POWER PVTECH

Volume 28 PV POWER PLANT TECHNOLOGY AND BUSINESS August 2021

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Introduction

Welcome to volume 28 of *PV Tech Power*. If the solar industry has proven anything in the past decade, it's that it remains among the fastest-paced sectors of the global economy. Technology trends pass in a blink of an eye and, as the value chain has discovered throughout 2021, pricing volatility can emerge just as fast.

The swift decline of module prices since 2010 has led to solar being increasingly cost competitive in markets the world over, edging out fossil fuels and leading the technology – as discussed in *PV Tech Power* vol. 26 – to be crowned the 'new king of power markets' by the International Energy Agency. But with heightened demand comes pressure on supply chain, and tightness of supply has sent costs soaring.

The average price for polysilicon has more than doubled since the start of the year, sending module prices up by as much as 25%. At the same time, a global shortage of semiconductor chips has sent electronics manufacturers scurrying for whatever supply they can find, and unprecedented demand for shipping and freight – exacerbated by ongoing turbulence from the COVID-19 pandemic and even the Suez Canal blockage earlier this year – has sent logistics costs through the roof.

Those headwinds would be enough to curtail any industry, but as you can read here (p.15), solar is finding ways to mitigate such supply chain volatility and ensure that any blip is only temporary. Meanwhile, we also explore recent policy developments in the US, particularly the Withhold Release Order on polysilicon, US President Joe Biden's looming budget reconciliation bill and uncertainty surrounding the future of Section 201 tariffs to determine exactly how the industry is responding to the opportunities and threats they pose. The US, of course, is set to be second only to China in terms of solar deployment out to that critical net zero waypoint of 2030, and we profile how US states outside of the 'Big Three' are helping drive growth to new heights in the country (p.30).

While the supply chain has captured most of the industry's attention in 2021, the issue of module performance remains of equal pertinence. Earlier this year we heard from PV Evolution Labs and its 2021 Module Scorecard, coverage of which you can find on page 55, and we also hear from a consortium of research institutes, PV CAMPER, on how they are tackling some of the industry's most prominent causes of underperformance (p.42).

Our Storage & Smart Power section is also jam-packed with exactly the kind of detail and insight you'd have come to expect from it, including a fascinating interview with Maria Skyllas-Kazacos, one of the founders of the vanadium flow battery, who discusses the story behind the energy storage technology and its next steps.

Thank you for reading volume 28 of *PV Tech Power*, and we hope you find it as interesting and insightful as we found producing it.

Liam Stoker
Editor in Chief
Solar Media

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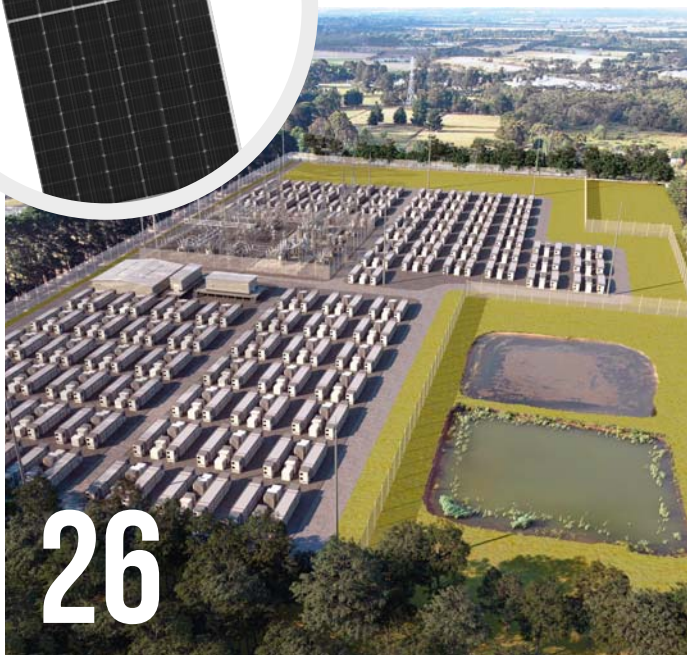

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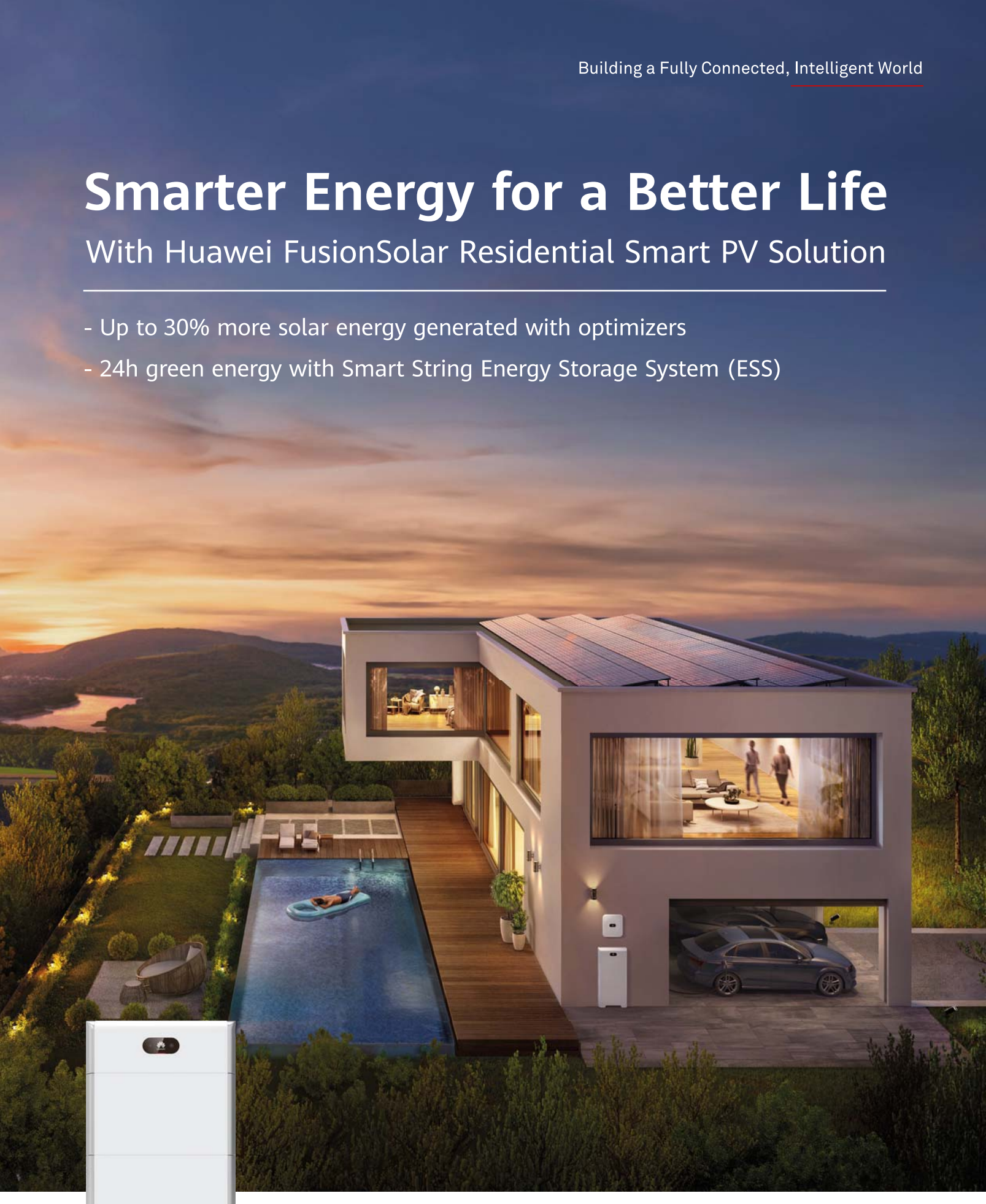

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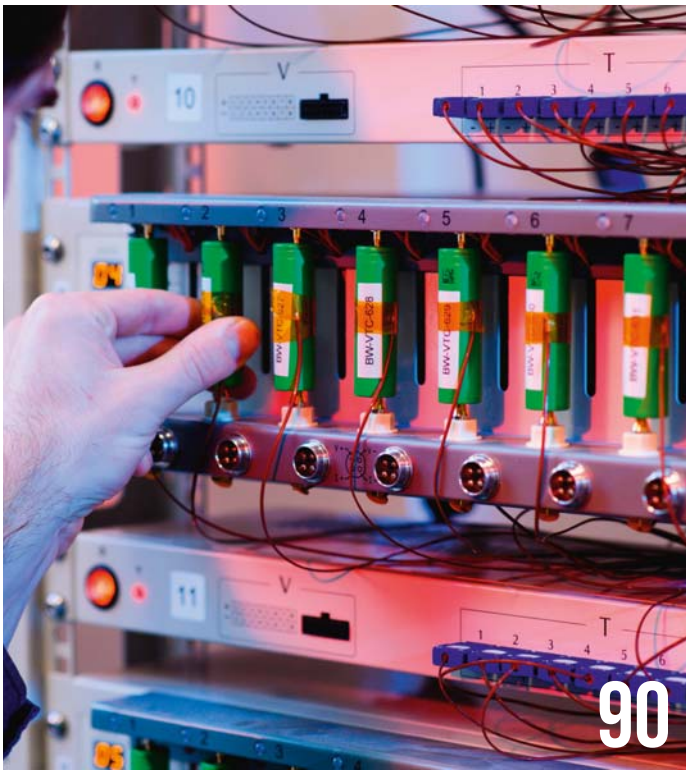

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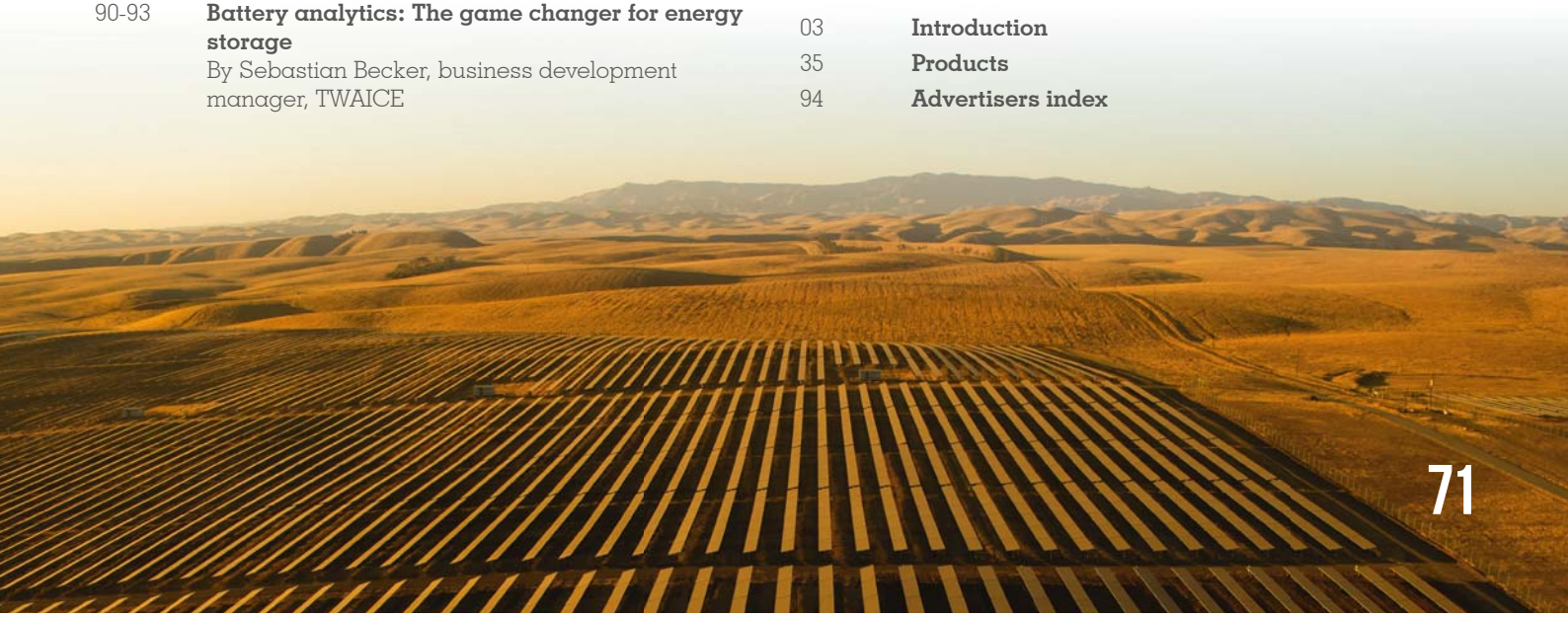

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EUROPE

Policy

'A step in the right direction': EU plans to increase 2030 renewables target to 40%

European Union (EU) countries may need to ramp up renewables deployment in the next decade to meet new proposed targets aimed at reducing greenhouse gas emissions across the bloc. As part of its wide-reaching 'Fit for 55' climate plan unveiled in July, the EU's executive branch, the European Commission, updated its Renewable Energy Directive to increase the overall binding target from 32% to a new level of 40% renewables in the bloc's energy mix by 2030. To increase the attractiveness of renewables projects for private investors, the Commission proposes measures to make permitting more efficient and to promote direct contracts between producers and consumers. These measures form part of a dozen draft proposals aimed at driving down greenhouse gas emissions across the EU by at least 55% by 2030, compared to 1990 levels, putting it in on a path to becoming carbon neutral by 2050.

Credit: Alternus Energy.

The 11.75MW Zonnepark Rilland project in the Netherlands.

Falling costs

Renewables now half the price of fossil fuels across Europe, says report

Generating electricity from renewable sources in Europe is now half the price of fossil fuels as polluting power production on the continent fails to recover from the pandemic and renewables grow, according to a new report by think tank Ember. This is down to a rise in the cost of fuels such as coal, with overall electricity demand rising from countries as COVID-19 restrictions are lifted, the report said. It highlighted how, in major European economies, production costs from new solar farms are far lower than those of fossil fuel generators. In Spain, for example, the cost of generating power from gas and hard coal plants is double that of new solar installs.

Auctions

Solar bidders awarded 2.2GW in Polish renewables auctions

Solar PV bidders picked up around 2.2GW of capacity in Poland's latest renewables auctions. An initial auction for projects with a capacity larger than 1MW contracted nearly 24.7TWh of electricity and will result in the development of PV plants with a combined capacity of more than 1.2GW. The lowest solar bid was PLN0.209/kWh (US$0.05538/kWh). Another auction for plants up to 1MW sold 11.9TWh of energy and featured a lowest bid of PLN0.207/kWh (US$0.05485/kWh). That tender will lead to the construction of solar projects with a total capacity of almost 1GW.

Spain to hold auction for 3.3GW of solar PV and wind in October

Spain will carry out an auction this October for 3.3GW of solar PV and wind capacity as the country's government aims to speed up renewables deployment in the face of soaring electricity bills. The energy and environment ministry revealed the auction structure will see 1.5GW of the capacity reserved for onshore wind and 700MW for solar PV. In addition, 600MW will be reserved for PV and wind plants in advanced stages that will have to be completed within eight months of being awarded so that they are online before the peak of summer 2022. The addition of renewables resulting from this auction "will directly reduce the price of electricity" by displacing energy produced from more expensive and polluting plants, the energy and environment ministry said.

Floating solar

BayWa r.e. commissions largest two floating solar projects outside Asia

German renewables developer BayWa r.e. has completed two installations in the Netherlands totalling 71MWp that it says are the largest floating PV plants outside of Asia. The company, together with its Dutch subsidiary GroenLeven, has commissioned its largest floating PV project to date, the 41.1MWp Sellingen park, as well as the 29.8MWp Uivermeertjes park. Built on former sand extraction lakes, the projects were installed on the deepest part of the water bodies to protect the flora and fauna in the banks. Commissioning of the plants brings BayWa r.e.'s floating PV portfolio in Europe to 11 projects that have a combined capacity of more than 180MWp.

Credit: BayWa. r.e.

The 41.1MWp Sellingen plant was constructed on a former sand extraction lake.

M&A

EDF, Cero Generation acquire French agroPV developer

EDF Renewables has partnered with a new portfolio company of Macquarie's Green Investment Group to acquire a French agrophotovoltaic developer with a 2.4GW solar development portfolio. The deal will see EDF Renewables and Cero Generation each buy a 45% equity stake in Green Lighthouse Development (GLHD), with the remaining 10% owned by the company's founders. GLHD's agroPV projects colocate agricultural activity with solar energy production, a solution the company expects to be increasingly important in France as the country aims to reach up to 44GW of installed PV by 2028. "France has hugely ambitious plans for solar energy. Agrivoltaic projects provide an opportunity to deliver that ambition, while supporting crop production and providing farming communities with additional revenue streams," said Nikolaj Harbo, CEO of Cero Generation.

AMERICAS AND MIDDLE EAST & AFRICA

Policy

US Senate passes bill to ban all products originating from Xinjiang

Legislation that would ban the import of all products from China's Xinjiang region into the US has taken a critical step forward, passing the US Senate. The Uyghur Forced Labor Prevention Act passed the US Senate unanimously and must now pass through the House of Representatives – the US's second legislative chamber – before President Joe Biden can sign the act into law. If passed, the act would mean that US customs officials would presume goods manufactured in Xinjiang have connections with alleged forced labour practices in the region. Unless those products are certified by US authorities, they would be banned from entering the US under the 1930 Tariff Act and detained.

Credit: Gage Skidmore/Flickr

The Uyghur Forced Labor Prevention Act passed the US Senate unanimously.

US Energy Committee votes in favour of US$100 billion clean energy act

The US Senate Energy and Natural Resource Committee has voted in favour of advancing a bipartisan energy infrastructure bill that would see US$100 billion of investment in renewable energy systems. By a vote of 13 to 7, the Energy Infrastructure Act was passed, although 48 amendments were attached. It will serve as the legislative text for key portions of the Bipartisan Infrastructure Framework, including power infrastructure. As amended, the Energy Infrastructure Act authorises more than US$100 billion to grid and transmission expansion, critical energy systems, clean energy technologies and more.

US Senate passes landmark infrastructure bill as attention turns to solar ITC extension

The US Senate has passed the landmark bipartisan infrastructure bill, paving the way for US$1.2 trillion of investment into the nation's infrastructure. But discussion has quickly moved to forthcoming acts which could pave the way for trillions of dollars of extra funding, including a proposed extension of the solar investment tax credit that has received the support of more than 180 members of congress. Senators voted 69-30 in favour of bill H.R 3684, otherwise known as the Infrastructure Investment and Jobs Act, after months of protracted negotiations between Democrats and Republicans.

South Africa raises licensing exemption threshold for embedded generation

South Africa's solar sector has welcomed a new reform that will increase the country's licensing exemption threshold for embedded generation projects from 1MW to 100MW. The South African Photovoltaic Industry Association (SAPVIA) said the announcement will be viewed as a "watershed moment" for industry in the country, with the new rules paving the way for the development of a more robust commercial and industrial solar segment. Currently, embedded generation facilities with a capacity of no more than 1MW are eligible for a licensing exemption. South African President Cyril Ramaphosa announced that this will be raised to 100MW, a move that is expected to unlock significant investment in new generation capacity.

Finance

US retains position as most attractive investment market for renewables

The US has retained its title as the top market for clean energy investments in audit firm EY's biannual Renewable Energy Country Attractiveness Index (RECAI), but India, the UK and France are catching up. The index shows that President Joe Biden's actions to foster a renewable energy expansion since he took office in January have helped keep the US in top position since it first leapfrogged China last year. It notes that Biden pledged to cut greenhouse gas emissions by up to 52% by 2030, based on 2005 levels. The US also installed 19GW of solar last year, an increase of 43% on 2019's installations, and also added 2.2GW of battery energy storage systems.

NREL: US utility-scale solar PV could be as cheap as US$16.89/MWh by 2030

Utility-scale solar PV in the US could be as a cheap as US$16.89/MWh by the end of the decade, new analysis published by the National Renewable Energy Lab (NREL) has shown. Research institute NREL has published its 2021 Annual Technology Baseline (ATB) report which provides electricity generation technology cost and performance data to inform the US electricity sector. It has highlighted how the levelised cost of energy (LCOE) in 2019 for utility-scale PV ranged from US$31.32/MWh for 'class 1' solar PV, effectively NREL's most cost-effective class, to US$50.23/MWh for 'class 10'.

Inaccurate solar irradiation estimates in Africa impacting investor returns, report suggests

Unreliable methods of calculating irradiation in Africa could slash energy savings for commercial and industrial (C&I) solar buyers and reduce investment returns for developers and investors, research has suggested. Biases within the data commonly leveraged to estimate solar production in Africa cause projections to often overstate solar irradiation, according to the research from independent power producer CrossBoundary Energy (CBE), which owns a portfolio of PV projects in Africa. Through an analysis of operating solar plants, CBE found that actual irradiation – measured by the firm's ground-based measurement systems – tended to deviate from the satellite data widely accepted as accurate for making calculations of long-term energy production during solar design.

Berkeley Energy raises €130 million for second African Energy Fund

Renewables developer Berkeley Energy has raised €130 million (US$157.5 million) in the first close of the Africa Renewable Energy Fund II (AREF II). The fund, which has a final target of €300 million, will target investments in hydro, wind and solar projects across sub-Saharan Africa, excluding South Africa, and aims to back mid-sized grid-connected projects of between 10-100MW. Engaged in the development and operation of clean energy projects across

emerging markets, Berkeley hopes AREF II will provide clean and accessible energy whilst stimulating local economies through employment opportunities.

Energea signs financing deal for Brazil community solar portfolio

Energea Global, a renewable energy investment manager, has announced a US$27 million deal with BTG Pactual to construct a portfolio of solar projects in Brazil. The investment will be used to construct a series of community solar projects in Minas Gerais with a total peak generation capacity of around 28MW. The electricity generated by these plants will be delivered to thousands of small businesses who have banded together to enjoy the cost and environmental benefits of solar energy.

Transmission

Record 462GW of solar capacity seeking grid interconnection across the US

A record amount of solar capacity and energy storage is currently in US transmission interconnection queues, according to a new study from Lawrence Berkeley National Laboratory (Berkeley Lab). At 462GW, solar accounts for most of the total generator capacity in the queues, which reached a record of more than 755GW and an estimated 200GW of storage capacity at the end of 2020. To put that in perspective, the US had 1,117GW of utility-scale electricity generating capacity in operation last year.

FERC eyes transmission reform to ease US connection process

The US Federal Energy Regulatory Commission (FERC) is eyeing potential reforms to transmission and interconnection rules for energy projects, a move which could help ease the connection process for solar and storage developments. FERC issued an Advanced Notice of Proposed Rulemaking (ANOPR) which seeks comment on the potential reforms or revisions, the first time an ANOPR has been issued in more than a decade. The commission said the ANOPR is a response to changing energy patterns, typified by a shift in electricity generation from dense population centres to more remote areas.

Manufacturing

First Solar to double US manufacturing capacity with new 3.3GW Ohio plant

First Solar has unveiled plans to more than double its US manufacturing capacity with a 3.3GWdc facility in Ohio that will produce thin film PV modules for the country's utility-scale solar sector. The 'Solar Module Super League' member will invest US$680 million in the plant, which is expected to begin commercial operations in the first half of 2023 and reach full capacity two years later. The 1.8 million-square-foot facility will be added to First Solar's two existing manufacturing plants in Ohio and take its total US manufacturing footprint up to 6GW. It also has two factories in Vietnam and a further two in Malaysia.

Canadian Solar launches US$150 million fundraise to support battery storage growth

Solar module manufacturer and developer Canadian Solar has launched a US$150 million fundraise to support its growth strategy and build out a substantial battery energy storage business. The 'Solar Module Super League' member said that it plans to sell up to US$150 million of its shares through the US Securities and Exchange Commission (SEC). Canadian Solar said it intends to use the proceeds from its at-the-market equity offering programme (ATM) to "execute its long-term strategic growth plans" which include both its battery energy storage business and an energy storage project pipeline.

New Capacity

US solar hits 100GW milestone but supply issues could hinder growth prospects

The US installed more than 5GWdc of solar capacity in Q1 2021, taking its cumulative capacity past the 100GW barrier, but supply chain constraints could pose a major barrier to further growth. That is the key finding from the Q2 Solar Market Insight Report, published by trade body the Solar Energy Industries Association (SEIA) and research firm Wood Mackenzie, which also revealed how Texas installed nearly three-times as much solar than any other US state in the first three months of this year. A 46% increase on Q1 2020, and the largest Q1 increase on record, means that solar accounted for 58% of all new power generation capacity added in the US in Q1 2021, the report revealed.

Projects

Scatec to develop 540MW of solar with battery storage following South African tender success

Scatec will develop three projects in South Africa totalling 540MW of solar and 225MW / 1,140MWh of battery storage after being awarded preferred bidder status through a government tender. The Norwegian independent power producer was awarded 150MW of contracted capacity through the country's technology agonistic Risk Mitigation IPP Procurement Programme. Each of the Kenhardt 1, 2 and 3 plants will have the same generation capacity and be developed in the Northern Cape province, with the solar-plus-storage installations set to provide dispatchable power daily from 5am to 9.30pm. Scatec will receive payment under a 20-year year power purchase agreement with a paid capacity charge.

ASIA-PACIFIC

China

China's NEA demands monthly updates on renewable projects from its utilities

China's power planning agency the National Energy Administration (NEA) has demanded regular monthly updates on new renewable energy projects from utility companies in the country. Starting from 15 August and repeating every month, all provincial-level energy authorities and major central power generation companies are required to present their renewable power projects from the last month.

Arctech delivers trackers for 575MW project in north China

Tracker and racking provider Arctech has delivered its SkySmart II tracking system to a 575MW agriculture-sharing solar project located in Nangong City, Hebei Province, China. Arctech delivered trackers for the project within three months, enabling the project to be completed on schedule, despite soaring steel prices and supply chain constraints, the company said. Arctech's SkySmart II's trackers were utlised, marking the first time they have been used in a large-scale project in China.

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Deployment

Asia Pacific PV capacity to triple by 2030 as China leads growth, says Wood Mackenzie

Solar PV capacity in Asia Pacific could triple to 1,500GW by 2030, with China driving deployment and Indonesia set to be the region's fastest-growing market, according to Wood Mackenzie. The research firm said ambitious solar targets mean China will add 619GW of PV by the end of the decade, by which time it will contribute more than 60% of Asia Pacific's total solar capacity. In Q1 2021, China deployed 5.56GW of solar, taking its total installed capacity to 259GW as of March.

Credit: Pattern Energy.

Solar power is booming in Asia Pacific, with projects like this 14MW Kanagi Solar Power Project in Japan popping up around the region.

Sungrow to focus on smart tech from new Nanjing research centre

Chinese inverter manufacturer Sungrow has opened another research and development (R&D) centre in Nanjing, China that will focus on smart technologies, big data and software integration. Expected to be the company's second largest R&D institute in the next three to five years, it will concentrate on software development and technological integration in diversified, interconnected and multi-faceted energy digitalisation, the Internet of things, industrial cyber security, and supportive grids.

China to install up to 65GW of PV in 2021, average installs could reach 90GW by 2025

China could install up to 65GW of solar this year, driven largely by a surge in demand for distributed solar installations, while average solar deployment could reach 90GW per year in the years leading up to 2025. The China Photovoltaic Industry Association (CPIA) said solar installations in 2021 would be between 55 – 65GW, following the country installing 48.2GW of solar in 2020, according to figures published by the country's NEA, meaning the CPIA is forecasting growth of between 14.1% and 34.8% for 2021.

Indonesia

Masdar JV begins construction of 145MWac floating PV plant in Indonesia

Construction work on a 145MWac floating solar project in Indonesia has started after the joint venture (JV) behind the installation reached financial close. Abu Dhabi-based renewables developer Masdar and PT PJBI, a subsidiary of Indonesia's state-owned electricity company PT PLN, said financing for the Cirata plant was arranged through Sumitomo Mitsui Banking Corporation, Société Générale and Standard Chartered Bank.

Credit: Masdar.

The Cirata project is set to be the first floating solar plant in Indonesia.

Japan

Pacifico Energy reaches financial close, begins construction of 121MWdc Japan PV plant

Solar developer Pacifico Energy has started building work on a 121MWdc solar project on the site of a former golf course in Japan, with juwi Shizen Energy hired as engineering, procurement and construction (EPC) contractor. Pacifico has also reached financial close for the plant, with financing mainly provided by MUFG Bank and Mitsubishi HC Capital. Under construction in Sanda, Hyogo Prefecture, the project will generate approximately 143 million kWh of electricity annually when complete in 2023.

Laos

EDF to develop 240MWp floating solar project paired with hydro plant in Laos

EDF has secured a contract to lead the development of a 240MWp floating solar project in Laos that will be co-located with a 1.08GW hydropower plant. According to the firm that operates the hydro facility, the Nam Theun 2 Power Company (NTPC), the installation will be the world's largest hybrid floating solar project when it is complete.

India

ReNew Power buys two new renewable operating portfolios in India in latest acquisition

Indian independent power producer (IPP) ReNew Power has acquired two operating renewable energy portfolios in India, building on recent acquisitions in the country and boosting the company's earning position. Announced on 11 August, ReNew Power signed binding agreements for 260MW/330MWp solar projects in the state of Telangana and a 99MW hydropower facility in Uttarakhand, the company's first hydro asset. The combined value of the acquisition was roughly INR28.5 billion (US$384.0 million) and the company has said it will add around INR3.8 – 4.0 billion (US$50.7 – 53.4 million) of EBITDA on a full-year basis.

Uzbekistan

Uzbekistan set to increase solar targets after low prices in recent tenders

Uzbekistan is considering raising its 2030 renewables deployment targets following the success of solar tenders carried out in the since 2018. The country's energy ministry said the current goal of reaching 5GW of installed solar PV by 2030 may be increased to 7GW, while its wind generation target could be raised from 3GW to 5GW.

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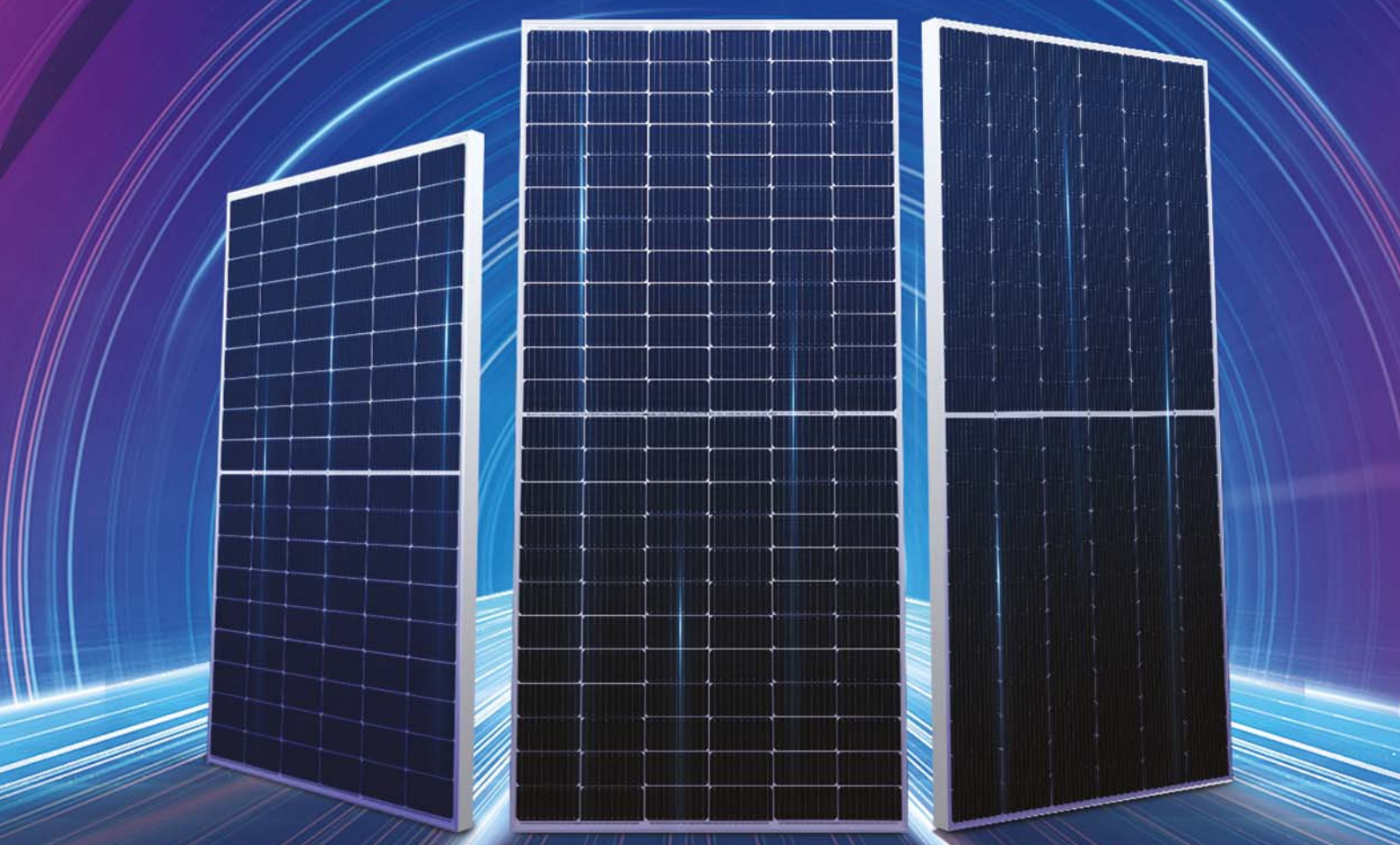

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MANUFACTURING

Heterojunction

Meyer Burger mulls legal action after Oxford PV ends heterojunction solar cell partnership

Meyer Burger is considering its legal options after long-time heterojunction tandem solar cell manufacturing partner Oxford PV ended its collaboration agreement unexpectedly. After completing construction of a manufacturing facility in Germany, Oxford PV said it had terminated its exclusive relationship with Meyer Burger after more than two years. Meyer Burger responded with its own statement, confirming that it was "considering legal options to enforce its rights". Meyer Burger said the announcement was unexpected, but stressed that the consequences of Oxford PV's decision would have no impact on its own business transition, nor on the guidance it has committed to.

Unigreen Energy breaks ground on gigawatt HJT factory

Unigreen Energy, owned by Hevel majority shareholder Ream Management LLC, has broken ground on a wafer and cell manufacturing plant that will produce 1.3GW of silicon n-type monocrystalline ingots and wafers as well as 1GW of heterojunction technology (HJT) solar cells. The new EnCore factory in Kaliningrad, Russia, which is along the Baltic coast between Poland and Lithuania, will be located at Chernyakhovsk industrial zone. It will be focused on HJT and production is scheduled to start in late 2022. According to Finlay Colville, head of research at PV Tech's parent company Solar Media: "Currently, Hevel Solar is the leading producer of heterojunction solar cells globally, and the new site in Kaliningrad has the scope to move Russian PV manufacturing to levels not seen before."

India

First Solar unveils India module manufacturing facility plans

First Solar has unveiled plans to construct a 3.3GWdc module assembly facility in India, bolstering its manufacturing footprint outside of the US. The 'Solar Module Super League' member is to invest US$684 million in the facility, which is slated to begin operations in the second half of 2023. However, the company has stressed that final approval for the site is dependent on the approval of Indian government incentives that are "satisfactory to First Solar". If approved, the site would come forward in the state of Tamil Nadu and First Solar expects that it would help take the company's total manufacturing output to 16GWdc by 2024. First Solar confirmed the would-be facility in India would use the same manufacturing template designed for its most recently-announced manufacturing expansion, a facility of precisely the same capacity earmarked for Ohio.

Trio line up manufacturing capacity expansions in India as race for market footholds intensifies

Three Indian manufacturers are reportedly eyeing up investments in their solar manufacturing capacity as efforts to take advantage of protective measures and financial supports ramp up. Reports in local press in mid-August suggested that India-based module manufacturers Vikram Solar and Waaree are considering the launch of initial public offerings (IPO), both aimed at raising around US$200 million, in a bid to finance new module manufacturing facilities. The news followed Delhi-based glass manufacturer Asahi India Glass and Vikasha Group, based in Ahmedabad, announced a joint venture to establish a solar glass manufacturing facility in Gujarat. The facility, expected to be commissioned within the next 18 – 24 months, would have an initial manufacturing capacity equivalent to fulfil the glass necessary for around 3GW of solar modules, the companies said.

1366 Technologies to invest US$300 million in solar manufacturing in India

Solar wafer provider 1366 Technologies is actively exploring manufacturing opportunities in India, seeking a local partner. US-based 1366 Technologies, which is backed by Bill Gates' Breakthrough Energy Venture, intends to invest US$300 million to establish a 2GW wafer and cell manufacturing facility in India. The partnership will operate under the Indian government's production-linked incentive (PLI) scheme. "The Indian Government has made domestic solar manufacturing a priority and our technology is particularly well suited for the Indian market," a 1366 spokesperson told sister publication PV Tech.

