POWER PVTECH

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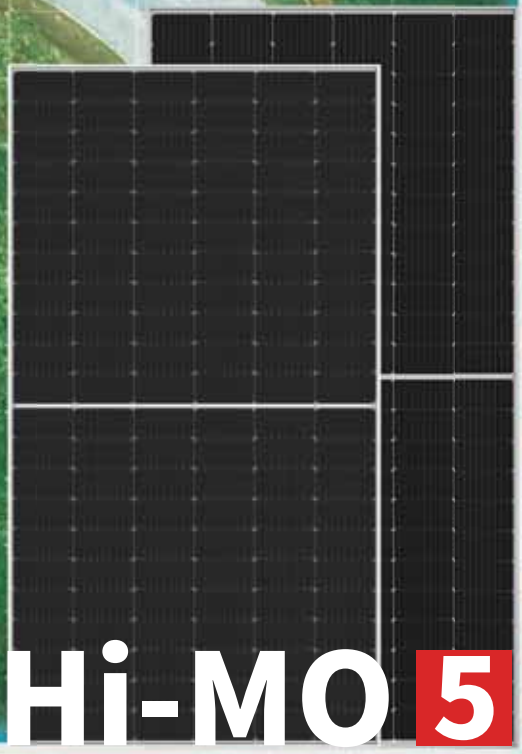

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Introduction

Welcome to volume 32 of *PV Tech Power*, published just days after US President Joe Biden signed into law what has been billed as the largest climate package in the country's history.

The Inflation Reduction Act promises to lay the groundwork for accelerated solar deployment and a ramp-up in domestic PV manufacturing, providing policy certainty for the next ten-plus years while giving US industry players the green light to scale up their operations.

Its passage into law provides a much-welcome reprieve for the industry in the US following uncertainty stemming from an investigation into alleged circumvention of solar tariffs and a toughened stance on products from China's Xinjiang region owing to forced labour concerns. We chart the events of the last 12 months (p. 29) and how the various policy headwinds destabilised module procurement.

One segment set to benefit from the Inflation Reduction Act is community solar as we explore the drivers of deployment and what obstacles need to be overcome to support its rollout (p. 23).

Our cover story (p. 16), meanwhile, takes a deep dive into how solar projects are being adapted to their grid surroundings by connecting to other technologies, such as energy storage systems, other renewables or green hydrogen electrolysers. This hybridisation approach can deliver more predictable output, increase revenues for asset owners and ease curtailment – an issue of increasing concern in some areas as more solar comes online.

Octopus Hydrogen's Alissa Tripp details how green hydrogen electrolysers co-located with PV plants can be mutually beneficial while also providing a potential solution to solar curtailment (p. 48).

We hear from Enerparc's Yoojin Lee about how the company's artificial intelligence approaches are making day-ahead forecasts more accurate (p. 68) while TÜV Rheinland's Yating Zhang and Christos Monokroussos discuss the importance of understanding the import parameters of PAN files (p. 58).

In our Financial, Legal and Professional section, Alexa Capital CEO Bruce Huber explores how the new era of inflation is affecting solar project revenues (p. 76) while Liam Stoker reports on how relations between manufacturers, distributors and developers have changed amid supply chain constraints, sky-high prices and contractual disputes (p. 80).

This issue is my first editing *PV Tech Power* as Liam leaves Solar Media after more than seven years. I hope to carry on his sterling work as our editorial team continues to document the industry's growth. Thank you for reading, and we hope you enjoy the journal.

Jules Scully
Section editor
Solar Media

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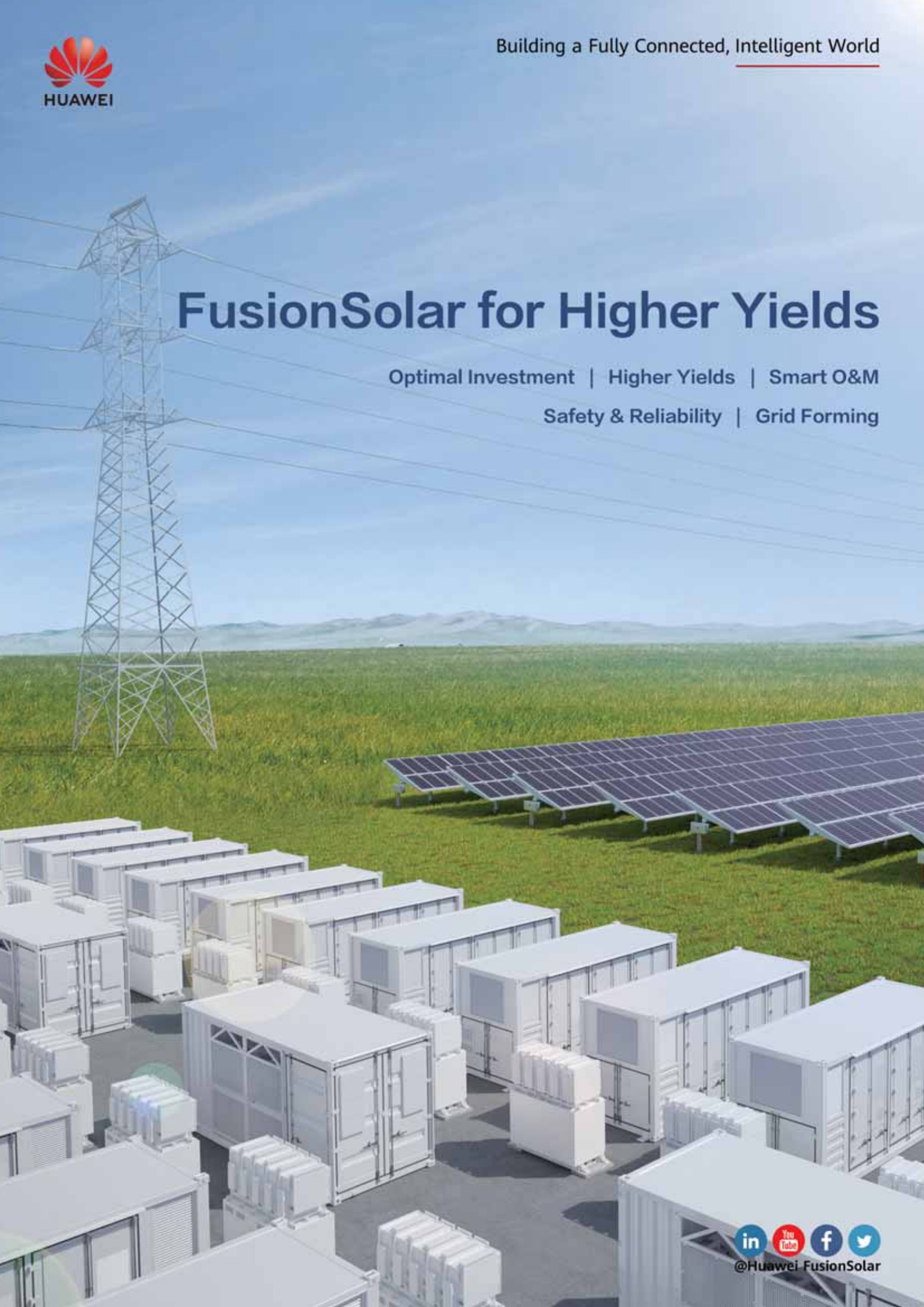

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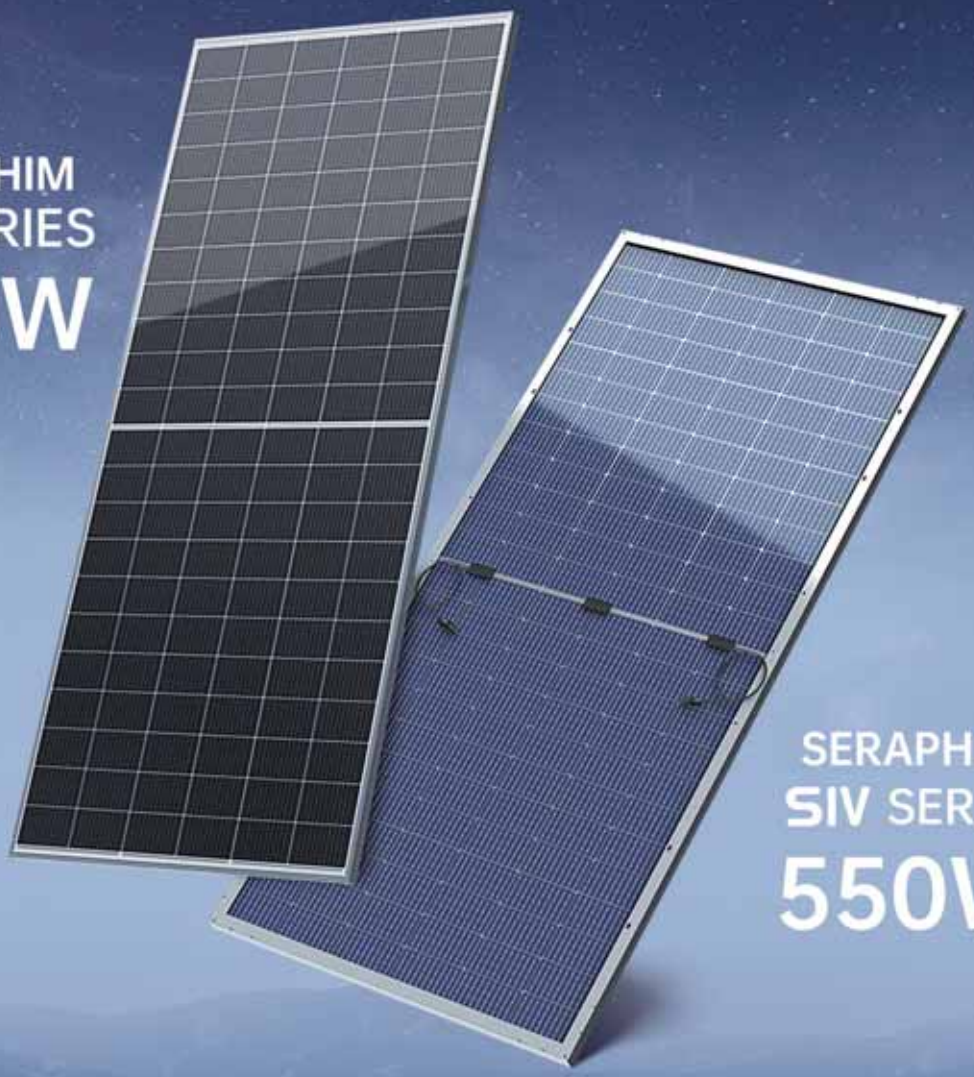

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EUROPE

EU

EU solar plan sets 2030 deployment target at 740GWdc

The European Union (EU) has significantly ramped up and brought forward its solar deployment targets as part of its updated REPowerEU strategy, redesigned to combat the bloc's reliance on fossil fuels, and in particular Russian gas. The European Commission (EC), which released its EU Solar Energy Strategy alongside the REPowerEU strategy, is now targeting 320GWac/400GWdc of solar PV by 2025 and almost 600GWac/740GWdc by 2030, although this is still short of what some states and industry organisations have called for. Previous drafts of the strategy had aimed at around 300GW of solar by 2028 and 500GW by 2030. Referencing its objective to dispel its dependency on Russian gas, the EC said "solar energy will be the kingpin of this effort" as it called for a "massive deployment of solar energy".

EU on track to deploy record 39GW of solar this year

A record 39GW of solar PV will installed across the EU this year, according to trade association SolarPower Europe (SPE), as the continent scrambles to deploy renewables and wean itself off Russian gas. The figure is a significant jump on the 27GW of solar deployed in the bloc in 2021, which was itself a decade-long installation record. Following Russia's invasion of Ukraine, and the subsequent rise in energy prices, European governments have looked to accelerate renewables deployment as a means to reduce their reliance on Russian energy imports. "European solar is rolling out as fast as possible in anticipation of a difficult winter," said Walburga Hemetsberger, CEO at SPE.

Auctions

2.2GW of solar successful in UK's latest renewables auction

More than 2GW of solar has won contracts in the UK's latest renewables auction, clearing at a strike price of £53.40/MWh (US$64.19/MWh). The country's Department for Business, Energy and Industrial Strategy (BEIS) confirmed the results of the fourth allocation round (AR4) of the UK's Contracts for Difference scheme, revealing 66 solar projects totaling 2.2GW had secured contracts. The auction's results confirmed the winning strike price for solar to be £45.99/MWh (US$55.30/MWh), however the auction's prices are based on pricing in 2012 which, when taking into account inflation, means projects will be paid £53.40/MWh – or £0.0534/kWh – for the ten-year duration of the contract. Of those contracts, five are to begin generating power within the 2023/24 financial year, with the rest set to come on stream in 2024/25.

Ireland awards 1.5GW of solar in second RESS auction

More than 1.5GW of solar PV projects have been successful in Ireland's second Renewable Electricity Support Scheme (RESS) auction. Provisional results of the auction, published by grid operator EirGrid, include 66 solar PV projects ranging in size from 0.65MW to 120MW, for a total of almost 2GW of projects awarded between solar and wind. Nearly double the amount of solar capacity was awarded compared to Ireland's first RESS. However strike prices rose, reaching €97.87/MWh (US$104.46/MWh), more than €20 higher than the first RESS average strike price of €72.92/MWh.

Spain launches new renewables auction with 1.8GW of solar capacity sought

Spain has announced its fourth renewables auction round, to be held on 22 November 2022, with 1.8GW of solar capacity sought to accelerate the decarbonisation of the country's power system. The Ministry of Ecological Transition said it will accept the scaling up or hybridisation of existing installations for this latest round. Moreover, if some of the allocated capacity is not entirely filled for solar PV (1.8GW) or wind (1.5GW), the capacity could be transferred to the other technology. This will be the fourth auction Spain has held. The first took place in January 2021, when more than 2GW of solar was awarded, and the second in October 2021, allocating 866MW of solar capacity. The third will take place on 25 October 2022.

Spain

Iberdrola commissions Europe's largest solar plant at 590MW

Iberdrola has commissioned the 590MW Francisco Pizarro PV project in Extremadura, southwestern Spain, which is Europe's largest solar plant. Representing an investment of €300 million (US$310 million), the project uses 1.5 million PV modules and created more than 1,500 jobs during peak construction periods. Iberdrola will supply electricity from the plant to corporations including Danone, Bayer and PepsiCo. The utility has now installed more than 19.3GW of renewable energy in Spain with a plan to reach 25GW in the coming years. It has allocated €14.3 billion to the deployment of renewables and smart grids by 2025.

Credit: Iberdrola.

The Francisco Pizarro PV plant features 1.5 million modules.

PPAs

BayWa r.e. claims industry first with 10TWh tender for corporate PPAs

German renewables company BayWa r.e. will tender 10TWh of green electricity later this autumn, describing the move as a "turning point" for Europe's power purchase agreement (PPA) market. The company said it will issue Europe's first tender initiated by a developer for corporate PPAs, with the energy to come from a portfolio of renewables projects in Germany and Spain. It is expected that output from the plants will be shared with several off-takers, which will secure ten-year contracts. The company said it was witnessing high corporate demand for renewable electricity globally, especially in the Europe, Middle East and Africa region.

