined previously.

CONTRACT MANAGEMENT

The O&M provider is normally tasked with some form of contract management responsibility. The task force suggests that as a best practice, the contract manager should function as an initial and triaging portal for all external questions regarding a plant's operation. This would ensure adherence to the contractual responsibilities occurs.

KEY PERFORMANCE INDICATORS:

The task force breaks KPIs down into two categories: PV plant KPIs that allow a plant owner to keep tabs easily on the performance of its asset; and KPIs relating to the O&M contractor. According to the guidelines, the former should cover parameters such as plant availability, performance ratio and energy performance index. The O&M KPIs should encompass a range of quantitative and qualitative factors, including reaction time to alarms, reporting and the overall contractor experience.

CONTRACTUAL COMMITMENTS

It is up to the asset owner to ensure the two halves of the O&M equation – the most likely remote operations services and more localised maintenance activities – are well managed, particularly if being undertaken by different providers. The O&M provider KPIs should provide the basis for the asset owner and O&M contractor to define the latter's level of accountability. These will be translated into appropriate bonus schemes for over-achievement or liquidated damages where agreed standards are not met.

The guidelines are available in full at solarpowereurope.org

players in the market – the O&M service providers – will help to bridge a lot of current communication gaps and execution gaps. Sometimes an owner is not happy with the performance of the plant, but is not able to identify whether it is the equipment, the O&M provider, whether it's the grid operator or where it comes from. So this document really helps people to get on the same level of communication and expectation around O&M principles.

What happens next in terms of disseminating this as well as adapting it over time?

It's now available from the SolarPower Europe website to be downloaded. But this is version 1 and we are expecting feedback; SPE is taking care to send it out particularly to groups of stakeholders – technical advisers, lenders etc. – and collect their feedback. And we are using it in our general communication with the market. We've actually developed a badge, which shows that the companies using this badge are following or are at least aware of these principles. The idea is that by using this badge in your emails or on your invoices or on letters, whatever, you can really communicate to the market – hey, we are part of this group and we are following these minimum best practice guidelines.

There has been some discussion that these guidelines could be a precursor to full certification of the solar O&M business. What is the thinking here and how might such a thing be developed in time?

This will be the next step. So after this badge, that everyone can use voluntarily, the ultimate goal would be that O&M companies need to undergo a kind of qualification audit process – which still needs to be developed by the way – and then get a certain certificate. When you have this the owner can trust that this company is working to mutually agreed and released guidelines to the market. This is a long-term target. What we have now is version 1.0; we want to enhance it, we want to sit together a couple of times a year to think through what can be improved, do we need some localisation into particular markets, can we use this as an education document for installers... So we have lot of ideas going forward to further enhance the usefulness of this work to the market.

If certification like this were to be developed, who would be the obvious body to do this?

I can't refer to a particular name or institution at this point in time. UL was part of our group to develop this, but there's no preference at this point in time. We're just talking about the idea, but going there in real life will mean a huge amount of work; to develop this into real standards, where you have a checklist which can be applied – that won't come in six months, this is a long-term plan.

Could this apply to other markets outside Europe?

Yes, of course – the US already has similar documents. NREL [the National Renewable Energy Laboratory] and SunSpec Alliance released their O&M guidelines in early 2015; this was one of the sparking elements for our idea. And we see interest to apply or to work on something similar definitely from the Middle East,, and markets in Asia-Pacific or Africa may apply these. PV is now becoming an industry, a matured player of energy generation. It has been a start-up atmosphere for a long time, but now it's getting to a more structured way of doing things, and this is just a very natural development what we are doing here. ■

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The case for better PV forecasting

Grid integration | Rising levels of PV penetration mean increasingly sophisticated forecasting technologies are needed to maintain grid stability and maximise the economic value of PV systems. The Grid Integration working group of the European Technology and Innovation Platform – Photovoltaics (ETIP PV) shares the results of its ongoing research into the advantages and limitations of current forecasting technologies

Forecasting and monitoring technologies for PV are required on different spatial and temporal scales by multiple actors, from the owners of PV systems to transmission system operators. Power system operations require a real-time view of PV production for managing power reserves and networks. They also require forecasts on all timescales from the short (for dispatching purposes), where statistical models work best, to the very long (for infrastructure planning), where physics-based models are more accurate. For PV system operators, accurate forecasting is also critical to maximising the commercial value of the electricity they produce.

In its review of the challenges and opportunities associated with massive deployment of solar PV generation [1], the Grid Integration working group of the European PV Technology Platform (now ETIP PV) identified forecasting and observability as critical technologies for the planning and operations of the power system with large PV penetration. In this article we spell out in more detail what features are needed from these technologies and, after an assessment of their current status, how they need to be developed.

Some very good reviews of forecasting techniques have been published in recent years [2,3]. We have built on these by taking a step back and analysing the different use cases for forecasting in relation to PV. To estimate the economic value of further improvements in forecasting, we linked the effect of forecasting errors with the current imbalance settlement prices charged by balancing authorities in Europe.

Power system dynamics

At all times in all power systems, consumption (including charging of storage systems, and losses) and production (including discharging of storage systems) need to be equal. In a conventional power system operating in alternating current (AC), frequency is a real-time indicator of that balance. To ensure that balance is maintained any fluctuation of production or consumption needs to be anticipated as much as possible before it translates into frequency deviations.