Materials

Maxeon facing manufacturing disruptions amidst material uncertainty

Maxeon Solar Technologies has said it may face manufacturing disruptions if it is unable to mitigate the impacts of raw material and component cost increases from its suppliers. The module manufacturer said it will continue to be dependent on a number of third-party suppliers for certain raw materials and components which could prevent it from delivering products to customers within required timeframes and may, in turn, result in cancellations, penalty payments and loss of market share. It continues to experience elevated freight rates from Asia and Mexico, and higher costs of certain raw materials such as glass, aluminium and copper, as well as silicon wafers and solar cells.

Capacity expansion

JinkoSolar, Canadian Solar cut tweak 2021 expansion plans

'Solar Module Super League' members JinkoSolar and Canadian Solar have amended their capacity expansion plans for 2021 in the wake of supply chain volatility. JinkoSolar said in late June it had tweaked its plans to finish 2021 with solar wafer, cell and module production capacities of 30GW, 24GW and 32GW respectively, a downgrade on the 33GW of wafers, 27GW of cells and 37GW of module production capacities it initially intended to have at the year's end. Canadian Solar meanwhile confirmed in August that it had tweaked its own capacity expansion plans for 2021, reducing its module capacity outlook by nearly 3GW to 22.7GW while marginally increasing its prospective cell capacity to 13.9GW. JinkoSolar said it had revised its capacity expansion plans for this year after "taking into account supply chain and market conditions", notably pointing towards spiking polysilicon and logistics costs forcing companies to increase module prices, dampening end market demand.

Credit: JinkoSolar

JinkoSolar said supply chain and market conditions had factored into its decision making.

Steadying the ship

Supply chain | Material pricing spikes, key component shortages and an unprecedented increase in shipping and freight costs have meant for tempestuous times for solar's supply chain this year. Sean Rai-Roche and Liam Stoker unpick what has caused supply chain volatility, uncover its winners and losers and detail how a fast-shifting policy environment could yet cause more turbulence

Photovolatility: What's caused the surging price of PV modules?

Module prices | Several factors have overseen an increase in the price of modules. Some of them look sure to ease, while others may be more persistent. Sean Rai-Roche delineates the events behind the rise and speaks to industry experts about what businesses can expect moving forward.

Credit: LONGi

The cost of raw materials and other elements such as shipping and logistics has soared since last year, putting pressure on module manufacturers and EPCs alike.

Module prices have risen by up to 25% in the last year as the cost of raw materials and transportation have soared, dampening downstream demand and disrupting the entire solar supply chain. The main driver of this has been an increase in the price of polysilicon, almost tripling in cost since its low in 2020. While analysts believe the cost of polysilicon, and in turn modules, will come down, there is uncertainty as to when, with most predicting higher prices continuing into 2022.

While polysilicon supply is the most significant factor impacting module costs, shipping chaos borne from COVID-19 has also caused upward pressure on prices. As the true significance of the pandemic dawned in March 2020, both demand and supply of freight collapsed as countries around the world went into lockdown. Since then, demand has recovered but supply, beset by COVID-19 complications, has not increased to meet it, resulting in significantly higher transport costs. While polysilicon prices are expected to fall next year, shipping costs are not, with insiders telling PV Tech Power that the freight industry may never be the same again.

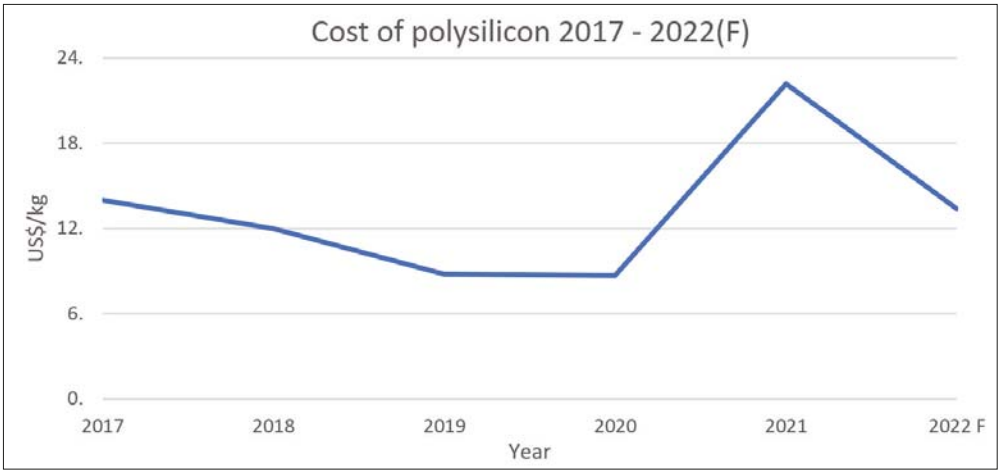
All of this has put substantial pressure on engineering, procurement and construction companies (EPCs) as rising costs have impacted purchasing, project timelines and expected profit margins.

Falling modules prices a case of when, not if

The price of basic monofacial modules at the factory gate in China has risen from below US$0.19/w last summer to US$0.24/w today, according to Jenny Chase, head of solar analysis at BloombergNEF (BNEF). This was largely due to fierce demand for polysilicon coupled with curtailed availability. As a result, wafer manufacturers sought to lock in supply, signing long term contracts that put further upward pressure on prices. Compounding this was glass shortages and increases in the cost of silver at the end of 2020, although these pressures have abated. Analysts expect last year's supply shortages to end as some of the largest manufacturers bring significant capacity expansions online.

Polysilicon has gone from a low of around US$6/kg last year to upwards of US$28/kg today, says Chase, which has in turn forced the price of modules up by around 25%. PV InfoLink data supplied to PV Tech Power puts the puts the price at a slightly tighter range, showing polysilicon soaring from a low of US$8.7/kg in 2020 to US$22.2/kg this year. Worldwide demand for polysilicon in 2020 was 140GW, while supply from so-called 'tier one' manufacturers only reached 133GW by the end of the year, according to Corrine Lin, chief analyst at PVInfoLink. Lin argues that planned capacity expansions by polysilicon manufacturers were not brought online soon enough to meet demand.

While Lin puts most of the price pressure down to lagging capacity, Chase says the exact cause of polysilicon supply tightness is uncertain. There was broadly enough supply to meet demand over the year, she says, but bottlenecks occurred. "I think the increasing cost of polysilicon was probably exacerbated in the first half of the year by wafer makers really needing to secure



Source: PV InfoLink Data

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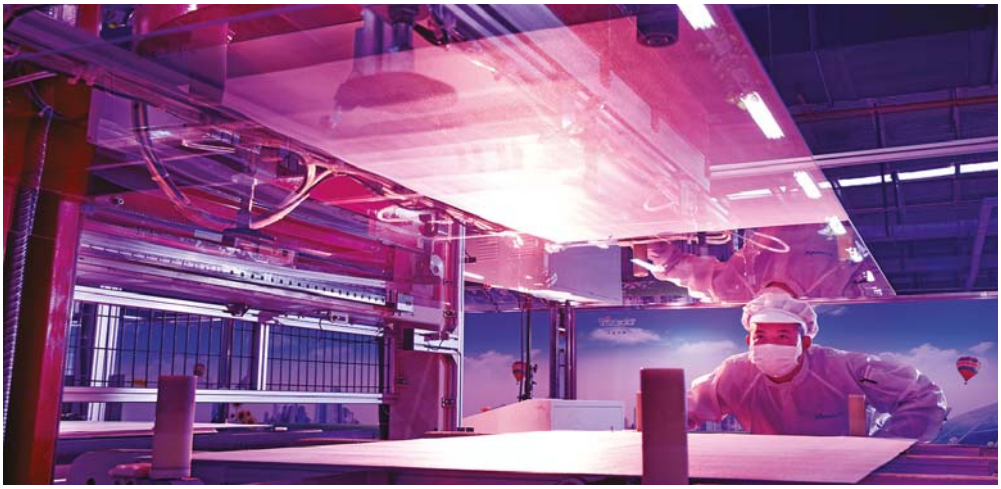


Credit: Trina Solar

supply, meaning they signed long term contracts for large amounts of inputs at spot price rates," says Chase, driving up prices even more.

Other material factors include the cost of silver and glass. In November last year, module manufacturers started to lobby the Chinese government to intervene as the price of solar-grade glass went "out of control" after more than doubling in four months. Chase predicts that a recovery of the glass supply, which had brought the cost of modules down US$0.02/w to US$0.18/w earlier this year, will pose no further issues moving forward. Similarly, rising silver prices should not trouble the industry as modules continue to incorporate less of the precious metal and alternatives such as copper-nickel alloys are explored.

But what does the future hold for the price of modules? Will polysilicon supply be enough to meet demand? And when might prices come down again?

Worldwide demand for modules from leading manufacturers is expected to be 160GW this year, with a supply capacity of 180GW by the end of the year, according to PV InfoLink data. The forecast for next year is even more favourable, with total supply hitting 349GW against demand of just 181GW, suggesting prices could drop substantially next year as supply outstrips expected demand.

BNEF expects 183GW of module demand this year, with a higher-end forecast of 204GW. Chase estimates that there is enough polysilicon to meet this demand, with an expected 207GW of supply. Its February 1Q 2021 Global PV Market Outlook Report expected an 18% growth in polysilicon output capacity in 2021 compared with 2020, assuming all factories run as planned. About 60% of this capacity is from existing factories which have experienced bottlenecking, with the remainder coming from new and reopened sites.

Solar glass prices were described as being "out of control" after doubling in four months late last year.

Both PV InfoLink and BNEF have pointed to significant expansions to polysilicon production by the largest manufacturers as the reason for expected module price decline. PV InfoLink data shows that Tongwei, Daqo, East Hope, Asia Silicon and TBEA plan to add 245,000 metric tonnes (MT) of polysilicon from Q4 2021 to Q2 2022, equating to around 84GW of added solar module capacity. BNEF expects 265,000MT of added production throughout 2022 – but also includes potential contributions from OCI in Seoul (5,000MT) and Xinte (100,000MT), although the latter isn't expected until 2023.

Analysts advise that the price of polysilicon, and in turn modules, will come down, either towards the end of the year or in H1 2022. Lin says that PV InfoLink recently revised its polysilicon price forecasts, which initially predictied price rises in Q3 and Q4 due to strong European and US demand. The analyst now expects prices to be flat at around US$26.5/kg moving into the new year, falling slightly in Q4. In 2022, it expects the price of polysilicon to drop significantly to US$13.4/kg, down 40%. In turn, modules are expected to plateau at around US$0.246/w in Q4 2021, not coming down to lower levels until at least Q2 2022. Nonetheless, both Chase and Lin were certain that prices would come down, it is just a matter of precisely when.

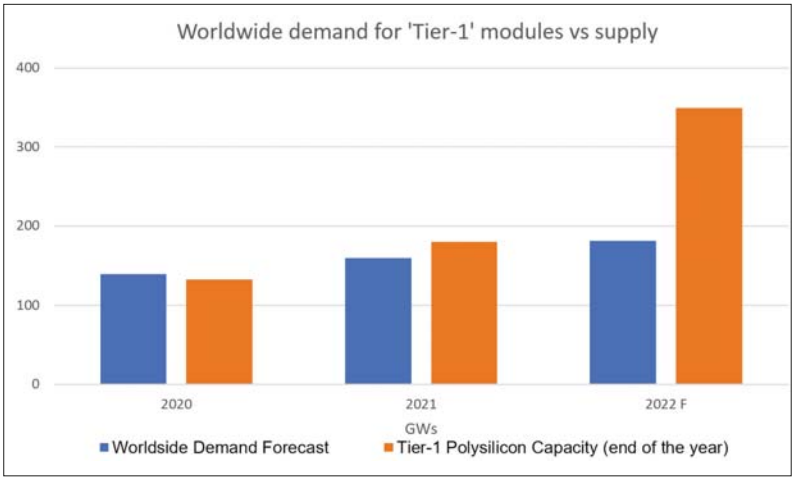
Shipping troubles could be here to stay

While the production cost of solar modules is expected to fall next year, higher shipping costs are here to stay. In March 2020, when the world woke up to the true impact of the pandemic, shipping companies were in disarray. Demand had collapsed, countries were locking down and consumer confidence wasn't just shaken, it had broken. Since those worrisome days at the start of last year, the shipping industry has enjoyed unprecedented profits. It is currently charging significantly higher prices while delivering a poorer service when compared with that of a year ago, say analysts. As a result, there is no reason why things are likely to change soon, and prices may even go up in the near term.

It currently costs around US$17,000 to move a 40-foot container from Asia to Europe, says George Griffiths, global pricing specialist at S&P Global Platts. A year ago, it cost US$1,650. Asia to the west coast of North America is up from just below US$3,000 a year ago to US$6,500 today, Griffiths notes. This, in turn, puts upwards pressure on module prices as the cost of transportation is now several times what manufacturers are used to.

The rising prices are a direct result of COVID-19. "There have been some periods of large prices rises in the industry, but not on the scale seen in 2020-21," says Joanna Konings, senior economist of international trade at ING.

At the start of the pandemic, the only



Source: PV InfoLink

Blue is demand for tier 1 modules, Orange is Tier-1 Polysilicon Capacity by year's end.

things keeping the shipping industry afloat was the movement of personal protective equipment (PPE) and home improvement goods, says Griffith. Meanwhile, containers in Europe and North America were left empty due to cancelled sales, which caused freight rates to increase rapidly, while regular port closures due to COVID-19 outbreaks caused significant backlogs for entire supply chains.

Furthermore, alliances between shipping firms to streamline their operations brokered in 2013/14 meant that fewer ships were being used to transport the same amount of goods, which again had the effect of reducing the supply pool, Griffiths explains. "Container liners seem to have learned to manage capacity better in their alliances," adds Konings.

Now, demand has rebounded from businesses worldwide as lockdowns have eased, while supply has remained at 2020 levels, causing massive increases in the cost of shipping. "The harpex index, which aggregates world charter rates for containers, is up nearly 450% on a year ago," says Konings.

Shipping companies are now in the envious position of being in high demand but with substantially less supply, resulting in unprecedented profits. For example, freight rates at Danish shipping giant Maersk increased by 18% in H2 of 2020, compared with 2019, according to the company's 2020 annual report. And according to consultancy firm Sea Intelligence, the 11 largest shipping companies saw unprecedented operating profits in H2 2020, reaching US$13.3bn.

"There's nothing they can do to create more supply and demand is still outstripping what they have," says Griffiths, adding that any hopes that the pressure would alleviate in H2 2021 appear to be ungrounded. The most conservative estimates expect prices to start falling in Q1 2022, says Griffiths, although he caveats this by explaining that most industry insiders had expected them to be falling already.

Konings points to new capacity additions that will ease price pressures, but not until 2023. "When the new capacity is ready for use, it will represent a 6% increase after years of low deliveries, which the scrapping of old vessels is not expected to offset," she says. "So there will be an increase in capacity, which along with global growth will put downward pressure on shipping costs."

In the meantime, however, "competition for ocean freight capacity is set to remain, while the unbalanced recovery will continue to exacerbate some of the problems for world trade," says Konings. "It all adds up to more pressure on freight rates in the near term."

With carriers now able to charge up to US$17,000, why would they ever let them drop again to US$800? asks Griffiths. "The days of three figure freights from Asia to Europe are long behind us," he says, adding that while crates could come down to under US$10,000 from Asia to Europe, they will never return to the lows of 18 months ago.

> "The days of three-figure freights from Asia to Europe are long behind us"

The downstream impact on EPCs

EPCs have responded to the rising cost of modules in different ways. Some have delayed projects, while others have taken a hit to their profit margins in order to construct projects on time and keep pipelines manageable.

Nikos Papapetrou, general manager of renewables and storage development at Mytilineos, says the company has responded to the higher prices by pushing back around 10 projects on clients' behest after close consultation. It has also delayed around five of its own projects.

He says that strong client relationships were crucial in managing expectations and postponing projects. Papapetrou now expects a surge of new installs after Q2 2022, at a greater profit margin, as module prices come down.

Nevertheless, and even with the delayed projects, Mytilineos has installed 50% more capacity this year than it did in the corresponding period last year and around 25% more than in the same period of 2019, says Papapetrou.

BayWa r.e, meanwhile, has seen the cost of modules it purchases increase by around 50% from September 2020, says Tino Weiss, head of global purchasing solar projects. Played out on a larger scale, this increases the cost of a 150MW project by US$15 million, he explains. The company has renegotiated almost all of its contracts with suppliers from November 2020 to April this year as a result of the higher module costs.

Normally under such circumstances, Weiss would recommend postponing projects but with no certainty about when prices might fall it is difficult to advocate. Given this, BayWa r.e did not cancel any projects in its pipeline because of higher module costs. Instead, the German company took a hit on its profit margins. "Investors are willing to reduce their margin expectations or just pay more," Weiss says.

He cautions, however, that planned polysilicon expansions next year may not translate into lower module costs if myriad companies look to restart their operations in full, causing spikes in demand. BayWa r.e has agreed future contracts with module suppliers based on current polysilicon and sea freight prices but has agreed to reassess the price closer to the project deadline in a risk sharing exercise.

RES has also seen a rise in its module prices, says Tomaso Charlemont, global solar procurement leader at RES. "We estimate most cost impacts will be temporary and that things should revert back to previously anticipated level eventually by 2023."

Importantly, "module cost per watt increase needs to be put into perspective," says Charlemont. "Module suppliers are bringing larger wattage modules to the market, meaning you get more watts per container than with smaller modules." The EPCs agreed that increased module cell sizes have helped to offset some of their costs.

Supply and demand factors have forced up modules price substantially. And, to a lesser extent, so has exploding shipping costs. This has caused EPCs to make tough business decisions, balancing the needs of clients and shareholders with their business goals and pipeline ambitious. While most experts and companies expect the price of modules to fall next year, shipping will not be getting cheaper anytime soon and if it does fall, it won't be back down to pre-pandemic levels.

Nevertheless, the appetite for solar remains undiminished, especially as governments around the world look to exit COVID-19's economic slump with energy infrastructure investments. Stakeholders of the industry should be optimistic that short terms pressures will ease, but some caution is perhaps needed about the pace and extent of such easing given the uncertainty that surrounds the many factors at play. ■

Turn over to page 20 for more insight into supply chain volatility, exploring the impact of the trade sanctions on module supply.

Securing the chain

Supply chain | As prices rise and component availability remains tight, both solar's upstream and downstream are rallying behind the common cause of ensuring which projects can go ahead, do go ahead in a timely fashion. Liam Stoker assesses the industry's efforts to keep the supply chain moving forward.

As the preceding pages have documented, an array of factors, from raw material prices to end market demand to global shipping and freight pressures have nudged prices northward, impacting on upstream manufacturers and downstream developers alike.

The two ends of the stream have always enjoyed a close, albeit at times fractious, relationship, however the pricing pressures of the last nine months have led to them becoming perhaps more intertwined than before.

With perhaps more visibility over tightness in the supply chain, component manufacturers have been steadying themselves for pricing volatility since late last year. Concerns over glass pricing sent reverberations throughout the sector in November 2020 and while prices for that material have since stabilised, it proved to be the warning tremor before polysilicon pricing spiked in early 2021.

The surge in polysilicon price has ricocheted throughout the sector, with module prices up between 20 – 25% on last year, Jamie Vaux, commercial director at solar distributor Midsummer Energy, says. This led to a weakening of demand throughout the value chain, which in turn prompted manufacturers to reduce factory utilisation rates. Indeed, reports earlier this year suggested some factories were running at utilisation rates as low as 60%. The year to date has proven to be a careful balancing act, weighing up pricing and demand, with one clear factor in mind: margins.

Manufacturer results in the opening quarter expressly displayed the issue at hand. Canadian Solar, for example, witnessed revenue from its manufacturing division (CSI) increase marginally in the opening quarter, up 0.8%. However gross profit fell by nearly 60% on the back of a significantly higher cost base, resulting in the division slipping to a loss of US$52.7 million. The clearest sign of the impact of pricing volatility was seen in the division's gross margin, which had swung from 23.5% in Q1 2020 to just 9.7% in Q1 2021.

It proved to be a swing that refocused CSI to put profit over shipment volume, a pivot which was then reflected in the company's Q2 results. An (albeit marginal) improvement in the division's margin to 12.9% helped secure a return to profit, however a reduction in full year shipment forecasts illustrated the pressures price increases are placing elsewhere in the value chain. CEO Shawn Qu said the ~2GW reduction in shipment forecast this year would effectively be the result, in equal measures, of a recalibration of costs versus supply, the prevalence of logistics issues (see p.16) and projects being pushed back into later quarters.

That decrease in module shipment guidance has further caused Canadian Solar to tweak its capacity expansion plans for 2021, reducing its originally-forecasted module assembly capacity by 3GW while simultaneously increasing its intended solar cell manufacturing capacity by around 600MW. JinkoSolar has also scaled back its planned capacity expansions for the year, citing the pressure pricing increases have placed on end-user demand.

> "Customers know not only where the modules come from, but also other products like cells, wafers, ingots. The whole supply chain is much more transparent to our customers."

But the fact module makers are making tweaks rather than wholesale cancellations indicates that it's not necessarily a case of responding entirely to demand or pricing fluctuations, but rather in adapting to a new status quo wherein upstream pressures lie elsewhere in the chain. Both CSI and JinkoSolar have stepped up efforts in producing more solar wafers and cells internally in recent years in much the same way as their 'Solar Module Super League' (SMSL) peers have – in August JinkoSolar confirmed it had broken ground on a 7GW ingoting and wafering facility in Vietnam, the first such major solar ingot facility outside of China – in order to exert more control over their supply chains. Henning Schulze, corporate assistant president at SMSL manufacturer JA Solar, says his company's vertically integrated nature has proven to be a considerable strength amidst pricing volatility. "It does make it easier to control the supply chain. And it, of course, also has the advantage for customers. Customers know not only where the modules come from, but also other products like cells, wafers, ingots. The whole supply chain is much more transparent to our customers," he says.

Controlling the chain

While module manufacturers have been able to lean on vertical integration in order to mitigate pricing volatility to a certain extent, other component providers have not been that lucky. Inverter producers have been forced to contend with a semiconductor chip shortage that's impinging on vast swathes of the global economy, from electric vehicles to consumer electronics, while tracker and mounting suppliers have witnessed steel prices more than double in the course of the last year. Between April 2020 and May 2021, the price of hot-rolled coil steel rose from US$515 per short ton to US$1,348, and has continued to increase since.

Tracker manufacturers have been forced to adapt and amend procurement practices, bulk buying steel and locking in long-term contracts, often from new suppliers in a bid to contain the volatility. After withdrawing its full-year guidance amidst "unprecedented" increases in the cost of steel, tracker manufacturer Array Technologies took actions to mitigate its exposure to such price increases, negotiating longer-term contracts with material

Credit: LONGi Solar

With material and shipping costs having soared in the past year, manufacturers and developers alike are finding ways to mitigate these new pressures.

and freight providers. Likewise the global semiconductor chip shortage has led inverter manufacturers to search for new providers

But for every company to have lost out in pricing volatility, there's an entity to have benefited. Polysilicon manufacturers have largely never had it so good, with most – like solar glass manufacturers earlier in the year – posting record profits in the second quarter. Daqo New Energy is to capitalise on its bumper Q2 by ploughing investment into an ambitious capacity expansion plan despite a forecasted levelling out of average selling prices throughout 2022.

As those upstream have been able to mitigate, those further down the supply chain have perhaps not had the same luxuries, instead anxiously watching key component prices creep up. Down the stream, it's also a matter of control and restraint.

Biding time

"Pricing has been extremely challenging," says George Hershman, president at US-based renewables EPC Swinerton. With module prices on the rise and margins shrinking across the board, an inevitable consequence is projects being pushed back until such a time that module prices normalise. Industry estimates vary in this regard, with anywhere from 10 – 20% of utility-scale solar projects in the US having reported to have been delayed, however there has yet to be any widespread report of cancellations.

Indeed, Hershman says that his company has yet to record a single cancellation, with its clients merely electing to push back by a quarter or two. "A number of our customers are either trying to extend out their COD dates and get to somewhere where we can see some cost reductions in some commodities, and we're working with them on that, to try and push those projects out as far as possible," he says. "We haven't had any project cancellations - usually our projects don't just go to hard cancelation, they go on hold - and we try to move them into a later period of time where the economics may work."

But these delays are not always possible, especially if a developer has negotiated a power purchase agreement that has a hard deadline. Investors are not exactly famed for their patience, and uncertainty in the market – be it relating to pricing or availability, or anything else for that matter – can lead to issues with a project's bankability. "Once there's uncertainty in the market, then the tax equity goes somewhere else [and] the debt financing goes somewhere else, right? Lenders don't like uncertainty, and they have money to lend… so they're going to go find markets that bring more certainty," Hershman says.

As a result, it is a developer or EPC's job to manage not just the supply chain, but an investor's expectations under the current market conditions. Pushing projects into forthcoming quarters may be one option to explore, but is clearly not applicable as a 'one size fits all' solution given how each project is designed to different time frames. It could then fall on the developer to lean higher up the value chain, leveraging any size or scale it can in the hope of securing better deals.

Distributors have meanwhile managed client expectations by making pricing increases incrementally, rather than in one fell swoop. Midsummer Energy's Vaux says constant communication with his company's customers, explaining the situation and keeping them informed, has been critical to keeping them on side. Furthermore, it has led to a change in the way modules are purchased. "We have done as much forward buying at lower prices as we possibly can, to minimise the impact on our customers," Vaux says.

Arevon Energy, the solar and storage developer recently spun out of investor Capital Dynamics, intends to use its scale in the coming months to not just get it the best possible deal, but to secure its supply of key components in the first place. CEO

> "If you don't do that [procurement] efficiently, especially on smaller projects, the costs are going to eat you alive."

John Breckenridge says Arevon – which has a 4.5GW portfolio of solar and storage assets at various stages of operation and construction alongside a 3GW pipeline of further projects – will be using its "purchasing might to help us navigate the tight supply situation". This doesn't just include components and other hardware, but "everything from EPC contractors to [shipping] containers", Breckenridge adds. "We're consolidating our purchases and we have our procurement organisations very focused on all of that. There are a lot of things we're doing in this tight market that are designed to address some of these issues," he says, adding: "If you don't do that efficiently, especially on smaller projects,

Awakening of the new energy world: Innovations, trends and developments at Intersolar Europe Restart 2021

Hardly any other sector has seen as much change as the solar industry over the past 30 years. The driving force behind this industry is Intersolar, which is celebrating its 30th anniversary this year. After almost two years of missed events due to Covid-19, the organizers are delighted to finally be able to invite you back to Munich for the Intersolar Europe Restart 2021. This will be held from October 6–8 as part of The smarter E Europe Restart 2021 at Messe München.

The most recent Global Market Outlook 2021–2025 from SolarPower Europe shows that in 2020, despite the effects of the COVID-19 pandemic, 138.2 gigawatts (GW) of new PV capacity were deployed worldwide. This equals an 18% growth compared to 2019 and marks a new global record for solar power. The total photovoltaics (PV) output installed around the world now stands at 773.2 GW. SolarPower Europe expects 2021 to be another year of outstanding growth. The average scenario predicts an 18% increase of newly installed capacity to 163.2 GW.By 2025, SolarPower Europe expects the global installed capacity to be close to 1.9 TW.

Solar cells: Bigger, more powerful and more cost-effective

PV modules are becoming increasingly more powerful while PV system costs continue to fall. This change is being driven by a huge learning curve in the industry due to growing production, technical optimization as well as the use of larger wafers, half cell modules and the refinement of PERC cell technology. High efficiency technologies such as silicon heterojunction technology (SHJ), integrated back contact solar cells and PV tandem technology are set to become increasingly important in the coming years. When it comes to cell formats, the current trend is for wafers to be larger, yet thinner, making for bigger and more powerful modules. This is reflected by one of this year's Intersolar AWARD winners. LONGi Solar Technology will be in attendance in Munich with the new Hi-MO5, a high output, bifacial module for large solar parks. Technological developments, rising demand for photovoltaics and decreasing costs once again make the production of PV products in Europe an attractive option, as does the wealth of knowledge in research and mechanical engineering. European companies such as Meyer Burger are bringing PV production back to Europe and reestablishing production plants.

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Phase II of the Moss Landing Energy Storage Facility in California was commissioned in mid-August, despite battery cells being in short supply.

the costs are going to eat you alive."

Scale has become particularly pertinent in the energy storage sphere where product availability is of real concern. Tesla's Megapack product is sold out until 2023 with other manufacturers citing long lead times. "If you want access to batteries today, and you're a small buyer, you're going to be waiting a long time and paying a high price. We're buying billions of dollars worth of batteries, so that gives us a lot of more opportunity to access that market," Breckenridge says. While co-located solar-storage projects are on the rise, particularly in the US where more than 34% of the 459GW+ currently sat in an interconnection queue is hybridised, the prospective introduction of a standalone energy storage investment tax credit could lead to further pressure on the supply chain, Breckenridge says. "If we have an IT, for batteries, even though in the long run that's good for a battery, the battery industry, and the storage industry, that actually in the short run may exacerbate the problem," he says. "So it's interesting how regulatory moves which have certain positive goals in mind sometimes have these other consequences that we have to manage through," Breckenridge adds, noting how the solar ITC has ensured demand for solar modules has remained high in spite of pricing issues.

Regulatory hurdles elsewhere, however, could pose altogether different challenges in terms of supply and demand.

Avoiding chaos at the border

Allegations of forced labour in the solar supply chain are nothing particularly new, with polysilicon providers named in numerous reports last year, however it was not until the summer when governments began to match action with rhetoric. The US' decision in late June 2021 to enact a withhold and release order (WRO) on products made by Hoshine Silicon Industry and its subsidiaries – effectively acting as a block on solar products made using polysilicon connected to the Xinjiang-based supplier – amounted to the first major response to allegations in the solar industry, however other nations are said to be laying the groundwork for similar sanctions.

Arevon's Breckenridge says that while the industry must of course tackle allegations of forced labour head on, it must also find a way to facilitate a continued flow of solar modules from the industry's largest suppliers. "To abruptly just start stopping panels at the border without any sort of way for the industry to have been prepared for that has a huge cost to it, potentially. And so I think the industry has to find a way to address this problem without creating total chaos," he says.

While a limited amount of modules have been detained so far – ROTH Capital's Philip Shen indicated in mid-August 2021 that around 100MW had been seized by customs officials at the time, with a further 2.1GW of solar projects jeopardised by related concerns – the WRO offers little certainty to developers or other module buyers with the US Department of Commerce not confirming the identities of manufacturers suspected to be in breach of it.

A traceability protocol developed by the US Solar Energy Industries Association (SEIA) alongside its members intends to provide assurances that modules coming into the US are free of forced labour. Swinerton, which has helped in the design of the protocol, has distributed documentation to all of its vendors to ensure compliance, while the EPC is currently undergoing a material audit of its supply chain. "Is it perfect? Are we 100% clear on where everything comes from today? No, but we recognise that this is an issue," Hershman says.

"There's heightened levels of concern around modules, but we're also looking at our tracker manufacturers and where their products are coming from. We're taking as much information as we can from other industry sources, and a number of suppliers in the industry are looking at their own supply chain and providing more information. There's a heightened level of scrutiny, and where we maybe took things for granted before, we're now requiring our vendors and suppliers to provide us information," Hershman says.

All of this scrutiny and clarity will, inevitably, come at a cost. Andy Klump of Clean Energy Advisory, a consultant also working on SEIA's protocol and manufacturer compliance with it, has suggested there may be a few months of delay as manufacturers get their paperwork in order and costs associated with compliance could be passed onto the customer, but nothing more than US$0.02c/W. Still, coming on the back of nine months of material cost increases, those few cents could easily be the difference between economic viability and a project being nudged back further. Midsummer Energy's Vaux is expecting module demand in Europe to be shaped by requests for similar transparency. "That may translate into changing module preferences, and there are likely bottlenecks that will come into play there," he says.

Regulatory decisions are "creating a ripple effect in the market", Hershman says. The filing of a petition in late August arguing for anti-dumping and countervailing duties in place under Section 201 in the US to be extended to include module manufacturing subsidies throughout Southeast Asia would turn those ripples into waves.

Section 201 tariffs have been in place in the US since February 2018 and are due to expire after a term of four years, however the Biden administration could yet choose to extend them pending the results of an investigation from the US International Trade Commission. Those tariffs, set at 30% on cells and modules imported from China, have raised the prices of modules from mainland China and pushed trade elsewhere. To extend those tariffs elsewhere, Hershman says, would have a significantly limiting impact on US solar deployment. "For an industry so ripe for growth and with so much opportunity, it would really just put the brakes on," he says. ■

See overleaf for more detail on trade policy.

Policy impacting trade

Policy | While the supply chain has recoiled from surging materials prices, component shortages and unprecedented volatility in shipping and freight costs, national policies and regulations have also emerged as a sizeable hurdle to frictionless solar trade. Here PV Tech Power recaps the policies to watch in the coming months.

The Withhold Release Order

In late June, the US Department of Commerce confirmed that it had enacted a Withhold Release Order (WRO) against Hoshine Silicon Industry and its subsidiaries, blocking the import of metallurgical-grade silicon and silicon-based products that can be traced to Hoshine. Two months after the WRO was enacted, US Customs and Border Protection (CBP) was said to have started seizing module shipments at the US border, however at the time of publication there has been no definitive statement confirming this, nor the amount of shipments seized. The WRO works by detaining shipments suspected of not complying with the order and requesting the importer supply documentation proving products contained are not linked to the party in question. It has 90 days to provide this, after which CBP will either allow them to leave the port of entry or block them from entering the country permanently. Importers then have a further two months to arrange reshipment, after which goods are presumed abandoned and destroyed. While the WRO remains in place against only Hoshine and its subsidiaries as it stands, the situation has been described as "fluid" with commerce department officials also expressly stating more entities, and perhaps more importantly their customers, are being identified on a regular basis. The order has thrust importance on supply chain transparency and traceability, with most estimates suggesting it will be months yet before manufacturers are in a position to satisfy customs officials.

The budget reconciliation amendment

US President Joe Biden is eager to push most of his agenda within a budget reconciliation bill that is currently passing through the US Senate, with speaker Nancy Pelosi said to want the bill to be in a position to pass by 1 October 2021. While the precise text has yet to be agreed, the bill is set to include an extension of the solar investment tax credit and production tax credit, as well as a direct pay option and tax credit for standalone storage. A potential manufacturing tax credit, as championed by Democrat senator Jon Ossoff, is also under consideration. However during the bill's first reading session in August, Republican senator Dan Sullivan proposed an amendment which would prohibit any renewable energy project using China-made technology or material from claiming any federal funding or subsidy, including the ITC. The amendment was passed with a strong majority – securing 90 votes in favour with just nine against – resulting in what could be a surprise addition to the bill's final text. There is still some way to go for the amendment to be included, but it could be one to watch heading into the latter stages of the bill's progress.