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AMERICAS

Policy

US solar prospects 'dramatically enhanced' with Inflation Reduction Act

US solar players have hailed the country's landmark Inflation Reduction Act (IRA), signed into law by President Joe Biden in August, as a once-in-a-generation legislation that lays the groundwork for accelerated PV deployment and a significant ramp-up in domestic manufacturing. Billed as the biggest climate package in US history, the act earmarks US$369 billion for decarbonisation efforts. A key component is the extension of the investment tax credit at 30% for commercial and residential solar systems for the next decade, while standalone energy storage facilities will also be eligible. The bill also adds solar projects to the list of power generation facilities that can receive a production tax credit. For US manufacturers, the legislation features tax credits for PV components including modules, cells, wafers, backsheets, polysilicon, inverters and trackers. Gregory Wetstone, CEO at trade body the American Council on Renewable Energy, told *PV Tech* that prospects for US solar "are dramatically enhanced, and we can expect to see steeper growth and much higher levels of investment".

Credit: President Biden via Twitter.

Biden signed the Inflation Reduction Act into law in August.

Biden waives Southeast Asia solar import tariffs for two years

US President Joe Biden has waived tariffs on solar imports from Southeast Asia for two years while also authorising the US Department of Energy to use the Defense Production Act to accelerate the production of clean energy technologies, including PV modules and components. Developers were quick to welcome the announcement, which has allowed the industry to kickstart deployment following months of uncertainty stemming from the Department of Commerce's inquiry into alleged circumvention of antidumping and countervailing duties (AD/CVD) by PV manufacturers in Cambodia, Malaysia, Thailand and Vietnam. Research organisation Wood Mackenzie said the tariff freeze "brings relief to the US solar industry", which had been "steeped in uncertainty regarding the anti-circumvention investigation".

Solar performance

US solar remains beset by underperformance issues as capex costs on the rise

Utility-scale solar in the US remains plagued by underperformance issues as capex costs have risen for the "first time in decades". That is the conclusion reached by insurance provider kWh Analytics within this year's Solar Risk Assessment report, which has called for a concerted industry effort to resolve such issues. The report, which combines qualitative insight and research from contributors including BloombergNEF, PV Evolution Labs and NREL, amongst others, warns of a range of issues that continue to dent solar asset performance versus expectations in the US. It cites new research confirming that system degradation, inverter availability and overly optimistic PV modelling have meant that the solar industry has "significantly overestimated" expectations of solar assets and, as a result, will need to "reckon the realities in the field with the assumptions we use on paper".

Procurement

Solar consortium pledges US$6bn to buy up to 7GW of US-made modules per year

A consortium of four US solar companies has committed to spending US$6 billion on purchasing 6-7GW of crystalline silicon solar modules every year to encourage the rapid scaling of domestic solar manufacturing in the country. AES, Clearway Energy Group, Cypress Creek Renewables and D.E. Shaw Renewable Investments have formed the US Solar Buyer Consortium and have launched a competitive Request for Proposals for qualified manufacturers that can commit to a long-term partnership to supply up to 7GW of solar modules per year starting from 2024. The buying consortium will "encourage a stable, domestic supply chain for solar modules", AES said in a statement.

Grids

Solar capacity in US interconnection queues reaches record 676GW

There was almost 1TW of renewable energy capacity and an estimated 427GW of storage active in US interconnection queues at the end of 2021 according to a Lawrence Berkeley National Laboratory (LBNL) analysis, which also showed that queues were growing year-on-year. In total, over 930GW of zero-carbon generating capacity is currently seeking transmission access. Solar accounts for a record 676GW of this generation, beating the previous record of 462GW at the end of 2020. Solar and battery storage are by far the fastest growing resources in the queues – together accounting for 85% of new capacity entries in 2021 – but have some of the lowest completion rates, LBNL said.

M&A

Actis takes stake in Latin American renewables generator Omega Energia

Infrastructure investor Actis has acquired a stake in Latin American renewables asset owner Omega Energia as it looks to develop a pipeline of assets in the region. Actis is to join the controlling block of shareholders in Omega, which owns a 1.9GW-strong pipeline of solar, wind and hydropower generating assets in Brazil. Actis' investment will provide equity capital to support the development of a pipeline of early-stage assets the company says will "establish Omega as a leader in the energy transition space across the Americas".

MIDDLE EAST & AFRICA

Scatec signs PPAs for solar-plus-storage projects in South Africa

Independent power producer Scatec has signed power purchase agreements (PPA) for three co-located solar and storage projects in South Africa that include 540MW of PV capacity. The Norway-based company has signed the PPAs for the three Kenhardt projects in Northern Cape. They will provide dispatchable energy resources to grid operator Eskom to help reduce shortfalls in capacity on the grid, procured under the Risk Mitigation Independent Power Producer Procurement Programme. Scatec's three projects, which pair 540MW of solar PV with 1.1GWh of battery energy storage system (BESS) capacity, will provide 150MW of dispatchable energy from 5 a.m. to 9.30 p.m. The BESS will enable the flexible dispatch of energy and allow Eskom and Scatec to reduce the size of the grid connection needed to integrate the new resources.

Sonnedix sells South African solar operations to BTE Renewables

South African independent power producer BTE Renewables has bought Sonnedix Solar South Africa from Sonnedix Power Holdings. In doing so, it has acquired a 60% interest in the collective vehicle Mulilo Sonnedix Prieska PV which owns the 75MW Prieska solar project in the Northern Cape. The purchase has increased BTE Renewables' portfolio of renewable energy IPPs in the region to 473MW, the company said in a statement, adding the acquisition "fully complements" its existing power plants located in South Africa and Kenya.

Israel

Israel renewables roadmap targets 17GW of installed solar by 2030

Israel is planning to scale up solar deployment as part of a new government strategy designed to put the country on track to have 30% of its electricity generation from renewables by 2030. Having deployed 3,591MW of solar as of the end of 2021, that figure will jump to 9,800MW by 2025 and 17,145MW by the end of the decade under the new roadmap, published by Israel's electricity authority and energy ministry. The strategy highlights the need to explore agrivoltaics, upgrade network infrastructure and encourage local authorities to establish new renewables plants.

Finance

Partners establish Pan-African Renewable Energy Fund

Investor Harith General Partners and African power provider Anergi Group have partnered to establish the Pan-African Renewable Energy Fund (PAREF) to accelerate renewable energy deployment across Africa and close the continent's investment gap. The US$300 million fund aims to bridge the energy access gap across Africa while contributing to the just transition by targeting renewable and storage projects to decarbonise power systems on the continent. PAREF will build on Anergi's operations in the region by developing, financing and executing some of the largest independent power projects in Africa, it said via a media release.

South Africa

South Africa unveils solar FiT and licensing exemptions in response to energy crisis

South Africa's government has unveiled a raft of measures to bolster the deployment of renewables in the country as it responds to a growing energy crisis. The government is to remove a licensing exemption threshold for embedded generation and introduce a feed-in tariff (FiT) mechanism for rooftop solar as it seeks to hand more power to private power generators to respond to shortfalls of electricity. One year after South Africa increased the minimum licensing exemption for embedded generation from 1MW to 100MW, the country's president, Cyril Ramaphosa, has announced the complete removal of a licensing threshold to increase private investments in electricity generation. Moreover, the solar and wind capacity for the sixth bidding round of South Africa's Renewable Energy Independent Power Producers Procurement Programme has been doubled from 2.6GW to 5.2GW.

Credit: Scatec

The 258MW Upington project in South Africa's Northern Cape province.

Projects

Savannah Energy pens deal to develop up to 400MW of solar PV in Chad

British energy company Savannah Energy has signed an agreement with the government of Chad for the development of up to 500MW of utility-scale renewables. The first project, located in the south of the country and due to be operational in 2025, comprises up to 300MW of solar PV and a BESS that will provide power for the Doba Oil Project and two nearby towns. A second project involves the development of solar and wind farms of up to 100MW each – with a portion anticipated to benefit from the installation of a BESS – to supply power to Chad's capital, N'Djamena. This project is due to send its first power to the grid in 2025 or 2026.

Ncondezi Energy explores potential for 300MW solar-storage hybrid in Mozambique

African power company Ncondezi Energy has launched a feasibility study for a hybrid solar-storage project earmarked for Mozambique. The feasibility study is to assess the potential for a solar project with a generation capacity of up to 300MW to be paired with a BESS in the province of Tete. Led by engineering services company WSP, the study will explore the feasibility for a project to be developed within three preferred sites already identified by Ncondezi.

ASIA-PACIFIC

BP acquires stake in 26GW green hydrogen project in Australia

Energy major bp will acquire a 40.5% stake in and become operator of a green hydrogen project in Western Australia that could feature up to 26GW of solar and wind when complete. Due to be developed in multiple phases, the Asian Renewable Energy Hub (AREH) intends to supply renewable power to local customers and also produce green hydrogen and green ammonia for both domestic and export markets. At full capacity, AREH is expected to be capable of producing around 1.6 million tonnes of green hydrogen or 9 million tonnes of green ammonia per year.

India

Indian solar importers blocked from deferring BCD payments

Indian solar importers will no longer be permitted to defer payment of the country's basic customs duty (BCD) following an order from tax authorities. India's Central Board of Indirect Taxes and Customs (CBIC) said some solar power generating units had been granted permission to warehouse imported solar modules, thereby deferring payment of the BCD, which features a 40% import duty on solar modules and 25% duty on cells and has been in place in since 1 April 2022. While CBIC previously advised that BCD payments for imported goods stored in bonded warehouses could be deferred until they are cleared from the warehouse for domestic use, the latest communication said previous permissions should be immediately reviewed and further permissions should be denied.

ReNew Power signs PPAs with Indian utilities and corporates for 2GW of solar PV

Indian independent power producer ReNew Power has signed a number of offtake agreements with both state utilities and corporates in India totalling roughly 2GW. ReNew signed four solar power purchase agreements (PPAs) with state-owned Solar Energy Corporation of India and one with Punjab State Power Corporation Limited totalling 1.5GW, as well as multiple long-term purchase agreements with corporate buyers for 500MW of solar PV. The new utility solar projects will be located in the western state of Rajasthan, a solar hotspot in the country, and have flat tariffs over 25 years.

Credit: ReNew Power.

ReNew Power's 39MW Adoni solar project in the Indian state of Andhra Pradesh.

Australia

Australia's solar sector set to scale up deployment following 'game-changer' election result

Australia's solar sector is poised to accelerate deployment as the country's new government vows to unlock renewables investment, upgrade the grid and bring federal policy more in line with states and territories. Following his Labor Party's victory in May's federal election, Prime Minister Anthony Albanese pledged to make Australia a renewables "superpower". Since then, the government has raised the country's 2030 emissions reduction target to 43% below 2005 levels – up on a previous goal to slash emissions by 26-28% – as it aims to increase renewables penetration in the National Electricity Market to 82% by 2030. Nicholas Aberle, director of energy generation and storage at the Clean Energy Council, said the election result "is a game-changer in terms of policy support for renewable energy".

Floating solar

Trina Solar to build 71MW floating solar project in Malaysia after winning tender

Trina Solar will build a 71MW floating PV (FPV) project in the Malaysian state of Sarawak after winning a tender held by utility Sarawak Energy. Located at the Batang Ai hydroelectric plant to facilitate grid connection, the project, spread across more than 190 hectares, will constitute the first large-scale FPV project to be built in Sarawak, Trina said. The installation will use N-type bi-facial high efficiency PV modules alongside string inverters to "improve system performance efficiency and reduce the project's levelised cost of electricity", Trina said.

DNV partners with South Korean firms to explore floating solar opportunities

Quality assurance company DNV is collaborating with South Korean FPV component manufacturers to explore business opportunities in the global floating solar market. With the aim of increasing the number of FPV plants globally, DNV has signed a memorandum of understanding with South Korean partners including steelmaker POSCO, floating structure solution provider SCOTRA, module manufacturer SolarPark and structure producer DASCO. As well as exchanging technical information to develop systems in accordance with the requirements and practices of the global FPV sector, the partners will identify projects and markets of mutual interest and cooperate on joint marketing initiatives.

Kyrgyzstan

Masdar signs MoU with Kyrgyzstan to explore 1GW of renewables in country

UAE-owned renewables company Masdar has signed a memorandum of understanding (MoU) with Kyrgyzstan's Ministry of Energy to explore the development of renewable energy opportunities in the Central Asian nation. As part of the MoU, Masdar will explore ground-mount PV, floating solar and hydropower projects, with a potential capacity of up to 1GW. Kyrgyzstan is targeting a 44% reduction in greenhouse gas emissions by 2030, with its net zero target set at 2050. The country already generates around 90% of its electricity from clean energy resources but this is almost exclusively from ageing hydropower plants, according to Masdar.

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MANUFACTURING

Supply chain

'Diversification is a must': IEA warns on China's growing dominance of solar PV supply chain

A secure transition to net zero emissions globally will require countries to diversify and expand the production of solar modules, whose supply chains are heavily concentrated in China, according to new research from the International Energy Agency (IEA). The study said that with global solar deployment needing to grow at an unprecedented scale, this will demand a "major additional expansion in manufacturing capacity", raising concerns about the world's ability to rapidly develop resilient supply chains. China's share in all PV module manufacturing stages – polysilicon, ingots, wafers, cells and modules – exceeds 80%, found the research, the first of its kind carried out by the IEA. "It is a must, in my view, to diversify," said Fatih Birol, executive director at the IEA.

China

China's solar exports double in H1 2022 as module shipments soar

The value of Chinese solar PV exports during the first half of 2022 more than doubled year-on-year as module shipments surged, according to government figures. China exported US$25.9 billion of PV products in H1 2022, an increase of 113%, while module exports jumped 74% to 78.6GW, the country's Ministry of Industry and Information Technology said. The country's polysilicon output during the six months was around 365,000 tonnes, a year-on-year increase of 53%, while wafer production rose 46% to about 152.8GW. According to the ministry, China's H1 2022 crystalline silicon module output increased by 54% to 123.6GW.

Polysilicon

Chinese producers tighten hold over polysilicon production rankings as expansions gather pace

Both GCL Technology and Daqo New Energy have leapfrogged Wacker Chemie in Bernreuter Research's annual polysilicon top ten rankings, completing a China-based top three. And Chinese polysilicon producers look set to occupy all five leading positions from next year, Bernreuter Research predicts, with Xinte Energy and East Hope both set to climb above Wacker in 2023. Tongwei, which aims to take its annual polysilicon production from 350,000MT in 2023 to as much as 1 million MT in 2026, cemented its lead at the top of the polysilicon rankings, while GCL technology rose to second spot. Daqo, which has itself doubled down on expansion plans after a year of bumper profits, took third spot, knocking Wacker Chemie down to fourth place.

Company news

Canadian Solar plans US$9 billion polysilicon, cell and module factory in China

Canadian Solar plans to build an integrated PV manufacturing plant in western China with a capacity of 200,000MT of high-purity polysilicon, 10GW of both cells and modules and multi-GW productions of raw and auxiliary materials. The project will be located in Haidong Zero-Carbon Industrial Park in Qinghai province by the end of 2027. Canadian Solar has also entered into an agreement with the municipal government of Haidong City in Qinghai province to build an initial facility with an annual capacity of approximately 50,000MT of high-purity polysilicon later in 2022. The facility is expected to commence production in mid-2024.

Trina Solar starts construction on huge vertically integrated PV factory in China

Trina Solar has started construction on a vast new industrial park in the central Chinese province of Qinghai that will cover almost the entire PV manufacturing chain from polysilicon production all the way down to modules. The Trina Solar (Xining) New Energy Industrial Park project, located in the provincial capital of Xining, includes production lines for an annual output of 300,000 tonnes of industrial silicon, 150,000 tonnes of high-purity polysilicon, 35GW of monosilicon, 10GW of wafer slices, 10GW of cells, 10GW of modules and 15GW of auxiliaries for modules. Construction is due be completed by the end of 2025.