For PV to play its full part in the grid of tomorrow, further work is needed to improve forecasting techniques

< 10 s	Inertia response
	Protection system operations
	Switching of power electronics
	Battery switching between charge and discharge
1 min	Fast start of pumped hydropower plant [4]
	Fast start of some combustion engines [5]
15 min	Gas power plant from 1/3 to full power [6]
1 h	Start-up and shutdown of most power plants
24 h	Commitment of generation units
1 year	Maintenance planning
10 years	Expanding transmission infrastructure
20+ years	Economic lifetime of PV systems
	Economic lifetime of grid assets

Table 1: Characteristic time constant of power system components

Indeed, any corrective action will be limited by the speed at which power system components can move to new set points. The characteristic time constants of power-system components range from less than a second to 10 years or more, as summarised in Table 1.

Prior to the introduction of variable renewable sources such as wind and PV, power consumption was the only variable component in the power system balance. The ability to forecast its variations was introduced in the 1940s. It has since been refined to take into account "seasonal" variations (day of the year, day of the week, hour of the day) and the specific characteristics of different electricity uses (heating and cooling, cooking, industrial equipment, lighting, etc.) [7]. However, the focus has always remained on regional or national aggregates.

The deployment of variable renewable generation is introducing new requirements on forecasting techniques. First of all PV and wind generators are much more sensitive to weather conditions. The main weather parameter with an influence on electricity demand – where heating or cooling is powered with electricity – is temperature. This parameter varies slowly in time and space. PV and wind on the other hand strongly depend on rapidly changing variables. As a result, the geographic distribution of the generators matter more for the aggregate variations than that of the loads.

In addition, PV generation is highly distributed in terms of locations and ownership. It is therefore often necessary to forecast generation with a higher spatial resolution than demand. Indeed single

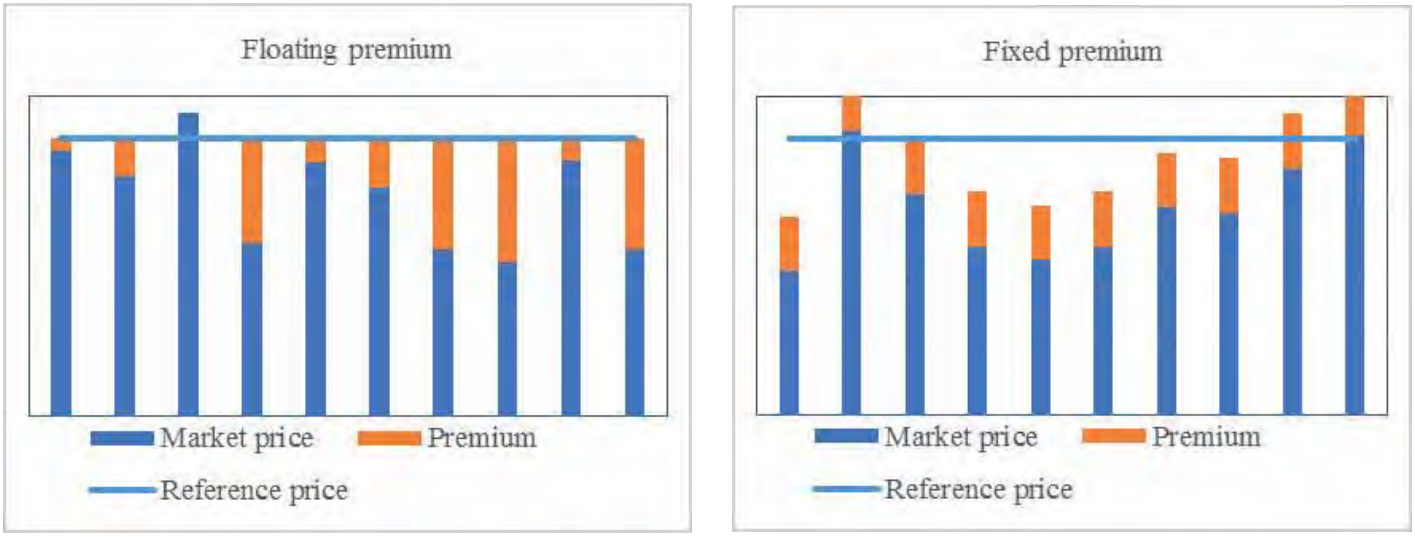

Figure 1: Working principle of market premiums; adapted from [15]

MW-scale plants may be exposed to market trades, and microgrid operations with self-consumed PV electricity require forecasts at the building or district levels. Such granularity increases the forecasting difficulty: the standard deviation of PV power production is reduced as $1/\sqrt{S}$ and $1/\sqrt{N}$, where S is the surface area of a PV power plant and N is the number of aggregated plants [9,10].

Drivers for PV forecasting

An important concept when dealing with forecasting in the power system is the balance group. Balance groups can include generation units, consumption units, or be 'virtual' when operated by financial actors who only trade. Forming a balance group is a requirement to participate in wholesale electricity markets. All balance groups report to a balancing authority, which in Europe is generally the transmission system operator (TSO). This authority ensures that trades on the electricity market are balanced i.e., that contracted generation matches forecast consumption. Balancing group managers are responsible for ensuring that at each time-step of market operations their contracted production and/or consumption matches the realised values. In case of mismatch between prediction and realisation, balance group managers are penalised based on intraday market prices; if the imbalance is in the same direction as the whole system (e.g., a producer under-delivering when there is a shortage in production), the penalty will be above the intraday market price and if the imbalance is in the opposite direction the penalty will be below.