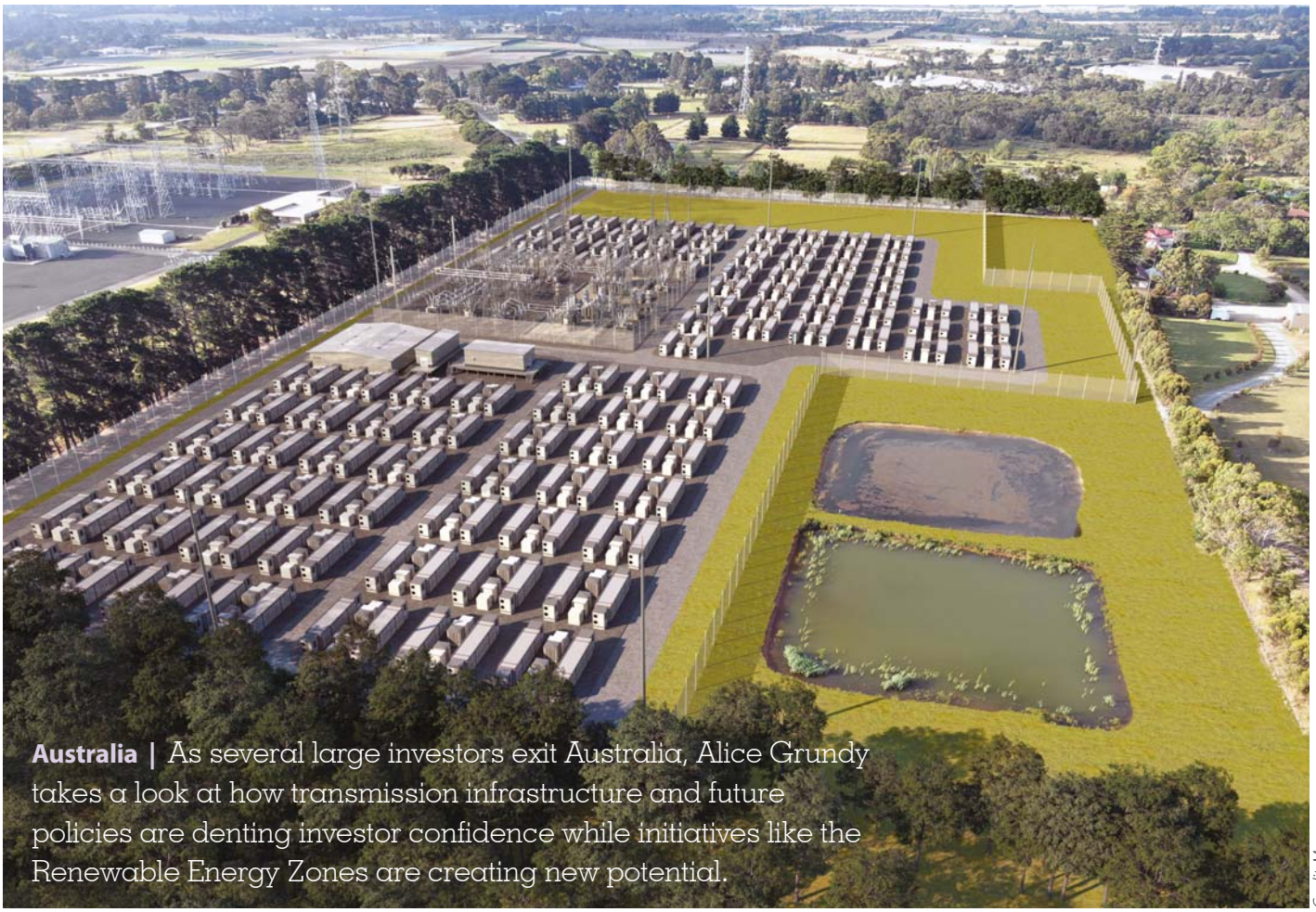
European alternatives

At the G7 summit earlier this year, US authorities insisted that its G7 partners were aligned in clamping down on alleged forced labour practices in Xinjiang. But, to date, not one has followed suit. The UK government has come under pressure from parliamentarians to enforce similar sanctions on imports from Xinjiang, however Prime Minister Boris Johnson has yet to confirm his stance on solar imports in particular. Meanwhile, the European Commission has not commented on future sanctions it may take under the EU Global Human Rights Sanctions Regime. One potential option for the EC to take is to adopt legislation passing in some member states, specifically in Germany and Denmark, which requires companies to conduct audits of their supply chains to ensure they comply with various ESG directives. Companies could face harsh penalties for failing to do so, in effect placing the responsibility solely on the customer or importer. The Commission is said to be publishing further documentation regarding this kind of approach in the autumn.

The Southeast Asia anti-dumping petition

Of perhaps most significance, and certainly of considerable concern from developers spoken to by PV Tech Power, is the petition filed with the US Department of Commerce calling for an investigation into alleged circumvention of anti-dumping and countervailing duties by Chinese module manufacturers. The petition, filed by law firm Wiley on behalf of the American Solar Manufacturers Against Chinese Circumvention (A-SMACC), a coalition of US-based manufacturers that have chosen to remain anonymous, contends that Chinese manufacturer are circumventing AD/CVD duties by shipping to the US market through subsidiaries based throughout Southeast Asia, specifically in Malaysia, Vietnam and Thailand. The case argues that AD/CVD duties currently reserved for modules originating from China under Section 201 – equivalent to 15% until February 2022 – should be extended to those countries. The investigation may also be complicated by the fact that the US International Trade Commission is set to investigate whether the existing S201 tariffs should expire in February 2023 or be extended, with the Biden administration set for crucial decisions to make in balancing its desire to support solar deployment with its trade policy.

REZtoring solar investor confidence in Australia



Australia | As several large investors exit Australia, Alice Grundy takes a look at how transmission infrastructure and future policies are denting investor confidence while initiatives like the Renewable Energy Zones are creating new potential.

Credit: Maoneng.

Alongside every solar success story is a side note tucked away in the margins; for every new PV plant to go into the ground, the remaining capacity available on the grid shrinks, a little at a time. It's hardly an issue in those markets where solar – and indeed other renewable technologies – make up a less than significant proportion of the electricity mix, but for Australia – which according to the country's Clean Energy Regulator added 1.7GW of new large-scale solar in 2020 – it is now very much a problem facing new developments.

Now, that's not to say that the market is struggling. The aforementioned statistics probably say enough on that matter. There is no shortage of new developments, and optimism in the sector currently seems high.

"I think there is plenty of scope for more renewable projects to be completed in Australia, because we're in the middle of a significant transition away from fossil fuels to green energy," says Morris Zhou, co-founder and CEO of Australian renewables developer Maoneng.

This is perhaps reflected in Maoneng's pipeline, which currently stands at 750MWdc of solar and 1,800MWh of battery storage. However, not every player in the market shares the same outlook, with several notable exits occurring over the past year or so. First up was Australia-based engineering, procurement and construction (EPC) provider Downer Group, which announced its withdrawal from the large-scale solar sector in 2020, with CEO Grant Fenn saying at the time that solar operators were faced with issues around connections,

While investor confidence in utility-scale PV has waned somewhat, battery energy storage continues to be popular.

grid stability and equipment performance.

Downer would not be the only one. A month later UK-based infrastructure giant John Laing said it would be exiting the solar and wind market due in part to issues such as transmission loss. It followed the company's 255MW Sunraysia solar project – which it developed with Maoneng – being particularly hard hit by transmission issues as well as delays with the Australian Energy Market Operator's registration process, which held up the project's connection to the grid.

Next up was New Energy Solar, which sealed its exit from the market with the sale of its 11MWdc Beryl and 56MWdc Manildra PV projects in New South Wales in June 2021. In the company's FY 2020 results, Stuart Nisbett and Jeffrey Whalan, chair of the responsible entity and chair of the

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company respectively, said: "Clearly, NEW is an Australian-originated business but the policy and regulatory environment for renewables in Australia is not conducive to growing the business and achieving economies of scale in Australia."

Policy: A tale of two sides

You'd be hard pressed to find a solar market without at least one policy-related complaint, and Australia is no exception. In fact, policy is one of the biggest challenges facing large scale solar developers today, says Kane Thornton, Clean Energy Council (CEC) chief executive, with "unhelpful and unpredictable government intervention" creating uncertainty for investors. This is of particular note as investor confidence is at its lowest level since December 2019, according to the CEC's Clean Energy Outlook- Confidence Index. Thornton gives example of two new gas plants in New South Wales, with one – to be located in Hunter Valley – to cost the Australian government up to AU$600 million, while the other – developed by EnergyAustralia – was approved by the government of New South Wales in May.

However, some government initiatives are certainly to be praised, in particular the Renewable Energy Zones (REZ) initiative. These are areas in the National Electricity Market where clusters of large-scale renewable generators can be efficiently developed, capitalising on economies of scale by connecting large amounts of renewables in the same location. A key element of REZs is upgrading transmission infrastructure to enable the mass deployment of renewables, addressing market barriers cited by some of the investors to leave the market.

The government of New South Wales launched a registration of interest process in June for Australia's largest REZ, which is expected to deliver as much as 8GW of capacity. While the NSW government itself has committed AU$78.9 million to its development, the REZ is expected to deliver AU$10.7 billion in private investment. It follows the state seeing a nine-fold oversubscription in interest for its first REZ, receiving 113 registrations of interest which totalled 27GW of capacity.

NSW is also not the only state to introduce these zones, with Queensland having also seen a deluge of interest for its planned REZs, with enough projects put forward in 2020 to create 60GW of clean energy in the Australian state. Additionally, Victoria is planning to establish six REZs with the potential to unlock 10GW of additional capacity for renewables.

But REZ schemes are not without their failings. "Unfortunately it appears these state government schemes will be negatively impacted by proposed policies from the Energy Security Board (ESB), particularly proposed 'access reforms'," Thornton says.

The REZ have been designed as a stepping stone towards the proposed access reforms, designed to improve the transmission system. Independent chair Kerry Schott stated in January 2021 that the ESB is concerned about security constraints in some of the NEM as well as increasing pressure on distribution networks from growing rooftop solar penetration, increasing large-scale renewable generation and low wholesale prices.

There are a vast number of measures included within the reforms, although chief among them are those to alter current market operations through the introduction of locational marginal pricing and financial transmission rights, with a proposal to also move to dynamic loss factors, something which the CEC said last year would be "more volatile and unpredictable than the current, already problematic marginal loss factor regime".

> "It's getting harder for us to manage the stability of the power system as the penetration of solar and wind, even at today's levels, pushes the system to its limits."

"These reforms could make it extremely difficult for solar farms to make the best use of the available grid, which will increase costs for consumers," Thornton says.

While low wholesale prices are a key concern for the ESB – and a motiviating factor behind the reforms – this is not an opinion shared by everyone. The fall in wholesale prices has largely been driven by the boom in residential solar in Australia – with 2.5GW of new capacity installed in 2020 according to the Australian Energy Regulator. AEMO found that wholesale electricity prices fell up to 68% in South Australia in Q1 2021, with this a result of a sharp uptake in renewables, including rooftop PV, with South Australia's average quarterly electricity price reduced by AU$10/MWh (US$7.75/MWh).

However, Anton Rohner, CEO of renewables project developer UPC\AC Renewables Australia, says: "Downward pressure on wholesale prices from rooftop solar is certainly a factor to be considered, but this must be weighed up against the upward price pressure caused by the closure of ~8GW of coal plants over the next decade, the timing of which may be brought forward by the rooftop solar boom."

Additionally, while changes in wholesale prices can create a challenging environment, movements in wholesale prices are a fundamental element of the National Electricity Market and volatility in wholesale prices are a traditional market risk for investors, Thornton says. "What is most important is that these investors have a stable and predictable regulatory environment, so that they can get on with their main focus, which is to manage wholesale price risk," he says.

Revitalising a buckling grid

The compressed wholesale prices are then, perhaps, not the most pressing of problems for new developments. Constraints on Australia's grid infrastructure, however, are proving to be a consistent stumbling block for both new projects – which struggle to connect in the first place, facing uncertainty over connection timelines – and existing projects, which are seeing their output curtailed. "Our grid is simply not fit for purpose as the clean energy transition continues," Thornton says.

While this is an issue impacting developers across the board, Rohner says that some new international entrants into the market in the last few years "haven't done their homework", paying particular mention to how transmission rules work in the country in regards to congestion or constraint analysis.

"Several investors have lost their money and are already managing their asset portfolios. We may be heading into a period of consolidation as the larger players shore up their positions in the market," Rohner says.

When it comes to mitigating the impacts of Australia's transmission infrastructure on new developments, there are several options available to developers. First is the method adopted by AC/UP Renewables, which has chosen its project locations on the higher voltage – and more robust – parts of the transmission network where constraint issues are less prevalent. The company tends to go for connections into the 330kV or 220kW system over the 132kV or 66kV sub-transmission system

which was until recently the favoured voltage for utility-scale solar plants due to its cost-effectiveness. But this strategy also means larger projects are needed to justify the connection costs, indicatively moving from 100MW+ projects up to 400MW size projects, Rohner says.

While this helps to circumvent some of those constraints, it is not a fix to the original issue, which Rohner suggests requires significant investment in new transmission infrastructure, something he says is recognised across the industry, including by the Australian Energy Market Operator (AEMO), the NSW government and transmission operators themselves.

Indeed, AEMO has established a joint initiative with the CEC called the Connections Reform Initiative to address connection challenges. It aims to deliver a consistent and predictable connections process that delivers repeatable outcomes, reduce re-work and improve efficiency and quality of information to address information asymmetry and create a collaborative working model between industry, AEMO and the network service providers.

The rise in utility-scale renewables is also causing other issues for the grid, however. As penetration increases, the cost of power generation is being pushed to zero and below, prompting spinning thermal generators, which are used for system stability including frequency control and inertia, to disconnect. "It's getting harder for us to manage the stability of the power system as the penetration of solar and wind, even at today's levels, pushes the system to its limits," said CEO of AEMO, Daniel Westerman, giving the keynote address at an event hosted by the Committee for Economic Development of Australia (CEDA) in July 2021.

The potential of storage

A technology capable of supporting both the stability of the grid in the long term and also individual renewable projects in the short term through co-location is battery storage. An oft-heralded technology throughout the power sector, battery storage's role in Australia's energy market is no less celebrated.

"While there are definitely grid constraints and challenges, battery storage can help alleviate these through its role in providing electricity back into the grid when it's most needed, helping overcome the intermittency of renewable generation through frequency response and regulation of pricing," Zhou says, suggesting that more people are realising the crucial role batteries can play at a national level.

Indeed, storage is being increasingly paired with solar, and standalone storage developments are also becoming more common. In July, the New South Wales government approved the Stubbo Solar Farm and Battery, a development from UPC/AC Renewables pairing 400MW of solar with 200MW/200MWh of battery storage in NSW's Central-West Orana REZ. Other recent developments include a 150MW/300MWh project in development in Queensland by state government-owned electricity generation and retail company Stanwell.

A spokesperson for Stanwell told PV Tech Power that Queensland experiences some system strength issues in weaker parts of the network, particularly in North Queensland, and that the energy market is rapidly changing. "Our focus has been on identifying battery storage solutions to create value for our portfolio and help facilitate the integration of renewable energy into the energy system. Our models show that a revenue stack is the current commercial pathway for large scale energy storage."

Playing into frequency control and ancillary services markets can be – in particular in South Australia – more lucrative than simply selling energy, according to Jon Ruddick, CFO of Australian microgrid firm eleXsys. Alongside the financial benefits, storage also helps stabilise the grid, allowing for more solar to then be connected, with this forming a positive cycle, he says.

A smorgasbord of planning processes

While it seems there is something of a consensus that transmission is a difficult issue for renewables in Australia, another key consideration for many developers looking for the perfect spot for their next asset is the ease of securing planning permission and the complexity of the process.

Developers seem to be relatively supportive of the current planning processes within Australia, which vary from state to state. However, this does mean that the timeframes for obtaining approval, the costs involved – including application fees – and the risks associated with obtaining approvals, appeals and so on also all vary from state to state. Alongside this, there is also a federal environmental approvals process which can by triggered by the Environmental Protection, Biodiversity and Conservation Act.

"This patchwork approach can act as a disincentive to new developments," Rohner says, "but generally speaking the rules are fairly clear and good projects get approved." The planning process was also praised by Zhou, describing it as well-structured and relatively straightforward, qualities that he says make Australia a good place to do business. "Of course, as a developer you need to be diligent and thorough in your approach, making sure your claims are backed by data and evidence for example, and taking a proactive approach to community and stakeholder relations… The system here rewards professionalism, whether you're working with people at the local level, a state government, or your suppliers and commercial partners."

It is factors like the transparency of the planning system that have attracted international players to the market, alongside elements like the low sovereign risk. BP, for instance, has certainly started making a presence for itself in the market, with its solar development arm Lightsource BP having secured AU$330 million (US$255 million) to fund the development of its second and third utility-scale solar projects in Australia in June 2021. Meanwhile, fellow O&G major Shell purchased a 49% stake of Australian utility-scale PV developer ESCO Pacific in 2019.

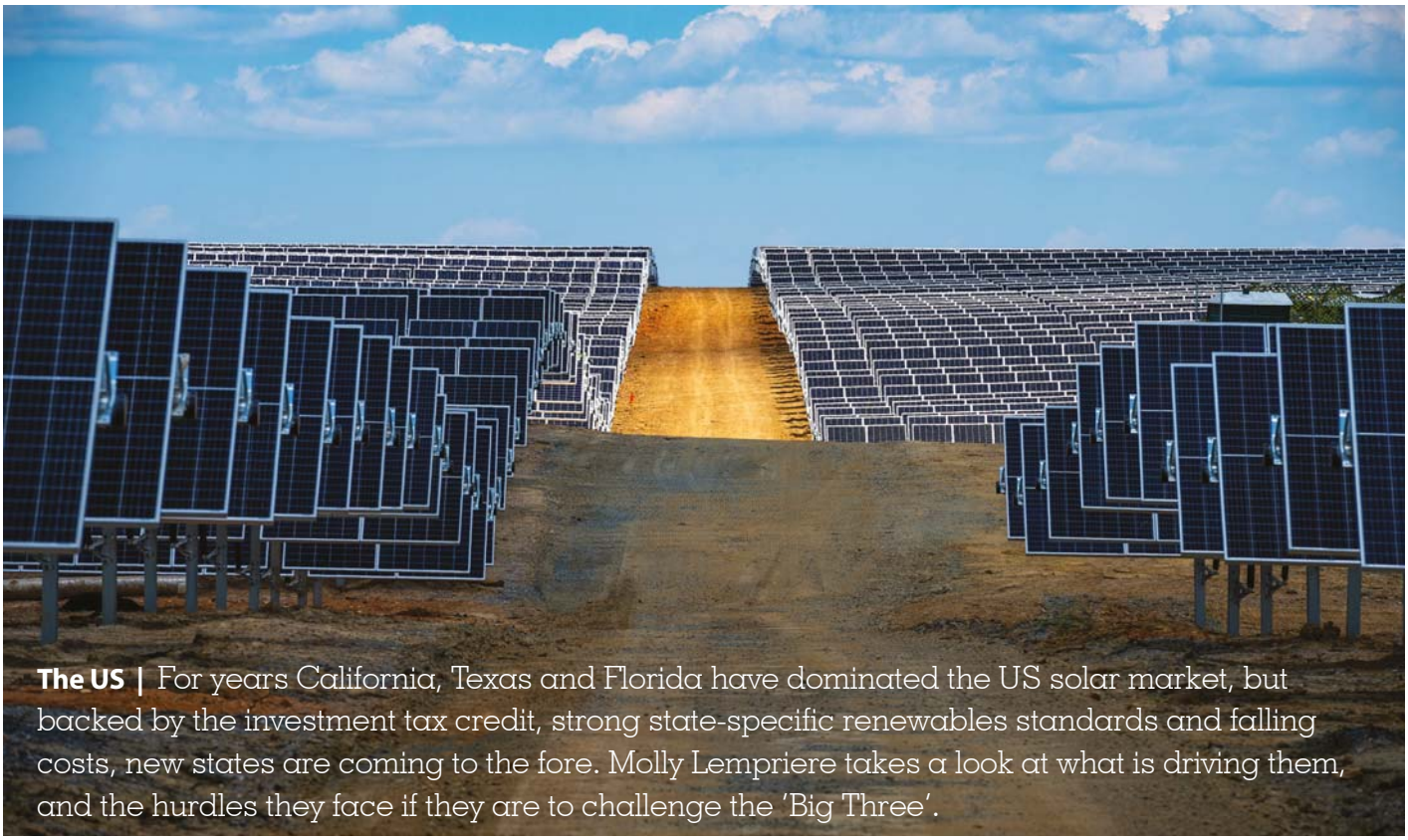
It is certainly a competitive market, but this is a positive, Zhou says, helping to sharpen strategies and encouraging companies to excel and be creative to ensure projects get delivered with good commercial returns. "There's room for everyone, and it's important to note that it's not a race to the bottom here on pricing either, like it is in some other countries," he says.

The competitiveness of the market is only increasing, with Thornton saying that there is in turn increased interest from major global energy companies. "There remains enormous long-term opportunity for sophisticated investors in renewable energy and energy storage," he says.

It seems that despite the challenges surrounding grid infrastructure and upcoming access reforms, the sentiment of those on the ground in Australia is one of positivity. The market has many attractive features, including the ease of planning and REZs, and there is much potential for new developments, even with the high level of interest in the market.

As Zhou says: "Overall, the transition to renewables means there's space for everyone, large and small, to do well in this market." ■

Beyond the 'Big Three': The US states booming and the policies driving them



Credit: sPower/Nextracker.

The US | For years California, Texas and Florida have dominated the US solar market, but backed by the investment tax credit, strong state-specific renewables standards and falling costs, new states are coming to the fore. Molly Lempriere takes a look at what is driving them, and the hurdles they face if they are to challenge the 'Big Three'.

The solar market is booming in the US, thanks to renewed confidence in the policy landscape, cost reductions and renewables targets. In June 2021, the Solar Energy Industries Association (SEIA) announced that the market had surpassed 100GW, doubling the size of the industry in just three and a half years.

"It's really just a bounty of opportunities across the US," says Kevin Smith, Americas CEO at Lightsource bp. "And largely, it's because of the price of solar power has just come down so dramatically over the last number of years, that utilities and corporates really can't resist the drop from solar; it's very, very cost effective."

5GW of new capacity was installed in the US in Q1 2021 alone, with a record 3.6GW of this from utility scale. Figures provided by SEIA show how Texas has led the way, installing 1.52GW of new solar capacity – three times more than any other state.

The Lone Star State forms one of the 'Big Three' together with California and Florida, as the states whose solar markets have buoyed the industry for years. But new states are now coming to the fore and developing significant pipelines.

SEIA has ranked the states in terms of their growth potential, with the Big Three followed by Virginia, New York, Indiana, Nevada, Arizona, Colorado and North Carolina. But what is driving solar in these up-and-coming markets? And what do they look like for developers?

Tax credits as a driving force

There are a number of factors aiding the rollout of solar throughout the US, most notably the ivestment tax credit (ITC). Originally introduced in 2006, the solar industry has grown by more than 10,000% since then, according to the SEIA.

"As you can imagine, the ITC is a massive, massive driver of making projects happen, helping developers to get their actual return on investment and it encourages a lot of the offtakers, the people signing the PPAs to think about actually building the projects before the ITC goes away, and maximising the incentive," says Michelle Davis, principal analyst for solar at Wood Mackenzie.

A 75MW solar farm developed by sPower in Spotsylvania, Virgina.

Currently, the ITC provides a 26% federal tax credit that can be claimed against the tax liability of residential, commercial and utility investors in solar energy under Section 25D and Section 48. The level of credit is set to step down to 22% for projects beginning construction in 2023, before the residential credit drops to zero and the commercial and utility credit drops down to 10%. This phase-down was set in December 2020, when the ITC was extended.

"Before the ITC extension at the end of 2020, it was supposed to just phase down every single year for the next several

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years," says Davis. "So you could actually see that utility-scale deployments from 2019 to 2020 literally doubled in the United States; that is the ITC at play. And so you can imagine the expected impacts that we are building into our forecast over the next three years given that that environment will be the same for at least a few years before the current law has the ITC expiring or starting to phase down at the end of 2023."

"You could actually see that utility-scale deployments from 2019 to 2020 literally doubled in the United States; that is the ITC at play"

There are calls now to further extend out the ITC, to ensure solar can grow to help meet the US's decarbonisation targets – currently set at a 50-52% reduction from 2005 levels by 2030. In March, President Joe Biden included plans to extend the ITC for both clean power generation and energy storage by 10 years, as part of a US$2 trillion infrastructure investment plan.

"As we've looked at new markets opening up, and opportunities to expand the ITC within a new infrastructure package, that is something that we're supportive of," says George Hershman, president and general manager at renewables engineering, procurement and construction firm Swinerton. "We believe that it is a great opportunity to maximise private investment in solar, which is so key to being able to bring in outside financial interests into these large projects."

State level standards

Beyond federal support from the ITC, one of the biggest drivers of utility-scale solar at a state level has been Renewable Portfolio Standards (RPS). These require a certain percentage of electricity sold by utilities to come from renewable energy sources such as solar.

The first state to establish an RPS was Iowa back in 1983, when legislators required its two investor-owned electric utilities to use a combined 105MW of renewable energy capacity. Since then 30 states, Washington D.C. and three territories have adopted an RPS, while seven states and one territory have set renewable energy goals. These vary from state to state in a number of ways, including the target level, the resources eligible and cost caps, but the majority mandate for between 10 - 45% of renewable energy to be obtained through renewable energy credits or certificates (RECs).

"When the utilities do their analysis, the lowest cost resource is utility-scale solar," says Wood Mackenzie's Davis. "And that continues to be the case. We're having massive growth in utility-scale [solar] over the next three years, it's really going to break records. We're having plus 10% growth for the next three years in utility-scale deployments."

According to the National Conference of State Legislatures, since the beginning of the 2000s roughly half of the growth of US renewable energy can be attributed to these RPSs. In recent years, a number of states have increased their targets further, pushing utilities to expand their solar and wind portfolios and the RECs they acquire.

While RPSs are a key driver of solar growth, and particularly in states which are seeing major growth, Lightsource bp's Smith noted that over the past three or four years corporate buyers have started to catch up with utilities.

"I would probably estimate that probably 50% or more of our power sales discussions and contracts are now with corporate buyers, which is a pretty substantial change than say five, six, seven years ago where probably it was 90% utilities. Now it's certainly at least 50/50 between utilities and corporates," Smith says. "And I would wager that the corporates are extending past 50% of the power buyers for renewables."

Indiana's 'remarkable resources'

The Midwest is set to see substantial growth in the coming years, and in particular Indiana. Currently the state has 939.1MW of installed solar capacity, making it just 20th in SEIA's national ranking. But this is already a jump from 32rd in 2020, and the Hoosier State is widely backed to leap further up that table. Over the next five years it is expected to see more than 4.5GW of new solar installations, the sixth-most in the US, according to SEIA figures.

"We're having massive growth in utility-scale [solar] over the next three years, it's really going to break records"

Indiana has benefitted from largely supportive policy, helping to drive forwards this growth. The state brought in its first piece of solar legislature back in 2002 with the Solar Easement Laws, and has since introduced compensation schemes and tax exemptions to help drive the growth of solar at a number of levels. In 2011 it passed its first RPS, which called for 10% of electricity to be supplied by renewable energy by 2025.

But challenges remain in the state, in particular around land use with 34 of its counties having ordinances that restrict wind and solar projects or prohibit their construction entirely. Despite state lawmakers working to change this, there has been significant push back, with the Indiana House Bill 1381 for example being quashed in April 2021 due to opposition from local governments.

Despite these obstacles large-scale solar projects are popping up throughout the state, such as Indiana-based solar developer Hoosier announcing 1.6GW worth of solar and storage projects in April 2021.

Carl Weatherley-White, Hoosier Solar's chief executive officer, said that Indiana has "remarkable resources for solar power" due to its agricultural sector. He said residents "want to preserve productive land for multiple generations" therefore solar projects provide farmers with "long-term, steady income that is neither seasonal nor dependent on weather or crop pricing".

Arizona RPS precipitating a market boom

Another market set to boom is Arizona, building on an already strong position in SEIA's national ranking. In 2021, the state moved from 9th to 5th as installed solar grew to 5.247GW. Over the next five years this is set to grow still further with 4.161GW expected to be installed in the state, putting it eighth in SEIA's growth projection rankings.

Arizona is one of the states that has benefited from particularly strong RPSs, which were established as a result of regulatory action adopted by the Arizona Corporate Commission in 2006, and then reaffirmed by the state's attorney general in 2007. This gave the state a goal of originating 15% of its power from renewables by 2025, a target that is supported by credit multipliers for in-state

solar installations and other renewable sources installed before 2006. Utilities in Arizona must source 15% of their energy from RECs, of which 30% much come from distributed energy sources. The impact of the strong RPS on driving solar development has already been seen, with Swinerton's Hershman suggesting the industry has seen it "drip drive the market significantly" in recent years.

In 2020, the Arizona Corporation Commission voted to approve a suite of amendments that would require the state's investor-owned utilities to phase out fossil fuels completely by 2050. Additionally, utilities would have to increase energy efficiency savings by an average of 1.3% starting in 2021, and increase energy storage capacity by 5%.

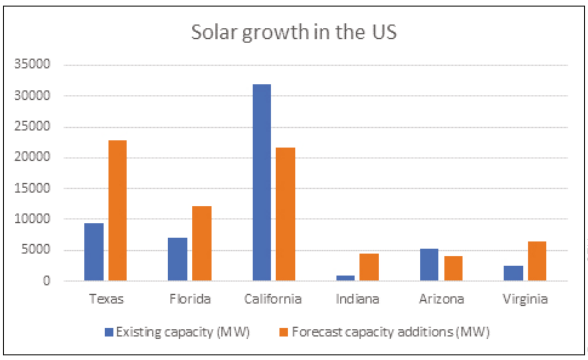
The vote followed Arizona Public Service (APS), the state's largest utility, announcing in January 2020 that it was targeting 100% clean energy by the middle of the century. Despite the challenges for utilities created by the COVID-19 pandemic, commented Jeff Guldner, APS chairman and CEO, the company has not "taken our eyes off the ball" and is continuing to work with stakeholders to reach a "carbon-free energy future".

With this increasing push from utilities in the state to decarbonise their offerings, combined with the reduced cost of solar, Arizona is set for significant growth in the utility-scale sector in coming years.

Moving beyond land-use challenges in Virginia

Virginia has been another state that has established strong RPSs, helping to drive the build-out of solar with the pace picking up. The Virginia Clean Economy Act was brought in in 2020, replacing the voluntary RPS with a mandatory renewable policy. This requires Dominion Energy Virginia and American Electric Power – the two incumbent utilities in the state – to produce 100% of their electricity from renewables by 2045 and 2050 respectively.

Despite this positive step however, there are still challenges to developing large-scale solar in Virginia, predominantly around land use, as Hershman says. "They've got significant land use requirements around their stormwater site control, site stabilisation requirements that on a much smaller development make sense, but when you're talking about the size of projects that need to be built to supply the demand, it makes it really difficult."



Data source: SEIA

Both existing capacity (as of 2020) and forecasted additions (2021 – 2025) of the US' big three solar markets and the country's three challengers.

Each portion of the site needs to be stabilised, moving from one to the next across thousands of acres. Therefore some sites become unworkable, as the land use requirements drive up the cost of the projects dramatically.

In recent years, there have been efforts to bring in legislation that would ease these land use concerns, such as siting agreements for solar facilities in opportunity zones. Introduced in July 2020, these agreements allow developers and localities to negotiate assistance beneficial to the low-income areas as defined under the 2017 Tax Cuts and Job Act. This was brought in to ensure communities benefit from solar developments, easing the concern of local governments.

Revenue share legislation was also introduced, which give localities the option to create an energy revenue share ordinance. If this is adopted, projects larger than 5MW are entitled to 100% machinery and tool tax exemption.

Both these pieces of legislation, along with other mechanisms, will hopefully help ease the challenges of developing in Virginia. Solar in the state is predicted to grow by 6.454GW over the next four years, the forth biggest level in America, according to the SEIA. This is well over double the state's current installed solar capacity of 2.546GW as the state eyes its decarbonisation goals.

Going further requires easing grid connection

Solar is set to grow rapidly in coming years across the US, but states can still go further to push development by easing grid connection processes. A study from the Lawrence Berkeley National Laboratory in May 2021 found that over 755GW of generator capacity was sat in connection queues across the US at end of 2020, along with an additional 200GW of energy storage projects. Of this total solar represented the largest chunk, with 462GW laying wait in queues that continue to grow larger each year.

Wood Mackenzie's Davis says the states that provide some certainty for developers through a streamlined, effective interconnection process as opposed to an arduous one are some of the most attractive. "And honestly, that's a big reason that Texas has a lot of build out because they have these massive transmission lines that they built out for renewable energy deployments, specifically," she adds.

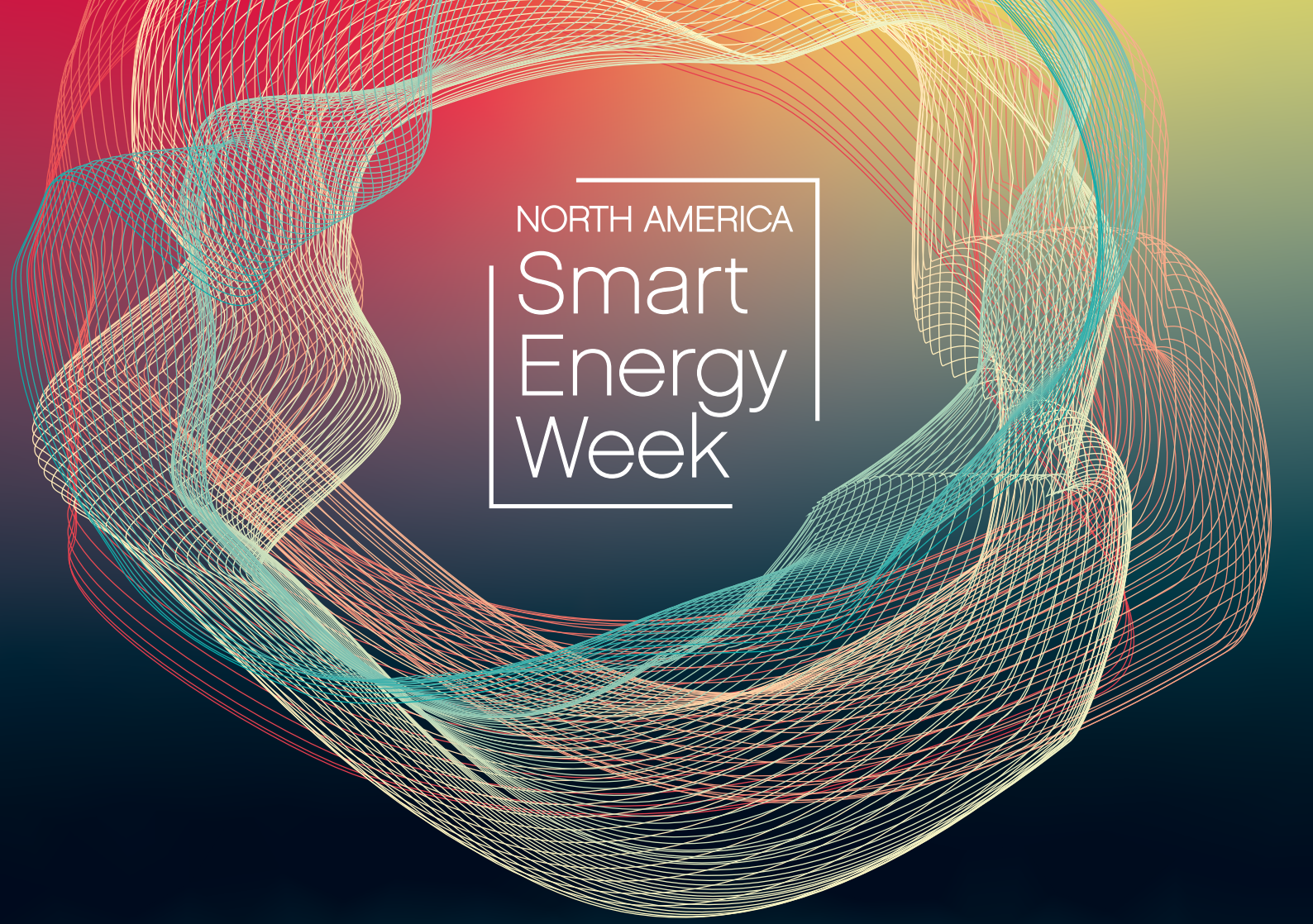
But the average wait time for generation projects in queues is increasing, with the time projects spend in queues before being built having grown from ~1.9 years for projects built in 2000-2009 to ~3.5 years for those built in 2010-2020. Additionally, being within a connection queue does not guarantee construction, with only around 24% of projects reaching commercial operation, a figure that's even lower for solar projects at 16%.

"I think probably the most critical thing that states, and probably in conjunction with their state utility commissions, can do is ensure a smooth interconnection process," says Davis. "So if grid investments need to be made, if interconnection queues are building up with lots of project delays, states and utility commissions can work on those kinds of issues."

"I think probably the most critical thing that states, and probably in conjunction with their state utility commissions, can do is ensure a smooth interconnection process."

Despite challenges like grid connection, the solar sector is looking forward to a busy few years with Swinerton's Hershman describing the current US solar industry experience as an exciting time.

"We're seeing a lot of movement and interest into the phase two infrastructure package that I think will do amazing things for renewables because I think it will extend the ITC, it will likely give an ITC bump for the use of prevailing wage and some positive labour type of movements. And so, I think that only will drive more deployment," he says. ■



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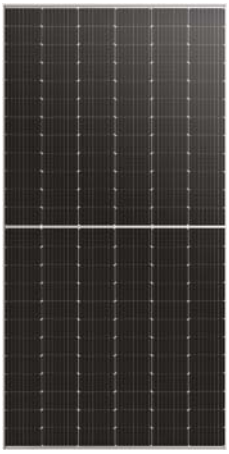
Product reviews

Modules — LONGi´s Hi-MO N module: A new breakthrough with n-type to lead evolution of efficiency and energy yield

Product outline: LONGi has launched its Hi-MO N module, its first bifacial module with n-type TOPCon cells, designed to deliver ultra- high value and lower levelised cost of electricity (LCOE) to utility-scale PV power plants.