Nextracker opens three US tracker manufacturing lines

US tracker manufacturer Nextracker has responded to global supply chain disruptions by inaugurating three new production lines in the country since April. So far this year the company has commissioned lines in Texas, Arizona and Pennsylvania through collaborations with steel manufacturers as it aims to reach 10GW of annual tracker manufacturing capacity in the US. When the Pennsylvania line was opened in June, Nextracker CEO Dan Shugar said the company's investment will increase the resilience of the US solar supply chain and bring manufacturing jobs and capacity back to America.

Credit: Nextracker

A Nextracker-dedicated production line Texas.

REC Solar wins EU grant to build 2GW HJT plant in France

Module manufacturer REC Solar has been selected by the European Union (EU) to receive a grant to support a 2GW hetero-junction (HJT) solar manufacturing plant in France. The bloc will contribute to the construction of REC's RISE (REC Innovation at Sarreguemines Enterprise) project, earmarked for the north of France. The description of the project given by the EU said the manufacturing facility will mostly manufacture bifacial HJT modules, however there will be further consideration for it to produce tandem-cell technologies such as HJT-perovskite cells in the future.

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The rise of solar-plus

Cover story | The proliferation of solar requires PV projects to adapt to their grid surroundings, which increasingly entails connecting alongside adjacent technologies, be it energy storage, other renewables or green hydrogen. Amid the growing threat of curtailment, Jules Scully looks at the rise of the 'solar-plus' market and the financial models underpinning it.

Credit: Xlinks.

On a sunny Sunday afternoon this May, California reached a major milestone on its path towards a carbon-free free power grid, as the state produced enough renewable electricity to meet more than 100% of demand for the first time.

Renewables generation exceeded demand for about 112 intermittent minutes and reached a new high of 103.45% for 1 – 2 minutes on 8 May, according to the California Independent System Operator (CAISO), which manages the flow of electricity for about 80% of the state.

The landmark followed a host of renewables records being broken in California throughout spring. Ashutosh Bhagwat, chair of the CAISO board of governors, said in April: "These moments help crystallise the vision of the modern, efficient and sustainable grid of the future."

Although the milestone illustrates California's progress in renewables deployment, it also raises questions about how the state will navigate solar curtailment and negative pricing as it bids to reach 100% zero-carbon electricity by 2045.

Some 5% of all utility-scale solar generation was curtailed by CAISO in 2020, research by the US Energy Information Administration (EIA) revealed. With curtailment more prevalent during spring when solar output is high and electricity demand drops due to moderate temperatures, the EIA found that CAISO curtailed an average of 15% of its utility-scale PV output in the early afternoon hours of March 2021.

To offset such trends, developers are increasingly hybridising solar projects with battery energy storage systems (BESS). A report from the US Department of Energy's Lawrence Berkeley National Laboratory revealed that with California grappling with 'duck curve' issues due to solar's relatively high market share, nearly 90% of the solar capacity in CAISO's interconnection queue at the end of 2020 was paired with a battery.

One major installation set to come online in California, 70 miles north of Los Angeles, is the Eland Solar & Storage Center, which will pair 400MWac solar PV with 300MW / 1,200MWh of battery storage.

"Eland will deliver a consistent, baseload power supply at record-low prices: US$0.02/kWh for solar only and less than US$0.04/kWh with storage," says Stephanie Perry, COO at project developer 8minute Solar Energy. "With a high capacity factor of 60% during the summer months (which is 50% more than a simple solar plant), the project maximises the use of existing transmission infrastructure."

Xlinks is developing a project in Morocco that will feature solar PV, onshore wind and battery storage.

Eland has a long-term power purchase agreement (PPA) secured with municipal utility Los Angeles Department of Water and Power and is expected to be fully operational in 2024.

With a pipeline including 18GW of solar and 24GWh of storage, 8minute is looking to address grid issues like reliability and resiliency with its hybrid power projects, which can come online in a fraction of a second, compared to several minutes for gas-fired plants, according to Perry.

"Our smart power plants alleviate more than just curtailment issues, but can deliver flexible, predictable output to the grid and help utilities dynamically manage load," she says. "Our novel controls enable storage and PV to work together as one seamless system, integrating renewable energy into existing electric grid control centres as if they were a traditional fossil fuel generator."

With solar-plus-storage projects becoming commonplace globally, research organisation BloombergNEF (BNEF) forecasts that the majority, or 55%, of energy storage build by 2030 will be to provide energy shifting, such as storing solar to release later.

Despite the strong outlook for solar-plus-storage, developing such projects "is inherently more complex" than standalone

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Credit: GroenLeven.

A pilot solar-powered green hydrogen facility in the Netherlands.

storage because of the addition of an entirely different asset that needs to be integrated together to work as a system, according to Vanessa Witte and Sylvia Leyva Martinez, senior research analysts at research firm Wood Mackenzie.

"This increases the complexity of the design of the system, the software and controls, and the offtake structures or other revenue opportunities the developer wants to pursue to make the project be economically viable," they say.

Additional hurdles include a more expensive and more complicated interconnection process, with two requests needed, as well as timing procurement, construction, and commissioning so they all overlap advantageously. "With the current supply chain disruptions in solar, and the longer than before procurement times for storage, this has proved to be more challenging than ever," add Witte and Leyva Martinez.

One company that is navigating these challenges is Primergy Solar, the developer behind the Gemini Solar + Storage project near Las Vegas, Nevada. Pairing 690MWac / 966MWdc of solar PV with 380MW / 1,416MWh of battery storage, Gemini is backed by 25-year PPA with utility NV Energy.

"A DC-coupled project of this scale and this size in single construction phase has not been done before," says Aaroh Kharaya, director of storage engineering at Primary. "With DC coupled, you can connect/tie a lot of storage with solar in an efficient way."

From a commercial standpoint, Kharaya says solar-plus-storage projects such as Gemini show that "renewable energy can become a dispatchable asset" like fossil fuel-based generation, while also helping to maintain grid stability.

Hybrid systems offer the solar industry a unique solution to dealing with grid connection challenges, said Fitch Solutions in a recent report, which namechecked Gemini as an example of a project that uses storage technology to enable older grid systems to facilitate renewable power.

The consultancy suggested that declining fossil fuel capacity in the US will leave legacy infrastructure, which is being repurposed, offering an easier deployment of renewables.

"We think that it's likely that hybrid

'A natural hedge against volatility': energy storage mitigating solar cannibalisation

With the threat of price cannibalisation rising in some markets as more renewables come online, battery storage has come to the fore as a possible mitigation tool to reduce an asset's profile risk.

That is according to software and advisory company Pexapark, which warned in a recent report that cannibalisation will become more of an issue in markets such as Spain as high amounts of new solar connects to the grid, posing a "significant risk" for the long-term remuneration of projects.

However, the firm said that in theory a storage asset is a natural hedge against volatility, and a perfect match to increase an asset's capture factors.

Werner Trabesinger, head of quantitative product at Pexapark, explains that energy storage enables assets to soak up production during times when the price is most cannibalised and then discharge those volumes later in the day when prices are higher. "What it does is it effectively floors the revenue level that you can get with solar production in the market," he says.

While Pexapark's report looked at three developed renewables markets in Europe where cannibalisation risk is already prevalent – Germany, Sweden and Spain – Trabesinger says countries such as Poland and Romania that are accelerating renewables buildout will over time be hit by lower price capture and higher cannibalisation.

Markets where there is a high anticipated solar capacity buildout, such as Spain, will lead offtakers to price very defensively, according to Trabesinger. "In other words, immediately get reflected in poorer levels of revenue on the PPA contract. And one way to escape that is to add battery storage to PV assets or, of course, for PV assets to be complemented by electrolyser assets."

He says soaking up excess solar generation to produce hydrogen for later use "will become one of the central points speaking in favour of electrolyser efforts".

technologies will be more effective here because a lot of that infrastructure isn't up to date and it isn't equipped to handle large volumes of variable power supply," says Thomas van Lanschot, associate director of power and renewables at Fitch Solutions. "This is long-distance, large-scale baseload power generation, so in order to use that more effectively, you have to couple in some kind of storage capacity."

Primergy Solar, a portfolio company of private equity firm Quinbrook Infrastructure Partners, closed a US$1.9 billion debt and tax equity financing deal for Gemini earlier this year and has started construction of the project.

Van Lanschot says that in the US solar-plus-storage market, the financial models and structures are in place to get money to developers. "There's quite a good diversity in finances as well. It's not like there's one particular bank to go after and they're willing to take this risk. I think a lot of the risk has been dealt with."

In addition to the potential of hybrid solar-storage solutions in the US, Fitch Solutions' report found that hydrogen will act as a capacity growth enabler in the country, unlocking grid-constrained regions and reducing curtailed generation.

Green hydrogen potential

One company that aims to use renewables generation that would otherwise be curtailed to power an electrolyser is Spanish utility Endesa, which has been awarded rights to develop a hybrid project in Portugal that will combine solar PV, wind, BESS and green hydrogen. The hybridisation of these technologies will make it possible to optimise production and obtain a high load factor, according to the company.

Set to replace Portugal's last coal power station, which was shuttered last year, the installation will cost €600 million (US$660 million) and feature 365MWp of solar and a 500kW electrolyser, which will capture surpluses that exceed the BESS' storage capabilities.

Pedro Almeida Fernandes, head of power generation at utility Endesa Portugal, said earlier this year that the company will be able to "fully capture all the renewable energy produced", avoiding curtailment while improving the profitability of the renewables projects in the process.

Speaking at Solar Media's Green Hydrogen Summit 2022, Almeida Fernandes said: "We can input this extra energy to the electrolyser at virtually the opportunity cost in order to be able to compete in H2 price."

In a recent report, BNEF suggested that Europe could reduce the need for electrolyser-dedicated renewables by using excess green energy from grid-connected solar and wind to power electrolysers. The research organisation said that if electrolysers use 70% of curtailed solar and wind from the power system by 2050, Europe can reduce the hydrogen-dedicated wind and solar build by 20%.

There are existing electrolyser technologies that can ramp up and down quick enough to be paired with renewables, even in a curtailment sense, according to Wood Mackenzie's Witte, Leyva Martinez and Bridget van Dorsten, a research analyst at the firm.

"The hydrogen produced then has multiple potential revenue streams and is therefore more versatile than battery storage," they say, with it possible to sell hydrogen to off-takers in its gaseous form, or it could be transformed into liquid hydrogen, ammonia, methanol or liquid organic hydrogen carriers (LOHCs). Hydrogen could also be stored at the generation site and be run through a fuel cell to produce electricity during peak periods on the grid.

The potential to use solar-powered green hydrogen to ease grid congestion is being explored at a recently completed pilot project in the Netherlands from GroenLeven, a subsidiary of renewables developer BayWa r.e., and electricity and gas distribution network company Alliander.

With the country's grid becoming overstretched as more renewables come online, the project – pairing 50MWp of solar PV with a 1.3MW electrolyser – is being used to explore whether hydrogen is a solution to prevent costly grid expansions.

The companies are running different scenarios, sometimes optimising for the grid and sometimes for the electrolyser, explains Frank Oomen, head of large-scale solar projects at GroenLeven. "With the amount of solar PV behind it, you have the opportunity also to create significant load hours for the electrolysers so it's not only for congestion."

A spokesperson from Alliander tells PV Tech Power that the network company is looking to learn how it can quickly and easily convert electricity from the solar park into hydrogen and what regulatory obstacles it might encounter.

Among the challenges the partners faced when bringing the project to fruition was a lack of experience from regulators and permitting authorities when working on such installations as well as issues finding suitable contractors. "For everyone involved in this chain, there are challenges as first-timers on how to do it," says Oomen.

It is expected that 100,000kg of hydrogen can be produced per year from the plant, with a taxi company and a fuel supplier signing up as offtakers.

Oomen believes it could still be a few years before a commercial solar-plus-green hydrogen plant becomes operational in the Netherlands. "It is relatively new to integrate all the things into such a solution,

A residential battery energy storage system in the US.

Credit: Sunrun.

but all the components are there, so it's not like we're inventing something completely new," he says. "The question is what the commercial feasible size will be."

Another developer that is looking to benefit from a forecasted growth in hydrogen demand is 8minute Solar Energy. Securing US$400 million in financing earlier this year to grow its clean energy portfolio, the company revealed it plans to expand into green hydrogen.

As well as powering hard-to-abate sectors, green hydrogen is especially compatible with solar for its role in expanding the capabilities of energy storage, according to 8minute's Perry. "As our country pushes toward a 100% clean energy grid, green hydrogen can critically extend the amount of renewable energy we store – potentially from a handful of hours to several months at a time," she says.

8minute is part of HyDeal Los Angeles, an initiative from non-profit organisation the Green Hydrogen Council that aims to deliver at-scale green hydrogen at US$1.50/kg in the Los Angeles Basin by 2030.

Perry adds: "We believe applying our integrated design approach and using our strategically positioned solar assets towards producing green hydrogen, we are poised to be an early cost leader in producing and scaling green hydrogen."

Alongside hybridising with BESSs or even electrolysers to limit curtailment or capture additional revenue, solar developers are co-locating PV plants with other renewables assets to overcome grid constraints and make the most of points of interconnection.

Hybrid renewables plants

The benefits of hybridising floating PV (FPV) with hydropower were revealed in a report published in June by NREL, which found that the two technologies together can lower solar curtailment as well as conserve water by shifting hydropower generation to other periods of the year.

FPV and hydropower are set to be combined with a BESS at an installation in the south of Portugal from utility EDP. Having announced the completion in July of a 5MW floating solar farm at a hydropower dam in Alqueva, EDP now plans to add a 1MW/2MWh battery storage system. The company said the three technologies will share a single grid connection point, promoting "asset optimisation and efficiency while reducing environmental impacts".

Rooftop solar and EV charger tie-ups abound

The increasing penetration of residential solar, large-scale installation of EV chargers and declining BESS costs are persuading companies to bring integrated solutions to the market by forming strategic alliances, according to Amaiya Khardenavis, EV charging infrastructure and grid edge analyst at Wood Mackenzie. Notable partnerships include:

- A collaboration between Sunrun and Ford has seen the solar and storage provider become the preferred installer of a system that allows the latter's F-150 Lightning electric truck to dispatch power to the home during an outage event. Sunrun also has the chance to persuade Ford F-150 Lightning owners to install residential solar and storage at the same time as an EV charger.
- SunPower partnered with Spain-headquartered EV charging provider Wallbox last year, adding EV charging technologies to its portfolio. Through the tie-up, consumers can choose to have both rooftop solar and EV charging technologies installed at the same time, while SunPower has become Wallbox's preferred solar and storage provider.
- Wallbox has since joined forces with Svea Solar, becoming the main EV charging solution for the European home solar installer's customers in Sweden, the Netherlands, Belgium, Germany and Spain. A Wallbox app allows homeowners with rooftop solar to charge their EV solely from their home PV installation or combine onsite solar with grid power.
- Microinverter supplier Enphase Energy secured a deal last year to acquire ClipperCreek, a California-based EV charging station manufacturer that offers solutions for residential and commercial customers across the US. Enphase said the deal would provide its distributors and installers with EV charging solutions that can be sold alongside solar and battery systems.
- US residential solar and storage provider Sunnova offers its customers EV chargers through a partnership with charging solutions provider ChargePoint.
- According to Khardenavis, Tesla's Powerwall offers a solution by providing stored solar energy to charge an EV through the home electrical panel.