PV generators were until recently shielded from this balancing responsibility. In Germany for example, TSOs carry the responsibility and operate a balance group for PV systems which are connected under the Renewable Energy Sources Act (EEG) in their area [11]. Regulators are now pushing to increase exposure of PV generators to market conditions and increase their responsibility in the balancing mechanisms. A 2014 ruling by the Italian regulator introduced imbalance charges for renewable power generators of more than 1MW in capacity; the mechanism is similar to that applied to conventional balance groups but the fees are modulated to take into account the inherent volatility of the different sources [12]. The resulting cost for PV generators is estimated around €5/MWh, which is still significantly lower than imbalance prices applied to regular balance groups in Europe [13,14].

In addition, support mechanisms for large PV generators are evolving from feed-in tariffs to market premiums in France, Germany and the UK [15] under which these

generators receive a regulated payment on top of market prices. As illustrated in Figure 1, these premiums can be fixed, or floating, i.e. cover the difference between the average market price over a certain period of time – generally one month – and a reference price set by the regulators. In both cases generators have a direct interest in maximising the value on the market of the electricity they produce and the volumes they can effectively sell. Since a generator can only commit on the market power it is confident it can produce, accurate forecasts are essential to maximising these sold volumes.

Finally, the development of micro-grids and of combined PV-plus-storage systems requires local energy management, which, for optimal operations, relies on predictive control. Single-system or neighbourhood-level power forecasts on timescales from a few minutes to 24 hours are therefore necessary.

These drivers and the dynamics of power system components described earlier together create a range of use cases for forecasts on time horizons ranging from 15 minutes or less to decades, and on geographical scales ranging from the single site to an entire region or country. These use cases are summarised in Table 2, which shows in particular the central role of day-ahead forecasting.

Time horizon	Single site (10 m – 100 m) **PV plant owners PV plant operators**	MV distribution grid (1 km – 10 km) **DSOs Microgrid operators**	Transmission system (100 km – 1000 km) **TSOs Market operators**
15 min	Management of storage system	Management of active/reactive power	Activation of reserves
1 h	Management of storage system Intra-day trades	Storage and load management	Intra-day trades
24 h	Management of storage system Compliance with regulations Day-ahead trades	Storage and load planning	Booking of reserves Transmission scheduling Day-ahead trades
1 year	O&M contract	Planning of maintenance operations	Long-term trades
20+ years	Investment case	Infrastructure planning	Infrastructure planning

Table 2: Summary of use cases for PV power forecasting

Metric	Formula	Application
Mean bias error	$MBE = \frac{1}{N}\sum_{i=1}^{N}(Y_{forecast} - Y_{realised})$	Investment decision
Mean absolute error	$MAE = \frac{1}{N}\sum_{i=1}^{N}\lvert Y_{forecast} - Y_{realised}\rvert$	Balance group management
Root-mean-square error	$RMSE = \frac{1}{N}\sqrt{\sum_{i=1}^{N}(Y_{forecast} - Y_{realised})^2}$	Optimisation of generation reserves

Table 3: Main performance metrics used to assess forecasting methods

Forecasting approaches and performance

Performance criteria

Because the use cases are so diverse, there is no single metric to characterise an absolutely "good" forecast. Instead, any of the three most commonly used metrics, which are listed in Table 3, can be preferred depending on the target application. These metrics are generally reported in a normalised way; particular attention must be paid to the normalisation factor and to the integration period. It is good practice to integrate the error only over daytime hours, since PV production is sure to be zero in the night. And while errors in irradiance forecasts are generally normalised by the average measured irradiance, those on power forecasts are often normalised by the nominal peak power of the system. This difference mechanically results in reported errors which are about three times lower for power generation than for irradiance.

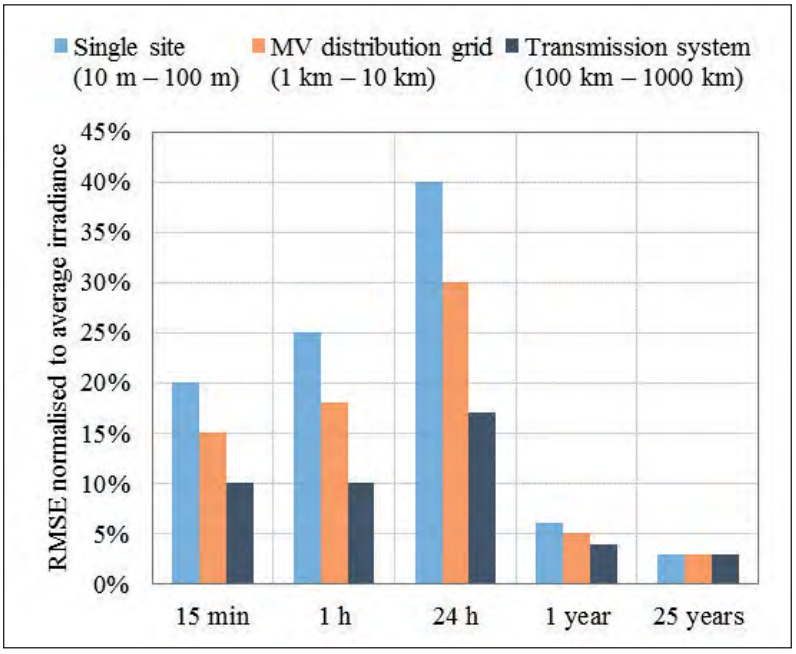

Figure 2: Error obtained with state-of-the-art physical forecasting methods for irradiance.