Problem: The challenge for all module manufacturers remains to support customers to continue reducing LCOE, increasing module power and efficiency and save on balance of system (BOS) costs for their utility PV projects, giving them access to more economic financial models.

Solution: The Hi-MO N uses LONGi's HPC technique and is based on n-type TOPCon technology to achieve higher bifacial gains, better temperature coefficient and low irradiance performance, lower working temperature, better light-induced degradation (LID) and potential induced degradation (PID) performance. As a result, energy yield is 2-3% higher than that of mainstream p-type bifacial modules.



In addition to high energy yield and low LID, Hi-MO N also shows its value in reducing BOS costs with its higher module efficiency. The 182mm-size module can minimise costs associated with racking, cable, inverter and labour. Its high conversion efficiency of 22.3% can enhance installed capacity by over 3.5% in areas of limited space and reduce BOS costs

Applications: Utility-scale PV power plants.

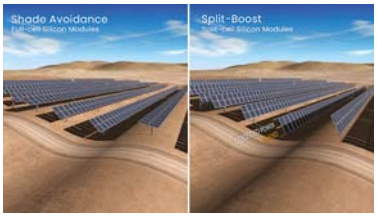
Platform: Hi-MO N is verified and confirmed to be compatible with mainstream inverters and tracking systems. The Hi-MO N panel has the following dimensions: 2256mm x 1133mm x 35mm, and a weight of 32.3kg.

Availability: Expected to enter mass manufacture in Q4 2021, becoming available to purchase in Q1 2022.

Software — Nextracker TrueCapture Split-Boost enhances production by up to 6% through precision control

Problem: Flat land is a myth in the utility-scale solar industry and almost every PV project needs to account for terrain loss, while variance between pier heights from adjacent rows can also introduce an additional source of row-to-row shading, potentially reducing asset performance.

Solution: Split-Boost is a new control mode algorithm of Nextracker's TrueCapture software that takes advantage of the string architecture of split-cell PV modules. Split-cell PV modules have 6-string architecture that allows up to 50% of shading on the module for up to 50% power loss, as opposed to traditional modules where even a small amount of shading could lead to close to full power loss. The new Split-Boost technology kicks in for split-cell module sites, when the algorithm recognises that it could boost power when tilting towards the sun in a more optimal angle, while allowing less than 50% of shading on the split-cell module. Even on a theoretically perfectly flat site with no row-to-row shading, Split-Boost can increase energy production beyond standard backtracking due to the optimisation of incidence angle versus shade loss, up to 0.5 % due to electrical effects alone.



Applications: Utility-scale solar projects featuring split-cell modules.

Platform: TrueCapture is an advanced tracking algorithm designed to maximise yield for any module type (full cell, half-cell, thin film). It runs within Nextracker's advanced independent tracker row communication and control infrastructure, with wireless communications between tracker self-powered controllers (SPCs), network control units (NCUs), and our NX DataHub cloud connected remote monitoring system. Nextracker provides the latest software and firmware upgrades remotely for TrueCapture customers to enable Split-Boost technology on new and existing sites that have split cell PV modules.

Availability: Available now.

Trackers — Sun & Steel's single-axis tracker simplifies component design to reduce cost

Problem: Competitive tracker solutions are becoming increasingly complex, adding additional layers of cost to the capex, EPC and opex costs. Some trackers now use less steel, but with added dampers to reduce the effect of wind, while the addition of drives at each post and spinning drive shafts have introduced more risk.

Solution: Sun & Steel's round torque tube uses 25% less steel for the same torsional strength as square tubes used in alternative tracker designs. Bearings are used as natural dampers via friction, transfer the ground path to the posts and forgo plastic bushings. Thrust stops are also used to prevent N-S movement from terrain slopes or seismic events. Further cost-saving options include forgoing hot dip galvanizing and the option for field bolted or field welded applications. One programmable logic controller can track and backtrack a large number of rows to reduce costs further while also increasing tracker reliability.

Applications: Commercial and utility-scale solar PV projects, with each tracker row carrying around 50kW of solar PV in different formats.

Platform: Each row is independent with no obstructions, allowing machinery to travel row to row or down the aisles.

Availability: Prototype testing is now complete with the intention to bring the product to market by Q4 2022.

Procurement considerations for the large-format module era

Components | Spencer Jansen, head of new technology solutions at developers Hive Energy and Ethical Power, assesses how the introduction of large-format solar modules has had repercussions throughout the solar design and procurement process.

Credit: Hive Energy.

Hive Energy developed the 45MW El Salobral project in Spain.

The module industry experienced some substantial changes from the beginning of the millennium until 2014, however, the arrival of mono-PERC and then bifacial modules in 2018 represented a significant technological milestone, which was followed in 2019 by the production of large-format modules to accommodate broad wafers (M10:182x182mm and M12: 210x210mm).

The solar business has entered a new module-era, characterised by the production of the 600W+ bifacial ultra-high power modules, which leads to increased yield generation and a balance of system (BOS) cost reduction. Increased sized panels have significantly impacted multiple aspects of the rest of the installation, including inverter sizing and mounting structure design. Increases in project size from a typical 10MW project to 50MW+ has also highlighted the value of efficient and reliable communication technologies within our assets. With this increased reliance on newly developed installation technologies and communication software, safeguarding assets from liability has become a consideration of increased importance in the rapidly developing procurement landscape.

This article presents the background to Hive Energy and Ethical Power's experience in large format solar procurement, provides an overview of procurement considerations for inverters, mounting structures, communication software and design software, and discusses the importance of safeguarding your procurement decisions.

Broad changes in the solar industry

Hive Energy and Ethical Power have been operating within the solar industry since 2010. Having recently acquired 50% of Ethical Power, Hive Energy has gained a wealth of experience in the procurement considerations for large-format module solar parks.

Ethical Power started by developing rooftop systems before moving into the subsidised solar farm engineering, procurement and construction (EPC) business where it financed, constructed, and sold its solar farm projects mainly to the large financial institutions. In addition to managing its own solar projects, Ethical Power O&M managed third-party portfolios. Due to an abundance of government funding in the field, the industry saw a swell of inexperienced small developers building rushed solar assets to meet feed-in tariff and Renewables Obligation deadlines in the UK.

This resulted in poorly constructed projects with multiple faults and poor yield. Ethical therefore found itself in a position where project owners were asking it to come and fix faulty projects – this provided the company with valuable experience of what can go wrong and what to do about it.

Apart from fundamentally poor construction resulting in connection, cable and mounting system failures, another key issue was the poor selection of components. Inadequately selected components had ineffective performance monitoring and communication systems with money wasted on ineffective CCTV and poorly installed measuring equipment.

Since this period Ethical has acquired and developed an independent connections provider (ICP), providing further insight into the ICP world, and required connection considerations. As such, Hive Energy and Ethical Power's combined position as the only fully integrated company that develops and acquires projects, is an ICP, EPC and O&M, provides them with a unique position to understand what it takes to build a reliable solar park.

Considerations for inverters, transformers, and battery systems

One of the changes that has taken place in the large-format module era is that inverter manufacturers have had to adapt to the higher current levels associated with the new modules. In the case of central inverters or PV station solutions, the adoption of the higher current has been quickly implemented. However, it has also created a problem with the string combiner boxes that have seen increased costs due to the added complexity to their design as a result of the higher current coming from the strings, making the overall central inverter system more expensive.

String inverter manufacturers have also quickly adapted their products (mostly at zero cost) to high current modules, with a higher power rating with 250kW now typically available, taking an economically advantageous position since the combiner boxes are not needed, meaning there

is virtually no cost increase in the string inverter system. This adds to the typical known benefits from the string inverter system.

Furthermore, going forward, we will start to see bi-polar strings +/- 1,500V systems reducing cable cost and improving efficiency where there is a smart string control on the module array coupled to a centralised string inverter station next to the STC unit in 6MW+ blocks. This will see string inverters move to over 300kW and allow for other DC coupled devices, such as storage systems, to be integrated at the DC level where possible, removing the cost for a second set of inverters as an example.

One of the important benefits of string inverter systems, and an important consideration when selecting inverter technologies, is the power line communications technologies - where commands between inverters and transformer (TX) stations are sent via the power cables. These communications drastically increase the reliability of the system.

Previously, inverter failure would result in individual component testing, resulting in time and money wasted sending an engineer to pinpoint the fault. However, with integrated IV curve testing, in which inverter current and voltage is monitored in real time at string level, engineers can be sent directly to the fault. This integration of communications is an important consideration for us when selecting our inverter supplier, saving time and money when the solar farm is operational.

The second consideration when selecting a string inverter system over other technologies is that most of the big string inverter suppliers like Huawei and Sungrow now offer a wrapped-up solution including an inverter and TX station system. This allows them to compete with the PV station/central inverter solution and offers the EPC contractor and end client a much more robust contractual and warranty position, packaging the onsite electrical system from the end of a string to the client substation under one supply contract. Experience tells you that failures occur at the interfaces between contractors and is where any liability becomes unclear. Removing these interfaces improves reliability and reduces cost and gives greater accountability

Battery energy storage systems (BESS) over the next few years will become part of any standard solar farm solution at some level. It is therefore critical that any solar farm being developed today takes this into account and understands how these BESS will be integrated or specifically not integrated into the project. The lifespan of a battery is dependent on its operational management, how good the digital architecture is, how well is it cooled, how modular (plug and play) the system is, how well it integrates with the grid, and what common parts are used with the solar system. It may well be, going forward, that the BESS are distributed in blocks over the solar farm. These are key questions that need to be asked now from the supply chain partners to avoid last minute changes resulting in poor design.

Module Changes	Changes in Tracker Stiffness and Stability	Impact on Tracker/Components Design
Length increase	Chord increase High effect on aeroelastic critical wind speed	Higher structures Adjusted stow strategy
Width increase	Longer rows Lower torsional stiffness	Improved drive system
Surface increase	Higher wind load on module surface Higher torque on lock systems Higher foundation reactions	Bigger tracker surface Stiffer purlin Strengthened tube Higher post
Mass increase	Lower natural frequency Changes in damping High effect on aeroelastic critical wind speed	Improved drive system Adjusted stow strategy

Considerations for mounting structures

Large-format modules require new procurement considerations for the mounting structure due to geometrical and electrical features to incorporate bigger wafers, a configuration of lower open-circuit voltage, higher short circuit current, and a new string design.

Trackers, in combination with bifacial modules, are becoming the standard PV installation throughout the world. This is due to the increased yields that can be achieved when combining the two elements, which generates revenues that generally overcome the extra cost associated with the tracker installation within a few years.

Tracker systems have come a long way in the last five years, but they haven't been free from issues related to wind loading, with several examples of installations ruined under apparently low wind loads. Accordingly, the most critical challenge of the photovoltaic installation in this new era is the reconfiguration of tracker design, since the accommodation of 600W+ involves a higher pressure of wind load on the system that affects the trackers' stability and reliability.

The widespread availability of large-format modules and the increase of energy generation brought about a significant reduction in system cost. Additionally, the need arose for accommodating technology changes in the PV systems, since ultra-high-power modules add significant weight and require mechanical and electrical adaptations in trackers, to guarantee optimum yield and efficiency.

The design and configuration of solar trackers are closely related to the dimensions of the photovoltaic panel. The installation of large-format modules implies subject to different dynamic behaviour in tracker structure, including heavier loads.

The use of large-format modules requires longer chords, longer rows, stronger structures and, overall, more robust cross-sections to structurally bear the extra weight and conserve stability against wind effects.

The electrical configuration of the tracker is also affected by the mounting of ultra-high-power modules due to the change in the number of strings (modules connected in series) assembled in a row.

Eliminating procurement risk

Due to the rapid developments in this large format module era, there is a heightened chance that the technologies selected will be without an established operational track record. Therefore, building and maintaining relationships with manufacturers has become a primary consideration when designing utility-scale solar systems. Building a relationship upfront with Huawei and others has allowed us to eliminate risk where possible through the integration of inverters, transformers, and battery systems.

Beyond the maintenance of relationships with suppliers, risk within procurement is eliminated through frequent

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and thorough testing of components. In addition to seeking the confirmation of the relevant independent certifications from suppliers, we would also carry out factory inspections where, in the case of solar modules, we cover:

- Incoming quality controls
- Materials warehousing and storage controls
- Material and process controls used in all major assembly steps
- Outgoing quality controls and inspection
- Finished goods management
- Supply chain, production, and quality management
- General factory organisation, cleanliness, safety, employment, and environmental standards

In addition, we would also carry out production inspection and testing that would cover items such as:

Flash (IV) Testing – checking for power and resistance defects

Electroluminescence (EL) imaging – checking for cell defects

Visual inspection – checking module component integrity

Schedule and packing checks

And finally, we would also take sample modules from a batch to an independent lab to confirm that would typically be:

- Visual inspection
- Maximum power determination at STC
- Electroluminescence
- Wet leakage current
- Potential-induced degradation
- Stabilisation test
- LeTID test
- Low irradiance measurements at 200 W/m^2
- EVA gel content measurement

This is to ensure that the datafiles shared for modelling are accurate. As such, it is important that the supply chain is shielded from risk through production line checks, factory audits and material supply chain checks, so only manufacturers that pass the highest level of quality control within an independent laboratory will be utilised within the design of a utility-scale solar park. This benchmarking of manufacturers drives procurement considerations prior to any design and operational requirements of the selected technologies.

Increasing efficiencies in software procurement

For 5 -10 MW projects in 2016, utilising simple CAD software was sufficient to manually place our solar modules on fields, although it was a time-consuming process. However, for utility scale projects that incorporate large-format high current modules, transformers, and tracker systems there is a clear advantage in utilising software with fully automated and advanced modelling capabilities to design solar systems.

Credit: PV Tech

The SNEC 2021 exhibition saw many inverter solutions designed for the large-format module era.

Software has been required to keep pace with the development of solar components, and now design software procurement is as important a consideration as the physical structures within the park. Helios 3D is a fully developed software package used by Ethical Power that lays out the solar farm relative to topography and fully optimises the site both mechanically and electrically within a given set of parameters. This design can then be imported into to PVsyst, which then calculates the performance of the project, using SolarGIS typical monthly year weather data.

As with any software, success comes from having the right inputs and drivers with a deep understanding of how it all works and comes together, working hand in hand software provider. However, once you have mastered this, changes can quickly be made to any given design with an output that does not just give you a layout, but a full bill of materials (BOM) that covers cable sizing, lengths, and equipment placing, with some manual intervention to make it more practical where required,

Due to considerable reliance on technology within the large-format module era, building and maintaining a relationship with the software manufacturer helps achieve the full capability of the software to maximise solar yields. When issues in system design are highlighted, a close relationship with the software manufacturer means they can promptly modify the software, reducing delay in design timescales and ultimately project timescales. This means that gaining even small efficiencies in project design through long term relationship building and maintenance is a key consideration for us when deciding software usage.

A solar park is an engineering and procurement exercise. The rapid development of all parts of the solar park are resulting in a consistently accelerating procurement landscape. Beyond the technological requirements that drive procurement considerations both for solar components and software, building and maintaining long term relationships with manufacturers has allowed for Hive Energy and Ethical Power to design things that aren't widely available, and create innovative solar assets that optimise yields in complex scenarios.

Despite the trends of automation and integration for utility-scale solar projects within the large format module era, success in procurement is driven by experience in risk elimination through manufacturer quality control and relationship development. ■

Author

Spencer Jansen is head of new technology solutions at developers Hive Energy and Ethical Power, UK-based developers of utility-scale solar projects.

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Inside PV CAMPER: A global research collaborative to advance photovoltaic performance across a range of operating climates

Research | As solar finds itself installed in further flung climes, so it must operate in harsher conditions. PV CAMPER, a collaborative effort including some of the world's leading academic and research institutes, has set itself the aim of uncovering data to help drive the industry forward. Here, members of PV CAMPER discuss some of their preliminary findings.

Propelled by the precipitous drop in costs, global photovoltaic capacity continues its steady upward trajectory, with an average annual growth rate of 15% and a doubling rate less than three years (IEA, 2020b, a). In fact—despite the broad economic impacts of Covid—2020 was a banner year for solar, with a record-breaking 160GW+ installed across the planet (IRENA, 2021), the result of lower costs, industry momentum and favorable policies.

One notable manifestation of this explosive growth is solar's spread to traditionally unfavorable climates, where for decades, costs were too high and energy yields too low for economic viability. But as costs continue to plummet, solar is rapidly gaining energy share in high-latitude countries like Norway and tropical nations such as Brazil, which has 7.5 GW of installed solar and an annual growth rate of 64%. Even Fairbanks, Alaska, at a latitude of 64° North, now boasts a 500kW utility-owned PV installation.

Ensuring high lifetime performance across increasingly diverse geographic regions, however, is a growing challenge, the result of multiple trends affecting the global solar economy. One unknown is how emerging higher-efficiency PV technologies (from redesigned cell interconnects and architectures to module-level innovations) will perform long-term in relatively new operating environments. Another concern is the uncertainty around climate change, which is upending traditional patterns of humidity and temperature, forcing scientists to rethink the definition of a typical meteorological year and assumptions about measurement uncertainty. The third area of uncertainty, also related to climate change, is the uptick in extreme weather: PV systems everywhere appear to be at greater risk from natural disasters, including hurricanes, dust storms, hail, blizzards, and wildfires.

Hourly meteorological data for Koeppen-Geiger climate zones are available for modeling purposes but the available data represents only six zones (temperate continental, temperate coastal, tropical humid, subtropical arid, subtropical coastal, high elevation), and is too low resolution to adequately capture local climate profiles, including dynamic shifts in such critical variables as irradiance, temperature and a module's response to spectral and angle-of-incidence changes.

"But as costs continue to plummet, solar is rapidly haining energy share in high-latitude countries like Norway and tropical nations such as Brazil, which has 7.5GW of installed solar."

Attempts have been made to replicate climate-specific accelerated testing, but these lab-based attempts, which cannot replicate the precise stochastic and intermittent interactions of multiple field variables, are approximate at best.

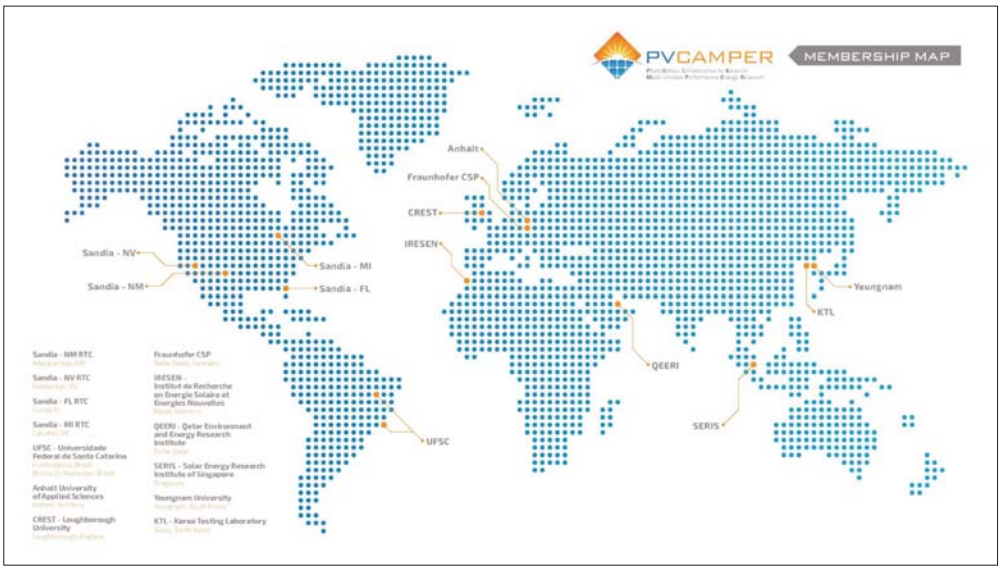
Lacking good data on cross-climate PV performance, manufacturers have had little incentive to develop PV modules and systems customised for their operating environments, that is, designed for optimal performance and reliability in specific climates. Instead, PV is largely viewed as a one-size-fits-all commodity and the majority of deployed modules are manufactured and sold without consideration for designing or matching those technologies to the geographic region in which they will be installed. Energy ratings in compliance with IEC 61853 are a step toward climate optimisation but fall drastically short of what is needed.

This article makes the case that high-fidelity ground-based measurements of performance variables, across multiple climates and operating environments, are critical to both accurate predictions of energy yields and also to informing the development of module technologies that are operationally more efficient. To have confidence in those measurements, however, requires building a technical foundation for quantifying the factors that influence the long-term performance and degradation of photovoltaic systems, thus increasing the amount of data generated while reducing measurement uncertainty.

To achieve that goal, researchers must have access to high-fidelity data across different climate zones and also engage collaboratively on data collection and analysis. Given the importance of this data in enabling a global solar economy, the purpose of this article is to describe a newly formed collaborative, which has prioritised cross-climate research, along with an overview of the organisation's current research priorities, with an eye to encouraging broader participation, by both industry and research organisations.

The Photovoltaic Collaborative to Advance Multi-climate Performance and Energy Research (PV CAMPER)

Better known by its acronym, PV CAMPER, the Photovoltaic Collaborative to Advance Multi-climate Performance and Energy Research represents a global network of research institutions collectively committed to tackling key challenges in the global solar sector, i.e., the need for more accurate performance



Credit: PV CAMPER

Figure 1. World map depicting the locations of PV CAMPER member institutions and their associated field sites (Sandia National Laboratories, 2021a).

models and levelised cost of energy (LCOE) calculations, and for breakthrough advances in the performance, reliability and value of PV systems across the world's climate zones. If PV CAMPER succeeds, its success will lie in providing the data needed to help the industry improve its technologies, instrumentation and performance calculations.

Although multiple international organisations promote networking and research, among them the International Energy Agency, the International Photovoltaic Quality Assurance Task Forces, and the PV Performance Modeling Collaborative, PV CAMPER brings a unique angle to global research by being both an intellectual (expert-based) and a physical (multi-site) entity.

At its core, PV CAMPER is a network of plug-and-play field sites, a community of researchers with a track record of working together, and a portfolio of research projects aimed at improving the efficiency and reliability of PV components and systems. The organisation differentiates itself from other collaborative groups by its (1) common research platform, with instrumentation of comparable quality and common O&M protocols.; (2) strategic focus on international research, that is, on performance and measurement challenges, ranging from soiling-loss factors to humidity and temperature oscillations to instrument drift and measurement uncertainty; (3) cross-climate field-validation services for emerging technologies; and (4) early-warning capabilities for climate-induced risks and failure mechanisms.

What began as an informal gathering of researchers in 2018 is now a formally recognised organisation, with 11 member institutions and a 16-site network of field labs distributed across both hemispheres and most major climate zones. Led in its early years by Sandia National Laboratories, which manages a similar, but smaller, network of field labs called the US Regional Test Centers for Emerging Solar Technologies (SANDIA NATIONAL LABORATORIES, 2021b), PV CAMPER is now governed by an executive committee and chaired by Fraunhofer Center for Silicon Photovoltaics.

Other members of the executive committee include representatives from Sandia, Anhalt University of Applied Sciences in Germany and the Universidade Federal de Santa Catarina in Brazil. Per the terms of PV CAMPER's organisational charter, members must meet a set of clearly defined technical requirements for instrumentation quality, calibration practices and characterisation procedures; they must also commit to participating in at least one collaborative research project a year and to leading one or more projects every few years. In addition, the charter specifies attendance and research participation, and defines a governance structure that promotes organisational stability and continuity, with an executive committee whose members rotate on an annual basis to ensure full member representation

"If PV CAMPER succeeds, its success wil lie in providing the data needed to help the industry improve its technologies, instruments and performance calculations."

This strong global network of sites, with common designs, instrumentation, protocols and standards, has enabled PV CAMPER to focus on a set of inaugural research initiatives that support the collection and analysis of :

- Albedo and other irradiance data, to inform performance models, and increase their accuracy and applicability
- Geographically diverse data to help address ongoing and widespread performance challenges, such as soiling-loss factors, cloud persistence, humidity and temperature oscillations
- Performance data to validate the cross-climate performance of emerging technologies and also climate-specific PV designs

Bringing greater accuracy to the quantification of PV performance

Measuring and quantifying the multiple factors that contribute to a PV system's performance is essential to lifetime yield projections and precise return on investment calculations. However, high-confidence data is hard to come by: the specific variables that contribute to the long-term performance and degradation of PV systems vary greatly according to location, notably spectral qualities, temperature range and oscillations, humidity levels, soiling rates, etc.

In addition, the data that is meant to accurately represent those variables may itself not be accurate, depending on the source (measured versus satellite) and the quality, calibration, and maintenance of the instrumentation, including its accuracy range, and the frequency with which data is collected (STEIN; KING, 2013). As a result, and in the absence of a set of best practices or standards for measuring and predicting the field performance of PV systems, a significant amount of measurement uncertainty exists, resulting in an even higher potential for measurement error.

PV CAMPER therefore considers the quantification and reduction of measurement uncertainty, which in turn directly affects the accuracy and global applicability of performance models,

The Solar Expo & Forum will showcase the diverse benefits and potential growth of solar power generation in the Middle East

The world's transition away from relying on hydrocarbon-based fuel for power generation and towards a clean energy future led by renewables is speeding up. Nowhere is this pivotal trend more apparent than in the Middle East, which is rapidly becoming the world's leading incubator of new clean energy innovations, capacity, expertise and financing.

Crucial to the growth of this potentially world-leading industry is the Middle East's development of solar power generation, as well as the essential support infrastructure that will enable its increasingly rapid rise. This is what makes the upcoming Solar Energy Expo and Forum such a vital platform for driving the development of a cleaner, more sustainable energy industry. The event is part of the World Future Energy Summit and will take place from 17 – 19 January 2022 at ADNEC, Abu Dhabi. Attendees will be able to discover details of the expanding regional solar project pipeline and witness hundreds of cutting-edge solar innovations through live demos and product launches on the exhibition floor.

These innovations, the key to maintaining the buoyant growth of the regional and global solar industry, will span PV, solar thermal, energy storage, trackers, inverters, mounting systems and Building Integrated PV (BIPV) technologies and solutions for utility scale, rooftop solar, distributed solar and smart grids. It is the increasingly integrated and holistic nature of new solar capacity – from the smallest individual rooftop panel to the largest solar farms – that will allow this form of clean energy to drive global adoption of renewables forward at the fast pace made necessary by the mounting threat of climate change.

As well as offering such a wide-ranging display of physical innovations and new technological solutions, the Solar & Clean Energy Forum is a perfect platform for discovering new ideas, best practices and strategies suited to optimising solar solutions at rural, urban, national and international levels. The 2020 edition of the forum hosted 90 speakers across 30 knowledge-sharing sessions, representing many of the best thought leaders from government, industry, academic, innovation and entrepreneurial sectors worldwide.

The 2022 Solar Expo & Forum during the World Future Energy Summit is part of Abu Dhabi Sustainability Week and is hosted by Masdar. To register to visit or for sponsorship and exhibition opportunities, please visit **www.worldfutureenergysummit.com**.

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Figure 2. Pyranometers, such as the plane-of-array sensor shown here, require periodic calibration to maintain their accuracy. What is unknown, however, is how local climatic factors affect calibration drift and therefore how much measurement uncertainty exists across different operating environments.

to be a key research objective. To that end, PV CAMPER has made generating and validating a set of best practices for cross-site data collection an important priority. Comparing data from different sites is only possible when common instrumentation, common O&M protocols and common validation techniques are respected and employed, a defining feature of the collaborative.

To illustrate the scope and impact of PV CAMPER's research activities, three ongoing projects are described below, one focused on the measurement accuracy of pyranometers, another on the measurement and modeling of albedo, which is a key contributor to bifacial gain, and a third on condensation as a factor in soiling losses. All three projects, both individually and collectively, offer benefits to multiple stakeholders, among them researchers, manufacturers, developers, investors, underwriters and asset owners.

Assessment of pyranometer drift and measurement uncertainty

Because irradiance is the single most important determinant of a PV system's performance; this work aims to identify climate- and installation-specific variations in solar irradiance measurement uncertainty, and to quantify the dominant uncertainty contributions in each case so that PV plant operators may improve their system performance assessments and system health diagnostics in the most cost-effective manner.

Irradiance measurement data underpins PV system performance assessment, meaning that uncertainty in this parameter directly affects the accuracy of the Performance Ratio calculation, as well as any other indicator normalised to the input solar energy.

While existing standards for PV system monitoring (e.g. IEC 61724) specify a maximum permitted calibration uncertainty, the overall in-field measurement uncertainty is not explicitly considered. The calibration uncertainty is an important contribution to the overall total, but there are many others: influences such as linearity, temperature and solar angle of incidence to the sensor are known, but rarely quantified in practice.

Historically, the lack of measurement fidelity was justified by the limited deployment of monitoring sensors and by the significant uncertainty in electrical output data captured by sensors used for energy monitoring. However, as the quantity and quality of string-level and even module-level data has increased in recent years, system diagnostics have also evolved from a simple plotting of energy output against time, to the monitoring of PV behavior under specific or normalised conditions.

As a result, there is now a greater need for more accurate determination of those conditions (especially irradiance). Furthermore, the rapid pace of technological evolution, including the deployment of bifacial and/or partial tracking systems require ground-reflected irradiance measurements, irradiance fluxes that differ significantly from typical sensor calibration conditions (high irradiance, low or zero angle to the sensor) and are non-uniform across the back of an array. This study is therefore focused on the full characterisation of multiple sensors, coincident with case studies of deployed use, to determine the boundary conditions for calibration and their impact on final uncertainty.

The main challenges are the development of significant full-characterisation methods, at a cost that is reasonable and practical to use, and the sourcing of a wide range of different system installation types and operating environments. Fortunately, the PV-CAMPER collaborative is made up of partners distributed across the globe in many different operating climates, with access to commercial PV systems of different designs and operating the highest quality research laboratories.

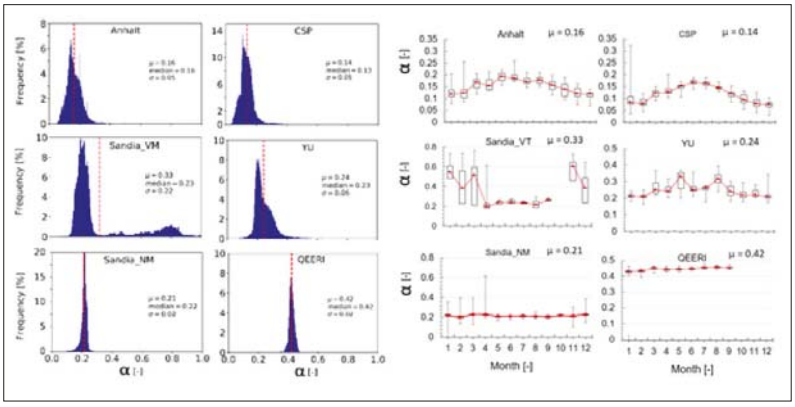
So far, the study has focused on quantifying variation in the angular response of different pyranometers, using different calibration methods, which provides plant operators the choice of either a more reliable uncertainty envelope, or to calculate a point-by-point uncertainty. The next phase will determine the influence of operating climate on rates of calibration drift, to provide data-based decision-making on the necessary frequency of sensor recalibration. The ultimate goal is to develop readily implemented full-characterisation methods, at a cost that is reasonable and practical to use across a wide range of system installation types and operating environments.

A study of the accuracy of ground-based albedo measurements versus satellite-based data

Albedo, the diffuse reflectivity of a surface, is an important measurement in PV performance evaluation and simulation, especially for bifacial module technologies, which are rapidly gaining market share. Yet many performance models assume albedo is constant over time for a particular substrate, even when evidence shows that albedo values can shift dramatically based on sun angle, seasonal irradiance, type and seasonal variation in vegetative ground-cover, degree of backside shading, presence and degradation of snow, and prevalence of airborne particulates, such as soot, that absorb light. Only by quantifying the temporal and spatial variation in albedo

Table 1: Site description

Site	Country	Lat., Long.	Climate zone
Anhalt	GER	51.77°N, 11.76°E	Cfb
CSP	GER	51.49°N, 11.93°E	Cfb
YU	South Korea	25.32°N, 51.43°E	Cwa
Sandia_VT	VermontUSA	44.47°N, 73.10°W	Dfa
Sandia_NM	New MexicoUSA	35.05°N, 106.54°W	Bsk
QERRI	Qatar	35.83°N, 128.75°E	Bwh



Credit: PV CAMPER

Figure 4. Preliminary results of one-year albedo data with different measurements setups: (left) - Histogram of α for each test site together with mean (μ), median and the standard deviation (σ), (right) - Seasonal variation, monthly average of rear/front side ratio, (Sandia_VT: no data for October, QERRI: 9-month data only) (DITTMANN et al., 2019).

measurements can one accurately predict the performance of bifacial systems.

Equally concerning is the lack of standards for ground-based albedo monitoring. Typically, ground-based measurements rely on dual-pyranometer instruments, which consist of a class A pyranometer horizontal to the sky, and a "low cost" class C pyranometer horizontal to the ground, although sometimes combinations of pyranometer/reference cells or even reference cell/reference cell are employed. Most such instruments are fixed in place and their height can vary.

Lacking a set of best practices or standards for measuring albedo creates data inconsistencies and introduces significant measurement uncertainty, with diurnal and seasonal changes in albedo and uneven backside shading rarely considered. As a result, the potential for measurement error can be significantly higher than recognised.

With the participation of five CAMPER member institutions and the deployment of high-fidelity albedometers (dual-pyranometer instruments) across six geographically diverse sites, the objectives of this study are to:

1) Establish a set of best practices for ground-based albedo measurements, including type and placement of instrumentation, and calibration and maintenance protocols;
2) Measure diurnal and seasonal shifts in albedo across difference climate zones and for multiple years;
3) Quantify the reduction uncertainty in albedo measurements by the above technical approach;
4) Validate simulation methods for rear-side irradiance.

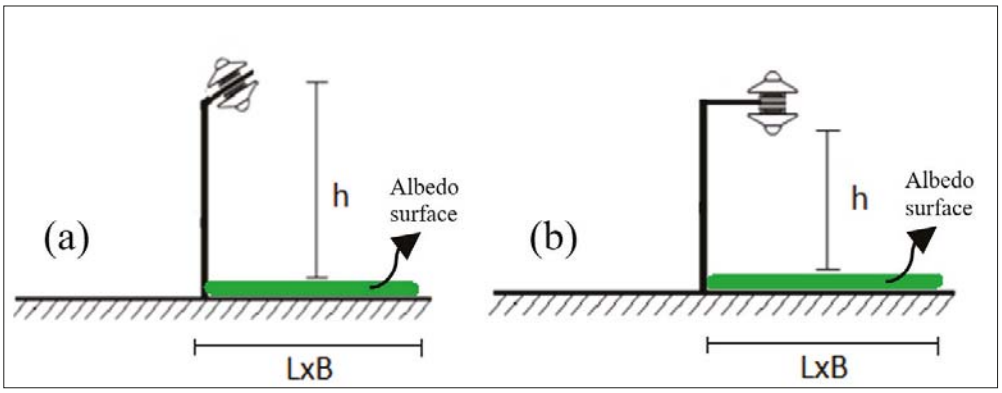
Preliminary data collected from six sites are displayed in Figure 4. Two of the sites (Sandia, New Mexico and QEERI in Doha, Qatar) show relatively little deviation in albedo throughout the year, a fact attributable to a relatively consistent climate. In contrast, the one site that sees persistent snow in winter (Sandia, Vermont) shows clear spikes in albedo five months of the year.

Table 1 provides the location, geographical coordinates, Köppen-Geiger climate classification [7] and the measurement period for the six sites included in this study. Three sites are located in temperate climates (Anhalt/CSP in Germany and YU in South Korea) while Sandia_VT (Vermont, USA) represents a humid continental climate. Sandia_NM (New Mexico, USA) and QEERI (Qatar) are located in cold desert climate and a cold semi-arid climate, respectively.

Figure 4 (left) shows the histogram of α for each test site together with mean (μ), median and the standard deviation (σ). In moderate climates, α is more widely distributed around the mean, while in the desert climates the distribution is very narrow. At Sandia_VT two maxima are formed in the distribution. One around 0.2 which represents the summer months and around 0.7 which represents the winter months with persistent snow cover.

Figure 4 (right) shows the monthly mean value of α in a box plot diagram. Seasonal variation at Anhalt can be attributed to changes in vegetation as the grass turns from green to yellow/grey to brown. At CSP, the albedo similarly reflects vegetative changes but is also affected by the shading of nearby PV modules. In contrast, the constant albedo measurements at QEERI are indicative of a consistent climate and highly reflective substrate. The data from Yeungnam University in Korea should similarly show low variability, but in this case the sudden upticks in May and August can be attributed to artificial whitening of the substrate.