Following its success in Portugal's solar auction earlier this year, EDP will also add an additional floating PV plant at the Alqueva dam. The grid connection it secured through the auction will allow the utility to install up to 154MW of renewables capacity, including the 70MW of contracts for difference-backed floating solar, 14MW of ground-mount PV and 70MW of wind.

Posting a negative bid in the auction, EDP said the hybridisation component and the scale of the project will ensure its economic viability.

"Hybridisation is nowadays considered the logical growth path in the electricity generation industry since it increases project efficiency, allows the sharing of electric infrastructures [and] promotes cost stability," EDP said in a statement sent to PV Tech following the auction.

The company plans to invest nearly €400 million (US$405 million) to develop more than 1.3GW of hybrid projects in Portugal in Spain that will feature a combination of solar PV, wind, and hydropower.

Hybridising solar, wind and battery storage is a strategy set to be deployed by Xlinks, a company that bids to transmit electricity from a desert in Morocco to the UK via four 3,800km-long subsea cables.

Its Morocco – UK Power Project will feature 7GW of solar PV, 3.5GW of onshore wind and 5GW / 20GWh of battery storage that provide a near-constant source of flexible and predictable renewable energy, designed to complement renewable energy generated in the UK, according to the company.

When UK renewables generation falls due to low winds and short periods of sun, the project will harvest the benefits of high solar irradiance in the south of Morocco alongside consistent desert winds to provide an alternative source of zero-carbon electricity.

Xlinks will charge the BESS throughout the day, when there is excess generation, and then discharge it overnight, allowing the company to use the transmission system for more of the time and provide a more reliable generation profile to the UK, explains Richard Hardy, project director at Xlinks.

"Battery storage does play a very key role in that it allows us to have a far more stable network within the generation site, which is the first important point, it also allows us to deliver the power at the most valuable times to the UK," he says.

The four high-voltage direct current (HVDC) cables will be rated at just over 4GW in Morocco and be installed along the coasts of Portugal, Spain and France before linking to Britain's electricity network through two connections in Devon, southwest England, where 3.6GW will be injected into the network.

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With groundbreaking scheduled for 2024 and power delivery to the UK by the end of the decade, the project is expected to deliver power at £48/MWh (US$57/MWh) when it becomes operational, meaning it will generate savings for consumers, said Xlinks.

While export projects such as this promise to accelerate the transition to net zero while generating savings for consumers, homeowners are increasingly looking to counter soaring energy bills and the threat of power outages by deploying their own solar-plus-storage systems.

Home batteries and EVs

BNEF expects energy storage located at homes and businesses to make up about a quarter of global storage installations by 2030, with major drivers being a desire from electricity consumers to use more self-generated solar and an appetite for backup power.

The research organisation said in a report that as energy storage costs fall, a second transition is beginning, where customer-sited solar combined with storage can begin to provide greater benefits to the power system in terms of energy balancing, grid services and increased resilience.

Germany, Italy, Austria and the UK are residential energy storage leaders in Europe, Wood Mackenzie said last year. The group forecast that the continent's residential energy storage market will expand nearly tenfold this decade amid the need for power market flexibility.

Van Lanschot of Fitch Solutions says hundreds of thousands of domestic batteries are installed each year in Germany, which is "driving the residential solar boom" in many parts of the country. "This has created a whole new sector of community energy pools where people's homes are communicating with each other, harmonising like a little mini-grid."

Such growth in residential storage means utility-scale batteries plants in Germany are "almost being outcompeted" and are less prevalent than in other markets such as the UK, US or Australia, van Lanschot says.

In the US, trade body the Solar Energy Industries Association forecasts that more than 29% of new behind-the-meter solar systems in the country will be paired with storage by 2025, compared to under 11% in 2021.

With regional transmission operators across the US issuing warnings to customers in anticipation of grid capacity shortages this summer, home solar and storage provider Sunrun said in July it is ready to support the country's grid by dispatching the company's installed battery capacity of more than 150MW. CEO Mary Powell said at the time that the firm's solar and battery systems can provide a critical service by discharging electricity to the grid when it's most needed.

Rival residential solar and storage provider SunPower is part of a consortium that has secured US Department of Energy funding to develop two home communities in California that will feature PV systems and be used to compare community-level versus residential-level energy storage batteries, while providing grid services to the local utility.

Both Sunrun and SunPower are among the growing list of residential solar providers that have collaborated with electric vehicle (EV) charging companies as they look to maximise the benefits of combining the technologies.

Shawn Fitzgerald, vice president of corporate development at SunPower, explains that the company's partnership with EV charging provider Wallbox allows SunPower to control the EV charger, subject to the customer signing up to its virtual power plant solution. "It just gives us more flexible loads to work with," he says.

While utilities typically design rates so that the middle of the night is the most optimal time to charge an EV, Fitzgerald says consumers with an EV plugged in during the day can take advantage of low or negative power prices when there's too much solar being exported to the grid.

Amaiya Khardenavis, EV charging infrastructure and grid edge analyst at Wood Mackenzie, says that as markets move towards a higher penetration of distributed energy resources in the electricity system, residential solar and storage offer an efficient and cost-effective way of EV charging when paired with level 2 chargers.

He adds: "Since most EV charging currently happens at home, such deployments would reduce the energy bills of EV owners, especially with the likelihood of sustained increase in electricity prices, driven by high natural gas prices."

According to Wood Mackenzie, 17% of new residential solar systems in the US will be paired with storage in 2022, rising to 32% by 2026. At the current levels of EV adoption, the number is much lower for projects paired with EV charging.

However, the requirement for residential EV chargers will grow as EV uptake increases, Khardenavis says, leading to more homes installing chargers in conjunction with existing or new residential solar and storage systems.

With BNEF forecasting that at least 63% of the 1.4 billion passenger vehicle fleet globally will be electric by 2050, there will be significant potential for customer-sited flexibility and rooftop solar.

In terms of the outlook for pairing utility-scale PV with other technologies, the number of cross-border interconnection developments featuring renewables generation and BESS, such as Xlinks' Morocco project, looks set to expand and take solar to new heights.

With plans to deploy 17 – 20GWp of solar and 36 – 42GWh of battery storage in Australia, developer Sun Cable is progressing with its landmark Australia-Asia PowerLink project that bids to transmit 2GW of electricity to Singapore.

Financial close for the project is set to be reached in 2024, when construction work will also begin. With full operations aimed for 2029, electricity will be transmitted to Singapore through 4,200km of HVDC subsea cables.

The development "will unlock solar energy's latent potential to support many more projects to meet energy demand in the region", says project director Andrew Barton. He adds: "Yes, the AAPowerLink is the first of its kind, but we believe it will be the first of many." ■

A home electric vehicle charger from Wallbox.

Credit: Wallbox.

Drivers of community solar in the US

Community solar | Community solar in the US is projected to grow substantially over the next decade and represents a means of expanding access to underserved communities who are being left out of the energy transition. Sean Rai-Roche explores the drivers of community solar and what obstacles need to be overcome to support its rollout.

Credit: Luminace.

An operational community solar project in New Jersey.

In the race to deploy terawatts of solar power capacity across the US as a means to achieve the country's clean energy targets, an often neglected area of deployment is community solar. There is at present around 4GW of community solar deployed in the country but the potential market size is more than ten times that when accounting for the various project pipelines that currently exist. And the speed of deployment is increasing.

Last year saw 1,154MW of community solar deployed in the US, up 29% year-on-year. And experts have commentated on a 'paradigm shift' when it comes to how the technology is viewed, with simpler, streamlined business models emerging and increasing financier appetite coupled with greater consumer appreciation driving the sector forward.

This paradigm shift has seen thinking move away from the idea that utility-scale solar parks are the fastest and most cost-effective form of PV deployment and towards a greater focus on new business models that join utility-scale and local solar with storage to maximise customer savings. According to organisation Local Solar For All (LSFA), under the US' current power targets, leveraging expanded local solar and storage can save the US US$473 billion by 2050 and shatter traditional business models dominated by utilities.

"Without better models, our traditional utility models will add hundreds of billions of dollars in unnecessary cost while leaving millions of jobs and billions of dollars of local economic development on the table," LSFA said.

PV Tech spoke with experts, developers, trade bodies and more to discuss the potential evolution of the community solar industry in the US, what the newly passed Inflation Reduction Act (IRA) means for future deployment and access and what barriers need to be overcome to unleash its potential.

An overview of community solar in the US

What is community solar?

The US Department of Energy (DOE) defines community solar as any PV project or purchasing programme "in which the benefits of a solar project flow to multiple customers such as individuals, businesses, non-profits and other groups. In most cases, customers are benefitting from energy generated by solar panels at an off-site array."

Credit: CCSA, LSFA, Vibrant Clean Energy, Vote Solar.

Distributed solar resources in the US are forecast to experience strong growth over the next few years.

Under the system, customers can either buy or lease a portion of the plant – the systems are not residential rooftop arrays – and usually receive an electric bill credit for power generated by their share of the community solar system.

Most community solar subscribers will receive two bills—one from the community solar programme and the other from the local utility for the traditional power they've used, although some states are looking to simplify the process and combine the bills.

"Community solar can be a great option for people who are unable to install solar panels on their roofs because they don't own their homes, have insufficient solar resources or roof conditions to support a rooftop PV system," the DOE says. And this is also a key point – community solar is not rooftop solar, usually reserved for the wealthy who can afford it, but is a form of community organisation focused on clean energy supply.

How much community solar does the US have and need?

According to data compiled by the Solar Energy Industries Association (SEIA) and research firm Wood Mackenzie (WoodMac), there was more than 4GW of distributed solar in the US in 2020. Of this, however, the majority was residential solar. The only year where deployment of non-residential solar surpassed residential solar was in 2017.

Nonetheless, both types are growing fast and the above organisations estimate that more than 4GW of distributed PV – both residential and non-residential – will be installed per year through to 2024, with residential solar doing most of the heavy lifting. A recent WoodMac report into community solar forecast growth of at least 7GW in the next five years.

LSFA said in the US the "cleanest, lowest cost grid" requires 223GW more local solar by 2050 and would be essential in unlocking the full potential of renewable assets as well as diversifying the US' grid infrastructure and power system.

Inflation Reduction Act a boon for community solar

The IRA that was passed by the US Congress and signed into law by President Joe Biden in mid-August will be a major boon for the community solar sector, analysts and experts told PV Tech.

The IRA extends the solar investment tax credit (ITC) for another ten years at a rate of 30% which would "help accelerate community solar deployment", according to SEIA, through lowering capital costs of projects. Energy law firm Lowndes notes how the IRA "expands the ITC to solar facilities located in low-income or Native American communities".

Moreover, the IRA gives an advanced manufacturing production credit to promote the domestic production of PV cells and modules, which could help address module shortages and supply-side constraints in the US solar market.

SEIA notes how community solar "installations were down an incredible 59% from Q4 2021 to Q1 2022," which it said reflected "challenges with interconnection, price increases and supply chain constraints". Addressing these supply-side constraints through the greater buildout of a US solar supply chain will support the roll-out of community solar in the US.

Jeff Cramer, president and CEO of the Coalition for Community Solar Access (CCSA) said the passing of the IRA would "unleash billions of dollars in private capital to build clean energy infrastructure across the country and lower energy bills for millions of Americans – especially those most in need."

"The bill provides unprecedented long-term certainty for the market and incentives for states to deploy more community solar and storage projects. We will look back on this bill as the fuel that accelerated the country's shift to clean, resilient power."

Cramer said the legislation "doubles down" on the vital role that community solar will play in US energy security through some of its provisions. Crucially, the solar ITC extension includes provisions such as low- to moderate-income (LMI) bonus credits and the inclusion of interconnection costs, and US$7 billion in incentives for states to create or expand distributed solar programmes.

"Ultimately, the act will help to lower costs and increase customer bill savings. It will lower costs because the tax credit now includes interconnection costs, and it will increase customer bill savings by offering a bonus tax credit to provide access to LMI customers," Cramer said.

And this leads onto another key facet of community solar – its expansion of access to underserved communities who are locked out of more dominant means of acquiring clean energy.

Expanding access to clean energy for all

If you are a renter or live in social housing, investing in solar PV is probably quite far down your wish list, especially given the upfront capital costs. But community solar is a vehicle to change this.

"In the US, the vast majority of American electricity customers don't have access to solar directly on their properties or on their roofs. And so community solar serves as an opportunity to directly access the benefits local solar without the need of having it on your roof," Cramer explains.

Those households that can install residential solar systems are typically middle-class residents who own their own homes. And there is little recourse for people in marginalised, poorer communities to access clean energy and reduce their carbon footprints. But things are changing.

In July, the DOE, in collaboration with the Department of Health and Human Services (HHS), launched the Community Solar Subscription Platform to connect families with solar energy and lower electricity bills through the Low-Income Home Energy Assistance Program (LIHEAP) and other low-income assistance programmes.

"Community solar, which allows multiple customers to benefit from a shared solar energy system, provides a solution for individuals who cannot get rooftop solar panels," the DOE said, adding that its target was to power 5 million homes and provide 20% savings on a subscriber's energy bills, up from 10% on average today.

"Every American community, especially those that face disproportionately higher energy burdens, deserves the economic and health benefits that come with

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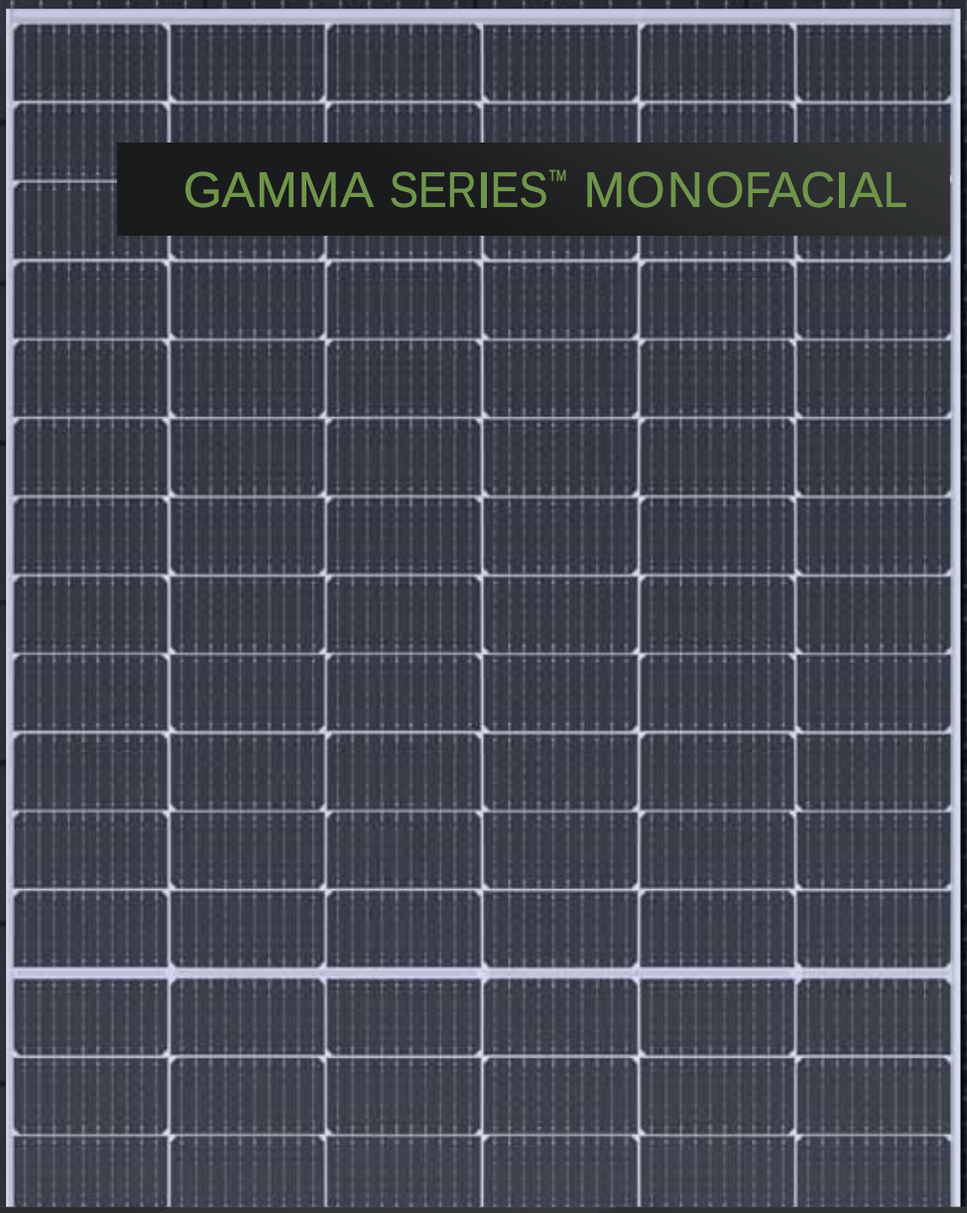

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increased access to affordable clean energy," US Secretary of Energy Jennifer Granholm said at the time of the launch.