Current forecasting techniques

The first approach in PV power forecasting relies first on the prediction of relevant weather parameters (at least temperature and irradiance), followed by a calculation of the corresponding power output. This

approach can build on existing weather forecasting tools. The most appropriate tool to predict irradiance depends on the desired time horizon.

For resource assessment – i.e. to predict patterns of energy generation over the lifetime of the system – statistically representative time series of weather parameters are generated based on interpolation of ground-level measurements (weather stations) or satellite images to produce "typical meteorological years".

For time horizons between six hours and three days, numerical weather prediction (NWP) is preferred. NWP data are generated by global or mesoscale simulation models which provide the numerical integration of the coupled differential equations describing the dynamics of the atmosphere and radiation transport mechanisms [16]. The initial conditions are given by satellite, radar, radiosonde and ground station measurements. NWP data are often corrected by post-processing algorithms called Model Output Statistics (MOS) which use historical ground measurements to partially remove systematic errors [17].

For time horizons between two hours and six hours, visible and/or infrared images are acquired by satellite-based sensors. A cloud index is computed based on reflectance measurements and is typically used to derive ground-level global and direct irradiances [18]. As compared to NWP, only a few relatively simple modelling assumptions have to be applied to derive the solar resource. Persistence of cloud speed and direction (as derived from the last two images) is generally assumed. The dynamic nature of clouds challenges cloud-motion vector approaches as cloud distribution can change substantially within the typical 30-minute interval between two images. It is indeed challenging to account for cloud convection, formation, dissipation and deformation. However, since large-scale cloud systems (such as those associated with a cold front) are more persistent, satellite-based forecasts typically perform more accurately than NWP-based forecasting models up to six hours ahead, mostly because of ingestion, data assimilation and latency of calculations required to "spin up" NWP-based forecasts.

For time horizons below 30 minutes, total sky imaging is the preferred method. It consists of four steps:

1. Acquisition of the sky image from a ground-based, wide-angle camera;
2. Analysis of the sky image to identify clouds;
3. Estimation of cloud motion vectors;
4. Prediction of future cloud cover and ground irradiance.

The maximum accuracy with this method is generally obtained between five and 20 minutes; with low and fast-moving clouds it can be reduced to three minutes and for high and slow-moving clouds it can be extended to 30 minutes. The state-of-the-art accuracy for all these physical forecasting methods is summarised in Figure 2.

Models for computing PV power from irradiance and environmental parameters also carry their own uncertainty, which compounds the error on forecasted irradiance. In a review of major modelling tools, the hourly root-mean-square error (RMSE) on AC power output was found to be below 7% in all situations [19].

To avoid this amplification of errors and to deal with time horizons between 30 minutes and two hours where there is no satisfactory physical forecasting technique for irradiance, stochastic learning techniques are used. These methods can be separated between:

Univariate methods i.e. methods where only time series of the target variable (here, PV power) are fed into the model. These include:

- Persistence: P(t+1)=P(t);
- STL: seasonal decomposition of time series by Loess;
- Holt-Winters seasonal method;
- TSLM: linear model fit with time series components;
- ARIMA: autoregressive integrated moving average;
- BATS: exponential smoothing state-space model with Box-Cox transformation, ARMA errors, Trend and Seasonal components;
- Nnetar: Feed-forward neural networks with a single hidden layer and lagged inputs for forecasting univariate time series.

Multivariate methods i.e. methods where exogenous variables such as measurements of ground irradiance, temperature or humidity levels are fed into the model in addition to the target variable. These include:

- MLR: Multi-Linear Regression Model;
- SVM: Support Vector Machine;
- ANN: Artificial Neural Network;
- Regression Tree.

Value of forecasting

To estimate the value of forecasting, and of improvement in forecasting techniques, the best analogy is the operations of balance groups, since for them forecasting errors have a well-defined cost. Indeed, European TSOs currently charge a typical imbalance price of €20/MWh.

If a 1MWp plant in the North of Italy were a balance group on its own it would then be charged this price. The mean absolute error over four years for such a plant is 11.6% of nominal power with clear-sky persistence, and 7.1% with an advanced forecasting technique (numerical weather forecast plus support vector machine) [20]. Since only daytime is taken into account (12 average), these errors translate into an annual imbalance of 0.50 MWh/kWp and 0.31 MWh/kWp, respectively. So the annual imbalance cost would be €10,000 and €6,200 respectively. As a comparison, with power purchase agreements at €80/MWh as are now contracted in Germany, annual income for this plant would be €80,000. So two conclusions can be drawn:

- Forecasting errors can reduce the value of PV electricity by more than 12%
- Advanced forecasting techniques can generate a value of almost €4,000 per year for a 1MWp plant.

Conclusion

Accurate forecasting of PV power production has many use cases in both current power system operations and foreseen evolutions towards a more PV-centric system. Many of these cases require day-ahead forecasting, which is also the time horizon among those considered for which forecast errors are the largest. Research and development efforts should therefore focus on this horizon.

Other promising developments for using forecasts in power system operations include the communication of confidence intervals in addition to forecast values [21], and regional clustering to improve the accuracy of estimates of current power production and of forecasts.

Both physical and stochastic learning techniques are available to forecast PV power. Their choice mainly depends on the target time horizon and on the availability of sensors.