Overall, this work demonstrates that albedo or the rear/front side irradiance ratio (α) can vary over time, depending primarily on the substrate type as well as the local climate. If not carefully considered, all these effects can have



Credit: Anhalt University of Applied Sciences in Germany.

Figure 3. Representative albedometers, with upward and downward-facing pyranometers, one set at a tilt angle representative of plane-of-array irradiance; the other one horizontal to the ground (h=1.5m).

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a profound impact on the uncertainty of performance projections. This work speaks to the importance of applying standardised and reliable measurement methods to multiple sites to reduce measurement uncertainties and to increase the accuracy of performance models and associated LCOE calculations for bifacial PV plants.

The effect of condensation on PV soiling rate – A global study

It is well known that condensation (dew) plays a major role in PV soiling. The main effect is that moisture traps dust particles to the module surface, and it can also "cement" the dust in place after the condensation dries out. On the other hand, if there is a lot of condensation it can run off the modules and in fact clean them.

Despite these important effects, the quantitative link between condensation and PV soiling rate is not well known. The main reason is that condensation sensors (and data) are not common — such sensors are not included in usual weather stations, and there are few "industrial grade" products available in the market for standalone use.

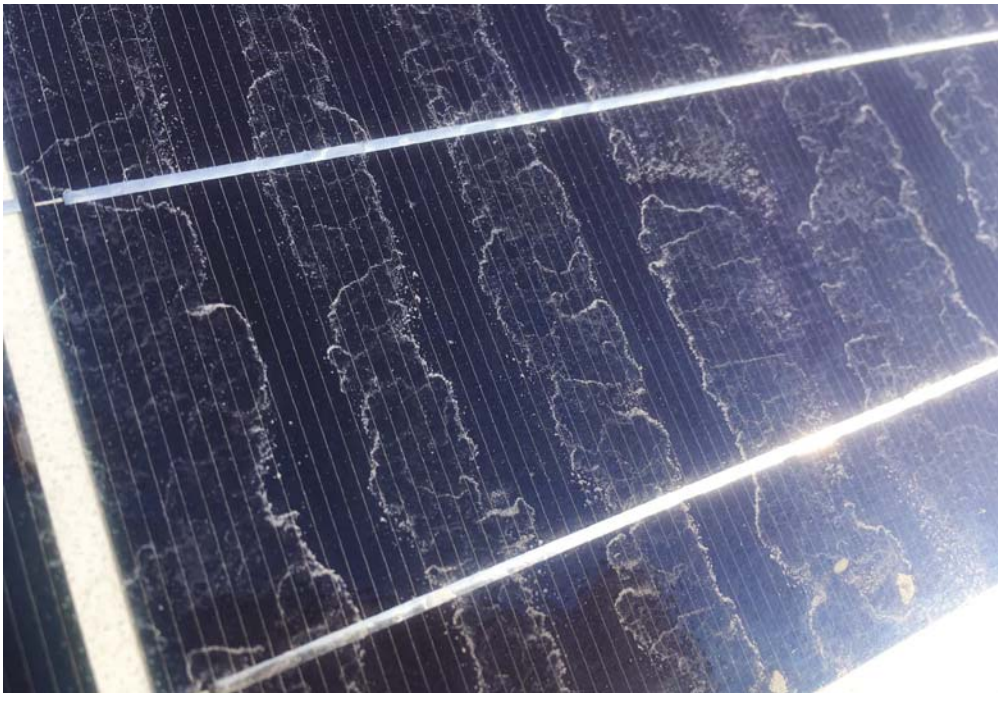
The goals of this PV CAMPER study are twofold: First, to develop and validate an inexpensive condensation sensor for use with PV systems; and second, to deploy such sensors globally to study the effect of condensation on the PV soiling rate, in different environments.

The study is led by QEERI, and currently involves nine PV test sites run by PVCAMPER and other organisations. The condensation sensors were developed and validated by QEERI in 2019-20, and confirmed to give similar values as a commercial reference sensor (costing roughly 100 times as much). QEERI began making and supplying condensation sensors for the project participants from mid-2020.

As well as condensation, participants measure other meteorological conditions and the PV soiling rate at their sites. The data is being consolidated and verified by QEERI. So far, the goal of achieving a wide variety of condensation and soiling conditions has been met. It is expected that by late 2021 sufficient data will be available for robust statistical analysis of the effect of condensation on PV soiling rate in different climates. Hopefully, this information will help improve predictive models of PV soiling rates, and improve physical understanding of the soiling process.

Conclusions

As the global solar economy continues to expand and diversify, a coordinated research effort is needed to 1) ensure the performance and reliability of emerging technologies across different operating environments; 2) support the development of technologies that are climate optimised; and 3) build greater confidence in lifetime energy predictions for PV systems by improving the accuracy of performance models and the data that feeds into them. PV CAMPER has stepped into that void, providing both researchers and industry partners with a technical platform for reducing uncertainty in the solar sector and a scientific basis for technological evolution that recognises solar is not a one-size-fits-all commodity. ■



Credit: PV CAMPER

Figure 5. Condensation is important and complex in PV soiling because it can trap dust particles but also remove them

Acknowledgments

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References

DITTMANN, Sebastian et al. Comparative Analysis of Albedo Measurements (Plane-of-Array and Horizontal) At Multiple Sites Worldwide. *36th European Photovoltaic Solar Energy Conference and Exhibition*, p. 1388–1393, 2019.

IEA. *Solar - Fuels & Technologies*. Disponível em: <https://www.iea.org/fuels-and-technologies/solar>. Acesso em: 16 ago. 2021a.

IEA. *Solar PV – Tracking Report*. Disponível em: <https://www.iea.org/reports/solar-pv>. Acesso em: 16 ago. 2021b.

IRENA. *World Adds Record New Renewable Energy Capacity in 2020*. Disponível em: <https://www.irena.org/newsroom/pressreleases/2021/Apr/World-Adds-Record-New-Renewable-Energy-Capacity-in-2020>. Acesso em: 16 ago. 2021.

SANDIA NATIONAL LABORATORIES. *PV CAMPER*. Disponível em: <https://energy.sandia.gov/programs/renewable-energy/photovoltaics/pv-systems-and-reliability/pv-camper/>. Acesso em: 16 ago. 2021a.

SANDIA NATIONAL LABORATORIES. *Regional Test Centers*. Disponível em: <https://energy.sandia.gov/programs/renewable-energy/photovoltaics/regional-test-centers/>. Acesso em: 16 ago. 2021b.

STEIN, Joshua S; KING, Bruce H. Modeling for PV Plant Optimization. *Photovoltaics International*, v. 19th, n. February, p. 101–109, 2013.

Authors

Laurie Burnham, Sandia National Laboratories. Sebastian Dittmann and Ralph Gottschalg, Anhalt University of Applied Sciences and Fraunhofer Center for Silicon Photovoltaics CSP. Tom Betts, Centre for Renewable Energy Systems Technology. Ben Figgis and Ricardo Rüthe, Qatar Environment and Energy Research Institute (QEERI) BKU. Aline Kirsten Vidal de Oliveira and Marília Braga, Universidade Federal de Santa Catarina. Carlos D. Roriguez-Gallegos and Thomas Reindl, Solar Energy Research Institute of Singapore (SERIS). Soo-Young Oh, Yeungnam University. Khawla Ettalbi, Institut de Recherche en Energie Solaire et Energies Nouvelles (IRESEN).

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Demanding data

Software | Pressures on PV plant performance have led the solar industry to be more demanding and forensic of the data operational projects generate, as well as the power. Jules Scully explores the growing role software is playing in the utility-scale solar arena and how it must evolve further still to meet expectations.

Data spanning areas such as equipment performance, system monitoring and price forecasts have presented an opportunity for software providers to help solar asset owners maximise output from operational PV plants and optimise revenue streams.

PV project data can be collected from a supervisory control and data acquisition system (SCADA) and grouped into asset management platforms to improve operators' understanding of plant performance.

But while data offers invaluable inputs to the design and operation of solar assets, a recent report from DNV revealed that "an incredible volume of data remains largely under-utilised", specifically the detailed performance and operation of plants and components. Insights into the performance of modules, inverters and trackers often remain buried under the uncertainties of weather, system availability, module soiling, shading, clipping and curtailment losses present in operating systems, the quality assurance consultancy said.

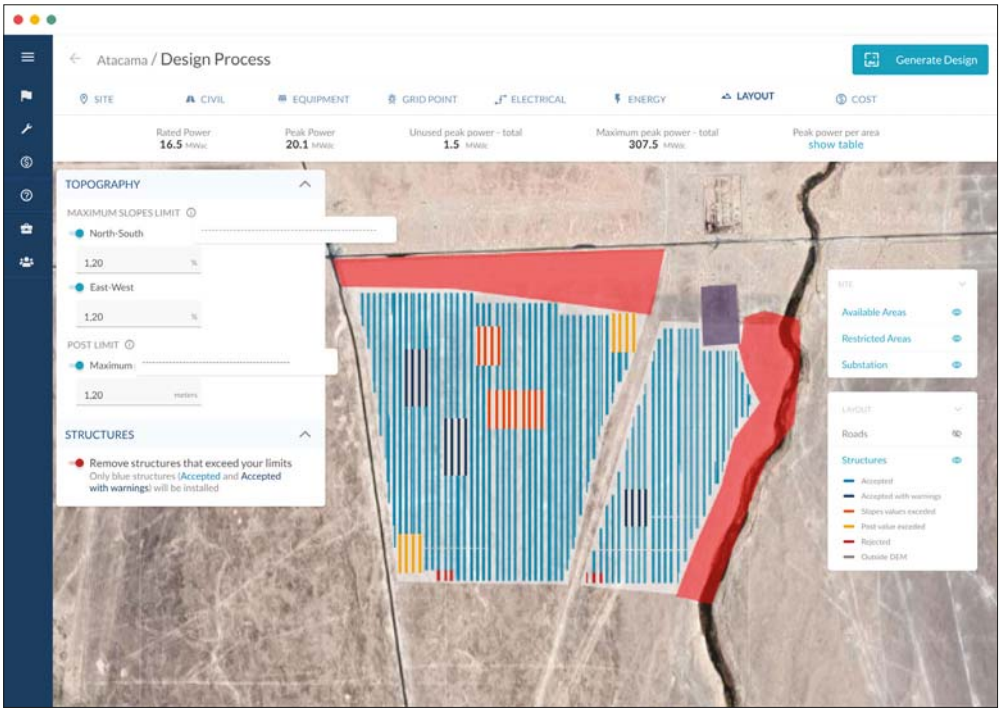
One software provider that aims to distil and interpret operating PV plant data to improve performance is Clear Sky Analytics, a US-based company that has offered insight for more than 150 solar projects since its inception in 2017. Acquired by testing, inspection and certification firm UL in May of this year, Clear Sky offers software that integrates data quality management, performance modelling and analysis algorithms.

The automation of codified PV subject matter expertise and data curation methods allowed for the development of algorithms designed to attribute observed losses to specific categories, says Ajay Saproo, global lead, solar asset advisory at UL, and founder of Clear Sky Analytics. The resulting accounting of lost and generated energy is said to enable actionable analytics to assess and optimise solar plant performance.

Saproo says a wealth of operational data on available solar resource, weather, energy generation and operating parameters from inverters and other components is being collected from a rapidly growing installed base of operating solar plants, with software evolving in response.

"With subsidy-free business models and overall improvement in capital efficiencies with new technologies, there is a greater focus on improving return on deployed capital. This drives demand for software that allows the PV power generation industry to optimise technical and business operations," he adds.

The acquisition of Clear Sky came two months after UL launched software called HOMER Front & UL Analysis with the intent of helping project developers evaluate the profitability of utility-scale solar, wind and storage systems, and follows a recent trend of consolidation in the solar software space.



Credit: RatedPower.

A screenshot of RatedPower's pvDesign solar software.

A consolidating market

California-headquartered Power Factors has grown to support 110GW of renewables assets following its purchase of Europe-based software providers Greenbyte and 3megawatt. Bringing together Power Factors' presence in the US and knowledge of solar with Greenbyte's strength in Europe's wind market means that investors who have assets in multiple regions can benefit from the combined companies' experience in both regions, according to 3megawatt CEO Edmée Kelsey.

"We see increasingly that investors invest in multi-technology portfolios, so they not only do solar, but they may do solar, wind and hydro. So they will need the software that will be able to support all these different renewable energy resources," she says.

While Power Factors and Greenbyte are focused on the asset performance monitoring space, 3megawatt is said to be stronger in commercial asset management, in areas such as invoicing, reporting, and contract and complaints management. Alongside automating repetitive

Consolidation in the solar software sector in 2021

This year has seen an uptick in merger and acquisition activity in the solar software space as companies combine to bolster their offering and access new markers. Here are some of the M&A highlights of 2021 so far.

January: Enphase Energy snaps up Sofdesk
In a deal that Enphase said would "supercharge" its digital transformation efforts, the microinverter supplier bought Montreal-based Sofdesk, the developer behind Solargraf, a platform that enables solar installers to design PV systems and produce quotes for customers. The transaction also included Sofdesk's Roofgraf tool, which is used by roofing contractors to generate proposals.

February: BayWa r.e. buys Kaiserwetter platforms
Complementing its 2019 acquisition of Canadian software house PowerHub, BayWa r.e. purchased two platforms from German firm Kaiserwetter. The ARISTOTELES software included in the deal is designed to maximise the performance of renewables portfolios, while the IRIS tool provides insights for areas such as due diligence.

April/May: Power Factors acquires Greenbyte, 3megawatt
US-based Power Factors secured two European deals in as many months, buying asset management platform Greenbyte as well as 3megawatt.

May: UL purchases Clear Sky Analytics
Having launched software for renewables hybrid projects in March, certification firm UL went on to acquire Clear Sky Analytics to boost its capabilities in assessing and optimising solar plant performance.

August: Aurora Solar acquires Folsom Labs
Building on a US$250 million funding round earlier in the year, solar sales and design software provider Aurora Solar bought Folsom Labs, the developer of HelioScope, a software solution for designing commercial PV systems.

tasks such as invoicing, 3megawatt's BluePoint software centralises power plant information, creating workflows for day-to-day activities.

Questioned on the challenges of providing solar software solutions, Kelsey says hurdles can arise when engineering, procurement and construction (EPC) contractors use obscure or cheap equipment, potentially leading to higher running costs for asset owners that may need to fund the installation of improved telecoms equipment, for example, in the future.

"Luckily, I think for the industry, there are now more experienced operators who will know what questions to ask when they buy assets, and they know what they're getting themselves into. But there are plenty of people still out there that will just say, well, I'll take the cheapest, and then they get problems down the road," she adds.

Data on the rise

The falling cost of internet of things sensors and communications networks has helped expand the use of advanced analytics such as asset performance management and also the use of in-field digital tools such as augmented reality, according to BloombergNEF (BNEF). The research organisation last year predicted that the global power sector would spend US$3.2 billion on software in 2020 to optimise the performance, costs and revenues of generation and grid assets.

BNEF projected that utility-scale solar and battery plants will be the fastest growing sectors for software adoption, considering the large amount of capacity to be built over the coming years.

This forecasted increase in software investment follows recent technological advancements allowing data to be communicated to solar project owners. "I think the difference between now and say five or ten years ago is the amount of data that is bubbling up through the ranks," says Liam Smith, a director at sustainable infrastructure investor Actis.

While investors might have historically been limited to analysing plant output, the availability of data at cloud level means they can now explore the performance ratios of plants adjusted for heat and climate as well as key performance indicators (KPIs) such as inverter level availabilities, soiling losses, irradiance and temperature.

"I don't think it's more data, it's just data that's now finally being communicated," Smith says. "Previously, it was all just being lost in a data lake never to be reviewed again; now, it's actually being accessed."

With this increase in available data, Smith says there are now three pillars of different software that help solar asset owners optimise project performance, the first of which is an off-the-shelf platform such as PVsyst. The second category relates to what Smith describes as more bespoke asset monitoring software, such as WinJi or Bazefield, that enable the first round of synthesising the data into something that is understandable and actionable. The final pillar consists of bespoke machine learning algorithms that allow asset owners to be proactive rather than reactive and is centred on areas such as improving availabilities and minimising grid penalties for unpredictability.

In a rapidly changing technological environment, Smith says some software providers have been able to keep up with the "incredibly quick turnaround time" between when bifacial modules were in the lab to when they were commercialised. Actis consequently monitored bifacial performance at lab scale and then used bespoke algorithms and machine learning approaches to develop its own bankable predictive modelling.

Other solar asset owners and managers contacted by PV Tech Power that have created their own software or platforms include German independent power producer Enerparc and WiseEnergy, which is part of the NextEnergy Capital Group and has managed more than 1,500 PV projects globally.

"There are a lot of different solar software products for different purposes, some just for monitoring, others just for performance analysis, others that include financial figures related to the PPAs," says Jose Francisco Correia Pascoal, WiseEnergy head of technical operations. Despite recognising that software providers are quick to adapt to changes in the solar market, Pascoal says WiseEnergy couldn't find one platform to meet all the company's requirements.

The company has consequently developed its own asset management platform that allows it to both improve the efficiency of its teams and improve the performance of assets by increasing availability and reducing underperformances.

'There's no magic software'

Nearly all PV systems have monitoring capabilities enabled by SCADA systems, while asset management platforms provide a constant stream of data from sensors and inverters on site. Advanced analytics can replace Excel-based models and automate them in software to bring efficiency and additional resolution on the performance and losses of PV plants, allowing asset managers to evaluate specific losses at each site.

With a wealth of information available, asset owners face challenges when consolidating data from different SCADA providers used within a portfolio of projects. While new projects are well prepared in terms of SCADA connection, hurdles can arise when accessing data from older installations.

In a move to organise and collect SCADA data, renewables asset manager Quintas Energy set up a project called Parklife that involves creating a digital replication (digital twins) of all components within a solar project.

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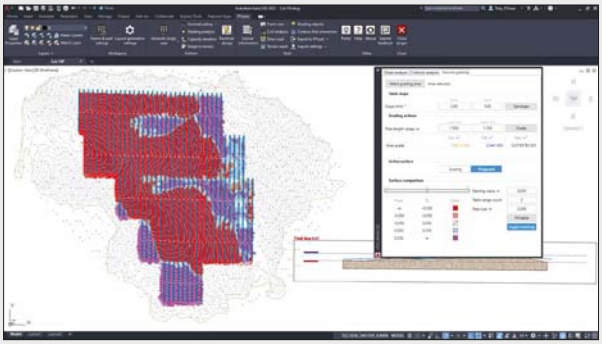
PV design software adapting for new variables

Whether used to automate time-consuming tasks or to assess site feasibility by estimating capex, software can be invaluable for developers and EPCs looking to simplify the solar project design process.



Credit: PVcase.

A screenshot of software from PVcase.

As well as helping designers make development decisions, software allows them to accurately assess energy yield and improve site performance with shading and civil analysis tools. But advancements in solar technology, such as the introduction of trackers and bifacial modules, have presented hurdles for software providers required to continuously update their offering to incorporate the latest industry trends.

"This is not simple," says Mario Bennekers, product manager at RatedPower, which created its pvDesign software to automate and optimise the design and engineering of solar plants. "For example, to develop the bifacial calculation we had to completely adapt our energy model, as well as our modules and structure database," he says.

In a recent analysis of project simulations carried out with its software in 2020, RatedPower observed a rise in mock-ups using bifacial modules as the year went on. While 56% of simulations in the US featured bifacial modules last year, just 6.5% in the UK and 3% in Germany included the technology.

Introducing new products, keeping older products up to date as well as catering to a user base from different parts of the world are among the challenges that PVcase, another solar design software provider, has been faced with.

CEO and founder David Trainavicius says users of the company's software are increasingly working with larger installations and need more help dealing with areas such as mechanical piling and the civil parts of their designs.

"During the first years of software development, our clients were mainly looking for a time-saving tool without caring too much about terrain-based PV," he says. "Now, with PV-suitable flat land becoming harder to find in many regions, clients are looking for terrain-based layouts and civil analysis solutions."

Credit: RatedPower.

A screenshot of RatedPower's pvDesign solar software.

According to Trainavicius, the software provider has seen a "massive shift towards overall digitisation of solar engineering processes", with solar companies looking for more convenient ways to approach feasibility studies, design, construction, and operations and maintenance.

As part of a one-off process for each site, the company carries an onboarding phase involving the registration and mapping of all components to the economic and SCADA variables before the standardised data is included in a database, allowing the firm to benefit from a KPIs calculation layer. It uses Power BI, a business intelligence and data visualisation tool from Microsoft.

"It's not really software that we use to create these visualisations or to visualise data and calculate KPIs. The most relevant thing is how data is being ordered, how data is being governed from the very beginning from the collection side through these digital twins," says Antonio Dominguez, head of analytics at Quintas Energy.

Quintas has come under increasing pressure in recent years from clients looking to collect more data from assets and get the most from existing data, and the firm acts as a hub to provide information for offtakers, operators, technical advisors and clients. "So we need to be very open in that sense," Dominguez says. "And we also need that all these stakeholders become more open."

The need for additional data sharing has also been noted by Enerparc, which is required to provide more live data to the grid operator, while power purchase agreement offtakers are demanding more information related to areas such as CO2 certificates from the asset owner.

For the sector to further improve plant performance, affordable instruments to get the right input data need to be provided, according to Robin Hirschl, CTO at Danish solar investment and management company Obton.

The firm, which has solar PV systems under management across Europe with a combined capacity of more than 1GWp, is currently carrying out a programme to evaluate software solutions. "The most common answer that we get is that the raw data quality is not sufficient for the software to do what it is supposed to do. And if we get any results, they are telling us what we know anyway," says Hirschl.

"The most common answer that we get is that the raw data quality is not sufficient for the software to do what it is supposed to do.

As software providers or asset owners themselves work to develop tools to assist in the operation of ever-expanding solar project portfolios, yields can be increased and profits maximised. And as more renewables connect to the grid, software can also be expected to play a growing role in areas such as load balancing.

While there is software spanning the solar sector, from site design, accounting, predictive maintenance, site monitoring, Dominguez says "there is no magic software to manage everything". Therefore, the industry needs to make the most of existing software and business intelligence tools to ensure that everything is well governed. Dominguez says: "We can collect all data in the world, but it will never be helpful if we are not able to govern it and transform it into relevant information." ■

Junction boxes and BOMs: Takeaways from the 2021 PVEL Module Scorecard

Modules | The 2021 edition of PV Evolutions Labs' Module Scorecard saw a record number of module manufacturers recognised, but equally highlighted a growing incidence of module failure rates. Liam Stoker unpicks some of the key trends from this year's edition of the scorecard.

Credit: PVEL

Solar PV has a performance problem. Numerous studies have found operational solar projects to be performing below expectations with a plethora of problems proposed as the leading cause. While solar's underperformance against forecasts in certain cases is no doubt the result of many different issues, it is equally undeniable that some solar modules do not stand up to scrutiny.

The 2021 edition of PV Evolution Labs' Module Reliability Scorecard, published earlier this year following the testing organisation's Product Qualification Program (PQP), has highlighted a number of the most pressing issues for the industry to address as it stands on the cusp of a significant growth in scale and size.

The seventh edition of PVEL's scorecard celebrated a record number of manufacturers having been granted 'Top Performer' status. A total of 117 modules from 26 manufacturers received such status, with JinkoSolar and Trina Solar recording the "tremendous accomplishment", as PVEL head of module business Tristan Erion-Lorico described it, as having received 'Top Performer' status in all seven editions of the reliability scorecard to date. As in each of the last six editions of the PQP, in order to be recognised as a 'Top Performer' modules must have less than 2% degradation following each reliability test sequence,

Inspections underway during the 2021 Product Qualification Program.

while in the PAN file performance sequence Top Performers must finish in the quartile for energy yield according to PVsyst simulations.

Alongside regular testing sequences such as thermal cycling, damp heat and both potential-induced degradation (PID) and light and elevated temperature-induced degradation (LeTID) sensitivity, this year's PQP added a mechanical stress test sequence in response to durability concerns relating to extreme weather.

Junction box failures and BOMs

Perhaps the leading conclusion from this year's scorecard was that more work must be done by the industry to tackle

Inaugural entrant	2x Top Performer	3x Top Performer	4x Top Performer	5x Top Performer	6x Top Performer	7x Top Performer
DMEGC, ET Solar, HHDC Xining Solar, Jolywood, Risen, VSUN	Hyundai Energy Solutions, LG, Talesun Solar	Boviet Solar, First Solar, HT-SAAE	Adani, SunPower/ Maxeon, Phono Solar, Seraphim, Silfab Solar, Vikram Solar	Astronergy, GCL-SI, LONGi Solar	JA Solar, Q CELLS, REC Group	JinkoSolar, Trina Solar

The history of Top Performers charted from 2014 – 2021, indicating in how many years the named module manufacturers have received 'Top Performer' status.

the increasing prominence of junction box failures, the incidence of which rose from one in five in 2020 to one in three in the 2021 edition of the scorecard. This rise in junction box failures is an ongoing trend, with the number of manufacturers experiencing such issues rising each year.

Erion-Lorico says one of the issues of most concern regarding junction box failures is the number of junction box lids that have fallen off during transit. Furthermore, junction box manufacturers are also failing wet leakage testing – which examines the insulation resistance of the module – a core certification test that would prohibit a module from being certified for use if it failed during testing. "Seeing the number of manufacturers that are struggling with that basic test, which has been part of certification for, frankly, over a decade... That's significant, and that is something that we would have hoped the industry would have solved by now," Erion-Lorico says.

The issue with junction box failures could lie in the manufacturing process. In a standard solar module assembly line the junction box step remains manual, meaning that it is an individual's job to manually put the junction box lid into place. In most facilities, Erion-Lorico says, they do the potent dispensing too, however there is growing automation in this particular step. This leads to potentially greater room for human error in a module assembly process which is becoming increasingly automated.

> "The scale is just going to keep increasing, and we can't sacrifice quality for scale."

In addition, the evolution from largely monofacial modules using full cells, which had just the one large junction box, to bifacial modules featuring half- or triple-cut cells that require three junction boxes has increased the potential for failure even more. Those manual workers are now having to fit three times as many junction boxes just to complete a module's assembly. "When you think of the scale of this manufacturing, just on a multi-gigawatt scale, there's a bigger opportunity for error," Erion-Lorico says.

And it's this increase in scale which stands to increase the rate of module-level failures in the years ahead. As it stands, Erion-Lorico says, around 100 million solar cells are being soldered each day, and this is to cater for demand of around 170GW. To hit ambitious climate targets more than a billion solar cells will need to be soldered each day. "The scale is just going to keep increasing," Erion-Lorico says, "and we can't sacrifice quality for scale."

Also on the rise was failure rates within the bills of materials (BOMs) used in modules, with around 26% of BOMs eligible for this year's scorecard recording at least one failure. This was up on last year, when one-in-five BOMs recorded a failure. The growing failure rate of BOMs should be of interest to the industry, Tara Doyle, chief commercial officer at PVEL says, because many buyers still do not currently request BOM details during the procurement phase. "Between supply chain instability and the ever-present push for lower prices, one cannot assume that every module sold under a given model type uses tested BOM components. Buyers must specify their desired BOM in supply contracts to achieve this," she says.

Weather factors and large-format modules

For the first time in this year's PQP modules were put through their paces in a mechanical stress load sequencing, testing modules' susceptibility to cell cracking under pressures designed to replicate the kind of weather extremes an increasing number of projects are having to contend with. This sequence generated more failures than any other testing sequence in this year's PQP.

The PQP uses IEC61215 static mechanical load requirements as the basis using conservative mounts and, as a result, PVEL recommends batch testing or conducting qualification testing using chosen mounts for those intending to mount modules in a more extreme or less than ideal fashion. This year's testing discovered that microcrack susceptibility can significantly increase when using non-ideal mounts, but also that modules can still experience significant cell cracking using ideal mounting standards.

Some modules did, however, perform better than others in the PQP. Notably, half-cut cells performed better than full cells, while modules featuring 120-cell designs performed better than those designed in 144-cell formats. Multi-busbar cells performed better than those using three, four or five busbars, and interdigitated back contact, cadmium telluride (CdTe) thin film and double-glass module technologies exhibited minimal degradation.

As an extension of what was seen in this year's PQP, some developers have noted concerns that large-format modules could be more at risk of microcracks as a result of clamping larger, heavier modules using traditional systems that would place the module under greater pressures during wind or other mechanical load events. Erion-Lorico says that while PVEL does have a number of BOMs of large-format modules undergoing stress tests, the results have yet to be compiled. Nevertheless, it is an area of concern for PVEL given the results of this year's PQP.

"We have seen, and we've already reported on an increase in microcrack susceptibility between identical BOMs of 60-cell and 72-cell [modules] using smaller format cells. With 158.75mm and 166mm [cells] we see a pretty significant difference in microcracking between two identical modules of different sizes, so by extension, it stands to reason that going to even larger modules is going to result in more microcracking," he says.

The real crux of the matter is if that greater microcracking actually results in increased power loss. As the results of this year's mechanical stress sequence identified, modules with multiple busbars demonstrated less power degradation, meaning a large-format module with multiple busbars could still perform well despite microcracks. "Microcracks aren't always a bad thing, I don't think they're a

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PVEL 2021 Mechanical Stress Sequence 'Top Performers'

Manufacturer	Model Types
Boviet Solar	BVM6612M-xxxL-H-BF (BVM6610M-xxxL-H-BF); BVM6612M-xxxL-H-BF-DG (BVM6610M-xxxL-H-BF-DG); BVM6612M-xxxL-H-HC-BF-DG (BVM6610M-xxxL-H-HC-BF-DG)
ET Solar	ET-M672BHxxxTW (ET-M660BHxxxTW)
First Solar	FS-6xxxA
JinkoSolar	JKMxxxM-7RL3-V
LG Electronics	LGxxxN1C-N5 (LGxxxN1C-V5)
LONGi Solar	LR4-60HPB-xxxM; LR4-72HBD-xxxM (LR4-60HBD-xxxM); LR4-72HPH-xxxM (LR4-60HPH-xxxM)
Maxeon/SunPower	SPR-Axxx-G-AC (SPR-MAX5-xxx-E3-AC, SPR-Axxx, SPR-MAX5-xxx)
Phono Solar	PSxxxM4GFH-24/TH
Q CELLS	Q.PEAK DUO L-G5.2 ;Q.PEAK DUO BLK ML-G9+
Seraphim	SRP-xxx-BMA-BG

good thing, but they don't always lead to significant performance loss," Erion-Lorico says.

Further sequences to replicate weather events such as hail are under consideration, however the lessons for the industry from this year's mechanical stress sequence are that PQP reports per module are used as a guide, rather than any definitive example of performance under stress. If the mounts used by PVEL aren't representative of those intended for a particular project, then more significant failures could be expected in the field. "We have seen modules break and we have seen broken glass in mechanical stress sequence testing… and I think we're going to see more of that as modules get larger, particularly because… the frames aren't necessarily getting thicker, the glass isn't getting thicker, it's using the same module BOMs just on a larger format, and there's inherently some risk involved there," Erion-Lorico says.

Looking forward, Erion-Lorico also notes that the trend for larger-format modules to have smaller distances between each cell – utilising novel approaches such as gapless or seamless soldering or tiling ribbon, but all in a bid to bolster module efficiencies – could result in thermal cycling results deteriorating in future PQPs. Module performance under thermal cycling has improved in recent years, however PVEL is concerned that this could reverse as larger-format modules become more common. "We haven't yet finished the thermal cycling test sequence on large-format modules with gapless soldering. I think until we've tested a number of BOMs through that and gotten more comfortable, that's still quite a question mark," Erion-Lorico says.

For the full details of PVEL's 2021 Module Reliability Scorecard, visit **modulescorecard.pvel.com.**

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Unlocking floating PV's power potential

Floating solar | Toni Weigl, head of product management for floating PV at BayWa r.e., explores the current trends for designing and developing floating solar projects and poses the question, where next for floating PV?

Credit: BayWa r.e.

The Bomhofsplas solar farm near Zwolle in the Netherlands.

Over the years, ground-mounted solar installations have become a familiar sight across the world. Sprawling solar farms and rooftops decked with solar panels are now commonplace. However, as governments and businesses across the globe strive to further innovate and diversify the renewable energy mix, some exciting new PV applications have entered the space.

One application that is experiencing rapid growth is floating PV, having grown more than 100-fold in the past five years. Resting on large bodies of water, these installations have a number of benefits - not least in helping to avoid land conflict, as many parts of the world become more and more densely populated and less able to relinquish land to ground-mounted solar.

These benefits - amongst others that we will move on to further in the article - are beginning to position floating PV as far more than just a niche contributor to global solar capacity. In a recent report, The World Bank noted that worldwide there are around 400,000 square kilometres of man-made reservoirs, suggesting that this new technology has theoretical potential on a terawatt scale. It says, as a conservative estimate, that this could unlock more than 400GWp of floating PV, which is equivalent to the total global installed solar capacity in 2017. It's estimated that Europe's contribution alone to this generation total could be around 200GWp, if only around 10% of Europe's man-made freshwater reservoirs would accommodate floating PV.

In August 2021, the IPCC published the world's largest ever report into climate change, setting out the stark reality for the state of the planet. Whilst there isn't a silver bullet for changing the trajectory of global warming, now is the time for economies and organisations across the world to consider new and evolving possibilities for the renewable energy mix. Floating PV is certainly one of those possibilities, but what are the challenges it faces and how can we overcome them to help further grow the technology's potential across the globe?

The many advantages of floating PV

This brings us to the sprawling advantages of floating PV. One of its biggest benefits, is that it can make an important contribution to the green energy revolution while diffusing debates around land usage. This is particularly beneficial in countries or regions where high population density increases pressure on the availability of land. Many expanses of water offer significant surface areas which are not used for any purpose (like disused mining or mineral extraction lakes) or can be combined with floating PV (like water storage or irrigation reservoirs).

Of course, if the water surfaces do serve another purpose like human recreational activities or as important habitats for animals, those lakes are not to be considered for floating PV, but the remaining water surfaces still present a huge untapped potential. Decommissioned open-cast mines and quarries, gravel pits, reservoirs and aquaculture ponds are all suitable water surface sources for floating PV installations. In addition, compared to other renewable energy technologies, floating PV offers comparatively fast and easy installation and maintenance.

The cooling effect

While this is still a relatively new technology, it's already clear that floating PV can also offer potentially higher yields than its ground-mounted equivalent, thanks to the water-cooling effect. The anticipated potential extra yield of 2-3% in the Netherlands where floating PV is already being employed in Europe may not seem hugely significant, but over a lifetime of 25 or more years that is a lot of energy and every percent of extra gain makes a huge impact. Furthermore, it is an early sign of its global

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potential particularly in warmer climates that will benefit from the water-cooling effect even more.

Surface shade and water cover

A further benefit is that as solar panels provide both surface shade and water cover, they reduce water evaporation and limit the impact of wind and waves on the banks. Water quality is also improved as the panels discourage the growth of certain algae. In countries where water shortages are becoming of increasing concern, the evaporation-reduction feature of floating PV installations can be particularly advantageous. It's worth noting that according to professor Eicke Weber, former director of the Fraunhofer Institute for Solar Energy Systems, more water evaporates from reservoirs than is consumed by humans!

Perfect partnership with hydropower

The existing electrical transmission infrastructure located at hydropower sites, such as dams, means floating PV and established hydropower operations can make great partners. The floating PV park could benefit from the electrical infrastructure of the hydro power plant while it is reducing water evaporation, leading to higher yields for the hydro power plant. The combination of the two energy sources can also help the dam's operator manage water levels or to use the dam simply as a huge battery. According to the World Bank report, where floating PV is deployed on large hydropower sites: "The solar capacity can be used to boost the energy yield of such assets and may also help to manage periods of low water availability by allowing the hydropower plant to operate in 'peaking' rather than 'baseload' mode.

"The benefits go both ways: hydropower can smooth variable solar output by operating in a 'load-following' mode. Floating PV may therefore be of particular interest where grids are weak, such as in Sub Saharan Africa and parts of developing Asia."

The challenges

Yet, with every emerging technology, challenges exist to slow down its success and viability as a positive force on the climate. From water contamination and salt levels being too high and impacting implementation, to costs, technical challenges and a lack of societal support – floating PV has come up against a number of issues. However, the first step is identifying the challenges.

Societal support

Often local-level objection halts global enhancement. NIMBYism and community understanding can sometimes greatly delay the execution and completion of the project. For a project to be implemented, planners must be granted a permit - and this can be a challenging topic.

The first issue surrounding permits is – at times – a distinct lack of understanding surrounding which permits are actually needed for the operation of floating PV installations. Specific regulations addressing permitting or licensing, and legal interpretation is required in each country, but sometimes they do not exist or are not fully formed. Sometimes (i.e. in Germany) even within a country the framework is different in each region and the interpretation is different between lawyers and local authorities. Nor are there any universal standards surrounding water rights, electrical connections, construction requirements or energy/water company permits.