"This is why DOE is working across the federal government to open up community solar that will rapidly lower electricity bills for households that need it most."

A patchwork system of access

WoodMac is predicting at least 7GW of US community solar is expected to come online in the next five years. But this deployment is not spread evenly across the US, with states like New York far outstripping others where access is poor.

"New York accounted for nearly half of all community solar installations in 2021 due to its proactive work in establishing and expanding incentive frameworks like the NY-SUN Megawatt Block programme," explains Will Giese, Southeast regional director at SEIA.

New York singlehandedly has more than 1GW of community solar, its governor, Kathy Hochul, announced in May this year.

According to the DOE, around a third of US states have "enabling policies" for community solar, meaning they have "passed legislation that created a third-party market for community solar requiring project developers and utilities to follow certain regulations in order to enrol customers and develop community solar installations."

This patchwork system is, says Cramer, a result of state inertia. States have regulatory authority over their distribution systems and state legislatures pass a bill that creates a community solar programme that allows for third-party community solar developers to plug systems into the grid to enable customers to benefit. But for a variety of reasons, legislators don't always act, he says, and there is still a huge amount of red tape in many US states that prevents greater community solar deployment.

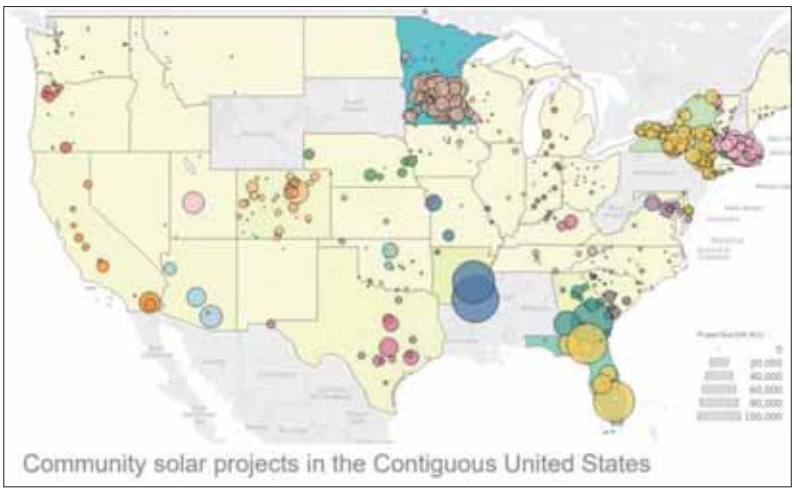
This lack of maturity in community solar markets in many states does have its upsides, however. "This market sector is mostly underdeveloped, or in some states completely untapped, whereas residential, commercial, or utility-scale markets might be more developed," says Giese. "Therefore, financers of solar projects may be more willing to finance projects in a new market segment, such as community solar, than in other more saturated markets."

Interconnection problems

Long interconnection queues have been a thorn in the side of the utility-scale solar industry for years. And community solar is no different, with experts identifying interconnection problems as a major barrier to overcome to achieve greater deployment.

In April, a Lawrence Berkeley National Laboratory (LBNL) analysis showed there was almost 1TW of renewable energy capacity – of which 700GW was solar – and an estimated 427GW of storage active in US interconnection queues at the end of 2021, with wait times growing year-on-year and solar PV experiencing particularly long queues.

In a recent whitepaper outlining the reforms it believes are needed in the US interconnection system, SEIA said "outdated interconnection policies pose a major threat to solar and storage deployment" across the US and that policies "have not kept pace" with the demands of a new energy market that has seen interconnection applications for solar and storage "skyrocket".



Credit: NREL via Sharing the sun project list 2020

Community solar resources in the US are not evenly distributed.

"Interconnection continues to be a significant challenge for community solar growth," says Giese. "Grid upgrades are often necessary to connect these projects to the grid, and in many states, the study process can result in delays or upgrade costs that make projects uneconomic."

Under the recently passed IRA, interconnection costs for projects under 5MW – which covers most community solar projects – will be subject to the ITC and Cramer said this would help boost community solar deployment and get more projects connected.

However, the US' interconnection problems won't go away anytime soon despite the work of the DOE, the Federal Energy Regulatory Commission and the i2X initiative, launched by the DOE earlier this year to ease grid connection issues. Interconnection problems remain a significant hurdle to overcome to enable greater solar deployment, including community solar.

A key piece of the puzzle

Although utility-scale solar is the engine room of the US' transition to a decarbonised society, community solar should play a critical and supportive role in helping to drive that change. Appetite for the resource is growing as more people tune in to the benefits of solar and the IRA should turbocharge growth in the sector moving forward. Meanwhile, government programmes such as the i2X initiative should start to address the US' interconnection problems and enable greater connection to the country's grid system.

But current access to community solar is uneven and more needs to be done by federal and state authorities to ensure those wanting to increase their community's energy security are able to do so. Community solar not only represents an effective form of distributed generation that can support the US' wider energy transition, but it is also an egalitarian form of infrastructure that can connect poor and marginalised communities with solar PV.

There is often a lot of lip service paid to the idea of a 'just transition' but it is unfortunately not always backed up by spending on concrete policies. Community solar embodies the idea of a just transition and can help get swathes of the US population get on board with a project that they might feel they have a role in. The opportunity is there, but it requires the will to seize it. ■

Product reviews

Inverters — GoodWe's HT1500V inverter series solves challenges posed by modern-day utility-scale solar development

Problem: The need to reduce the levelised cost of electricity (LCOE), project design complexities, plant profitability, O&M resources, demanding grid codes, supply chain issues and challenges related to the weakness of the grid have become pressing matters for the PV industry. Inverters play a fundamental role in any solar farm and need to be capable of delivering the best possible response to those challenges.

Solution: The new HT1500V Series (225/250kW) is GoodWe's leading inverter with a list of features designed to reduce system and O&M costs, making it an ideal choice to maximise the return on investment for utility-scale solar projects. The HT1500V Series boasts options of 6 MPPTs and 12 MPPTs, power line communication 2.0 and is compatible with bifacial 182mm/210mm modules. It features string level monitoring and incorporated I-V curve diagnosis for intelligent detection of voltage and current issues. The series is also equipped with an optional PID recovery function and can enable 24-hour monitoring of PV arrays. The unique mechanism of smart string protection switch that comes with the GW225KN-HT & GW250KN-HT models can reduce energy generation losses when a short circuit or reverse connection occurs.

Applications: Utility-scale PV globally.

Platform: The HT1500V series is available in options of 6 MPPTs and 12 MPPTs and has an MPPT operating voltage range of 600 – 1,500V. The GW225K-HT and GW250K-HT models enable two strings per MPPT, while the GW225KN-HT and GW250KN-HT models allow three strings per MPPT. All models have type II DC and AC surge protection.

Availability: Available now.

Modules — JinkoSolar's Tiger Neo n-type series delivering higher efficiencies and optimised LCOE

Product outline: JinkoSolar's Tiger Neo 78HL4-BDV N-type module, built on a 182mm M10 monocrystalline silicon wafer, is based on tunnel oxide passivated contact (TOPCon) technology. The TOPCon cell uses an ultra-thin tunnelling oxide layer and achieves a breakthrough efficiency of 25.4%.

Problem: With the rapid development of renewables around the world, land resources for projects are becoming increasingly scarce in many regions. Optimising profitability and space by selecting the highest efficiency module is an important topic.

Solution: The Tiger Neo adopts half-cell and multi busbar technology, has a maximum power of 610W and a temperature coefficient of -0.30%/°C. This means the power generation performance is optimised at high temperatures. The module is offered in dual glass format with a bifaciality factor up to 85%, contributing to a power gain up to 11.48%. Compared with traditional PERC modules, the N-type TOPCon module has a better low light performance, extending the power generation period by about one hour in the morning and one hour in the evening.

Application: Utility-scale power plants.

Availability: Currently available

Software — Huawei's SmartDesign 2.0 offers versatile design solutions for rooftop solar, energy storage professionals

Product outline: Huawei's SmartDesign 2.0 is a web-based PV and energy storage system design tool that can help installers quickly complete designs for residential and commercial solar and energy storage systems.

Problem: Some professional design software can be difficult to learn and complicated to operate.

Solution: SmartDesign 2.0 software offers satellite-based design services within ten minutes, providing site surveys with an automatic module layout and electrical connection details. The tool offers multiple product solutions to achieve optimum design.

Application: The software is aimed at solar PV and energy storage designers in the residential and commercial segments, as well as sales representatives.

Platform: SmartDesign 2.0 is an entirely browser-based design solution that can be accessed by installers via Huawei's website. Satellite imagery and data is provided by Google Maps.

Availability: Available now.

The US 'solarcoaster' takes developers for a ride

Policy | The US solar market was widely expected to thrive this year, but various policy headwinds have destabilised the module procurement market and created uncertainty to such an extent installations stalled. Liam Stoker reflects on events of the last 12 months.

Credit: NREL

President Joe Biden during a visit to a National Renewable Energy Laboratory facility in Colorado last year.

When President Biden assumed office in January 2021 there was every expectation that a light at the end of the tunnel for US renewables had been reached. A ceremonial re-joining of the Paris Climate Agreement would pave the way for a suite of supportive policies designed to send the market back up the renewables rankings, buoyed by gigawatts upon gigawatts of deployment.

But, so far, that has yet to come to pass. And indeed, so great has the policy uncertainty been in relation to renewables – and solar in particular – that some developers earlier this year remarked that Biden had, in fact, been worse for the industry than even his predecessor.

Since the president's inauguration, the solar industry has had to face two consecutive anti-dumping and countervailing duty (AD/CVD) investigations, an extension of Section 201 tariffs, a withhold release order on polysilicon from Hoshine and a toughened stance on products from China's Xinjiang region owing to forced labour concerns.

While Biden secured a major policy victory with the passage of the Inflation Reduction Act – including a host of provisions to boost solar deployment and manufacturing – in mid-August, his tenure as president has not been the smooth sailing the US industry had hoped for.

This has resulted in markedly weaker deployment forecasts for this year, caused by the upheaval in module procurement that has sent developers sprawling for alternative, often pricier modules.

The extent of delays and project pushbacks has been highlighted in two recent studies in particular. Analysis of satellite data by tech analyst Kayrros concluded that one-third of utility-scale solar projects in Texas expected to complete this year have either not started yet or been placed on hold, while the American Clean Power Association recorded a 53% slump in utility-scale solar installations US-wide in Q2 2022, driven entirely by policy headwinds and trade issues.

Axed because of Auxin

Developers in the US have concluded that of all the headwinds they have faced, it is the AD/CVD investigation(s) that have wreaked the most damage. While other developments have made module procurement more difficult or inflated prices, none have effectively stopped PV module shipments overnight in such a way that the AD/CVD investigation did.

In that respect, it is of more pertinence for developers that Biden's subsequent intervention – to effectively waive those tariffs for two years – removed a considerable amount of uncertainty in the market. Paul Wormser, vice president at Clean Energy Associates, says that uncertainty was effectively a barrier on numerous facets of solar procurement in the US, to factories running at full speed, to shipments entering the US and to contract negotiations on new supply, wholly because the AD/CVD risk was perceived to be so significant.

By removing that risk – if only for a two-year period while the Department of Commerce's investigation proceeds in the background – Wormser says modules can now start to ship and projects start to progress.

> "[Module] demand right now is what you might think of as a bubble"

But, there is a caveat to this point. While supply lines to the US have been reopened by Biden's intervention, it merely means that the significant amount of latent demand in the

AD/CVD: A timeline

August 2021: A group of anonymous solar manufacturers, dubbed the American Solar Manufacturers Against Chinese Circumvention (A-SMACC), petitions the US Department of Commerce to investigate alleged circumvention of AD/CVD tariffs by manufacturers based across Southeast Asia.

September 2021: The Department of Commerce delays its verdict on the A-SMACC petition, requesting new information to proceed, including the identities of those companies included within the group.

November 2021: The Department of Commerce rejects the A-SMACC petition, citing the ongoing anonymity of those included within the group as an obstacle to further proceedings.

February 2022: Auxin Solar, a hitherto little-known US module manufacturer, launches a new petition with the US Department of Commerce to investigate potential circumvention of AD/CVD tariffs by Southeast Asia-based manufacturers.

March 2022: The Department of Commerce confirms it will investigate alleged AD/CVD circumvention following Auxin Solar's petition, effectively halting US module supply from Southeast Asia.

May 2022: Eight major module manufacturers with operations in Southeast Asia are selected as mandatory respondents to Commerce's investigation.

June 2022: With the investigation still ongoing, the Biden administration confirms it will waive certain trade tariffs on solar products for two years, effectively meaning AD/CVD tariffs will not be implemented until June 2024 at the earliest.

August 2022: The preliminary findings of the Department of Commerce's investigation are announced.

January – April 2023: A final decision on the investigation, including any prospective tariff rates, are to be announced by the Department of Commerce.

US market can be satisfied. Demand for modules in the US market had been building for more than a year before Biden's AD/CVD intervention, with module supply disrupted by the withhold release order on products linked to polysilicon products made by Hoshine Silicon.

"We did not see demand destruction, but we saw demand delay because of shipments being delayed," Wormser says, adding: "And that means that the demand right now is what you might think of as a bubble".

The AD/CVD investigation merely served to exacerbate the situation and allow that bubble to grow larger, with manufacturers that have been able to cater for the US market now increasingly sold out through 2022 and 2023. One, Wormser says, is sold out through 2024.

So if the AD/CVD investigation had caused pent-up demand to continue to build, simply suspending that risk will not be an immediate panacea to the US solar industry's supply chain woes. And it certainly did not prove to be that way, with yet another policy spanner in the shape of the Uyghur Forced Labor Prevention Act (UFLPA) coming into force just months later.