In a simple case, the lost value of PV electricity due to forecast errors can be estimated at more than 12% of annual revenues. Using advanced forecasting techniques can significantly reduce this loss and generate a value of almost €4,000 per year for a 1MWp plant based on power system balancing only. In smaller, weaker power systems than those considered here this value would be even higher. ■

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Business models for PV in a digitised and decentralised energy market

Business | The combination of rapidly evolving technologies and the trend towards decentralisation is demanding increasingly sophisticated commercial models. Simon Göß looks at some of the emerging solutions and considers the place of blockchain technology in tomorrow's energy system

PV has experienced a dramatic decline in costs. While this is important, many developers of PV power plants have also struggled to generate profits, as reimbursements via feed-in tariffs or other remuneration schemes have likewise declined. Is it still possible to earn money with PV and what are the consequences for PV business models? This article looks into several business models for PV and also provides a glimpse into a disruptive future with community PV power fuelled by storage and blockchain technology.

The underlying setting

Since 2008 prices for PV modules have fallen by 80%, while investment costs for PV power plants in Germany have declined by almost 75% since 2006. This is an average of 14% per year as documented early this year by the Fraunhofer Institute for Solar Energy Systems in its report, 'Recent facts about photovoltaics in Germany'. The drop in average end customer prices – the net system price – for installed rooftop systems with rated power of the PV plant from 10 to 100 kWp is depicted in Figure 1 [1].

The drop in prices was also reflected in the feed-in tariffs paid to PV system owners, which fell to about 10 cents/kWh for rooftop system and to about 7 cents/kWh for ground-mounted or bigger rooftop systems. The implications are vast, as gross domestic electricity prices for both households and industry are now above PV feed-in tariffs.

Current business models

In terms of business models for PV two main cases can be distinguished: grid-parity and generation-parity business models.

As soon as PV power reaches grid parity, electricity consumers might rather cover some part of their demand with electricity from PV than buying more expensive power from the utility. At a later point when PV reaches generation parity, it competes with generation prices of other power generators. According to German trade body BSW Solar business models for PV can be distinguished according to these two different levels of competitiveness, where Figure 2 gives an overview [2].

GRID PARITY	GENERATION PARITY
PV competes with grid electricity, i.e with costs of generation and distribution at point of consumption	PV competes with generation prices of centralized generation, i.e avoidance of distribution cost cannot be leveraged
Self-consumption	Utility PPA
Net-metering	Virtual Power Plant
Direct line PPA	PV-hybrid mini grid

Figure 2. Differentiation of various business models for PV

A short sketch of the some of the above models follows, where a more exhaustive analysis of the underlying assumption for business models can be found in the BSW Solar report referenced below.

Self-consumption

In the case of self-consumption the owner of the PV system and the consumer of the electricity generated by the system are identical. Electricity is directly consumed at the site without using the grid. Any excess might then be sold to third parties, e.g. the grid operator for a feed-in tariff. A key driver for models based on self-consumption is the difference between electricity from the grid and levelised cost of energy (LCOE) from the PV system.

Net metering

The assumptions are quite similar to self-consumption. The main difference however is how excess electricity from the PV system is handled. Power fed into the grid is balanced by credits or reversed metering and thus lowers the electricity bill for the consumer.

Direct line PPA

In a business model based on direct line PPA the owner of the PV system sells the

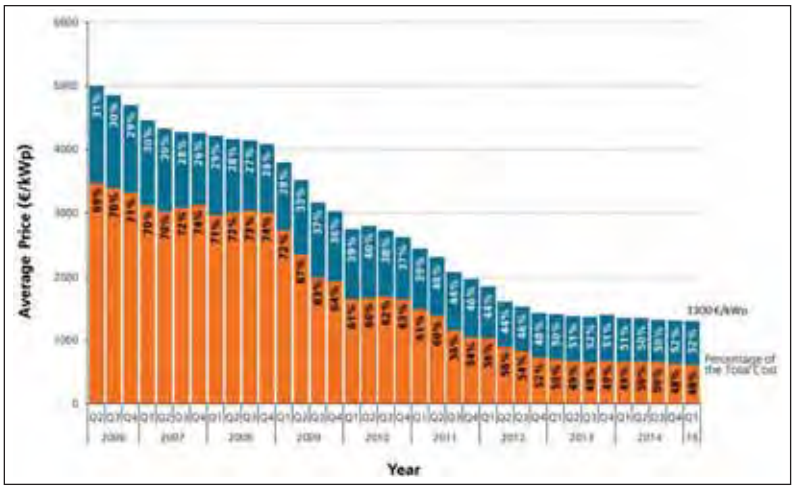

Figure 1. Average end customer price (net system price) for installed rooftop systems with rated nominal power from 10 to 100kWp (blue: BoS including inverter; orange: modules)

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electricity within the same building or via a direct line to a consumer in the vicinity of the power plant. Its profitability is driven by not using the public grid and thus the non-applicability of regulative issues. In addition, the cost of electricity from the grid is nowadays in many cases more expensive for a third-party consumer than sourcing power directly from a PV facility.

This business model may become more attractive in Germany especially due to the new amendment of the renewable energy act which will come into effect in January 2017. This new amendment reduces or in some cases abolishes the renewable energy levy for PV systems operated by a third party and supplying tenants of a building.

The economic viability of business models based on grid parity largely depend on the levies and taxes on electricity that have to be paid by the owners of the PV power plant.

Utility PPA

When PV power reaches generation parity it may directly compete with other generation units and selling the electricity directly to a utility or the grid operator may be a viable alternative. The PPA's underlying remuneration has to be structured in a way suitable for PV.