Therefore, even if what appears to be a very safe and effective project is presented to the authorities, a lack of understanding of what constitutes 'meeting the standards' for implementation, means authorities often have difficulties to approve it to go ahead.

Of course, it is only expected that local authorities and residents may question how the implementation of floating PV will impact on their quality of life and the quality of their natural environment. Before any installation takes place, it's important that floating PV can integrate into the landscape on an aesthetic and practical level. Floating PV arrays do not have a high visual impact as they are more likely to blend in with the surface water where they are located. Nevertheless, community outreach and alignment are vital in ensuring floating PV makes a positive impact on the local environment and population. Ahead of a project's construction, many information evenings, personal discussions and feedback opportunities can be organised with local residents and associations to ensure a collaborative approach to the project. Neighbours to BayWa r.e.'s Tynaarlo floating PV park are testament to this. Community funds can also been set up to promote ongoing sustainable activities and investment in the local areas.

This is also the case for the general implementation of renewable energy technologies, particularly in light of the ever-worsening climate crisis that the world faces. Solar and wind solutions can generate more power from the same footprint than ever before. However, we are increasingly seeing that the pace of innovation is moving faster than local policy allows. It is a race against time, and to help implement projects at a faster speed, governments, businesses and policy makers must focus on local education and collaboration with communities to overcome legislative barriers and gain community trust. This kind of education - alongside education about protecting the environment generally - could begin at a school age to help educate children about climate change and the technologies that exist to combat it.

Economic viability

Clearly, investment and cost of capital are important considerations when applying any technologies, especially relatively new ones. But while installation costs for floating PV are currently slightly higher than those for ground-mounted solar, it is anticipated that these will fall fairly quickly as the technology matures and production rates increase.

Even in the shorter term, it is important to note that higher yield from water

Credit: BayWa r.e.

BayWa r.e.'s Tynaarlo floating PV park is an example of residents and associations taking a collaborative approach to the project

cooling effect, reduced O&M costs and quick installation balance out the higher initial investment costs that are needed. The huge water surface areas available will offer the potential to build much larger power plants, which in turn reduces the specific build costs thanks to economies of scale.

The World Bank's view is that while this is a nascent sector, there should be sufficient experienced suppliers active in the market to enable developers to achieve appropriate project finance. Several parties, including BayWa r.e., have proven that banks and investors are keen to finance and buy these projects. And once built, operation and maintenance of such floating PV installations is straightforward and cost-effective – providing, of course, that the design and construction has been carried out diligently.

Technology, structure and design

All floating PV needs adequate anchoring and mooring to withstand wind, waves and current – a recurring problem for some of the early projects. Also, depending on the location and climate, individual plants need to be able to withstand additional conditions caused by the surroundings.

Questions of cable duct durability and stability needed to be addressed too, along with identification of the most appropriate materials – plastic or steel – and the choice between east/west or south-facing floating arrays. While the number of suppliers in this sector had previously been limited, many new suppliers have emerged in recent years.

Developers keen to maximise their opportunities in this sector would be wise to draw on the experience of other companies which already have a track record in operating in an aquatic environment. Additional funding and policy support can also help to build up more knowledge throughout the industry.

Ecosystems

Comparatively speaking, little is known about the impact floating PV may have on the environment, however first results from Hanze University of Applied Sciences in Groningen about a BayWa r.e. floating PV park have been published. This independent research found positive results on water quality. Further, BayWa r.e. is working with Buro Bakker / ATKB on an investigation of biodiversity and ecology of floating PV.

"Bio huts" are being submerged beneath the floating solar panels at the floating PV park Bomhofsplas, filled with seashells to potentially encourage marine life and greater biodiversity

According to the water quality monitoring carried out by Hanze University of Applied Sciences, the water quality showed no major differences in the measured key water quality parameters below the solar panels, such as conductivity, temperature or dissolved oxygen. The temperature at the upper layers was only slightly lower under the solar panels, and there were fewer temperature fluctuations detected. The system used in the project, which allows wind and sunlight to easily reach under the panels, was identified as a possible reason for this. When looking at the site as a whole, the researchers found that the water quality below the floating PV farm remained at the same level as the surrounding water surface.

As part of the university's research into the effects of floating PV panels on water, ecology and biodiversity, it also observed that the presence of the panels leads to less wind activity on the water surface, resulting in less erosion of the banks and therefore protecting and stimulating vegetation. Furthermore, the floating PV park can be additionally equipped with bio huts to further stimulate the growth of the fish population.

After this first year of research, no initial negative effects have been seen. However, multi-year research is required to establish clear results and studies will be ongoing over several years to monitor the long-term effects in detail.

Developers and operators alike will need to consider the impact on ecology, wildlife and marine life – the more this can be measured and recorded, the easier it will be for future installers to demonstrate minimal environmental impact. This will also pave the way for more acceptance and easier, more straightforward permit procedures.

What's next for floating PV?

The benefits of floating PV are clear. In a world that is becoming more densely populated by the second, land is scarce and with the climate challenge racing towards us, we need new options for generating solar power. Whilst the technology still has many 'unknowns', initial research shows that floating PV does not have a negative impact on the environment. However, this research must continue.

Although capex costs are still a bit higher in comparison to other solar technologies, these are anticipated to fall as technology advances. There's also a small but growing pool of suppliers and developers with the expertise to achieve commercial project finance, which will in turn help to increase uptake.

As floating PV continues to evolve, it will become a technical and economical option that is complementary to 'standard' PV systems. Thanks to the falling cost and increased understanding of the benefits of the application, the future of floating PV is bright. The global expansion of floating PV will serve as an important contribution to the green energy revolution without competing against other uses for land.

There is excitement around floating PV, and for good reason. At BayWa r.e. we see the vast potential, and encourage others to do so too. Our goal is to implement a further 500MWp of floating PV projects by 2025, and by 2030 we hope to be able to also build them in more challenging environmental conditions like offshore. ■

References

[1] Nan Zhang, 2020, Nano Technology, Volume 77

[2] World Bank Group, 2018, Where Sun Meets Water: Floating PV Report, Volume 1

[3] Talal Yusaf, 2021, "Sustainability", 13 (11), 6421

Author

Toni Weigl has been dedicated to photovoltaics since 2008 with a strong background in electrical and mechanical engineering from his M.Sc. in Power Engineering from the TU Munich. He worked in various PV related environments. In 2018, Toni joined BayWa r.e. Solar Projects as a project manager. He is now head of product management floating PV, driving forward the global expansion of FPV within BayWa r.e.

PV MODULETECH BANKABILITY RATINGS

The industry's most trusted PV module supplier bankability rankings – quarterly-updated analysis from PV Tech Research

The report provides everything you need to benchmark all your existing/ potential suppliers against each other in terms of bankability, limit your supplier short-lists to only the most financially stable, risk-averse companies and help you avoid the near-bankrupt entities claiming to be "Tier 1 suppliers".

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- **Financial operations of each company - both public-listed and privately-held - in a clear, understandable format, all benchmarked to PV industry operating norms**
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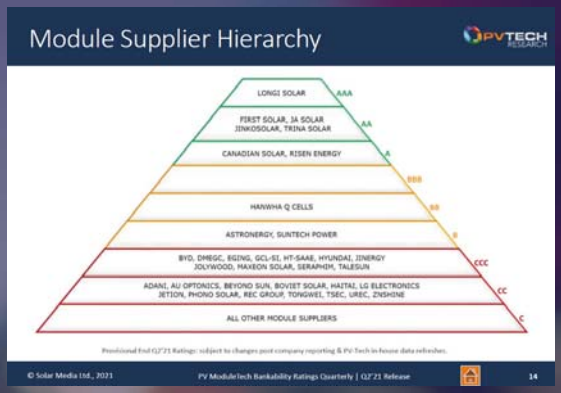
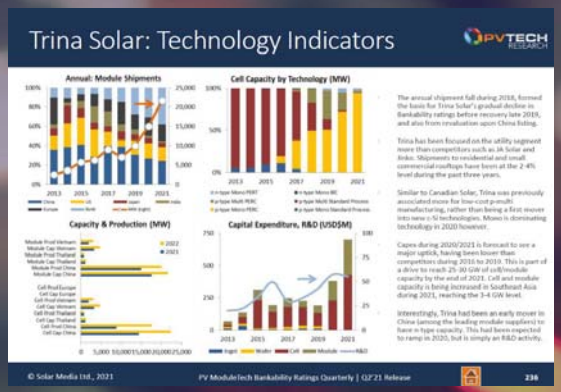
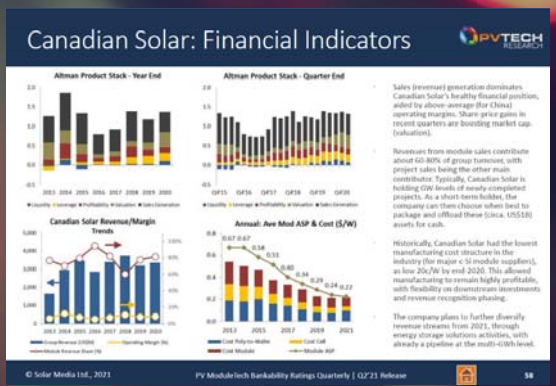
- **A must-have for buyers of modules or anyone undertaking assessment of potential suppliers at the utility scale level.**







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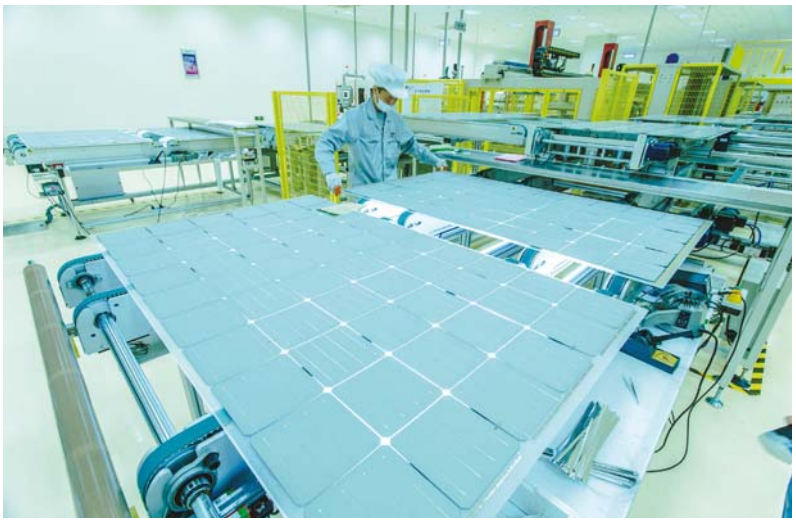
SOLAR MEDIA MARKET RESEARCH

PV ModuleTech Bankability Ratings: Perspectives on reporting accuracy two years after the initial release

Bankability | Finlay Colville, head of research at PV Tech, reviews the PV ModuleTech Bankability Ratings two years after their initial launch, reflects on those manufacturers to have moved up and down the ratings hierarchy since its launch and ponders how the rankings will evolve in the coming quarters.



Credit: LONGi.

LONGi Solar remains the only AAA-rated solar module manufacturer in PV ModuleTech's Bankability Ratings.

Following nearly a decade of feedback from the PV sector, PV Tech released its first PV ModuleTech Bankability Ratings report in the second half of 2019. This was accompanied by a host of feature articles on pv-tech.org that explained clearly the methodology used to benchmark module suppliers for supply to large-scale commercial and utility-scale projects globally.

The output from the quarterly updates to the ratings report has now been firmly accepted within the industry as the leading platform to fully understand module suppliers in terms of manufacturing and financial health status. The ratings assigned to each company (AAA-Rated for the highest, down to C-Rated for the lowest) are now used routinely by investors and developers to help de-risk module supplier selection for individual sites and portfolios of projects globally.

When we released the methodology and analysis, we analysed in detail the prior decade of data accumulated for the different module suppliers (from manufacturing and financial perspectives). This was key to ensuring that the ratings assigned to each module supplier were accurate for any given time period in the industry over the trailing decade, in addition to what was being seen in the market in real time. This was critical in developing the methodology and statistical analysis, and the relationship between quantitative and qualitative inputs.

When we released the analysis in 2019, we emphasised that the strength of the model was in being able to identify risk factors (or 'red flags') on a forward-looking basis. In fact, two years down the line, this has been the most common factor discussed each quarter with the users of the report; for example, knowing which companies are at risk from a lack of in-house manufacturing, are aligned with a non-mainstream industry technology, or have growing debt/profitability concerns.

This article reflects upon the report output over the past couple of years, using some of the leading ranked module suppliers to illustrate the accuracy of the PV ModuleTech Bankability Ratings output during this time. The results of the latest report (the Q3 2021 release) are then shown, with a discussion on some of the major changes in the past couple of years at the supplier level. Finally, areas that are under review within the analysis are discussed, including those that may be required to be adjusted going forward in order to keep the benchmarking as accurate and relevant as possible.

Where does the data come from?

Before looking at the output from the ratings reports, it is prudent to address the most common question we receive from report users during early discussion phases: "where do you get all the data from?"

It is not entirely surprising that module users ask this question. The PV industry still has a few hundred companies claiming to make modules (even more when we include companies that simply rebrand products to the end-user), and many of these suppliers are based in China with limited audit trails visible to the global community. Additionally, even when looking at the top 20 module suppliers, only a few of these companies today are reporting quarterly data using 'western' accepted accounting practices. As a point of reference, by early 2022, the only top 10 module supplier that will be listed on a US or European stock exchange will likely be First Solar, with the final US-listed entities (Canadian Solar and JinkoSolar) moving manufacturing activities to Chinese exchanges.

Aside from the lack of readily-available quarterly accounts being available (purely from a debt/profitability perspective), a bigger issue relates to manufacturing metrics. Increasingly, this part of 'reporting' has been taken offline, and at times communicated to the outside world with in-built confusion and a degree of somewhat manipulative data distortion. Simply knowing who made what, where, when and how appears to be a thing of

Connections for sustainable change

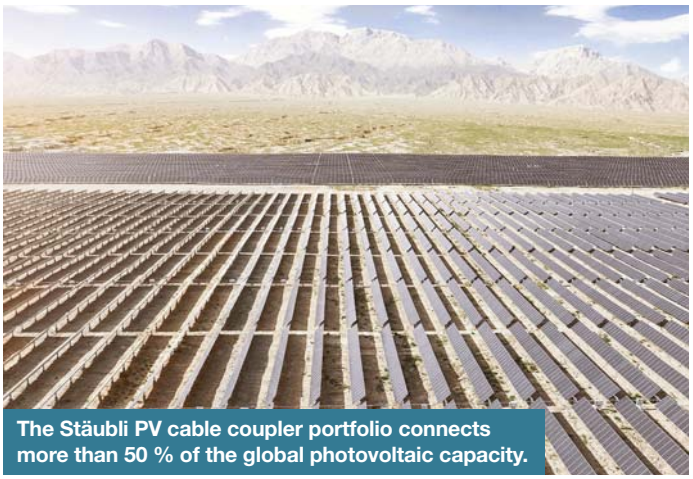
Stäubli Renewable Energy offers tailored products and service solutions for eBoS (electrical Balance of System) applications along the PV project lifecycle and advances its resource capacities. In the fast and dynamically growing photovoltaic industry, the market leader for PV connectors continues to invest in quality and expertise to optimize the efficiency of PV systems.

With the rapid growth and fast boost of photovoltaic capacity worldwide, there is also a considerable challenge not to neglect care for quality products and services. The faster the market develops, the more players participate. Prices and margins become tighter and competition increases. However, this development can have a negative impact on the quality of all project phases of a PV system. Quality in terms of planning, the materials used; quality with regard to products, and also the installation is essential for reliable long-term operation of a PV plant.

Small components – big impact

Since the very early stages of the PV industry, Stäubli Renewable Energy has been an active player in the market, with its first pluggable PV connector MC3. For the past 20 years, the successor model, the Original MC4 connector of Stäubli, has set the benchmark in the industry and the company has become the industry's leader with its PV connector portfolio. At present, around 50 % of the worldwide cumulative PV capacity rely on Stäubli PV cable couplers.

The PV connectors are among the smallest components within a PV plant. As part of the eBoS application (electrical Balance of System) in the PV system, they have to ensure stable, constant and reliable transmission of the generated DC power. The Stäubli commitment to quality sets the internal test specifications for its PV connectors beyond the test sequences requested by the international standards and regulations. An additional success factor for the proven quality of the Stäubli PV connectors is the expertise on in-house manufacturing and assembly, thus owning and monitoring the entire process. Hence, quality is key.



The Stäubli PV cable coupler portfolio connects more than 50 % of the global photovoltaic capacity.

The experienced Stäubli experts provide answers to mitigate risks in PV plants.

The lifelines of a PV system

Based on the many years of experience, Stäubli Renewable Energy has always not only set the focus on the details but has also put them in relation to a holistic overview. Today, the company has advanced from pure product manufacturer and supplier to solution provider with an offering that covers products and services of the eBoS application. This subsystem, connecting the power generation to the power conversion, can be considered as the lifelines of a PV plant. In addition to providing long-lasting eBoS components with high-quality PV connectors, Stäubli cares to offer the best solution throughout the entire lifecycle of a PV installation from the very beginning of the project during the planning phase, through construction, to operation and maintenance (O&M).

Reliable partner for lasting alliances

The complexity of PV projects requires careful selection of all involved parties and components during all phases of the project, from project planning and conception through construction and installation and operation. An interaction of committed partners, knowledgeable staff, quality components and experienced suppliers are key for reliable PV installations. If one part of this chain is weak, the risk of failure during operation might cause severe damage, power loss and hence, a lack of project return.

All eBoS components from Stäubli as single source.

The Stäubli experts act as proficient partners in the industry in order to raise awareness on how to mitigate the risks in PV installations.

The connector specialist is committed to fostering a close relationship with its customers and business partners in order to advise them. The Stäubli experts act as proficient partners in the industry in order to raise awareness on how to mitigate the risks in PV installations. They rely on their profound knowledge to share insights on best practice for connectors' assembly, installation and beyond that, focusing on complementary services. With its a strong presence in the PV industry over all these years, Stäubli Renewable Energy has continuously invested in product innovation, product safety and product quality. Furthermore, the company also strongly advances on production capacity and human expertise.

"We go with this market development and take up the pace. Our global team is growing and we gain additional competence to anticipate the customer's needs and make sure that the Stäubli quality promise will last for the future" confirms Matthias Mack, Global Director at Stäubli Renewable Energy. This overall expansion, as a response to the industry development, also empowers Stäubli to continue to grow faster than the market. Matthias Mack amplifies: "It's worthwhile to look for partners with experience and to look for quality products as well as valuable service solutions based on advanced technology and know-how to ensure safe, long-lasting and profitable performance in your PV plant."

About Stäubli

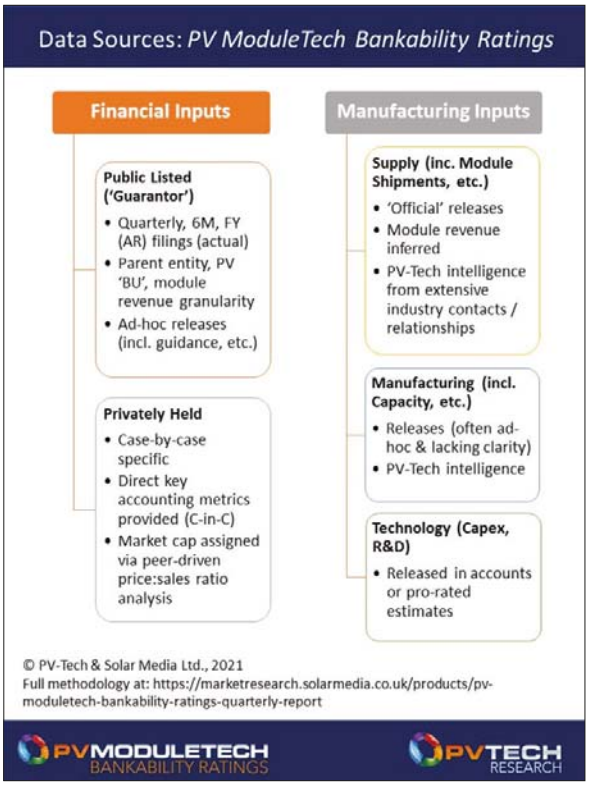
Stäubli offers innovative mechatronic solutions in three core areas including Connectors, Robotics and Textile. Founded in 1892, today Stäubli is an international group headquartered in Pfäffikon, Switzerland with more than 5,500 employees worldwide. Stäubli has a presence in 29 countries with production companies, sales and service subsidiaries and is supplemented by agents in 50 countries.

As a world market leader in the field of connectors, Stäubli manufactures quick connector systems for all types of fluids, gases and electrical energy. The Electrical Connectors product portfolio ranges from miniature connectors to high-performance connectors for power transmission, industrial automation, transportation, test and measurement. In Photovoltaics, Stäubli Renewable Energy is the global market leader with its MC4 connector components. The core of all Stäubli electrical connectors is the unique MULTILAM technology. **www.staubli-renewable-energy.com**

the past to many module suppliers in the PV industry today, and something that has truly come back to bite the industry in 2021 as scrutiny has moved to country and region of raw materials production and related supply chains.

The best way to answer the question of "where does the data come from?" is illustrated by way of the flow chart shown in Figure 1. Instead of discussing each of the boxes shown in this figure, it is perhaps more important to note that the three main routes for data collection are as follows: reported or audited filings in any form (quarterly, etc. or ad-hoc) from public-listed entities; direct inputs from PV Tech's network of industry stakeholders going back 15 years; understanding of the business models operated by all the companies, specific to PV manufacturing and module sales.

In turns out that the final pillar of the methodology/analysis cited above (understanding each company's business operations) outranks everything else, including data released legally by way of stock market listings. It goes without saying that, when analysing data, all numbers must make sense in the first instance, and this turns out to be essential in PV where module margins are notoriously thin and being seen as a leader in renewables



Credit: PV Tech Research

Figure 1: Input data for PV Tech's PV ModuleTech Bankability Ratings analysis come from a host of different sources, feeding into financial and manufacturing benchmarking for all leading PV module suppliers within the sector.

tends to dominate over running a prudent business unit.

The best way to illustrate this is by way of some examples. If a company's PV revenues are, say, US$50 million annually, module shipments cannot be at the gigawatt-level. If retained earnings are diminishing and debt is building up, operating margins cannot be healthy. If marketing-prone companies go radio-silent or spend excessive time highlighting a 100kW rooftop delivery, it is unlikely multiple gigawatts of product are shipping in stealth mode elsewhere. And finally, if a company has known declining module shipments (market share) with underutilised fabs, it is unlikely the company will be adding additional gigawatts of new capacity in the coming months.

Make no mistake though. Tracking PV module suppliers today is a massive challenge, constantly needing a firm dose of reality-checking in the process, while understanding that no model is 100% perfect at any given time and constantly under review as market conditions evolve going forward. With this in mind, it should be somewhat clearer now why there was such a need in the market for comprehensive third-party analysis of PV module suppliers globally, and why the data-sourcing question is asked so much by report users when they are first introduced to the PV ModuleTech Bankability Ratings reports.

Reflecting on the first two years of PV Tech's bankability ratings analysis

The PV industry has always had access to rankings and top 10 tables, often disseminated in the public domain: annual shipment tables, categorisation by risk of bankruptcy (absolute Altman-Z scores), corporate parent-entity turnover (revenues), etc.

These lists often get used by companies and media outlets, possibly due to the absence in the past of more credible module supplier benchmarking. For example, rarely have there been rankings across working capital, long-term debt or profitability. In addition, there has certainly been a lack of rankings based on levels of in-house production of key components (ingots, wafers, cells).

In setting up the methodology for the PV ModuleTech Bankability Ratings, it was clear that benchmarking all of the module suppliers for both financial and manufacturing health was essential. Specifically, our reference to the word 'health' is critical; for example, financial health is obviously more than just company turnover (favouring module suppliers that are part of large entities with other significant revenue streams), profitability (that can be transitory in nature) or market capitalisation (which is highly variable based on investor whim and/or country of listing). On the flip side, manufacturing health is not just based on (claimed) module shipment volumes or 'announced' capacity expansion plans.

However, establishing separate financial and manufacturing benchmarking (scoring all module suppliers across these categories, quarterly, pro-rated to a 0-10 scale) was just one part of the overall goal; ultimately, the key thing is combining these to form an overall bankability ratings score (again 0-10, industry pro-rated quarterly) that allowed the final AAA to C ratings assignation.

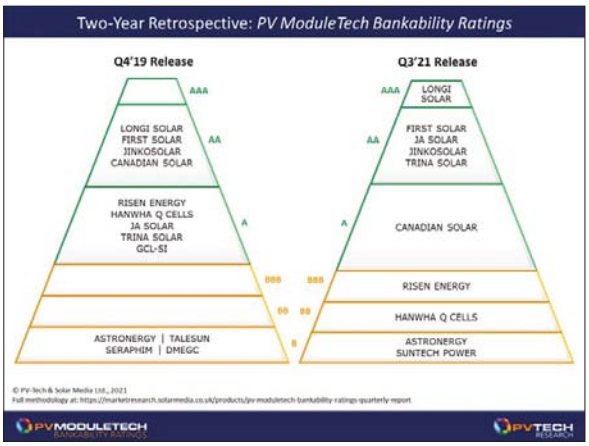
The ability to combine module suppliers' individual financial and manufacturing health scores (into a single module bankability score each quarter) is what makes the PV ModuleTech Bankability Ratings analysis truly unique within the PV industry today.

Therefore, with two years of reference material available now since we released the first rankings pyramid hierarchy in 2019 (showing A-Grade to C-Grade module suppliers), it makes sense to review how accurate the findings have been: for example, are there any leading indicators that can 'predict' which module suppliers will be at 'risk' as suppliers in the coming quarters/years; what aspects of the analysis need tweaked going forward to keep the reporting as close to market conditions as possible?

Figure 2 (overleaf) shows abridged versions of the PV ModuleTech Bankability Ratings pyramids (hierarchy ranking with AAA-Rated at the top) taken from the first release of the report (October 2019) and the latest release (from August 2021). Here, we have listed just the A and B-Graded module suppliers (AAA to B-Rated), as this subset is by far the most important in the sector today, in particular for global utility-scale supply contracts.

While a number of the companies have retained ratings positions (or moved marginally between ratings levels) – including here JA Solar, Trina Solar, Canadian Solar, First Solar – the most significant changes can be found across other module suppliers.

LONGi Solar has been the only AAA-Rated module supplier for the past 12 months, and scores so high in the bankabil-



Credit: PV Tech Research

Retrospective comparison between the releases of the PV ModuleTech Bankability Ratings reports for Q4 2019 and Q3 2021, showing the companies occupying A and B-Grade ratings positions.

ity analysis the company could almost be described as an outlier from a statistical standpoint. Hanwha Q CELLS has fallen several rating places, showing the impact of having almost static shipment volumes at a time the end-market is growing at high double-digit rates. GCL-SI has moved from being a top-ranked module supplier in 2019 to outside the upper A/B grades – a direct result of seeing both financial health (profitability/debt) and manufacturing health (shipments/market-share) decline simultaneously in the space of 12-18 months. Talesun has moved out of the A/B Grade listings (resulting mainly from market share/working capital declines over 2-3 years) and Suntech Power has moved in (largely due to exiting the ailing Shunfeng holdings structure).

Most of the changes in bankability ratings for the companies in Figure 2 have not been a massive surprise; the factors outlined above, explaining these companies' changing fortunes, were starting to become clear 2-3 years ago, and certainly got exposure in the first release of the report at the end of 2019.

What has been more interesting in the past two years has been JinkoSolar's rather compliant acceptance of no longer being the number one module supplier by annual shipment volume, and loss of market share. The previous drive by JinkoSolar to be number one module supplier appeared to keep the company ahead of its Chinese competitors; without this goal, one wonders what will now shape the company's tactics and strategy that were so powerfully in synch for a number of years.

Finally, the uptick in fortunes at JA Solar were also not foreseen a couple of years ago. JA Solar is now on the verge of being the first Chinese cell technology-leading proponent to challenge for module supply top 2/top 3 status; noting that previous module supply leaders from China (Yingli, Trina, Jinko) were initially low-cost module assembly companies that added wafer/cell capacity later, mainly to reduce in-house costs (as opposed to boost technology leadership).

Which metrics are potentially over-valued/over-rated by module suppliers?

Benchmarking module suppliers depends critically on knowing what value to put on specific data (from financial and manufacturing sides), or subsets of data/metrics: or put another way, which variables are the most sensitive in determining the outcome of module suppliers in terms of market-share and profitability (ongoing operations).

Each quarter, we scrutinise this question. For example, how important really is it for a PV module supplier's operations to be profitable, if module supply revenues account for less than 30% of the parent entity's turnover? At what point does debt become an unsustainable parameter for Chinese-run operations: is it even an issue for module suppliers that are part of holding companies that are state-owned in China? Can we see long-term trends supporting having in-house technology leadership across the manufacturing value chain, or will there always be scope for a pure-play module supplier to simply outsource cells and become a top 10 module supplier by shipped volume?

At least one thing should be clear to anyone tracking the PV industry for the past couple of decades: being the number one module supplier by shipped volume is definitely not a strong leading indicator when it comes to financial health and longevity within the industry! Currently, our attention mostly centres around the level of importance afforded to two metrics, often perceived as key factors by many: market cap and capex.

Market cap is one of the major contributors to Altman-Z scoring (the starting point within our financial health analysis of module suppliers), but its importance is possibly overrated and can either fluctuate hugely month-to-month or merely be a trailing indicator of doom and gloom 'after the event'. It is rare for an uptick in share price to be aligned with any real mid- to long-term strategic changes at the company level. Currently, there is an open question as to the level of importance to assign to each company's market cap, and whether more weighting should be placed on short-term cash flow or working capital metrics.

At the manufacturing level, it is also debatable whether having high capex allocations is a good or a bad thing. In some ways, high capex (like R&D allocations) ought to be a strong indicator of continued market leadership; but there is an argument for talking about prudent capex, not absolute capex. Just how one determines 'prudent capex' (or indeed R&D spending return-on-investment) is far from clear. It may simply be easier to decrease the relevance of these terms (lower than existing values), rather than try to conjure up some new metrics that are hard to fully quantify.

Finally, the issue that is most pressing today relates to in-house capacity, technology type and location of manufacture. Thankfully, these parameters were identified at the start of the report releases as heavily-weighted within the manufacturing health scoring methodology. However, the new variable in the mix of recent is coming from US/China trade issues. Somehow, winners and losers from this are likely to be based on the levels of in-house manufacturing control on offer across different (Chinese) module suppliers; the details here however are just not known for now.

As the industry moves into 2022, the percentage of market supply coming from the top 10 module companies to global utility projects is likely to reach the 90% mark. When this happens, purely benchmarking these companies will take on a new level of importance. At this point, differences in companies all occupying, for example, AA-Rated positions will become more relevant than doing any side-by-side comparison between A-Grade and C-Grade companies. Capturing this next phase of the PV ModuleTech Bankability Ratings analysis will surely be a key topic two years from now, when we reflect on the next phase of activities across module suppliers to the PV industry. ■

Author

Finlay Colville is head of research at PV Tech and Solar Media Ltd. He has been tracking the PV industry for almost 15 years, focusing on manufacturing, company operations and end-market demand drivers.

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SOLAR MEDIA

Understanding and negotiating PPA's in the new world of energy trading

PPAs | Power purchase agreements are a constantly evolving sector, with new structures and styles emerging as the solar sector matures. Pexapark's PPA transaction manager Amanda Niklaus takes a look at how these agreements are being tailors to fit the "new world".

The Los Banos solar farm in California, US.

In 1597, Sir Francis Bacon, an English philosopher and statesman, who served as Lord Chancellor, noted in his work *Meditationes Sacrae* that "knowledge itself is power". That was a long time before what we now refer to in the sphere of renewable energy as the "old world" of feed-in tariffs.

But as renewable energy enters a new, post-subsidy world, it seems pertinent to adjust that famous saying – coined by Bacon – for a 21st Century context where, actually, in renewable energy, acquiring knowledge before producing power is what's imperative. For, the acquisition of knowledge and access to sound data are now critical to anyone involved in buying or selling renewable energy and managing risk.

Power purchase agreements (PPA) are becoming the norm when it comes to managing investment risk in the increased absence of feed-in tariffs and as the energy market undergoes the next stage in its evolution. But before we delve into the intricacies of PPAs and negotiating them, it is key to remember that a PPA is only as good as the energy risk management strategy for a portfolio – the knowledge, evaluation and action to mitigate risk - that underpins it.

So what do investors need to understand about PPAs now, as we emerge from a market underpinned by feed-in tariffs? How are PPAs evolving and should negotiations and PPA origination

Credit: Ab Inbev.

Earlier this year Budweiser revealed its UK operations were solely powered using renewables, aided by solar PPAs in the country.

be approached now? What knowledge of risk and contract negotiation is required? And how can the necessary data and information be acquired?

An end to feed-in tariffs

For over a decade, the sun has shone unrelentingly on the global solar market. The industry has seen the levelised cost of energy (LCOE) generated by photovoltaic panels come down from US$1.61 per watt in 2011, to just US$0.16 cents per watt in 2020, leading the International Energy Agency to dub solar the "cheapest… electricity in history" in its World Energy Outlook Report in 2020.

With the climate emergency rightly becoming the world's number one priority, net-zero targets are being set by governments and businesses across Europe and the world. This has led to huge uptake and demand to install solar arrays, and investors have grown in confidence when it comes to managing any previously perceived risk around solar.

But much of this confidence and exponential growth has been fuelled by feed-in tariffs, which have also helped in driving down the cost of solar energy. And as has been well documented, those subsidies are being phased out, particularly in more established markets. In the EU, subsidies are all but extinct.

This means that developers and investors are now significantly more exposed to highly volatile power markets in a post-subsidy world. A prime example of this is the recent increases in the cost of raw materials for solar components, which has caused the trend of falling LCOE from solar to plateau, injecting just a little more risk into a marketplace that has generally been a safe bet for investors until now.

That's not to say that interest from lenders doesn't remain high; energy transition industries secured over US$500 billion of investment globally in 2020 according to statistics from BloombergNEF. Three-fifths of that (US$303.5 billion) went to renewables. And the outlook for the next decade and beyond is for continued growth in solar.

But the difference now is that future growth will come against the backdrop of a rapidly changing energy market. And for solar project investors and developers, that means taking on new risks – including more exposure to power price – and using deal structures with which they may be unfamiliar.

It's at this point that PPAs come in. Owners and investors increasingly see PPAs as the key to taking their project to financial close – and across Europe, around a dozen PPAs covering the production of thousands of MWh of energy are being agreed every month.

The emergence of PPAs

PPAs have become more prevalent, not just in the solar industry, but across renewables.

The removal of subsidies means that there is less financial security for lending institutions, such as banks, to invest in a renewables project. As a result, lenders require a way to secure their investment and PPAs are successfully doing that by proving that the concerned renewable asset has already found a long-term buyer at a fixed price.

PPA contracts thus enable renewable investment by providing revenue certainty to investors and lenders in unsubsidised markets.

In recent years, various forms of PPA have emerged. Among them are physical PPAs, which refer to the purchase of energy at the meter point (the reception point of production). A physical PPA customer receives the physical delivery of (or title to) the energy through the grid.

And then there are financial PPAs – also referred to as "virtual" or "synthetic" – which allow a company to buy renewable energy virtually. There is no need to own the title of physical energy and it enables companies to focus on reducing their carbon footprint, by receiving renewable attributes. These "green" additionalities allow a credit link between the purchaser and the renewable asset owner and will not impact the source of energy consumed by the purchasing company. This form of PPA is proving popular in the USA, but is favoured less in Europe, because it is treated as a financial product within accounts, and companies may not be willing or ready to handle that.

Both are complex in their structure and pricing. Overlooking or inadequately negotiating a contractual clause can impact the overall revenue of a PPA. This necessitates a thorough understanding of energy risks, valuation and negotiation.

It might seem obvious, but investors and project owners need to ensure that PPAs work for them. That means forgetting standard, carbon copy agreements and honing in on specific requirements. This can be done by giving careful consideration to four key areas before embarking on the PPA process.