A tough stance on forced labour

After passing the US Senate late last year, in June the UFLPA came into force, effectively prohibiting the import of products linked to China's Xinjiang region over allegations of forced labour. Modelled on previous policy tackling forced labour accusations, the UFLPA assumes that any items "wholly or in part" made in Xinjiang are prohibited from entering the US.

Given the region's connections with polysilicon production and a general lack of existing traceability documentation – with the UFLPA requiring documentation down to the quartzite level – it had initially been feared that the requirements for entry would be higher than previously thought. This fear was not eased when news of the first shipments being stopped under the UFLPA spread earlier this summer.

But while those fears have not exactly proven unfounded, the Solar Energy Industries Association has moved to dispel outright concerns by stressing that most US solar importers should be able to meet those requirements. It may, however, take time for documentation to be processed and the act has certainly been identified as yet another stumbling block for modules made in Southeast Asia to ship to the US freely.

This has given fresh impetus to calls for the US to get serious on its domestic solar manufacturing footprint, something which – alongside an extension to investment tax credits (ITCs), which would add further certainty for the US solar downstream community – would give the sector the jumpstart it needs.

All eyes, therefore, fell on Capitol Hill and, more specifically, one senator in particular.

Manchin machinations

The US solar community has placed significant importance on the passage of Biden's Build Back Better (BBB) agenda, given how it would provide such considerable certainty for not just downstream supports, but investment in upstream.

The Solar Energy Manufacturing for America (SEMA) Act, as proposed by Georgia senator Jon Ossoff, stands to drastically overhaul the way the US government supports domestic solar manufacturing, offering incentives for each unit of polysilicon, solar wafers, cells and modules produced within the US. Domestic module makers such as First Solar have championed its importance to such an extent that the company has reportedly suggested future capacity expansions would take place outside of the US, and in Europe or India instead, were it not to pass.

Likewise, international module manufacturers with existing capacity in the US such as Qcells have stressed that if they are to even entertain expanding module capacity in the US, then incentives such as SEMA are imperative.

"This industry clearly needs some kind of incentive or subsidy… From the cost perspective [outlined in Senator Jon Ossoff's SEMA proposal], we are satisfied. If that policy support is in place, we may consider it," says Justin Lee, CEO at Qcells.

An extension for solar ITCs – a cornerstone of Biden's election campaigning around climate issues – has too long been part of BBB, and would pave the way for tens of gigawatts of additional solar to reach financial close in the US in the coming years, Wood Mackenzie has highlighted.

BBB, enacted through the US' budget reconciliation process to avoid the need of an outright majority in the House, faced months of delays due to West Virginia senator Joe Manchin. The Democrat, who occupies the party's right alongside Arizona senator Kyrsten Sinema, effectively stonewalled the bill's passage, labelling its multi-trillion-dollar spending bill as reckless. Initially expected to pass as early as November 2021, by July, with negotiations having broken down numerous times and relations within the Democrats fraught, many industry observers and politicos considered the legislation dead in the water. ROTH Capital's Phil Shen gave it just a 10% chance of passing, and even that may have been generous.

But in late July, with negotiations feared all but dead, Manchin and Senate majority leader Chuck Schumer announced a shock breakthrough. Manchin confirmed that he would

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support a bill that included various climate supports, including not only a ten-year ITC extension and a version of SEMA, but an ITC for standalone energy storage, long regarded as a much-needed enabler for the broader energy transition.

Wrapped up as part of a broader bill to tackle the threat of inflation, Manchin said the bill will "ensure our country invests in the energy security and climate change solutions we need to remain a global superpower through innovation rather than elimination" in a statement issued on 27 July 2022.

The following weeks saw the bill, dubbed the Inflation Reduction Act, pass both chambers of Congress before landing on Biden's desk to sign into law on 17 August. Earmarking US$369 billion for decarbonisation efforts, the act was described by the president as "the biggest step forward on climate ever".

Provisions included look set to lay the groundwork for accelerated PV deployment, with research from Princeton University projecting that the country could have as much as 49GW of solar installed per year by 2025, around five times higher than capacity additions in 2022. Wood Mackenzie, meanwhile, forecasts that the act will increase US utility-scale solar capacity buildout by 86% over the next ten years when compared to a scenario without tax credits.

The act will enable solar developers and manufacturers to make investments knowing that the policies will be in place for ten-plus years, according to Christopher Seiple, vice chairman of energy transition and power and renewables practice at Wood Mackenzie. "The renewables industry, solar included, has never had a period in its future where it had policy certainty for ten-plus years," he says. "We've always called it the 'solarcoaster', because of this whiplash from year to year responding to different policies."

"The renewables industry, solar included, has never had a period in its future where it had policy certainty for ten-plus years"

Jessica Lawrence-Vaca, vice president for government affairs at EPC contractor SOLV Energy, says the Inflation Reduction Act provides certainty from a procurement standpoint for the company, adding: "I think all of our partners across the board are really excited about the possibility here because the long-term certainty is just so critical to being able to grow, plan and do business."

Attention now shifts to the outcome of the Department of Commerce's AD/CVD investigation, and whether the Inflation Reduction Act and other legislation like the Bipartisan Infrastructure Law can help create a homegrown US solar manufacturing industry, regardless of that investigation's outcome. As always, the industry awaits the next twists and turns of the US 'solarcoaster'. ■

Additional reporting by Jules Scully.

The future for solar PV in Chile

Chile | Home to some of the world's highest solar irradiation levels and urgently in need of homegrown energy resources, Chile has established itself as a key PV market in Latin America. Jonathan Touriño Jacobo looks at that rise and asks what we can expect to see next for Chile.

Even though nowadays the solar industry in Chile is the second most important in Latin America, only behind Brazil, the boom for solar PV projects only started less than a decade ago. In 2013 it had merely passed a megawatt of solar PV before reaching its first gigawatt of total installed capacity back in 2016 and as of this year, is at almost 7GW. Last year it managed to install more than 1GW of solar PV in a single year for the first time, according to a report from SolarPower Europe. For 2022, the European trade body expects Chile to install 2.9GW of solar PV, continuing the country's expansion in renewables.

Chile is home to one of the highest irradiation regions in the world, the desert of Atacama, with "around 60 to 70% of solar PV" capacity so far installed in the regions of Atacama and Antofagasta, says Darío Morales, director of studies at Asociación Chilena de Energía Renovables y Almacenamiento (ACERA), the country's renewables and storage trade association.

Aside from a large pipeline of utility-scale plants, Chile has also invested in its distributed generation, also known as "pequeños medios de generación distribuida" (PMGD) which are projects of up to 9MW. "Of the near 7GW of installed capacity, a little bit more than 1.3GW comes from distributed generation," adds Morales. The difference with utility-scale is that the PMGD has expanded in the centre zones of the country, near the capital Santiago, as they are more practical as areas of large consumption of electricity.

It is safe to say that the solar industry in Chile is up and running, but it might need to further accelerate pace if President Gabriel Boric's government is determined to push forward the closure of all of its coal plants from 2040 to 2030, with a first decommissioning phase in three years' time.

Credit: Mytilineos.

A Mytilineos PV project in the Atacama Desert, one of the sunniest places in the world.

A phase out by 2030 is achievable

Before winning his presidential bid, Boric's programme had the goal to achieve the closure of all coal power plants before the end of his term in 2026. Even though it looks improbable that will happen, 2030 might sound a much easier goal to achieve according to Morales. But it still implies a high demand for renewable energy by that time.

Last year, the trade body ACERA made a study in collaboration with consultancy firm SPEC and the universities of Instituto Sistemas Complejos de la Ingeniería from Santiago de Chile and Universidad Técnica Federico Santa María, looking at what was needed in order to have a "successful" closure of the remaining fossil fuel plants.

Given the different dates explored by the government for the closure of coal plants still active, the study looked at three dates: 2025, 2030 and 2040. Morales says there were three conditions to be filled, to make the phase out a success. The first was to avoid any power cuts due to a lack of electricity, which then required study into the stability of a renewables-powered grid, which "opens a new technological challenge to operate a 100% renewable electrical system", says Morales. While the last condition is to make sure that costs don't increase and stay reasonable.

To successfully retire the remaining coal plants in Chile, 18GW of additional renewables will need to be installed in the next three years, says Morales. There are around 8GW to 10GW of projects announced so far, which means the other half is in "no one's mind." Morales adds: "Last year we had four years, but now there's only three remaining. It looks very complicated. If those conditions are not met, then we'll have problems with the electricity." For Morales, 2030 sounds already more reasonable and doable since instead of 18GW of new renewable energy needed it will be 22.5GW.

"It remains an important quantity, with an investment north of US$30 billion, which represents almost 10% of Chile's GDP. It sounds more reasonable." Concrete measures need to be taken if the country wants to achieve that goal, such as with regulation.

"We all want to decarbonise, but we need to do it well and for that we need to define the institutional operation, the market's needs, the technical conditions and the legal bindings that allows and incentivise such developments," says José Ignacio Escobar, chief executive at Colbún.

As one of the Chilean utilities which has yet to close its remaining coal plants, the

Credit: Sebastian Rodríguez

Chilean president Gabriel Boric was elected on a platform that included a pledge to phase out coal.

company's roadmap for decarbonisation involves increased investment in renewables, propelling energy storage forwards, developing green hydrogen projects and searching for new growth opportunities in Chile and in other countries, says Escobar.

If in the past Colbún made agreements with third parties for the purchase of renewable energy, it is now focused on developing its own portfolio of renewables, with the goal to reach more than 4GW by the end of the decade.

The utility has three solar PV plants in operation in Chile with a total capacity of 250MW, of which one is located in the Atacama region with a power capacity of 230MW. Two solar plants with a capacity of more than 1GW have received environmental approval, with a further 820MW of wind and battery storage under construction.

Transmission lines: the next big hurdle

If the phasing out of all the remaining fossil fuel plants was not enough of a challenge, Chile has faced a loss of hydropower due to increasing droughts, with power generation 21% lower in 2021 than it was in 2020. Most of its production is currently coming from the centre-south zone of the country which has been forced to run on diesel. "This creates a two-fold issue, in one side we have the contamination and on the other hand there's the problem of costs," says ACERA director of studies, Darío Morales.

This loss of power brings with itself another challenge related to the transmission lines, as most of the new renewable power installed currently comes from areas that lacked such infrastructure and needs to be brought there, according to Morales.

"The structure of the existing transmission line will probably need to be reinforced to bring more energy from the north to the zone of highest energy consumption. The issue is that the development of renewable plants is much faster than the development of the transmission lines."

Even though the north accumulates between 60 to 70% of new renewable energy projects, primarily solar PV, it is not the region with the highest consumption of electricity, even with the energy intensive mining industry's presence in the region. For Morales, the two main connections that need to be solved rapidly are from Concepción (500km south of Santiago) to the south and from Santiago to the north, as the transmission line infrastructure has not been developed fast enough.

The northern and central systems were only interconnected in 2017, and Morales says that despite it being an important feature, is it not robust enough. A new line nicknamed Kimal-Lo Aguirre is expected to be completed by the end of the decade and would further alleviate the situation. For Morales this will not be enough to fully solve the problem. Overcoming transmission line hurdles will be a "cornerstone" in the energy transition to achieve a 100% clean energy grid, Morales says.

Co-located solar with energy storage is the future

What might help reduce congestion in the country's grid is energy storage. Currently a law is being discussed that would answer questions on income from energy storage and reduce renewable energy curtailment contingencies.

Those curtailments contingencies that some companies are having could exceed up to 10 to 20% during the day, says Moisis Damianidis, general manager LATAM, renewables & storage development business unit at Mytilineos. Mytilineos has so far installed more than 500MW of renewable capacity for third parties and is developing its own portfolio with more than 600MW of solar set to be operational between 2023 and 2024. And one solution to avoid any loss and at the same time add the ability to offer energy during the night, would be co-located projects with battery storage.

"Recent talks we have been doing with a lot of companies, including of course our interest in this sector, is that all existing projects in the next three to five years are going to be covered by battery storage capacity," says Damianidis. "We're therefore speaking about a market, which according to our conservative calculations is going to exceed 10 to 12GWh over the next three to five years."

So far battery energy storage system (BESS) technology is near non-existent in Chile, with just 64MW of installed capacity according to ACERA's data. The reason for such a low penetration so far is "a mix of various elements: price, uncertainty about revenue and lack of regulation", says

Antofagasta, land of solar opportunity and green hydrogen

As Chile ramps up its investment in green hydrogen, two regions have created hubs around that technology: Magallanes in the south and Antofagasta in the north. While the southern region will mostly see green hydrogen projects coupled with wind energy, in Antofagasta and around the desert of Atacama, solar will be favoured. "There are more than 60 investment projects, some that have been published, others that have not," says Ricardo Rodríguez, director of studies at H2 Chile, the trade body for hydrogen in Chile. Of those projects, 10 are in Antofagasta. Both hubs will have a similar production capacity and an access to international markets.

"In Antofagasta's case, one of the advantages for green hydrogen investments is that the infrastructure has already been built, with excellent roads which are needed for the movement of the mining industry," says Rodríguez. There is also a good amount of public land that could be used for green hydrogen investments in the region, such as the programme 'Ventana al Futuro' ('Window to the Future') that was launched last year to attract green hydrogen electrolyser projects of at least 20MW by 2025 that would be granted 40-year licences. Or the Chilean economic development agency (Corfo) that held a first financial call offering up to US$50 million to finance a capacity of 400MW of electrolysers by 2025.

The mining industry has an important role in Antofagasta and represented 52% of its GDP in 2020, according to a report from the mining trade body Consejo Minero. With the industry today so dependent on fossil fuels, the development of technologies using green hydrogen for lorries and other mining equipment will create a "sort of dependency, or virtuous circle" between both industries that could help in the development of both.

The country is increasing its investments in green hydrogen and with the projects currently in construction it is nearing 5GW of electrolyser capacity, says Rodríguez, adding the country is aiming for 25GW by 2030.

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Morales. The issue of cost is primarily a question of time before prices drop and installing BESS with solar becomes affordable. This is why the proposed bill that is currently being discussed in the Chilean Congress could solve some of the existing uncertainties.

Without battery storage, it will be nearly impossible for developers to attract the "Holy Grail" which is the mining industry, as they do not want to discuss any power purchase agreement (PPA) unless it's for 24/7 power, says Damianidis.

Developing in the desert of Atacama

Chile has two regions that are highly attractive for renewable energy. In the south, Magallanes is pivotal for onshore wind. Up north, the region of Antofagasta and particularly the Atacama Desert region is well known for its high levels of irradiation.

This brings certain constraints or necessities when developing a project there, such as using bifacial modules or using trackers, according to Moisis Damianidis at Mytilineos who says it's a given that those technologies will be selected in an optimum design.

"Dealing with a project in a deserted area, it's a one-way road that you go bifacial, it's a one-way road that you go on with a tracker and it's a one-way road that you have to select equipment with maximum isolation protection, so IP65 and IP66."

In terms of operations and maintenance (O&M), the lack of nearby water resources in a desert area and thus its high cost to use for cleaning modules gives developers no other choice than to opt for dry cleaning. The advantage of the Atacama Desert, says Damianidis, is that given it is a very dry area, the dust will not get stuck onto modules, making dry cleaning much easier.

But an aspect that might be overlooked by developers, and that Mytilineos has faced with some of its previous projects, is the community. This has been an aspect the renewable division has been focusing on.

"All of the local community, where we are developing the projects, [are] being benefited from our development: whether it comes to employing personnel from the local community, or supporting the local community by building facilities, schools or something similar, in order for them to embrace the investment that we're doing. To give the message that when it comes to investment, all of the involved stakeholders should receive the best."