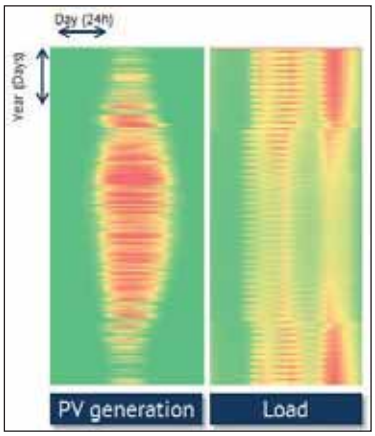
Virtual power plant

In this business model, electricity from PV power plants is directly sold at an electricity exchange. Pooling of a number of different PV systems and possibly other sources of power generation (e.g. wind or biogas) allows the creation of a generation profile that can take advantage of peak prices that occur during the day. Flexibility of generation can be increased by pooling different sources and thus also have positive impacts on grid operation.

Business models in a digitised and decentralised energy system

PV in particular offers a way towards a decentralised power system that also democratises energy generation. For the following section we will therefore mainly look into those business models which we classified as grid parity ones in the previous section. The generation profile of PV with its peak during the day and no generation at night is however not entirely suitable for such a system by itself. However a range of possible combinations of PV systems, battery storage and smart IT technology has the potential to facilitate a real decentralised energy system.

Figure 3. Generation of a 5.5kW PV system and load of household during every day (horizontal) of one year (vertical)



Calculations and source: Energy Brainpool

The generation profile of a household PV system along with the load profile of the household is shown in Figure 3. Obviously, in the morning and the evening, as well as in winter the load is higher than the generation by the PV system, while the trend reverses during noon and summer.

This gives leverage for applying storage systems on a household scale. Ultimately, combining a PV system with battery storage allows households to achieve higher levels of self-consumption of up to 50% without exceedingly high costs. This is especially true when battery costs decline to levels forecasted by the industry. The cost of energy storage technologies is to decline by up to 70% within the next 15 years, where batteries might have levelised cost of storage of about €100/MWh [3]. The important step for PV developers is to get to grips with the technical details of PV-battery storage systems and how to provide additional benefit through services to users.

Alongside this focus on mere private self-consumption, business models revolving around direct line PPAs or PV-for-tenants (German: "Mieterstrommodelle") are increasingly attractive, as they allow house owners to supply their tenants with electricity. Thus this opens up new possibilities for cooperation between PV developers and housing associations, particularly in cities, where the installation of a PV system cannot be undertaken by a single party in apartment buildings. Certainly, such PV-for-tenants approaches require "smart" devices that can meter the consumption of each of the different parties supplied by the PV system.

New business models

So far, we have covered the combination of PV systems and storage that allows households to achieve high levels of autarky in terms of electricity. To be sure, all the above also applies for businesses, which can use PV systems to cover parts of their electricity demand.

And now, we arrive at the point where a whole new world of business models might evolve. A range of businesses in Germany are already experimenting with and have actually put business models into practice that combine PV systems, battery storage along with smart energy management. These business models build upon the idea of so-called energy communities (Sonnen) [4] and flat-rate electricity prices (Beegy) [5].

But one by one: What do community energy business models entail?

Essentially a member of an energy community (generally an owner of a PV and a battery storage system) is able to be supplied by another energy community member with green electricity. Thanks to the balancing group system, the service provider is able to feed surplus from PV systems into a virtual energy pool. A user who needs more electricity than his system generates is then supplied from the virtual energy pool rather than from the utility. The aggregator and the operator of the virtual energy pool also provides a software platform that links all community members and monitors their generation and demand. Members of an energy community do not need a conventional energy provider and they are at least accounting-wise supplied by solar power all the time.

Figure 4 schematically shows how such an energy community works. The aggregator – the energy management or service provider – facilitates all the balancing and

Figure 4. Scheme of electricity sharing among members of an energy community [4]

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billing processes and "sits" between the different prosumers that might consist of single households with PV systems, businesses or PV-battery system owners.

The algorithm on which the aggregation and balancing software is based is a crucial part of such a business model. In some cases the providers of such a service also provide a flat-rate electricity price for its members. Often companies such as Sonnen or Beegy also deliver the battery storage system. For PV developers a business model based on such a community approach may provide additional activities and also directly link the customers to their business, not only for being a contractor of the PV system, but as a service provider for the entire energy community ecosystem.

How does blockchain technology enter the game?

We just heard about the possibilities of energy communities and the possibilities for a service provider to act as an aggregator of the distributed PV-battery storage systems. Now, imagine you own a PV system and you are able to sell excess electricity to your neighbour (not directly using the public grid) or any other consumer (using the public grid) without any intermediary.

A technology that could make such a vision reality is the blockchain technology [6].

The blockchain is a decentralised register, which stores all transactions running on the blockchain. In contrast to conventional databases, the blockchain and its content is not located on a central server and consequently accessible not only for one or several selected actors, but various copies store the blockchain in a decentralised manner. Each party that participates in the blockchain has access to the most recent status of the transactions, as each participant's computer or server features one copy of the blockchain. The administration of this public database consequently takes place in a decentralised manner via all connected PCs. The verification of transactions is achieved by so-called miners, who are solving the crypto problem. The results and the verification of the transactions will be distributed as copies to the decentralised peer-to-peer network. By distributing a high number of copies the blockchain cannot be manipulated. Everyone is able to join the peer-to-peer network. All in all, blockchain technology has the potential to abolish the middleman in transactions, because through its system of verifying transactions in an immutable and publicly transparent way, trust between the ones exchanging – in our case – electricity for money is not necessary. Therefore transaction costs can be considerably reduced.