Tailoring a PPA

Firstly, thought should be given to the intention of the PPA. Generally speaking, PPAs are used for providing revenue certainty that gives confidence to lenders, hedging against future power

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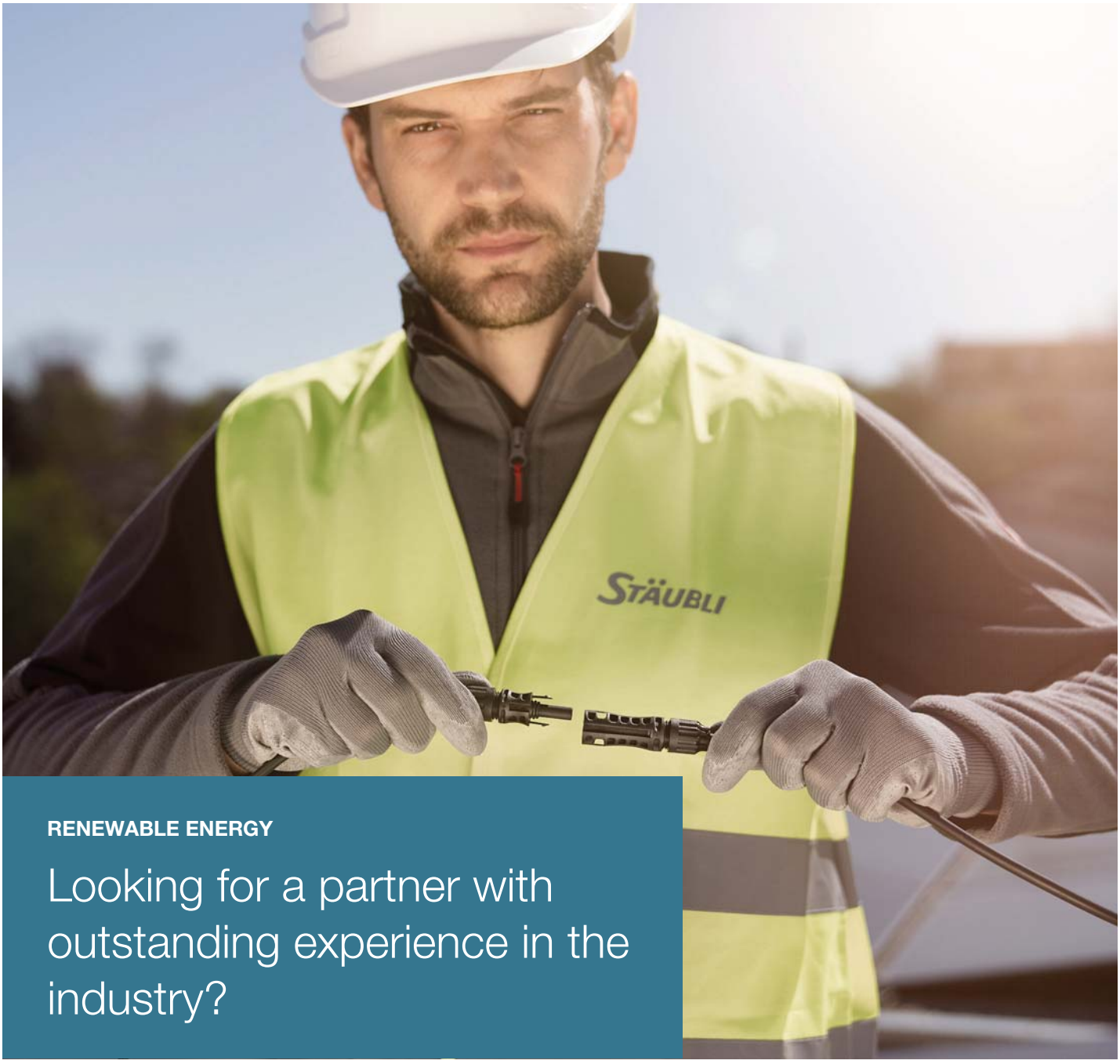

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price risks, managing risks optimally in a portfolio or optimising revenues and hedges.

This means that PPAs fall under two main types: bankable PPAs, and PPAs that are focused primarily on optimisation of project risks. Whether a PPA is bankable will impact on its length (or tenor), how it is structured (risk allocation) and counterparty risk.

Bankable PPAs will likely have to be of a certain length, and banks often have specific requirements around certain structures, specific terms and guarantees. PPAs required for other risk management purposes, can potentially consider other terms, structures and shorter tenors.

A diversifying market for renewable energy

Secondly, understanding active buyers in the market is critical. And it is here where the market is seeing change and diversification, particularly with more and more corporates emerging as buyers, along with vertically integrated players. This, in essence, boils down to simple supply and demand theory.

PPAs are being signed across the board in Europe – but particularly in Spain, Germany and Poland. But appetite and liquidity can change quickly – so access to good market intelligence data is crucial, as is giving close consideration to the different types of energy buyers in the chosen market. In countries where there are large numbers of corporate and industrial companies that want to buy power from wind and solar projects, PPA requirements will be different to those needed in markets dominated by utilities, especially those that are state-owned and seeking to price risk and profit from it. In the last 12 months, there has been approximately a 50/50 split between corporate and utility PPAs in Europe, by capacity.

Addressing risk

Thirdly, it is becoming clear that energy markets and PPAs work differently from country to country. That is leading to variation and additional layers of complexity in PPAs which require investors to tailor their proposals. Each market may have its own particularity, for example Italy has zonal pricing which is a significant risk, while Germany has specific treatment of negative pricing. It's good to know about these market-specific risks to manage them properly. There may also be additionalities that owners can take advantage of or, indeed, political or policy upheaval that may impact demand or lead to other market changes. So tailoring PPAs for different markets, different buyers and different socio-economic conditions is vital to mitigating risk.

"Each market may have its own particularity, for example Italy has zonal pricing which is a significant risk, while Germany has specific treatment of negative pricing."

Fourthly, there has been much discussion in the market about different PPA structures. The various volume structures, such as pay-as-produced, monthly baseload, annual baseload, fixed hourly profile, to name just a few, affect how the energy risks in a PPA are distributed among the parties. We will look at each of these energy risks in turn, which should be fully considered throughout the lifetime of an asset, via a broader energy risk management strategy. But when negotiating a PPA the key is to understand who takes on each commercial energy risk in the contract. As PPAs evolve and become more sophisticated, the risks tend to shift from the buyer to the seller.

A number of key risks have emerged when buying or selling on the energy market, which are worthy of careful consideration by all parties before negotiating a PPA. Among them are:

Price risk. There is always the risk that an adverse movement in the market will impact on price. It is unavoidable, but can be mitigated.

Liquidity risk. A market state where buyers and sellers can conclude large volume transactions quickly, without impacting the market price. Depending on the structure of the PPA, its cost or risk can be reduced, through, for example, getting a validity period (which comes at a cost) or agreeing on a price formula indexed on closing prices. The buyer and seller could agree to fix the PPA price closure referenced on publicly available prices such as forward prices observed on an exchange.

Volume risk. The annual energy production of a renewable asset is an estimate. Its likelihood is typically calculated and assessed on the basis of long-term meteorological data. If a renewable asset is hedging a fixed volume at a fixed price, there is a risk that certain amounts of volume are not produced and need to be procured. If this is the case, the producer may have to purchase the missing volume at market prices that may be worse than the original fixed price. Optimising the volume risk is crucial. PPA structures can be used to reduce this risk as can insurance guarantees.

Profile risk. This arises from the fluctuating nature of renewable energy (for example, there is no solar energy produced at night). In markets with high renewable energy penetration, times of high production can mean a significant decrease in power price, and in turn, revenue. This will depend of course on the location of the plant but this risk can be mitigated through certain PPA structures.

Credit risk. Much like any commercial contractual agreement, credit risk is also a key component in the negotiation of PPAs, ensuring that the risk a buyer will not be able to meet its contractual payment obligations is agreed and considered as part of the PPA contract. Protections can be put in place, such as advanced payments, margining requirements, increased frequency of payments and a Material Adverse Clause (MAC). The same applies to the seller if, for instance, the project runs out of money and energy generation ceases.

Balancing risk. This refers to the difference between what was scheduled (usually a day ahead) and actual production (the imbalance cost). This risk can be reduced by fixing the imbalance cost through an agreement or using intraday trading, if available.

While the PPA can mitigate against these risks, investors and owners have had to develop energy risk and energy portfolio management processes that ensure they're aware of and considering the risks cited above – which will vary depending upon a whole raft of factors.

Negotiating PPAs

Understanding these risks evidently forms a key part of negotiating a PPA. The structure of the agreement will dictate how those risks are distributed among the parties. For example, for the profile risk, in a pay-as-produced structure, where a fixed price is paid for any volume produced, the buyer will take on that risk fully.

Conversely, in a monthly baseload structure, a contract that buys a constant volume of energy every hour of each month but where the volume commitment changes monthly, the profile risk is mostly carried by the seller.

Other key considerations should be made when negotiating PPAs. These include:

Reference prices. Given contract negotiations often take more than six months to conclude, there is scope for prices to change. Therefore it is common now for reference prices to be defined through the negotiating period, with tools such as PexaQuote being used as a price reference by players on both sides of PPA deals.

Increasingly, negative pricing is becoming an issue with renewables. This reiterates the need to understand the market that the PPAs being tailored to, especially as there may be need to insert clauses in the contract that force the asset to stop producing during prolonged negative prices. This is an important and often overlooked item in a PPA contract.

Changes in law. Clauses that mitigate risks brought about by potential changes in the law that could materially affect the obligations of one or both parties in the agreement should also be handled as part of the PPA negotiation. An example of this might be changes in tax laws.

Performance guarantees. These should be considered, where for instance, production may not meet the level expected in the contract. In such a scenario provision should be made for how this settlement will be addressed between both parties. In which case will the seller have to compensate the offtaker?

Termination. Thought needs to be given to termination. What will trigger an early termination of a PPA contract, such as a default or delay to the Commercial Operation Date and the costs associated with it.

The importance of data and skills

It's evident that PPAs are crucial to mitigating risk as renewable energy enters a new frontier.

It might feel like energy sellers, generators, asset owner or investors need to be experts in contract law to ensure that their solar array is profitable. And while it's obvious that the transaction between off-takers and energy sellers needs the security of legal puppetry, project owners – especially those seeking capital investment in a project – can use the framework of a PPA to ensure their knowledge of the market and consideration to risks and variables is primed. Most will be au fait with the risks involved of buying or selling energy, but PPAs frame this in a way that mitigates against those risks and heightens awareness of them.

> "The duration of a PPA may not cover an asset's full life, so strategies and hedging need to be renewed and considered regularly."

PPAs are, however, just one tool in the post-subsidy arsenal of any entity involved in renewable energy generation or purchase. In addition to PPA origination, and as mentioned, renewable energy players need to build out energy portfolio management, and energy risk management and reporting processes. This requires reengineered operating system that enables entities to thrive, equipping them with the skills and insight needed.

The Intergovernmental Panel on Climate Change (IPCC) – which highlighted that human activity and global warming, much of it caused by carbon emissions and fossil fuels, is changing the climate in unprecedented and sometimes irreversible ways – described by UN Secretary General António Guterres as "a code red for humanity", is the sort of message that is going to intensify the energy transition over the coming years. And as the adoption of renewable energy is accelerated by governments and corporates, it means more and more people who have previously had no exposure to PPAs are going to be making their first forays into this minefield of complexity. To address this knowledge shortfall, community learning and resources for those engaged in the development of PPAs is also essential.

The future

It's abundantly clear that in the new world, renewable energy is going to have a huge stake in the future of the preservation and health of our planet. But sustainable energy needs to be just that, sustainable. PPAs are evolving to ensure that essential investment continues to flow into the solar market. But signing a PPA is only one part of an asset's energy risk management strategy over its lifetime – and the risks should continually be assessed. The duration of a PPA may not cover an asset's full life, so strategies and hedging need to be renewed and considered regularly. It is worth noting, too, that a PPA will only cover the output of one project, so there needs to a portfolio-wide strategy for generators operating multiple projects.

The key for both generators of power and for those buying the output is that they possess the knowledge and access to the right data. This will help ensure PPAs are right for them, as well as the broader operation and monitoring of their portfolio and the risks that come with developing renewable energy projects.

That knowledge will be what powers the "new world" of merchant markets, and – we all hope – what plays a critical role in saving our world. Sir Francis Bacon was right: knowledge itself is (renewable energy) power. ■

Author

Amanda Niklaus has seven years of combined experience in providing analytics for PPA transaction and analysing power markets and trading strategies for renewable assets across Europe, the US, and Australia.

Presented to you by: Energy Storage NEWS

STORAGE & SMART POWER

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Introduction

Welcome to another edition of 'Storage & Smart Power', the section of PV Tech Power brought to you by Energy-Storage.news.

We're excited to bring you a set of articles that really offer a cross-section of some of the most exciting and current topics that our readers want — and need — to know more about. When the climate crisis, global economic slowdown and the pandemic are pushing us all to the limits, it's time to get to work on doing what we can.

For the clean energy industries, this means to keep going, with relentless focus, passion and a hard-won sense of optimism that whatever is thrown at us, we can and will keep pushing back to find the answers. We understand that it's our readers' business to do that.

Our guest authors and interviewees in this edition all offer fresh and insightful perspectives on key topics in this area:

Lawrence Berkeley National Laboratory (Berkeley Lab) researcher Will Gorman looks at the phenomenon of pairing renewable energy assets with energy storage. Recent statistics show that in the US, hybrid resources have overtaken standalone storage for new project proposals. Berkeley Lab's exhaustive research dives under the hood of this phenomenon. Gorman looks at why it's happening but also explains that hybrid solar-plus-storage or wind-plus-storage isn't always the best answer for unlocking the most societal, technical and economic value that storage can bring.

Batteries have quickly become an essential component of the energy sector, but the ability to smartly monitor and control them are just as important, Sebastian Becker at battery analytics platform provider TWAICE argues in his article, 'Battery analytics: The game changer for energy storage'.

Becker looks at some of the technical risks that battery energy storage systems (BESS) face and why analytics software can mitigate them. In an increasingly competitive market, he also discusses how analytics can also be a powerful value proposition differentiator.

We also have a bumper look at vanadium flow batteries in this edition from two perspectives. It's a technology that has been a long time coming from its discovery to its development as a commercial proposition. Will the third 'D', (mass) deployment, come next? I was so privileged to interview one of the original inventors of the vanadium redox flow battery (VRFB), Professor Maria Skyllas-Kazacos of the University of New South Wales in Sydney and she told me so much about the scientific — and human — story behind it.

In our second feature article on VRFBs in this issue, I've heard about the market-facing strategies of two primary vanadium producers, Bushveld Minerals and Largo Resources towards what they hope will be an unstoppable wave of flow batteries for long-duration storage. With the help of Erik Sardain, expert at critical minerals analysis and research group Roskill and Professor Maria Skyllas-Kazacos, I hope we've been able to answer some of the questions you may have around this fascinating topic.

I'd just like to mention that Maria Skyllas-Kazacos told us that she's currently working on a comprehensive book on flow batteries, together with Professor Christina Roth from Beyreuth University and Professor Jens Noack from Fraunhofer ICT. To be published in mid-2022, the project has come about as a result of the UNSW team's collaboration with the CENELEST consortium.

Skyllas-Kazacos said that collaborative research programmes have brought her work on vanadium flow batteries from Australia into much closer contact with international partners around the world. This connection has helped keep the flow battery story progressing and there's no doubt there's plenty more to come on that.

I think there's a lesson for us all in there, especially in these days when remote working, the difficulty of travelling and hosting events keep us apart in a world that already seemed quite divided at times.

Andy Colthorpe
Solar Media

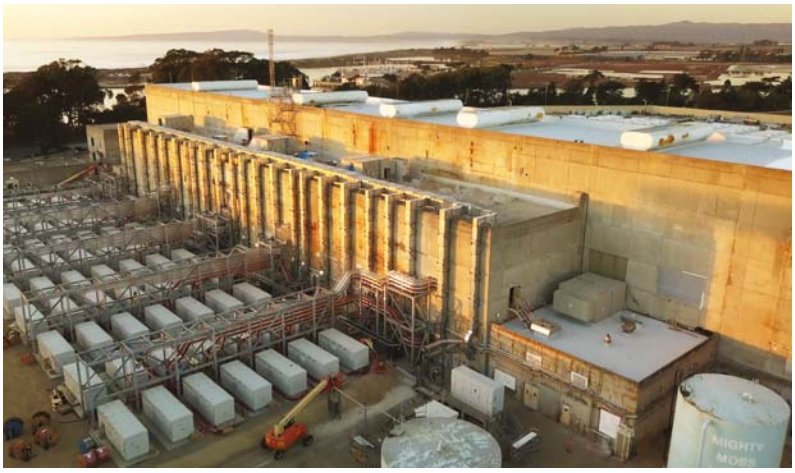
Expansion complete at world's biggest battery storage system

Augmentation at the Vistra Moss Landing Energy Storage Facility in California has been completed, with the world's biggest battery energy storage system (BESS) now at 400MW / 1,600MWh.

Vistra and lithium-ion battery rack supplier to the project LG Energy Solution held a media day, 19 August, to celebrate the successful completion in July of Phase 2. Along with the two companies and their engineering, procurement and construction (EPC) partner Burns & McDonnell, the event was attended by representatives from California grid and electricity market operator CAISO, utility Pacific Gas & Electric (PG&E), federal and local authorities and business leaders.

There is a 10-year agreement for Resource Adequacy in place with PG&E for the Phase 2 capacity, while the 300MW / 1,200MWh installed already during Phase 1 has a 20-year agreement along similar lines. The site could still be expanded further, up to 1,500MW / 6,000MWh.

Vistra's Moss Landing project repurposes a former gas-fired power plant site.



Credit: Vistra Energy.

India prepares to open up ancillary services market to energy storage

India's Central Electricity Regulatory Commission has drafted ancillary services market regulations allowing for energy storage and demand response resources to participate.

The commission has recognised that energy storage and demand response can respond rapidly and accurately to maintain grid frequency. Primary Reserve, Secondary Reserve and Tertiary Reserve ancillary services will be created, as well as others within the scope of the Grid Code.

Also during the past quarter, plans to install 1GWh of energy storage at existing power plants of NTPC, a state-owned IPP were revealed, as well as the national Solar Energy Corporation of India announcing a 2,000MWh storage tender and power minister RK Singh announcing four separate 1,000MWh tenders across Regional Load Dispatch Centres (RLDCs).

RWE builds 117MW of battery systems paired with run-of-river hydropower

RWE is constructing two battery energy storage systems (BESS) in Germany which will be "virtually coupled" with existing run-of-river hydroelectric power plants.

The Essen-headquartered power generation company will install 117MW / 128MWh of batteries at two sites: 45MW of BESS at its Gersteinwek power plant in Lingen, Lower Saxony and 72MW at Emsland power station in Werne, North Rhine-Westphalia. The battery projects will require an investment of around €50 million (US$59 million) and are scheduled to go into action at the end of 2022.

The BESS can be used to raise or decrease the flow-through of power at the hydropower plants, increasing the effective capacity available to be put into electricity system balancing markets. The hydroelectric generation adds about 15% extra capacity to the battery systems, with their primary application being to help maintain grid frequency.

UK sees record-breaking submitted battery storage capacity under planning

The pipeline for utility-scale battery storage in the UK has been continually increasing and is now over 20GW across more than 800 projects, according to Solar Media Market Research.

A recent surge in submitted applications for battery storage has led to a record-breaking quarterly submitted capacity for Q2'21 being recorded: 3.7GW across 60 sites. The total submitted capacity for the year-to-date by the end of Q2 was 4.7GW. Meanwhile operational capacity of energy storage in the US reached 1.3GW.

While the pipeline contains a mix of project sizes, the capacity is becoming increasingly dominated by large-scale projects. Many applications have been submitted this year for sites larger than 30MW in capacity. During Q2 there was even a pre-application submitted for a site in Scotland with capacity of 500MW.

Philippines power players roll out battery portfolios

Fluence completed the commissioning of two 20MW / 20MWh BESS in the Philippines.

They were delivered for Filippino energy group SMC Global Power Holdings Corp, a major power company which also contracted ABB and Wärtsilä for projects. SMC said in April that a total US$1 billion investment in energy storage will see it deploy 1,000MW of BESS projects.

Wärtsilä disclosed a 100MW / 100MWh total order booked from SMC and ABB referred only to 80MW of projects and did not reveal the size of its total order, Fluence said its new projects are part of a 470MW / 470MWh order.

Another Philippines power generator, supplier and distributor, AboitizPower, said recently that two large-scale battery energy storage system (BESS) projects underway by the company will be part of "the foundation to sustain its long term growth". AboitizPower is aiming to develop at least 248MW of batteries across 12 projects within the next decade.

US utilities set to add 10,000MW of storage to grid by 2023

The cost of battery energy storage in the US fell by 72% between 2015 and 2019 and utilities in the country are set to bring 10,000MW of new grid-connected capacity online in the next two years.

Enabling power grids to function more flexibly and resiliently, the deployment of battery storage across the US has increased from about 100MW at the end of 2012 to 1,650MW by the end of 2020, accelerating from an inflection point year in 2015. The figures come from a new report from the US Department of Energy's Energy Information Administration (EIA).

Planning data collected from project developers by December 2020 showed that with 10GW set to go online by 2023, the installed base would have increased more than 1,000% from 1GW of operational capacity in 2019.

Discovery and invention: How the vanadium flow battery story began

Flow batteries | Andy Colthorpe speaks to Maria Skyllas-Kazacos, one of the original inventors of the vanadium redox flow battery, about the origins of the technology and its progression

Credit: CENELEST via Twitter.

Prof Skyllas-Kazacos with UNSW colleague Chris Menictas and Prof. Dr. Jens Tübke of Fraunhofer ICT, in 2018 at a 2MW / 20MWh VRFB site at Fraunhofer ICT in Germany.

In Volumes 21 and 23 of PV Tech Power, we brought you two exclusive, in-depth articles on 'Understanding vanadium flow batteries' and 'Redox flow batteries for renewable energy storage'.

The team at CENELEST, a joint research venture between the Fraunhofer Institute for Chemical Technology and the University of New South Wales, looked at everything from the principles behind how flow batteries work, to their applications and potential.

One of the authors, Maria Skyllas-Kazacos AM, is an emeritus professor at the UNSW Sydney Australia. Recognised as one of the original inventors of the vanadium redox flow battery (VRFB) and holder of more than 30 patents relating to the technology. We spoke to her about how some of those original discoveries came about — and why it's been a long road for VRFBs from lab to mainstream deployment ever since.

The first vanadium flow battery patent was filed in 1986 from the UNSW and the first large-scale implementation of the technology was by Mitsubishi Electric Industries and Kashima-Kita Electric Power Corporation in 1995, with a 200kW / 800kWh system installed to perform load-levelling at a power station in Japan. So what has taken so long?

It took a long time for our work to even be noticed. But we were lucky that very early on, even though the scientific community hadn't really picked up on it, industrial groups like Sumitomo and Mitsubishi Chemicals did. We also had a couple of people here in Australia and in Thailand who picked it up fairly early, because they were working on flow batteries and they had an interest in vanadium.

One of Mitsubishi Chemicals' subsidiaries, Kashima-Kita, was using orimulsion made from Venezuelan pitch in their power stations, which was very rich in vanadium. So they had this huge amount of waste product that they were extracting from this soot from the power station, and they were looking for ways to use it.

They had been working on iron-chromium batteries for a few years in Japan, under NEDO (the National New Energy and Industrial Technology Development Organisation). But when they saw the work that we did on vanadium, they became quite interested. We licensed our technology to Mitsubishi Chemicals and Kashima-Kita Electric Power Corporation and in the mid-1990s, they installed the first industrial-scale vanadium battery at their power station at Kashima-Kita.

So it was picked up by industry and implemented in quite a reasonably sized field trial very early. After that, within Japan were also quite a few other companies that were involved in iron-chromium battery development that picked it up as well, like Sumitomo. But it took a lot longer for it to be observed and even noticed elsewhere.

This obviously has changed in the last 10 years. Especially since 2006, when our first

patent expired, a lot more companies and research groups were able to get involved. Especially in the US, there was no longer a problem with the freedom to operate, so researchers were able to get government funding to do work on vanadium flow batteries.

But the issue has been — or had been — about maybe 10 years ago, that the industry itself was still failing to acknowledge that you needed to store energy, that there was a market for energy storage.

It took quite a long time, but once they started observing huge issues with grid stability, they realised the grid isn't so good at stabilising all these renewable energies. People have realised that for the sort of energy storage we need for renewables, you really need long duration. And that's why flow batteries have been attracting a lot of attention.

Even before renewable energy came along, it seems a bit counterintuitive that electricity supply and demand should always have to be matched in real-time. It doesn't offer much margin for error, but I guess one of the main problems is that electricity markets have always been arranged around that?

A lot of the power industry has been extremely conservative, unfortunately. It didn't help that for many years, the renewable energy sector were preaching that you don't need storage, that the grid would be able to handle up to 30% renewables.

And that was not true. Overall, the whole system may be able to cope with distributed amounts, but you get local areas where you just can't cope, the distribution system just can't cope with too much renewable energy. We've started seeing major grid stability issues at much lower penetration levels than 30%.

Now that renewables are down in cost, we can address the issue of storage, and hopefully get the same sort of support from governments as well [that renewables had] to help get the volume up and bring the cost down.

I used to have a lot of contacts in the electricity sector, and they were scratching their heads and asking me, "Well, what can you do with batteries? And how can we use batteries?"

They couldn't work it out. That was a long time ago, but all they could see was renewable energy, off-grid applications. They couldn't see how they could use it in a grid-connected situation. That was very frustrating.

To get a little bit of a sense of what it was like for you and your colleagues to have actually kind of discovered this configuration of using vanadium electrolyte. Was it a kind of 'eureka!' moment? Or it was a more gradual process to come across that?

There wasn't really a single 'Eureka!'. Some parts of it, I suppose were, because people had suggested vanadium could be used as redox couples for a battery, but no one had. They were all discounting vanadium because all the literature was showing that the vanadium redox couples are not very reversible. That was a 'Eureka!' moment: we found that if we just roughly abrade our electrode rather than finely polishing and just roughly abrade it, we got good reversibility. That was very good and totally unexpected. We discovered something that no one had known before.

Another obstacle for vanadium which discouraged other people was because of the very low solubility of vanadium-five (vanadium pentoxide, V2O5) compounds. A lot of people thought, "Oh, well, you won't be able to dissolve it adequately to get the energy density you need".

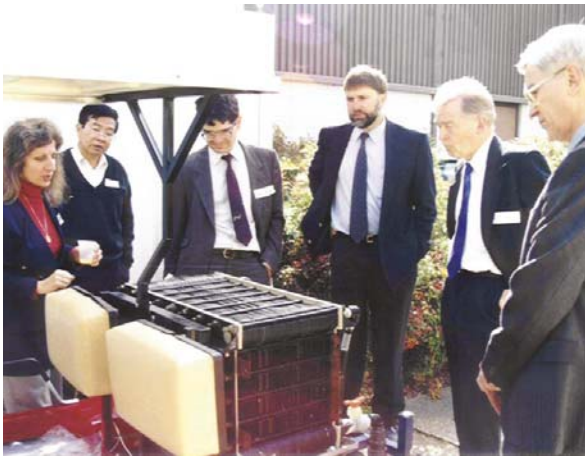
We thought we'd just try a few different ways of seeing if we can make vanadium-five solutions in different ways. We thought, if we did it a different way, we could get 2 moles per litre of vanadium whereas according to the litereature, 0.3 moles or something like that was the limit, which was not practical.

They were the two major discoveries that made us realise that this actually could work. We thought this would just be a few academic papers and that will be the end of it, but we just kept on realising that we can keep going with this, we can actually achieve a lot more than we had imagined at the beginning.

So we just kept on going. Before we knew it, 35 years had passed and more. We're still working on it. But it was also very fortunate, because very early on, somehow we attracted the interest of the media and that led to early licensing and collaboration with industry.

Right at the beginning, there was an article in the university magazine that got media interest and led to Sir Garrick Agnew [former Olympian and businessman] in Western Australia, whose company Agnew Clough had a vanadium mine. He got really excited about the vanadium battery.

He came to the university very early on and entered into a licence for the technology. At the time, we were still making vanadium electrolyte from vanadyl sulphate — which is really expensive — because we worked out that we can get high concentrations if we started with that raw material.



Credit: Courtesy of Maria-Skyllas-Kazacos.

Maria Skyllas-Kazacos shows off a vanadium battery installed on a golf cart in the mid-1990s at UNSW. Standing next to Prof Skyllas-Kazacos is Dun Rui Hong, the project's mechanical engineer in charge of battery fabrication and installation.

The first thing he said to us was that unless you use vanadium pentoxide, the cheapest raw material, it's not going to be practical. Straightaway, he sent us a barrel of vanadium pentoxide and said, "I want you to develop a process for that".

One of our colleagues, Rod McDermott — an absolutely amazing guy — got some of this vanadium pentoxide, stuck it in a beaker, started stirring it in sulfuric acid, put two electrodes in there and passed the current through it. Sure enough, it started dissolving. He came up to me one day and said, "Hey, Maria, I've got it, it's dissolving!" That was it, then I realised, well, it's going to work. And that was a major, major breakthrough.

That process itself would only take you as far as V4. But then, with that knowledge, that understanding that we can electrolytically dissolve it, we started developing more industrial-type processes that could be used to produce the electrolyte. They're the processes that people are using now.

I was so fortunate to be surrounded by a group of amazing, dedicated people who were just as passionate as I was about the technology and much of the success, I owe to them. From 1986 and up until 2010, my husband Michael Kazacos was always there beside me, sourcing materials and working with our subcontractors to manufacture components. He has since retired, but I am still working on it with colleagues at UNSW, Professor Jie Bao on battery control systems, and Professor Chris Menictas, on new materials and stack designs.

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Primary vanadium producers' flow battery strategies

Flow batteries | Vanadium flow batteries are considered a leading light of the push towards technologies that can meet the need for long-duration energy storage. Not least of all by the companies that mine the metal from the ground. Andy Colthorpe learns how two primary vanadium producers increasingly view flow batteries as an exciting opportunity in the energy transition space.

Credit: Australian Vanadium.

Vanadium ore at a site in Western Australia.

The Valley of Death: the difficult gap between the tireless efforts of academics and entrepreneurs to bring their discoveries to life and establishing commercial products or services that meet true end-market demand.

It's likely you've already read many articles discussing the potential of vanadium redox flow batteries (VRFBs) to offer a long-duration, high energy counterpart to the high power, shorter duration capabilities of lithium on the power grid.

Flow batteries decouple the energy and power components of energy storage systems. That means you can scale up the amount of energy (kilowatt-hours, megawatt-hours) of a system with a set amount of power (kilowatts, megawatts), giving the opportunity to store several hours of energy.

The batteries, based on liquid electrolyte, are also almost entirely free of degradation even over many years and frequent cycles of charge and discharge. They also come without the risk of thermal runaway that lithium-ion batteries can suffer if faulty, mishandled or mismanaged.

Despite these advantages, non-technical factors — mainly economic ones — have held VRFBs back. When it comes to the economics of vanadium flow batteries, the dynamics of supply and demand for vanadium, the silvery-grey transition metal which when dissolved forms the electrolyte and therefore the key component of the battery, have long been the key talking point.

There are only three primary vanadium producers in the world today; Largo Resources, which has a mine in Brazil; Bushveld Minerals, which has mines in South Africa and mining giant Glencore (also South Africa). They account for roughly 20% of the world's vanadium supply, while about 70% comes from co-production — vanadium as a by-product of steel production. Secondary production, recycling of spent oil refining catalysts that contain vanadium, accounts for about 10%.

Two of those primary vanadium producers, Bushveld and Largo, are betting big on the success of VRFBs. Both have established subsidiaries which diversify their interests into the energy sector. So are these primary producers taking a serious gamble here? And what strategies do they have for entering this brave new world?

A sensible bet

According to Erik Sardain, a principal consultant at critical materials supply chain intelligence group Roskill, about 116,000MT of vanadium was produced globally in 2020. Adding small amounts of vanadium to steel creates much stronger alloys and more than 90% of vanadium consumption was accounted for by steel production last year. Smaller market shares were taken by aerospace, chemicals and other industries where it is also used.

Sardain says "a very, very, very small" percentage was used for flow batteries in 2020, with no major projects coming online. In 2017 and 2018, between about 1% and 1.5% of vanadium demand came from the VRFB sector. By about 2030, however, this figure could rise to 10% according to Roskill projections. Flow battery demand is a 'wild card' for vanadium, he says, largely dependent on how the technology is going to evolve.

"It's very difficult to put a number on because it is something which is very binary. But, I think one of the questions a lot of people have is: 'Yes, but if the demand for VRB is really high, will you

have a shortage of vanadium?'

"I say no, because I believe that your supply and your demand are going to go in tandem, hand-in-hand. Because, if you have a new project of vanadium, you will not have the funding, banks are not willing to give the money unless you have some off-takers. Your demand is going to create your supply."

Bushveld Minerals and Largo Resources have customers in areas including steel and aerospace. In Sardain's view, they regard energy storage as a growth area with great potential, not an area into which they have to diversify or die.

"Let's take a worst-case scenario: Largo's production is going to be 6,500 tonnes of vanadium per annum. Even if the VRFB technology doesn't really take off, they will still have demand from aerospace, they still have demand from the chemicals industry. So they can probably live without it," Sardain says.

Fortune Mojapelo, Bushveld Minerals' CEO, says that steel is still the biggest driver of demand for his company and will remain the "main underwriter of demand," but flow batteries will become a serious opportunity.

US analysis and research group Guidehouse Insights has projected that 100GWh of new energy storage could be deployed in the next six years worldwide and Mojapelo says that even if VRFBs capture only 10% of that market, we're talking about 10GWh of storage systems.

"We would need about 55,000 tonnes of vanadium just to support that. VRFBs in time will contribute a significant amount of vanadium demand, way up from the single digits that it is today," Mojapelo says.

If the market does take off, the primary producers will have a competitive advantage over later entrants, smaller producers who Sardain says are unlikely to be able to come to market any time before 2024.

"They're taking a gamble, but a gamble in a position of strength."

The long road to long-duration

As we heard in our interview with University of New South Wales emeritus professor Maria Skyllas-Kazacos (see p.79), one of the original inventors of the vanadium flow battery, a gap of more than three decades passed from the first discovery of vanadium pentoxide as an effective electrolyte to today, where we are seeing commercially available VRFBs.

Fortune Mojapelo says it's an idea and a technology whose time has now come. Global energy consumption is increasingly taking the form of electricity, from about 10% in 1980 to 20% today. By 2050, it is projected to be 45%, not least of all because of the growing electrification of "just about everything, including mobility," Mojapelo says.

"With the move to clean energy, renewable energy is going to be a big part of new electricity generation capacity going forward, helped in large part by the cost-competitiveness of renewable energy. Today, we've got solar for example, which is comparable, if not cheaper, than fossil fuel-based electricity."

But with renewable energy from wind and solar intermittent — or variable — in its generation profile, energy storage will grow in importance, while the Bushveld CEO says the uptake of energy storage will also be driven by the need for utilities to become more efficient in how they use their capital.

"Energy storage can help a grid become a lot more efficient. It is not only for integrating renewable energy, but it helps, for example, with smoothing out your demand curve, load curve, away from a peak kind of construct shape to a flatter load curve. Storage helps, because you can basically load shift, you can you can store power during off-peak, which you can use to supplement during the peak hours."

"Within that, long-duration energy storage is going to be the biggest share of stationary energy storage, will account for more than 90%," Mojapelo says.

"That's great news for vanadium flow batteries, because they are really great and efficient for long-duration. Unlike lithium-ion, in a vanadium flow battery, the energy component where you store the electricity in the electrolyte is distinct from the power unit. If I want to store more energy, I don't have to replicate the entire system, I just need to extend my electrolyte tank content. Which is why the more energy I need to store, the more hours' duration, the more efficient it becomes."

For Bushveld, the question then became how the vanadium producer should support the rise and promotion of VRFBs. The answer, its CEO says, is around creating a vertical integration model between supply of vanadium and the production and deployment of battery storage using it.

Bushveld has established a subsidiary, Bushveld Energy, which is currently building an electrolyte processing plant in South Africa, near the parent company's vanadium mines. Bushveld Energy is also aiming to support VRFB deployments with project development, such as contracting Abengoa to build a system at Bushveld's own facilities. It has also invested in VRFB manufacturers, like Anglo-American company Invinity Energy Systems and Austria-headquartered Enerox-CellCube.

Changing a sceptical position on flow batteries

Largo Resources produces about three tonnes of vanadium pentoxide (V2O5) per month from its mine in Brazil. Largo is also bullish on the prospects for flow batteries and going even further into vertical-integration, launching subsidiary Largo Clean Energy, which will make its own VRFB systems.

Credit: Abengoa

Bushveld Energy contracted Abengoa to deploy a VRFB system for a solar microgrid at its Vametco production site.

"It's been a long time coming for this energy technology to develop and I have to admit, until a year or two ago, I was very sceptical. People were talking about how good it was, but we did not see any demand in the market," Largo Resources commercial VP Paul Vollant says.

However, there were a few different drivers that led Largo to rethink its position: "To the point that we are now completely transforming the whole company to focus on on integrating this battery business and essentially becoming a vertically integrated battery manufacturer," he says.