By getting the local community to feel involved in the project, either by hiring people for the projects during the different phases of it or simply getting something in return, will make them feel it is a part of them too, says Damianidis.

One other challenge Mytilineos was expecting to be a problem with energy storage was the dust, says Damianidis. This is because in many areas in Chile the dust is very fine and that ingress protection (IP) of the equipment would be a challenge, but that ended up not being the case after all. Instead, "…the big enemy of storage is high heat." One advantage of doing projects at a high elevation, between 1,000 to 1,500 metres above sea level, is that even despite temperatures reaching up to 31C, nights are much cooler, an advantage for energy storage equipment.

The Atacama Desert is positioning itself as one of the key regions in the world for renewable projects. Thanks to its great level of irradiation, it will be able to attract both green hydrogen plants and will increase co-located solar PV with energy storage, as Chile tries to accelerate the decarbonisation of its electricity grid. ■

Utility Colbún has three PV plants in operation totalling 250MW and another 1GW approved.

Credit: Colbún

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Singapore bets big on power imports

Singapore | Singapore is battling the need to decarbonise without the land availability to establish sufficient large-scale renewables plants. With the government looking to import electricity from overseas, Jules Scully looks at prospective power import projects and the consortiums behind them.

Credit: Sunseap

A 5MWp floating solar project from Sunseap in Singapore.

With limited space to install renewables projects and 95% of its electricity currently generated using natural gas, Singapore is betting big on importing clean power from abroad as it aims to improve energy security and support regional decarbonisation efforts.

The city-state announced plans in October 2021 to import up to 4GW of low-carbon electricity by 2035, which is expected to make about one-third of its electricity supply.

Trade and industry minister, Gan Kim Yong, said at the time that the energy transition will be especially challenging for the country as it has little wind, hydro or tidal power, while heavy cloud cover and a lack of land limit solar potential.

He explained that even if Singapore were to maximise all available space for solar deployment, it would still not be able to generate enough power to keep the lights on with the technology alone, even accounting for efficiency improvements.

"Meaningful abatement can only come through tapping on low-carbon energy beyond our shores," he said. "Importing low-carbon energy will be a key needle mover in Singapore's energy transition in the near to medium term."

A notable milestone was reached in June when Singapore commenced its first renewable electricity import, which comes from 100MW of hydropower in Laos, transported via Thailand and Malaysia using existing interconnections. Singapore's Energy Market Authority (EMA) said the project is one of the trials it has been working on to pave the way for larger imports.

According to a guide to electricity imports published by the EMA in July, importers must provide offers into the energy market and compete to secure dispatch into Singapore's network for half-hourly periods.

For projects that come from intermittent generation sources, power should be dispatchable, with imported electricity required to achieve a minimal quarterly load factor of 75% within five years of commercial operation.

And with existing local generation achieving 90% availability, the EMA said each imported supply shall achieve similar availability standards that would make it equally reliable.

Sunseap's Woodlands floating PV plant in Singapore features 13,312 solar modules.

Credit: Sunseap.

Such rules mean battery energy storage systems (BESSs) feature prominently in project proposals put forward so far.

The electricity import policy has so far garnered a lot of interest, says Joo Yeow Lee, associate director of power and renewables at financial information provider S&P Global Commodity Insights, adding that the first request for proposals (RFPs) received 20 proposals from prospective import projects, with a significant number to be sited in Indonesia and feature solar-plus-batteries.

Launched last November, the first RFP closed with proposals to supply electricity from sources such as solar, wind, hydro and geothermal power from four countries: Indonesia, Laos, Malaysia and Thailand. A second RFP was issued in July, with potential importers required to demonstrate their supply reliability, credibility, track record and cost-competitiveness.

Having received requests from participants of the first RFP for more time to develop their proposals, the EMA said it would combine the two RFP rounds as part of a more streamlined process.

Developers join forces

Among the developments to have been proposed so far include a project that would feature 7GWp of solar coupled with more than 12GWh of energy storage systems to be deployed in Indonesia's Riau Islands.

Led by Singapore-based developer Sunseap, the consortium behind the installation aims to achieve economies of scale and optimise the capacity of a proposed subsea cable by linking the solar systems – including 2.2GWp of floating PV – from various islands, providing 1GW of non-intermittent energy.

"Energy storage will allow us to deliver stable high-quality power to our clients in a very reliable manner. It will also allow us to provide energy 24/7 as opposed to just daytime when the sun is shining," says a spokesperson from Sunseap, which was acquired by EDP Renewables earlier this year.

> "Meaningful abatement can only come through tapping on low-carbon energy beyond our shores"

Sunseap previously said the consortium aims to be one of the parties to help fulfil 20 – 25% of the 4GW of low-carbon electricity imports to Singapore.

Noting that foreigners cannot own land in Indonesia, the spokesperson says that EDP Sunseap has partnered with local companies to secure the land, adding: "Having all the right permits and licenses is crucial, and good progress is being made on this front."

When announcing the power import policy last year, minister Gan Kim Yong warned that imported electricity may not mean cheaper electricity for Singapore. He explained that while the cost of generation may be lower, the costs of transmission and backup, as well as necessary grid enhancements, will add to the overall price tag. "This is an inevitable but necessary trade-off in the energy transition," he said.

The Sunseap spokesperson says that while the interconnection will require "significant capital investment", the advantage of solar is being able to maintain a stable price for its clients and not be subject to volatility often associated with fossil fuels. "This reliable stable delivery of clean energy is very much sought after by our clients who want to avoid the risks of fluctuating energy prices."

Sun Cable, the company behind a development that bids to transmit 2GW of electricity from Australia to Singapore via 4,200km of high voltage direct current (HVDC) cables, is forecasting "commercially acceptable" transmission losses, says the project's director, Andrew Barton. The loss calculation is also a function of a cost-benefit analysis, as various design choices will impact the transmission losses.

Set to include 17 – 20GWp of solar and 36 – 42GWh of battery storage in Australia's Northern Territory, Sun Cable's Australia-Asia PowerLink will enable 24/7 dispatchable electricity, according to the company.

Barton explains that advances in renewables generation, energy storage and HVDC cable transmission technologies have made it commercially and technically

viable to transmit dispatchable, renewable electricity over long distances. HVDC, he says, has "evolved to a point where the voltage is high enough at 525kW to support projects that need to transfer electricity over long distances".

The subsea cable will pass through Indonesian waters, with authorities in the country granting Sun Cable a subsea survey permit in September 2021. But as of May, no other formal permits or licenses have been issued to the company by Indonesia, Elrika Hamdi, an energy finance analyst at the Institute for Energy Economics & Financial Analysis (IEEFA), wrote in a recent commentary. She says: "They haven't been able to receive the subsea cable transmission permits, which is the crucial part."

Another consortium planning to transmit renewable energy from Indonesia to Singapore includes Abu Dhabi renewables company Masdar and France's EDF Renewables, whose agreement envisages the development of as much as 1.2GW of solar PV and "potential associated storage".

The partners have released limited details about the project, including its proposed location in Indonesia and how much generation it plans to transmit to Singapore. According to EDF Renewables, the company and its partners are working on the project's development but are at "a very early stage".

> "Energy storage will allow us to deliver stable high-quality power to our clients in a very reliable manner"

A statement from Masdar reads: "We are still working with our partners on evaluating the best options for all stakeholders and prefer not to discuss specific details at this stage."

Their consortium also includes Singapore utility Tuas Power and PT Indonesia Power, a subsidiary of Indonesian state-owned utility PLN. When details of the project were released earlier this year, PT Indonesia Power said it "is an essential partner for the power export in Indonesia".

According to IEEFA's Hamdi, PLN and its PLN Batam subsidiary are the only two entities that are legally allowed to export power from Indonesia without additional permitting processes. In a recent commentary she wrote that obtaining the relevant power export permit is time-consuming and complicated, and that "significant risks persist for current bidders, especially those who do not include PLN subsidiaries in their consortium".

Another consortium that includes a PLN subsidiary, PLN Batam, was announced last year by Singapore energy company Sembcorp Industries and also features Indonesian renewables developer PT Trisurya Mitra Bersama. They signed an agreement to develop 1GWp of solar power and energy storage in Indonesia's Riau Islands.

Also eyeing the Riau Islands for electricity exports to Singapore are developers Quantum Power Asia and ib vogt, which are planning to construct 3.5GW of solar PV and 12GWh of storage systems. A joint venture between the companies has secured agreements from corporates in Singapore to supply more than 4TWh a year of imported clean energy from the installation, set to span more than 4,000 hectares.

Finding land or water to construct the projects in the Riau Islands "would not be too difficult", says Hamdi of IEEFA, who suggests some developers may have found suitable land already. More of a problem, she argues, is securing the political willingness from the Indonesian government to supply electricity to Singapore.

Political headwinds in Indonesia

Prospective project developers have banked on being able to deploy their

Consortiums' project proposals in Indonesia

- A consortium led by developer Sunseap plans to construct 7GWp of solar coupled with multiple energy storage systems totalling more than 12GWhr in Indonesia's Riau islands. The project aims to provide 1GW of non-intermittent clean energy for Singapore and Indonesia. Other consortium members include EPC Samsung C&T and energy storage solutions provider Durapower.
- Developers Quantum Power Asia and ib vogt are partnering to construct more than 3.5GW of solar PV and 12GWh of storage systems, also in the Riau Islands. The US$5 billion installation is expected to be fully commissioned in 2032 and deliver about 8% of Singapore's annual electricity generation, according to the companies. A joint venture between the pair has partnered with an electricity retailer in Singapore that will handle connectivity of imported clean energy to residential, industrial, and commercial customers.
- Abu Dhabi-based Masdar and France's EDF Renewables are part of another consortium that is exploring the development of up to 1.2GW of solar and "potential energy storage" in Indonesia. They are joined by Singapore utility Tuas Power and PT Indonesia Power, a subsidiary of Indonesian state-owned utility PLN. At the time of writing no information on the proposed location of their project had been announced.
- Singapore energy company Sembcorp Industries has partnered with another PLN subsidiary, PLN Batam, as well Indonesian renewables developer PT Trisurya Mitra Bersama (Suryagen) for a proposed project in the Riau islands that would feature 1GWp of solar. They said the installation would also include a large-scale energy storage system.
- Singaporean utility PacificLight Power, independent power producer Medco Power Indonesia and investment company Gallant Venture are developing a 670MWp solar PV project in the Riau islands. It is expected the installation will provide 100MW of electricity to Singapore through a dedicated plant-to-grid 230kV HVAC subsea cable.

Credit: Quantum Power.

A 14.5MWp PV plant from Quantum Power in Indonesia.

Credit: Quantum Power.

Quantum Power's 7.25MWp Sambelia solar project in Indonesia.

renewable energy export projects in Indonesia after Malaysia's government announced last year that only non-renewable energy would be allowed to be exported to Singapore, while power sales through self-developed transmission and interconnection facilities to the city-state would be banned.

Malaysia's energy ministry said the decision was made to boost the development of local renewable energy, as it expanded a solar net metering initiative in the country following the announcement.

Singapore and Indonesia signed a memorandum of understanding on energy cooperation in January, spanning areas such as solar project development, cross-border electricity interconnection and an increase in human resource capacity.

However, comments made since by Indonesia's investment minister, Bahlil Lahadalia, indicate the government is having second thoughts on parts of the collaboration. He said the country will not export renewables generation, instead focusing on domestic needs first. "We haven't thought about exporting [renewable energy] yet," the minister said in May.

Daniel Kurniawan, a solar analyst at Indonesian thinktank the Institute for Essential Services Reform, says there has been a "huge change" from last year, when there were announcements in Indonesia related to joint development agreements with Singapore.

The current situation, Kurniawan explains, "is that the Indonesian government seems to be not giving clear certainty" for the solar developments, representing a "major setback".

A similar view is taken by IEEFA's Hamdi, who says Bahlil's comments should be of concern to solar developers.

One consideration for the Indonesian government is the structure of subsea cables, she says. "It becomes another bottleneck for the Indonesian government to decide whether or not they will want to go ahead with this."

Analysts have also warned that a strategy of transmitting new renewables generation to Singapore by the country's neighbours could leave them reliant on fossil fuel-powered generation.

"This is definitely a concern, especially if the exporting country does not have an abundance of renewable power currently," says Joo Yeow Lee of S&P Global Commodity Insights. "This is also a reason why Malaysia has banned the export of renewable energy from peninsular Malaysia to Singapore."

According to energy major bp, coal is increasingly dominant in domestic power generation in Indonesia, with a 66% share in 2020, compared to 6.1% for renewables. Figures from the International Renewable Energy Agency reveal Indonesia had just 211MW of installed solar as of 2021.

However, large foreign investments into new renewables projects could help to kickstart the nascent renewables sector in Indonesia, Joo Yeow Lee suggests, especially if governments can structure deals so that they also support some renewable development in their own country.

Kurniawan believes the proposed solar export project in Indonesia could support the growth of local EPCs, while regulators could also benefit as they work on cross-border electricity exports.

This is in addition to job creation potential. The JV between Quantum Power and ib vogt, for example, estimates that it could create up to 30,000 new jobs in the Riau Islands.

When Singapore started energy imports from the Laos hydropower plant in June, the EMA said it will serve as a pathfinder towards realising the broader ASEAN Power Grid vision of multilateral electricity trading beyond neighbouring countries in the region.

Hamdi says that with that pilot project taking at least eight years to carry out, this reflects how difficult it is to transmit power from one country to another.

She adds that while the ASEAN nations have been discussing a regional power interconnection for a long time, it hasn't been easy to implement because of energy security concerns, transmission issues and politics. ■

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 powered 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 16 – 18 January 2023 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), with technologies and solutions for utility scale, rooftop and 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 forward the global adoption of renewables 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 54 speakers across 21 knowledge-sharing sessions, representing many of the best thought leaders from the government, industry, academic, innovation and entrepreneurial sectors worldwide.

The 2023 Solar Expo & Forum during the World Future Energy Summit is part of Abu Dhabi Sustainability Week and is hosted by Masdar. To register as a visitor or for sponsorship and exhibition opportunities, please visit **www.worldfutureenergysummit.com**.

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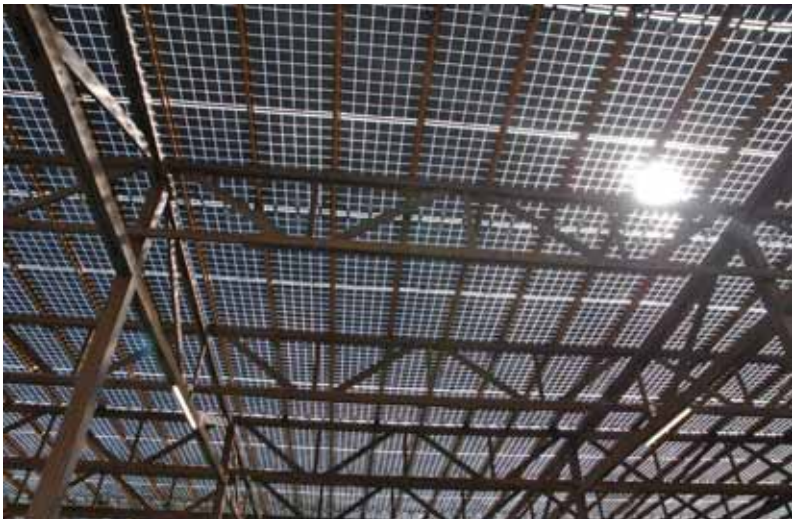
Meeting the solar PV cybersecurity challenge

Cybersecurity | Alexander Hansen Bakken, cybersecurity consultant at DNV, reveals the cyber vulnerabilities arising as solar farm operational technologies become more networked and connected, and recommends approaches to reduce the risk.