Recently, a new generation of blockchain functionality has been established, the so called 'smart contracts', which are able to execute and verify transactions of many different business models. Smart contracts (algorithms) allow certain specified commands to be conducted in an automated way.

Such a smart contract might therefore specify the conditions under which you sell electricity to your neighbour (e.g. whenever your demand is already met by the PV system and you have excess electricity), it automates all settlement and billing procedures and simultaneously records all the transactions in a transparent and immutable way. The first peer-to-peer electricity trade between neighbours has already been performed via the blockchain in New York earlier this year [7].

The application of the blockchain technology is certainly not only restricted to peer-to-peer electricity sales, but can also be used by aggregators or providers of energy management systems. A range of possible use cases for the blockchain technology in a decentralised energy world, several of them already described above, are the following:

- Physical delivery of energy managed via the blockchain
- Physical delivery of eMobility solutions managed via the blockchain (charging, car-sharing)
- Sharing (donating, no money involved), trading (selling and buying) of own-generated electricity
- Batteries/storage sharing
- Building up and supporting energy communities
- Connecting customers (buyers) with asset owners (renewable energy products) [8].

The combination of ever-cheaper PV systems, along with battery storage on a household scale and the utilisation of smart energy management systems that possibly build upon blockchain technologies for billing processes and the registration of transaction could well cause havoc for utilities and their business models. PV developers that are fast enough to react to those new conditions may however transform from mere contractors to service providers for integrated energy management systems in a digitised and decentralised energy market. ■

Energy sales via the blockchain in New York

Two Brooklyn residents used the Ethereum blockchain in April 2016 to facilitate a transaction that let one sell energy directly to the other.

The joint venture TransActive Grid, between the green energy startup LO3 and decentralised applications startup ConsenSys, allowed Brooklyn resident Eric Frumin to sell excess renewable energy generated from his own solar panels directly to Bob Sauchelli, a former programme manager at EnergyStar, a government-backed green energy initiative.

Every unit of energy created by Frumin is being counted and logged on the Ethereum blockchain. Programmable smart contracts are then used to make those units of energy available for sale on the open market. 195 credits were purchased for US$0.07 each.

As the power grid is typically set up in his neighbourhood Frumin was able to off-set his own energy-consumption with a series of solar panels on his rooftop in Brooklyn. But any excess energy he generated has to be sold back to the power company at a wholesale price.

This exchange of electricity between neighbours demonstrates that peer-to-peer exchange of electricity is possible without any intermediary. Furthermore, this pilot ensures that electricity generated from renewables, in that case PV, is also consumed locally. The value chain for electricity generation can thus be put on a track that is renewable, local and democratic.

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First Solar in a big hole over 2017

Business | First Solar's recent results suggest some challenges ahead for the US company, writes Mark Osborne

With First Solar's revenue and shipment guidance unchanged and basically locked-in for 2016, despite solar industry dynamics becoming increasingly fluid, filling demand for 3GW of thin-film module capacity in 2017 has become a priority for management as a rather large hole in bookings is proving difficult to fill.

In reporting second quarter 2016 financial results, First Solar reiterated previous revenue guidance for the full-year reaching US$3.8 billion to US$4.0 billion with module shipment guidance of 2.9GW to 3GW.

The company is therefore retaining manufacturing utilisation rates at 100% and has squeezed out a 1% quarter-on-quarter production rate gain that reached 784.8MW in the second quarter, up from 774MW in the prior quarter. Average CdTe module efficiency (16.2%) gains were flat with the prior quarter.

2017 challenges

First Solar's management had previously noted that bookings (system sales and module sales) for business generating revenue, specifically in 2017, would be an issue, due to a number of factors.

Firstly, its 'legacy' US utility project business, which had been a core part of its business in recent years – notably including some of the largest projects ever built – would be winding down and the company had admitted in the past that it had taken its eye of the ball in securing alternative business to fill the hole this created.

Secondly, the expected expiration of the US ITC incentive pushed out project development decisions and that last-minute extension of the ITC at the end of 2016 came too late to help First Solar with projects that could be started and completed in 2017.

Thirdly, the dynamics of the solar industry are shifting and these changes occur faster than often expected. Several factors in this aspect include looming module overcapacity, due to continued capacity expansion announcements that depress pricing and can delay project developer's timings on starting projects.

Volatile market dynamics are also a factor, with the US expected to double installations in 2016 to around 14GW but decline back to 2015 levels of around 7.5GW in 2017.

First Solar has therefore had to focus on international markets for 2017 and beyond, and the fact growth markets such as India and the MENA region are driving down PPAs and system prices to the lowest levels ever seen creates a highly competitive and shrinking margin environment. Picking the right projects to build or supply modules for becomes increasingly challenging in the face of diminishing rewards.

Filling the hole

The fact that First Solar has continued to delay providing 2017 revenue and shipment guidance demonstrates the challenges in hand for the company. Management noted in the latest earnings call that 2017 currently remained "opaque" and deferred providing better insight until much later in 2016, without being specific.

How much business First Solar has secured for revenue generation in 2017 is not clear but a certain level of clarity is possible.

According to Deutsche Bank analyst, Vishal Shah, First Solar secured around 500MW of early-stage bookings for 2017 revenue generation as well as around 450MW of mid-to-late-stage bookings for next year during the first quarter of 2016.

Management noted in its second quarter earnings call that it had booked around a further 250MW of systems projects, yet only around a third of the volume was scheduled for 2017 deliveries. The company noted it was targeting 1GW of systems business in 2017, yet around only 400MW was contracted for next year, although more was expected.