Vollant says Largo's position as a primary producer offers a head start, which it needs to capitalise upon. Largo needs to be "very dynamic," he says. The need for long-duration energy storage is "evident" and the company is "getting more enquiries than we can process".

The vanadium Largo has been producing for many years could be a key component in an earth-saving transition to renewable energy. Yet without an economic imperative the strategic transformation of the company would not be happening.

"We're very confident that we can make more money from batteries than from the traditional markets," Vollant says.

"We looked at the historical average price of vanadium pentoxide, which is about US$8 per pound and we translated that into a cost of storage for a vanadium redox battery, and at that particular point, we are much more competitive than lithium batteries, our main competitor right now, for…let's say six to eight hours duration."

In June, Largo Resources held a "Battery Day" to highlight its strategies for entering the global VRFB industry. While vanadium pentoxide (V2O5) as an additive for steel manufacturing is indeed around US$8 per pound, in the energy storage business that same V2O5 could be worth more than US$12.

Why leasing is so important

As mentioned previously, the upfront cost of flow batteries has been a major barrier to their market uptake. Although they actually come at a lower lifetime operational cost, Capex investment required has been an obstacle for many potential customers.

Granted, electricity market rules and design will have to change in the coming years to adapt to the need for long-duration storage. This is already happening in some parts of the world, like California which is preparing to launch its first gigawatt tender for long-duration in the next couple of years. The technology of VRFBs is gaining acceptance after several years of deployments around the world.

But even this being the case, how can a company like Largo seek to make higher margins from VRFBs than its other off-take industries without confronting the customer with costs that are too high? Largo, as well as Bushveld, see the answer in leasing the electrolyte, the flow battery's single most expensive component.

"The reality in a VRB is that the economics are very different from a lithium battery and lithium battery has a much lower capex, upfront cost, but much higher Opex. Long term, operation and maintenance cost. Lithium batteries are cheaper to make for the same capacity, but they degrade quite fast," Paul Vollant says.

"If you were paying for the full cost of a lithium battery, and for the full cost of a vanadium battery, you probably be ending up paying about US$6 to US$7 for lithium battery and probably US$10 for VRB upfront, but over 25 years, you probably need to replace your lithium battery two to three times.

So your lithium system will cost you much more at the end of the day, compared to a vanadium battery that does not degrade because of the intrinsic technical aspect of the electrolyte, the fact that it's vanadium on both the anode and the cathode side, there is no contamination and there is no degradation of the battery efficiency."

However, vanadium flow battery companies have to confront the fact that today's electricity market is largely focused on that Capex upfront cost. By leasing the electrolyte that uses vanadium coming straight from its parent company's mines to its customers, Largo Clean Energy will be able to effectively "subsidise" the battery initially.

"We're not getting the customer to pay for the full cost of the vanadium that is in it, but we are replicating the cash flows of lithium batteries."

UNSW's Maria Skyllas-Kazacos explains that there can be several key strategies for reducing the cost of VRFBs. Introducing automated manufacturing — the process is largely still manual in the small volumes of production that we see today — which can be located closer to demand centres would be one. Volume production, particularly of other key components like membranes, will further reduce costs.

Credit Fraunhofer ICT.

Electrolyte tanks at a 2MW / 20MWh flow battery demonstration project at Fraunhofer ICT, Germany. With VRFBs capable of many thousands of cycles without deteriorating, the electrolyte retains much of its capital value for many years.

The technology still holds room for improvement too, like increasing the electro-catalytic properties of the electrode to be able to run at a much higher current density without too much energy loss, increasing the output power capacity, or power density of the batteries. A lot of research effort has gone into those areas, Skyllas-Kazacos says, but it's still the electrolyte that remains key.

"When you look at long-duration storage, the cost of the electrolyte is more than half of the cost. I've done quite a lot of modelling on different costs and cost components and cost reduction and the effect of different… you can reduce the resistance of the stack by half and double the power density, but it has a tiny impact on the total system cost, depending on if the vanadium price is high, when you're looking at more than four hours of storage. So really, in the end, for long-duration, the big focus has to be on the cost of the vanadium."

What are the unknowns?

Leasing can bring down the upfront cost "dramatically," Maria Skyllas-Kazacos confirms, compared to cost reduction by other means. And for companies like Largo and Bushveld it helps establish a long-term customer relationship over many years rather than a series of one-off sales.

But what's in store for vanadium prices themselves? A few years ago, a spike in vanadium prices, driven by increased construction industry demand in China, led some people to consider using something else for flow battery electrolytes.

There are other options of course, like zinc-bromine or iron, but vanadium prices

have since come down and stabilised and Largo Resources expressed a view at their Battery Day that spikes tend to last a year to 18 months at most. It remains likely, as Erik Sardain pointed out earlier, that since vanadium is an abundant but largely untapped resource, supply can scale with demand.

According to Maria Skyllas-Kazacos, that's been something of a 'chicken and egg' question for the vanadium industry. The vanadium industry has been waiting for years to see an increase in demand from the energy storage industry which is only just now starting to materialise. A vanadium processing plant in Windimurra, Australia, was built in the early 2000s, only to be shut down and reopen again before being forced to close after a fire in 2014. That plant has been acquired again and elsewhere in the country, Australian Vanadium Ltd is developing a processing plant to capitalise on a high-grade deposit in Western Australia.

"There's a lot of vanadium around the place, but everyone is sort of waiting for what's the right time to start investing and, and putting in a lot of capital to increase the supply of vanadium," Skyllas-Kazacos says.

"Once that happens, then the vanadium prices will come down dramatically and the prices will stabilise and that's the important thing."

Roskill's Erik Sardain reiterates that the world is not likely to be in short supply of vanadium, but it's a question of getting the economics right, of companies' ability of "getting the money to take it from the ground and make it economical".

It's interesting to note that beyond the primary producers, the majority of vanadium co-produced from steel slag currently comes from China. Bushveld CEO Fortune Mojapelo says that the energy storage market would be big enough to support both primary and co-producers supplying into it, but also notes that with co-producers already operating at "almost full capacity today," they will not be the big drivers of supply into the flow battery space.

Having said that, China's government has established a programme to develop several large VRFB projects of hundreds of megawatt-hours each in strategic locations around the country. As with the solar PV and lithium battery industries, China could be the leader that kickstarts a global wave of long-duration VRFBs, Roskill's analysts believe.

"I believe that the VRFB story is going to be driven by China, because it's not only based on economics, it's also based on politics. Because if the Chinese government says, "Let's go for it," then they will go for it," Erik Sardain says.

"If it's successful, China is going to show the way. And basically the rest of the world is going to follow after that."

That said, the US government is on record expressing a view that the future lies with flow batteries for large-scale grid energy storage, Fortune Mojapelo points out, and the question remains within the flow battery space as to which chemistries will be dominant. Other electrolyte chemistries like those mentioned above "don't have any meaningful deployments to talk about," compared with vanadium flow batteries, he says.

But nonetheless, the race to decarbonise needs to speed up and different flow battery types — and other types of long-duration storage — can work together in powering the global energy transition.

"Here's the thing: you can have multiple technologies," the Bushveld Minerals CEO says.

"We're fine with that, because vanadium flow batteries just won't have the capacity to capture all of that market growth. If vanadium flow batteries get to even 20% of that stationary market, we think it's a massive deal. It's a big, big deal and we're very pleased for that. It's not a case of one technology, winning over all the other technologies, I think you will see multiple technologies very active in that space."

Largo Resources takes a similar view, Paul Vollant says. It takes about 6,000 tonnes of vanadium to supply about one gigawatt-hour of storage. Today, only about 1,000 to 2,000 tonnes a year goes into VRFBs at most. With the "strong inflection point in the demand for long-duration storage" that Largo is seeing, there will be a supply chain shock coming that only an increase in the global supply of vanadium coupled with a diversification of long-duration solutions can solve.

"Vanadium redox batteries are not going to be the only solution for long-duration, you have geographies where pumped hydro storage is a better solution, you've got other applications where compressed air would be better. The ambition for Largo and for the VRFB industry is not to capture the whole market, the ambition is to capture the applications where VRFB makes more sense, and that are most profitable."

Meanwhile Largo, and others, have the ability to scale up production, but it is a question of time and money. Vollant says it costs in the region of about US$300 million to US$400 million and about three to four years to establish and ramp up a vanadium plant.

"It's a bit like oil: there's no global shortage of oil, but there is a shortage of cheap vanadium as there is a shortage of cheap oil from deposits that are high grade and low cost. If the world really needs a lot more vanadium as when the world needs a lot more oil, then the world would have to pay a higher price for vanadium. So you will find an equilibrium between supply and demand." ■

Credit: Largo Resources.

Largo's vanadium flakes. The company believes vanadium pentoxide can be worth more per pound in energy storage than in some of its traditional markets

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Hybrid renewables-plus-battery power plants are growing rapidly — are they a good idea?

Credit: Dennis Schroeder / NREL

Hybrid projects | In the US, there is a growing trend for battery storage systems to be directly paired with onsite wind and solar generation, creating hybrid resources. Will Gorman from Lawrence Berkeley National Laboratory looks at when and where this configuration makes sense — and why sometimes it doesn't.

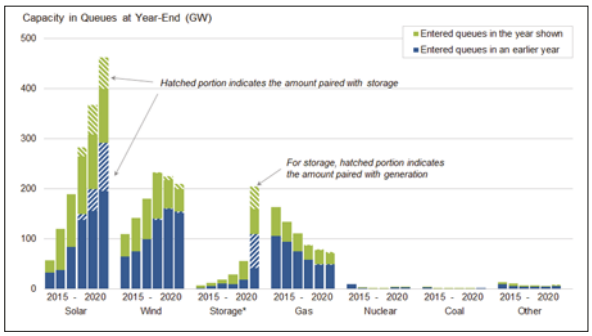
Meeting the demands of the electricity system with growing wind and solar requires greater balancing due to their inherent variability. While this is typically done at the network level, using dispatchable power plants, demand response, and other techniques, developers are seeing some advantages to integrating batteries on-site, potentially allowing the wind or solar plant to look more like a conventional power plant.

Solar projects can use batteries to shift generation from the day to the evening, to capture higher power prices as the sun goes down. Wind projects can use batteries to smooth power output and avoid congestion. As battery prices continue to fall and the penetration of variable wind and solar generation rises, power plant developers are increasingly turning to these "hybrid" power plants.

By the end of 2020, roughly 70 solar-plus-storage power plants were in operation in the United States, representing almost 1GW of solar and 250MW of battery capacity. This compares to 14 wind-plus-storage projects with 1.4GW of wind and 200MW of battery capacity installed.

NREL built a test bed 240kW PV array and 500kWh BESS in Colorado as a pilot to de-risk the AES Lawai Solar Project-Kauai, a 28 MW PV and 100MWh BESS in Hawaii.

But developers are proposing a massive increase in the number of hybrid plants. Looking at the major power plant interconnection queues in the United States, we found 160GW of solar and 13GW of wind being developed with co-located



Credit: Berkeley Lab

Figure 1: Capacity in Interconnection queues representing 37 United States Independent System Operators (ISO) and utilities, representing roughly 85% of U.S. electric demand. Source: Berkeley Lab, "Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2020"

batteries, amounting to almost 34% of solar and 6% of wind currently in the queues. (Figure 1).

In the western US the percentages are even higher, with 70%–90% of proposed solar paired with storage, including almost all grid-scale solar projects in California. Almost two-thirds of all grid-connected batteries in California are part of hybrid solar-plus-storage systems. In other regions, the share is typically less than 40%.

While wind and solar plants are located to take advantage of strong winds and sunshine, with plentiful land and good grid connections, batteries can be put practically anywhere. In high-value locations they can provide multiple values to the local grid, such as voltage support, congestion relief and resilience. With the right controls they can also provide system-wide benefits, such as capacity and load following.

If developers are co-locating batteries with wind and solar plants, it raises some questions:

- What are the benefits of co-location, compared to optimal siting for grid services?
- What are the relative cost savings?
- And how valuable are the opportunities developers might be missing?

Our research team at Lawrence Berkeley National Laboratory (Berkeley Lab) has been studying this hybridisation trend in order to better understand where batteries should be located to provide the highest value. We aimed to understand whether renewable-plus-battery power plants provide more value than independently sited installations.

In the process, we uncovered explanations for why commercial activity of hybrids is higher in the western US as well as for solar rather than wind technologies. Our answers point to strategies that can be used to understand the renewable transition and therefore have important implications for an electricity system aiming for higher levels of renewable energy.

To hybridise, or not to hybridise?

The growth of hybrids is, in part, being driven by significant declines in project costs. Power purchase agreement (PPA) prices for hybrid power plants have plummeted in recent years, with declining costs for wind, solar and for batteries. Based on contract price information for 50 solar-battery hybrid projects, we found that prices have fallen for mainland US projects from US$40-70 per MWh in 2017 to US$20-30 per MWh in 2020. In Hawaii, per MWh prices have dropped from US$120 in 2015 to US$80 by the end of 2020.

These PPAs also shed light on how hybrid developers are choosing batteries to pair with their generators. Simply put, the larger the battery, the larger the cost. We found that the cost of adding a four-hour duration battery at a utility-scale solar project ranges from US$5 to US$20 per MWh, depending on the battery to PV capacity ratio. Lower ratios (25%-50%) have smaller storage adders (US$5-10/MWh) and higher ratios (75-100%) have higher storage adders (US$15-20/MWh).

However, by co-locating the generators and batteries at a single site, project developers see cost savings by sharing equipment, cutting interconnection and permitting costs, capturing otherwise clipped energy, and taking advantage of federal tax credits that encourage coupling solar and batteries. Furthermore, batteries have greater dispatch flexibility, making them more attractive for grid operations.

There can also be a corresponding value boost from pairing a storage unit with a renewable energy generator. Using wholesale power market prices at utility-scale wind and solar locations from 2012–2019 across the seven main US independent system operators (ISOs), we found that co-locating a 4-hour battery with a 50% battery-to-renewable capacity ratio can add value ranging from US$3 to US$22 per MWh, depending on the year and market region being studied, with an average value boost of US$10 per MWh.

The greatest value came from the California market (US$22/MWh) where, thanks to a high penetration of solar (20% of energy in 2019), California is seeing low net load in the day, with a large ramp in the evening hours, as the sun goes down – a phenomenon known as the 'duck curve'. Prices have begun to correlate with this trend, so using hybrid technologies to mitigate the duck curve can bring in more revenues. The US$20/MWh value boost resulting from adding storage in California is double the US$10/MWh storage cost adder we found in PPA prices.

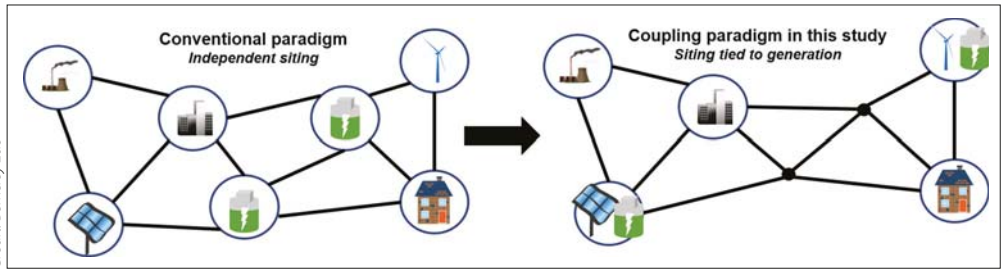
On the other hand, the power market in the Midwest (MISO) has a significantly lower value boost from storage (US$4-US$5 per MWh), which does not offset the US$10/MWh storage cost adder. So far, we have seen less hybrid development activity in these low value regions.

There are additional complications to hybrid development, including policy and market designs. In the US, only batteries that charge from renewable resources can take advantage of a 30% tax credit. If this tax credit expires or is expanded to standalone batteries, hybrid projects would lose this special advantage. Though by charging only from their co-located generators, batteries may be unable to offer their full flexibility to power markets.

Constraints on hybrid market value

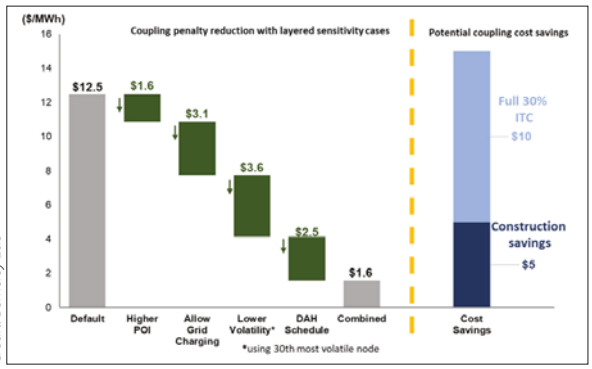
To understand the significance of these hybrid constraints, we compared the market value of hybrid projects to the value of the same generators and batteries deployed separately.

To do this we expanded our wholesale market value analysis to cover market



Credit: Berkeley Lab

Figure 2: Depiction of variable renewable energy operational paradigms in electricity networks. Source: Berkeley Lab, "Are coupled renewable-battery power plants more valuable than independently sited installations?"



Credit: Berkeley Lab

Figure 3: The penalty for co-locating generation and storage can be reduced by a variety of strategies, while co-location offers some cost savings and incentives. ITC = Federal Investment Tax Credit. Source: Berkeley Lab, "Are coupled renewable-battery power plants more valuable than independently sited installations?"

prices across all nodal prices points in the seven main US independent system operators (ISOs) rather than just market prices at utility-scale wind and solar locations.

We found that installing a battery separately in a nearby high-value location results in higher market values than from siting the same batteries together with wind and solar. This holds true in nearly all markets and years, with a higher value of US$2–US$50/MWh, averaging US$12.50/MWh.

We call this opportunity cost that results from co-location the 'coupling penalty'. The highest coupling penalties are found in particularly grid-constrained regions, like New York's Long Island, while lower coupling penalties occur in Texas in certain years of the study period.

Through a variety of strategies, the coupling penalty of co-located projects can be reduced, such as by recharging batteries from the grid during low-price hours, or sizing the interconnection capacity so both the generator and the battery can deliver power to the grid at the same time. Though independent batteries have the flexibility to be placed anywhere on the grid, it is not always straightforward to identify high value locations in the market. When accounting for these issues, we found that the coupling penalty could be reduced from the US$12.5/MWh cited earlier to US$1.6/MWh (Figure 3).

Though separating generation from storage usually delivers higher value, it may also deliver higher costs, as a project developer will need multiple sites and grid interconnections, and may lose the benefit of sharing equipment with generators. While it is difficult to precisely estimate the cost difference between combined and separated resources, a rough estimate found about US$15/MWh in cost savings from using a single location (Figure 3).

The biggest part of the savings is when the federal tax credit for renewable energy production is applied to batteries, provided the batteries are directly charged by the renewable generator. The tax credit, worth as much as US$10/MWh, can tip the scale toward co-location, making coupled projects more attractive to the developer than separate locations.

As developers and policymakers continue to search for the best way to deploy renewables and storage, this consideration of cost and value will be important. We found that the relative benefits and costs can vary by market, by time, and by other factors. Depending on conditions, both separate and hybrid projects can pencil out from a system optimisation perspective.

Opportunities and challenges

The multiple attributes of hybrid projects increase the opportunities for and complexity of engaging in the market. Hybrid plant operators will need to evaluate the market revenue potential from operating the plant as a single unit or operating multiple parts with different capabilities. As a single unit, developing bids may require the hybrid plant operator to forecast wind or solar to self-manage the state-of-charge (SOC) of the batteries. Alternatively, if treated as separate resources, wholesale market operators may need to implement methods to manage the SOC and variability of the wind or solar while accounting for any coupling constraints. This choice between operational models has implications for how hybrids will bid their capabilities into markets and what performance risks the power plant operator takes on.

Likewise the grid operator will need to know what to expect, as a hybrid plant could alternate from being a producer to being a consumer of grid power, depending on market conditions and battery/generator ratios. This could have big implications for resource planning, forecasting, market power mitigation, and interconnection policies. The grid operator sets the participation rules and is ultimately responsible for ensuring the reliability of the electricity system.

Open questions

Commercial interest in the hybrid model is growing rapidly, with signed PPAs and interconnection queues demonstrating major expansion of hybrid projects over the next several years. Time will tell whether this trend is a short-lived product of current policy drivers or a more lasting phenomenon.

Past considerations for solar and wind siting decisions were often limited to resource potential, transmission access, market value, and land availability. Our work suggests that nodal price volatility—which is well correlated with the market value of storage—will be another important power plant siting consideration in a future with higher development of battery and hybrid technologies.

However, the impact of high penetrations of wind, solar, and batteries on wholesale market prices remains uncertain. These technologies could increase or decrease wholesale market price volatility, with implications for the overall market potential of battery technologies in standalone and hybrid configurations. Whether hybrid plants are economically attractive is location dependent and will be influenced by these future wholesale pricing trends.

More work is also needed to clarify the long-term cost-reduction potential and risks/benefits of hybrid projects within the electricity system. Understanding the costs and benefits will give regulators and policy designers more insight into the drivers of the hybrid trend. Appropriate market participation rules should take advantage of this new power plant design while ensuring the reliability and efficiency of our electricity networks. Many of those rules are still being written.

Author

Will Gorman is a researcher in the Electricity Markets and Policy Department at Lawrence Berkeley National Lab. This article was largely based on two research publications: (1) 'Motivations and options for deploying hybrid generator-plus-battery projects within the bulk power system' and (2) 'Are coupled renewable-battery power plants more valuable than independently sited installations?' For links to these publications and more research see emp.lbl.gov and follow the Department on Twitter at @BerkeleyLabEMP.

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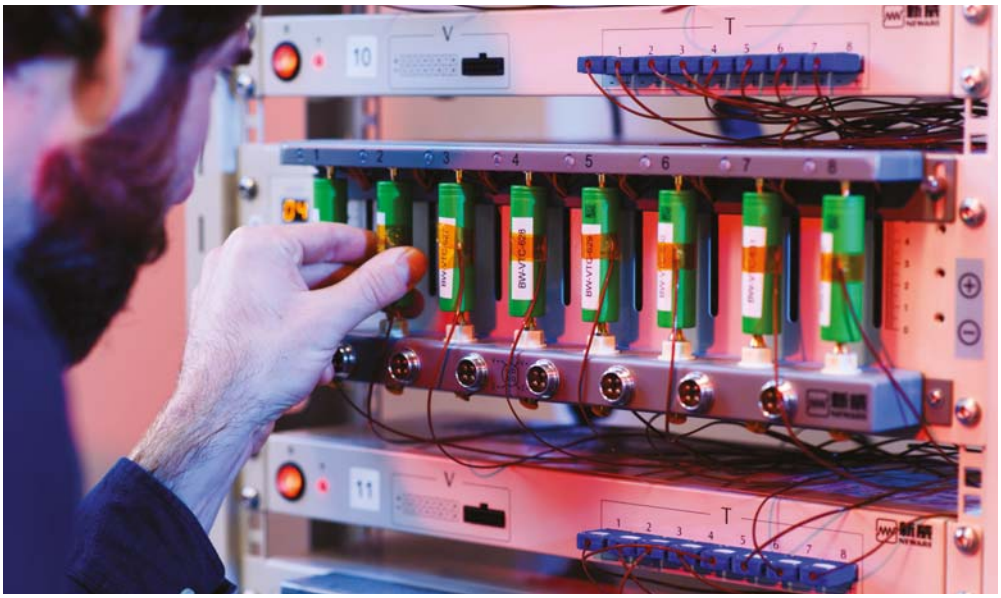
Battery analytics: The game changer for energy storage

Analytics | The phrase 'game changer' is used often, sometimes in hope rather than expectation. Lithium batteries have definitely changed the game for the energy transition, but require smart technologies and strategies to optimise them — which can be equally important — writes Sebastian Becker of TWAICE, a predictive analytics software provider.



Credit: TWAICE.

Battery cell testing in a laboratory at TWAICE.

Battery storage systems are an essential component of the energy sector. However, they are complex systems that require special attention. The primary goal of storage owners is to maximise the profit possible from the storage system without taking on additional risk. This is where battery analytics comes into play.

Booming market

Around 25GWh of stationary battery storage is already installed worldwide. This will rapidly increase, as battery storage systems are ideally suited to address the challenges of the energy transition. Unlike most other power plant technologies, batteries can not only supply energy, but also store it. And they can respond to the need to do so within milliseconds. This makes them suitable for numerous use cases, both front-of-the-meter and behind-the-meter. In addition, falling battery prices make investments more attractive. Combined, these factors fuel a boom in battery storage that is likely to reach hundreds of gigawatt-hours by 2030.

However, many market actors – system integrators, asset owners, partners and financial service providers – identify the main reasons for a decision not to move forward with a battery project as technical risks in conjunction with market challenges and a changing regulatory environment. Market risks involve fluctuating prices, while new regulations can destroy a business case (or sometimes also send it through the roof). One example of a bullet-proof business case is California. Here, market risk was all but eliminated by the revenue of most projects being protected by long term power purchase agreements (PPAs). Consequently, projects with hundreds of megawatt-hour capacities are no longer rare. But while being subject to these external market factors, with any battery storage project, careful assessment of the impact that the use case will have on the battery is required.

Challenges of technical risks

Batteries are complex electro-chemical systems and come with some technical challenges. As a new asset class, many players that have never dealt with batteries before now find that they are essential to their success. To ensure a common understanding, let's establish a few facts:

- Battery storage is generally a very safe and reliable technology. However, like any other technical system, battery cells or other components can fail. The consequences depend on the severity and the reaction. Best case, moderate reduction in performance or unplanned maintenance. Worst case, if the issues are not immediately addressed or an essential component fails without warning: unplanned downtime with major repairs. One eye-catching example is battery storage fires, e.g. in Korea and Arizona (2018 and 2019, respectively) which attracted a lot of media attention. The probability is less than 1:1,000,000 but if it happens, it can be a disaster.
- Downtimes are a technical risk that translates directly into financial risk. While downtime may not seem dramatic at first glance, certain use cases depend on the availability of a battery. When energy is not available when required, penalties due to breach of contract are incurred or, more simply, a very high bill is incurred. Energy solutions that include battery storage can save a high percentage of a company's electricity bill – if the storage fails during peak time there are no savings for that year (and the company still pays for the storage).
- At an advanced stage of the battery lifetime, there is the risk that power or capacity requirements are not met anymore. This results in the exclusion of certain markets and use cases, but also contains the risk of unexpected penalties.

Existing warranties can only partially address these challenges or become prohibitively expensive, as it is impossible

for the insurer to assess the risk. In short, batteries come with great opportunities but also high, yet manageable, risks. Let's take a look at battery analytics to understand why.

Battery ageing and analytics

Battery analytics refers to getting more out of the battery using software – not only during operation, but also when selecting the right battery cell or designing the overall system. For now, the focus will be on the possibilities to optimise the in-field operation of battery storage systems.

Why is battery analytics so important?

Battery degradation, also called ageing, has a significant impact on performance over the lifetime. In time, two major effects become visible: capacity fade and resistance increase, translating to less available energy and power. The overall capabilities are often collectively measured in a KPI called state of health (SoH).

This ageing behaviour and state of health is driven by numerous factors and can vary greatly from one battery system to another. Two batteries with 90% SoH may have wildly different remaining useful lifetimes, depending on their previous treatment. Let's look at some of these factors:

- **Temperature:** This has a large impact but depending on the situation and cell (chemistry) different temperature ranges can be beneficial. As a rule of thumb: When the battery is idle, low temperatures are preventing too much calendric ageing i.e., ageing that occurs with time without usage, while moderately warm temperatures (e.g. 30°C) may be the best option for strong cycling.
- **Charging rate (c-rate):** Different battery types are used for different use cases. In general, high c-rates tend to have a greater impact on ageing than low c-rates.
- **Average State of Charge (SoC):** While it is desirable to have a lot of energy available (depending on the use case), higher average SoCs may accelerate the ageing. Too low SoCs may threaten the business case, as not enough energy is available. Too low SoCs should always be technically prevented by the battery management system to prevent damage.
- **Depth of Discharge (DoD):** This refers to the amount of energy that is taken out of the storage at any given time. In a battery discharging from 80% to 35% SoC this translates into a DoD of 45%. As a rule, lower DoDs are beneficial with five swings of 20% being less harmful than one full cycle. Thus, 10 cycles in an arbitrage operation will have a larger impact on battery degradation than 10 cycles in ancillary services.

But the reality is more complicated. Every battery type reacts very differently to each of these stress factors. And if – to prevent battery degradation – the battery is operated 'over-carefully' regarding the described stress factors, a lot of potential is wasted.

So why not simply put a lot more capacity into the storage (called oversizing, or overstacking) from the beginning? Firstly, because the initial investment costs will skyrocket and ruin your business case. Most users will aim to leverage as much of the storage as possible.

Which leads to the second point: While a couple of years ago, the optimisation for a specific use case upfront may have been a valid idea, use cases have since become more complex. Multi-use strategies, or a change of operating strategy after a while, will become mandatory for high profitability. As a result, dimensioning the system at the outset has become less important and dispatch planning is happening regularly, requiring new insights into the current battery capabilities and the impact of different operating strategies.

Reducing the levelised cost of storage with battery analytics

Anyone purchasing a battery system wants guaranteed performance. It is therefore essential that manufacturers and integrators of such systems offer the best possible warranty. Tracking and simulating the impact of the usage on performance and corresponding warranty is the key to unlocking this potential.

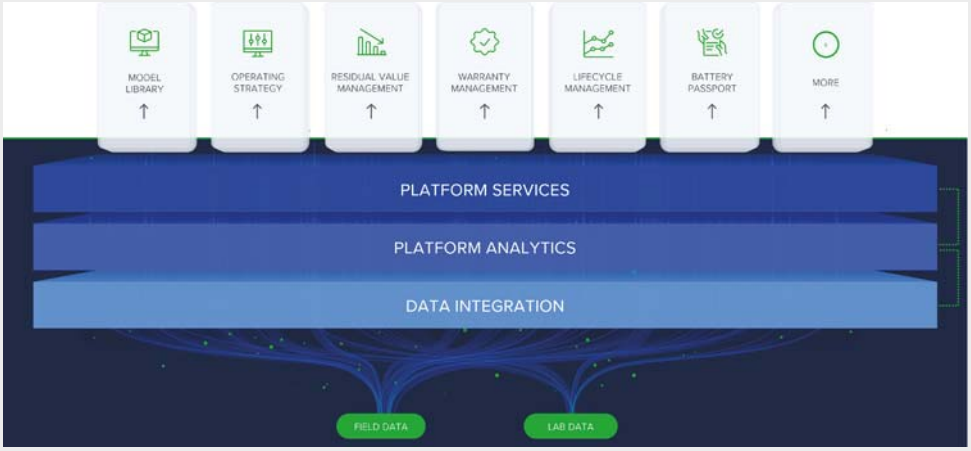
Integrators face the challenge of combining multiple supplier warranties into a system warranty for their customers. This also includes several performance warranties ranging from capacity performance to availability performance, and often even includes a warranty on roundtrip efficiencies. To have an overview on their performance warranties, integrators need to collect data, perform (manual) analyses and communicate the performance and the warranty status to their clients. In the event of a warranty claim, the agreed conditions must be restored and the claim forwarded to the cell supplier. The complexity increases with the variety of ingoing and outgoing warranties – it is the norm rather than the exception and there are no standard contracts.

In addition to the strategic considerations, let's not forget the operational benefits of a monitoring tool enhanced by analytics. Operation and maintenance (O&M) teams benefit from a more precise data analysis in real time, e. g. faulty modules or modules that have experienced ageing can be identified and replaced by the service team.

There is yet another challenge that can be solved. Today, it is difficult for integrators to renegotiate the warranty terms in the case of a new operating strategy because of the unknown impact on performance. The required transpar-

Figure 1: TWAICE Cloud Analytics Platform

The TWAICE cloud analytics platform provides insights and solutions based on field data. The differentiation factor is the end-to-end approach with analytics at its heart. After processing and mapping the data, the platform analytics layer runs different analytical algorithms, electrical, thermal and ageing models as well as machine learning models. This variety of analytical approaches is the key to balance data input quality



ency and predictability can be provided by predictive battery analytics simulating the impact on system performance as well as on the warranty terms.

Low profitability and long amortisation periods are two of the main challenges that owners face when planning and operating their battery storage projects. Energy prices are fluctuating, unpredictable and the regulatory environment differs internationally and even within the same country. For example, the German primary frequency response (PFR) market has experienced a significant price drop over the past few years. To restore profitability, many asset owners are considering adapting their operating strategy or working on a multi-use operating strategy. However, the complex ageing behaviour of batteries makes the optimisation and selection of the most profitable strategy difficult. A continuous use of battery analytics can generate value for the customer in a wide variety of ways:

- Considering battery ageing when planning operating strategies helps the owner to better decide between different strategies. This way, the optimal operating strategy can be selected to balance the expected revenue and battery lifetime to increase the overall return of investment – before and during operation
- When commercially operating a storage, an estimation of the true costs of ageing per cycle and energy can be incorporated into the market optimisation software and price planning – daily or even more frequently if needed. This enhances the profitability.
- Also, the owner will know that the storage can be used throughout the planned duration for the selected strategy. The risk of a premature storage underperformance is minimised as countermeasures can be taken preventively.

Giving batteries a retirement home – analytics driving 2nd life applications

2nd life usage of batteries is a controversial topic. Some experts argue that the costs for repurposing are too high and batteries should be purpose-built to reach their full potential. Consequently, they do not believe in the economic feasibility or plausibility of 2nd life applications and favor recycling instead of repurposing.

Other experts contend the issue of used batteries being recycled while still in good condition and able to add great value in other applications. .

The challenge will always be to efficiently select the batteries that are still suitable for 2nd life applications. An economic and ecological assessment, with regard to potential benefits from a second life compared to the alternative, must take place. The key here is an efficient assessment of the battery health as well as the performance that can be expected in the 2nd life application – battery analytics based on already existing data is the solution.

Looking at the economic aspects: High repurposing costs combined with the reduced bankability of most 2nd life batteries means there is currently little incentive to purchase a used battery. However, repurposing costs are falling, and the other issues can be solved as well – both due to battery analytics.

- The battery status can be determined based on historic data, and repurposing costs, which largely consist of bench testing and the associated logistics costs of shipping batteries from A (1st life operation) to B (testing facility) to C (assembly of 2nd life storage) can be minimized. The historic battery data can be used to provide a precise SoH and consequently physical testing can be avoided and repurposing costs are reduced significantly.
- All of the regular optimisations of energy storage that were discussed before also apply for 2nd life batteries. Including battery analytics, potentially in combination with an extended warranty, can increase the bankability of projects including 2nd life batteries.

Battery analytics are the essential differentiator

There is a lot of untapped potential in a market with increasing volumes, decreasing prices and an increasing consolidation – not surprisingly, this had led to strong competition and there are still many new players trying to gain a foothold in this dynamically growing and evolving market. Competitive pricing has become a necessary requirement to exist in a market with both powerful suppliers (battery and PCS manufacturers) and powerful clients (utilities and IPPs with ever increasing pipelines). Of course, integrators will seek to differentiate with innovative products and additional solutions – and will try to become more vertically integrated.

The top seven players of 2021 accounting for around two thirds of the integrated capacity in 2021 (compared to around 30% between 2016 and 2019) is a clear indication of an ongoing market consolidation. Nevertheless, due to the dynamic growth described here, new players keep trying to establish themselves in the market to get their piece of the pie. To secure their position, the established businesses are expanding their product portfolios. While a couple of years ago the physical system integration was their focus, most people – in addition to offering energy management system (EMS) software which has become almost a market standard – provide battery management system (BMS) software, and some even offer energy trading software.

Also, O&M services and engineering, procurement and construction (EPC) now belong to the standard portfolio. This is necessary, as these players are being squeezed by the suppliers, not only with respect to pricing and minimum purchase quantities, but also because of the suppliers' ambitions to increase their upstream activities. Additionally, there is also downstream integration by solar and battery project developers enhancing their system integration capabilities to source directly from component suppliers, i.e., to skip the middlemen.

Battery analytics is increasingly recognised as the key to more market traction and higher profitability. Improving transparency into the projects for which they still have ongoing warranty obligations or to driving the service offering towards the storage owners and operators enables users to differentiate from competition.

Finally, a word from the software provider's perspective: it is far easier – and cheaper for the customer – to connect to the storage and influence the data quality in an early project phase than retrofitting the solution to an existing project set-up. ■

Author

Sebastian Becker is business development manager at TWAICE, a provider of predictive battery analytics based in Germany. Previously a strategy consultant, Becker is driving the business development for energy solutions at TWAICE, enabling integrators, owners and operators of battery energy storage systems to maximise their assets' profitability. TWAICE's partnerships as an independent authority include working with Munich RE on insurance services and with TÜV on residual value determinations and certifications.

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