First Solar also noted that mid-to-late-stage booking opportunities stood at 1.8GW, with almost 90% outside the US. Over 400MW of awarded but not booked volume was included in this figure, according to the company.

Management also noted that the bookings total in the first six months of 2016 totalled only 800MW, although almost 600MW had been booked in July alone. However, management did not say whether these bookings applied to 2017 revenue generation.

Credit: First Solar

Third-party module sales look set to play a more prominent role in First Solar's business strategy next year

Module dependence

With the goal of 1GW of system bookings revenue in 2017, emphasis on third-party module sales becomes increasingly likely. Global module ASP decline issues aside, global end market demand growth is becoming increasingly fragile, save higher than expected utility-scale development in India and MENA.

Luckily, First Solar expects to have around 1GW of Series 5 module capacity available in 2017, which significantly improves its cost competitiveness at a time ASPs are expected to be under significant pressure. However, selling 2GW of its mainstream Series 4 modules becomes the issue.

According to management, the Series 4 sales strategy includes a focus on hot, humid climates due to the temperature coefficient advantages of CdTe thin-film modules over conventional c-Si products. Select market opportunities that have not become slim margin markets are therefore the focus.

However, that comes with some challenges of its own. "We're looking for pockets of strength where we can sell through and capture highest-margin opportunity entitlement that we have relative to what's going on in the marketplace, but we're very well aware of how aggressive some of the pricing has become," noted First Solar's CEO, Mark Widmar. ■

This is an edited version of a blog post that first appeared on pv-tech.org

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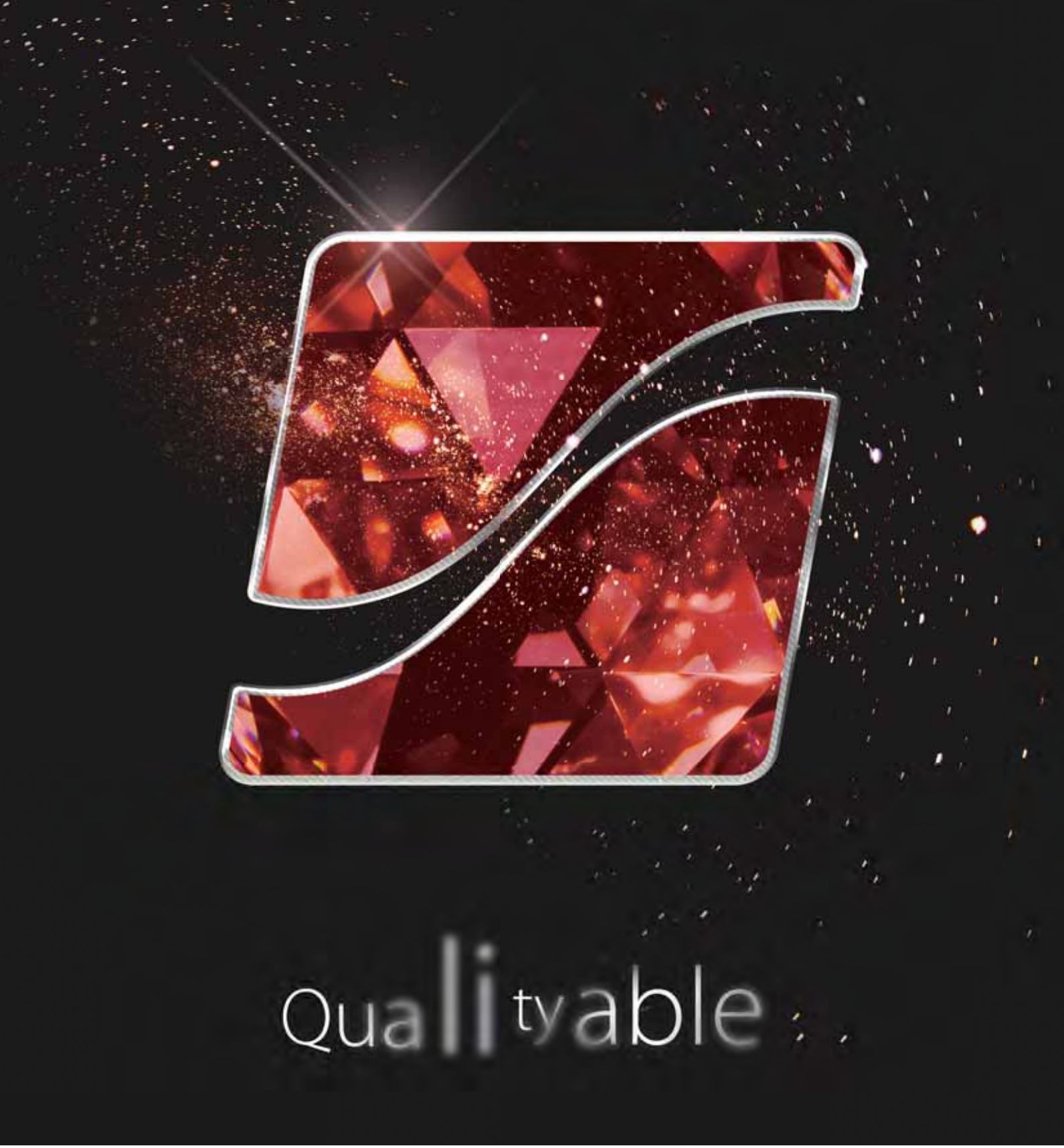

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