Credit: DNV

Cybersecurity threats to the grid-connected solar PV sector are becoming more common, complex, and creative as hackers gradually seek opportunities to disrupt the energy industry. Energy companies have been tackling IT security for several decades. However, securing operational technology (OT) is a more recent and increasingly urgent challenge. OT refers to the computing and communications systems used to manage, monitor and control industrial operations – for example, supervisory control and data acquisition (SCADA) and programmable logic controllers (PLCs).

As OT becomes more networked and connected to IT systems, attackers can more easily access and control systems operating critical infrastructure. It is now possible for attackers to stop solar PV inverters from working, disrupt energy supply in a power grid, shut down a wind farm and disable the safety systems in pipelines, refineries or oil and gas platforms.

The impact of this emerging threat is reflected in *The Cyber Priority*, DNV's study of 940 energy industry professionals on the state of the sector's cybersecurity, published in May 2022. The vast majority (84%) anticipate cyberattacks damaging assets and infrastructure within two years. Most consider it likely that cyberattacks will compromise life (57%), the environment (74%) and disrupt operations (85%).

Cyber attacks on solar assets are becoming more common and sophisticated.

Table 1 illustrates some recent cyber-attacks on energy industries. Two-thirds of respondents to DNV's *Cyber Priority* research say such incidents have driven their own companies to make major changes to their cybersecurity strategy and systems. Three-quarters say cybersecurity has significantly higher priority for their organisation than two years ago.

The 2022 IBM X-Force *Threat Intelligence Index* found 10% of the attacks it observed on industries operating OT in 2021 were in the utilities sector. It commented that while IT networks were compromised in the vast majority of these attacks, "the impact carried over to victims' OT technology in many of these instances".

The evolving threat landscape challenges solar PV asset owners, operators and suppliers to ask: 'What are the cyber risks? What effects could a successful cyberat-

When	Where	What happened
2022	Germany	A cyberattack led to a satellite link fault halting remote monitoring/control of wind turbines and solar PV plants. Thousands of satellite ground-terminal units needed replacing. Some solar PV plants used the radio link but were unaffected. There was speculation that the attack aimed to cripple Ukrainian command and control, with cascading effects impacting European countries, notably Germany. Germany has now issued a plan to prevent a repeat.[1]
2021	US	Ransomware attack on IT led to a six-day shutdown of the Colonial Pipeline carrying 45% of the US East Coast's gasoline, diesel, and jet fuel.[2]
2019	US	Solar PV (and wind) went offline in Utah after a cyberattack on a firewall halted communications between generating sites and a central control centre. Hackers caused similar 'blind spots' at a power grid control centre and small generation sites in California and Wyoming, without disrupting electricity supply.[3]
2019	India	Malware attack on Kudankulam Nuclear Power Plant in Tamil Nadu hit a single PC on an administrative internet server. Plant systems were not affected.[4]
2015 & 2016	Ukraine	The first known cyberattack that targeted a power grid and halted electricity supply (to parts of Kiev), reportedly via remote control of SCADA and substation infrastructure. The 2015 attack was more 'manual' in nature, whereas the similar 2016 incident was malware-induced. The latter, a malware framework known as CrashOverride or Industroyer, uses legitimate and standardized SCADA and grid protocols like IEC 104 and OPC to disrupt grid operation. Ukraine also says it fended off a Russian cyberattack on its power grid during the ongoing Russian invasion in 2022.[5]

Table 1: Selected actual and possible cyberattacks on energy infrastructure 2015–2022

Third-party IT services and cyber risk

Third-party IT services may have cyber vulnerabilities that could be remotely exploited and pose a potential threat for propagating further into IT and OT environments of a solar PV company. An example is remote internet protocol CCTV cameras monitoring the PV plant and normally installed within substation housings/enclosures. This service may well be provided by a third-party vendor with no knowledge or concern about industrial cyber risks. Many such CCTV systems are publicly available/accessible on the internet, perhaps via something as trivial as a default password (i.e. misconfiguration) or a weak password. If this CCTV system is then connected to the PV SCADA server, a hacker could gain access to the server by using the CCTV internet connection as a back door. In India in 2021, hackers are thought to have gained control of internet-connected DVR/IP camera devices for command and control (C2) of Shadowpad malware infections, as well as use of the open-source tool FastReverseProxy (FRP), though not in the solar PV context .

tack have? How do we prevent and detect such attacks? And how do we respond if an attack is detected?'

Cyber vulnerabilities

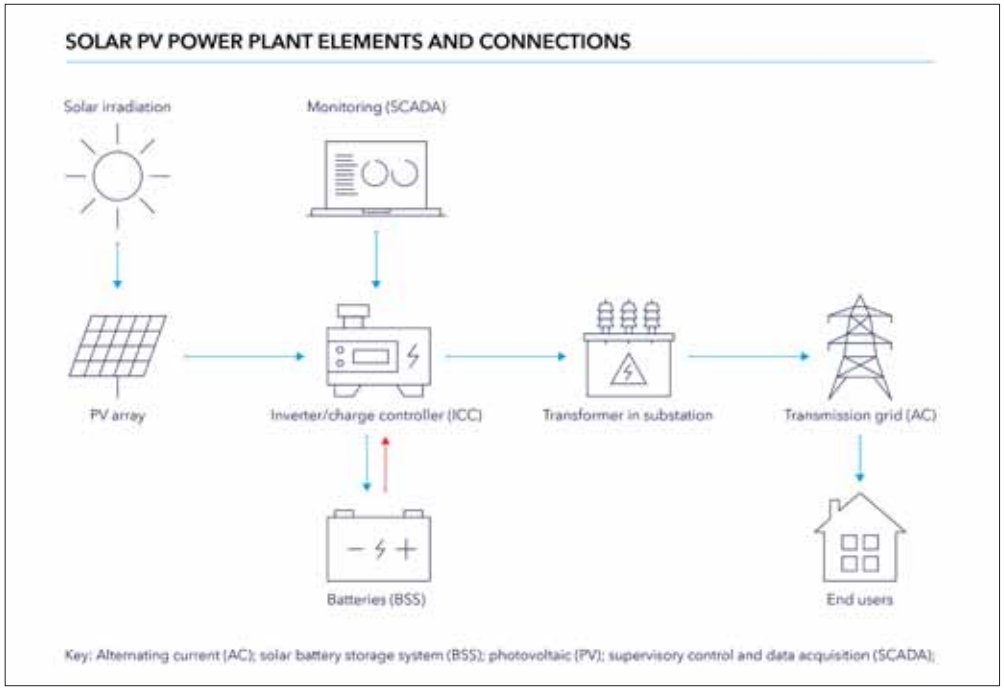
Examples of potential cyber vulnerabilities in grid-connected solar PV include those that can be found in OT that manages generation, inverters and the voltage of power supplied to the grid (Figure 1). Voltage control assists grid balancing to avoid damaging electricity users' equipment or tripping shutdown of electrical equipment.

Inverters are increasingly 'smart'. They are software-enabled, communicating with grids and remote centres handling operations and diagnostics. Some inverter suppliers offer software for remote access and control of their equipment, and several solar PV parks have multi-vendor remote access to aid maintenance and monitoring. These technologies can boost availability of power to the grid, lessen voltage fluctuations, reduce the levelised cost of electricity (LCOE) and raise profitability. Even where software updates and patches are part of the package, however, purchasers need to be sure they will not be exposed to the potential consequences of unacceptable cyber risk (see box 'Third-party IT services').

A cyberattack might result in a solar PV project going offline. An operator detecting a threat to their IT environment may disconnect their OT to guard against malicious actors accessing and controlling their OT. Or a hacker may bypass weak physical security or access controls, thereby directly accessing solar OT. The attacker's motive could be to immediately cut off grid connection or try to obtain a persistent remote command & control channel to disrupt operations in the future. If a company takes solar PV generation offline in a controlled manner, there is less risk of grid instability. If a cyberattack forces it offline, the risk of grid instability significantly increases. The inertia of synchronous generators in traditional power grids help mitigate oscillations. But inertia decreases with increasing penetration of inverter-dominated renewable power plants including solar. This can reduce the quality of the power and makes the network susceptible to power cuts.

Either way, attacks interrupting power supply and/or damaging the grid could lead to an operator paying financial penalties and/or damages. There could also be lost payments for energy not supplied and, if metering is compromised, through underpayment. The attacker could also steal data including names, passwords and other sensitive information. They could then use or sell the stolen data for identity theft purposes including fraud and accessing other parts of the solar and/or grid's OT and IT environments. A hacker accessing OT could damage inverters, motors for moving solar panels and connected battery storage systems (BSS).

In addition, disruption to supply due to cyberattacks could damage the generator's reputation for reliability with customers, including those with which it may have power purchasing agreements (PPAs).



Credit: DNV.

Figure 1: Solar PV power plant elements and connections

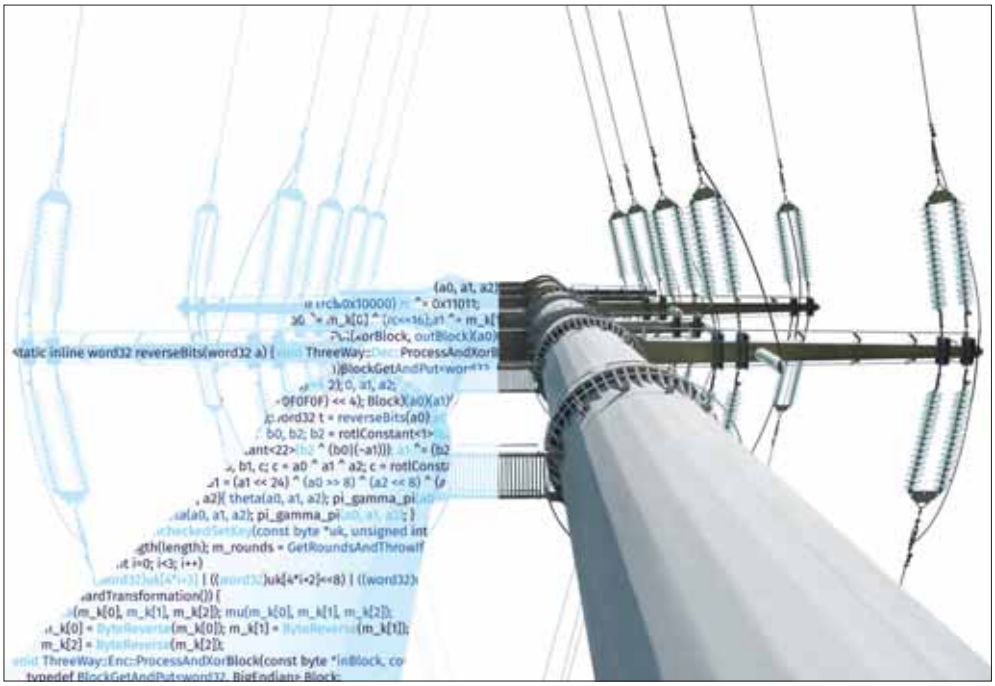
Solar's growing cyber challenge

DNV's latest *Energy Transition Outlook* forecasts that 69% of grid-connected power generation will be from solar and wind in 2050, and that global installed solar capacity will double by 2025 and quadruple to 3,000GW by 2030. Solar PV cybersecurity therefore becomes part of the climate change discussion given the role the sector will play in decarbonising energy. The more critical it becomes to the world's energy systems, the greater target it presents to cyber criminals.

As the frequency and consequences of industrial cyberattacks escalate, regulatory oversight of companies with industrial operations will increase. Heightened risk of cyberattacks on critical infrastructure will bring stricter requirements for organisations to demonstrate control of their own and their suppliers' security.

This trend is already in motion. North America has speedily introduced new regulation in response to rising security threats and recent cyberattacks on companies operating critical infrastructure such as the Colonial Pipeline. New measures have included mandates for government contractors to strengthen their networks. Another example is Europe's Directive (EU) 2016/1148 Security of Network and Information Systems, which is being updated.

Industry standards will also become increasingly important. Companies across the supply chain will more frequently need to apply – and demonstrate the application – of standards, guidelines and best practice in designing and operating energy infrastructure that involves communicating and storing data. For example, the ISA/IEC 62443 series of standards provides a



Credit: DNV.

Top-level managers should have a greater focus on what compliance means to reduce the risk to business, DNV says.

flexible framework to address and mitigate current and future security vulnerabilities in industrial automation and control systems. ISO/IEC 27001 standards provide requirements for an information security management system, enabling any organisation to manage the security of assets such as financial information, intellectual property, employee details or information entrusted by third parties.

The essence of ensuring cybersecurity is to assess and mitigate cybersecurity risks related to people, processes, and technology. At DNV, we recommend companies in the solar PV sector to consider four important issues when addressing cybersecurity: budget for cybersecurity; determine your vulnerabilities; maintain focus on your supply chain; and invest in people.

Budget for cybersecurity

With few published accounts of cyberattacks on solar PV infrastructure, it can be tempting for companies in the sector to assume that an attack is unlikely to happen in their own back yard. They would not be alone. Our research suggests that some energy industry companies may be playing 'wait and see' rather than launching long-term strategies and investment to build defence against attacks that could cost them dearly.

However, with life, property, and the environment now firmly at stake, senior management mindsets towards cybersecurity are tangibly shifting. The default position of company boards and c-suites was once to ensure compliance with cybersecurity regulation and standards, then move on to another year. Now, companies increasingly realise that they can still be compliant even if a significant issue is missed in their cybersecurity audit samples. More risk-averse top-level managers are starting to ask what compliance means and whether it earns them a get-out-of-jail card if a severe incident happens. The answer is 'no'. With cyber risk potentially translating into financial and reputational risk, directors will also want to ensure that the company is always aware of its cybersecurity status and constantly informed of the threat landscape and methods of defence against it.

Those responsible for oversight of the cybersecurity of operations and grid connections will come under increasing pressure to assure boards that the organisation is compliant and confidently cyber secure. But they may still struggle to reserve the budgets they need to upgrade their capabilities while large demands are being made on company finances to pay for digitalisation and energy-transition programmes. *The Cyber Priority* found around a third of respondents, on average, indicated that they are underinvesting in their IT and OT security capabilities. In arguing the case for the investment needed, it pays to articulate and demonstrate how cybersecurity can add value by supporting business continuity, license to operate, reputation, compliance and dealing with regulators.

Determine your vulnerabilities

Nearly two-thirds (60%) of organisations with industrial operations are unaware of their technologies' vulnerabilities, according to Gartner's 2021 *Market Guide for OT Security*. The most urgent task confronting energy sector companies is to discover where projects and operations are exposed to threats before hackers do. What is the attack surface and the potential entry points of attacks? By having a clear and complete overview of their environments, companies can prioritise the vulnerabilities and non-conformities they must address to stay confidently cyber secure. It allows them to put the right people, processes and technologies in place to build effective protection.

Knowing your system's weaknesses and vulnerabilities requires, among other things, a detailed, accurate, up-to-date network topology depicting how components interconnect and communicate (see text box, 'The network topology'). The topology should reflect a complete inventory listing of the solar PV IT-OT network, including both the internal local area network (LAN) and connections to the external wide area network (WAN). It should detail what the 'equipment under control' is, and what every server, switch, wireless transmitter (e.g., Wi-Fi router or SAT-COM terminal), PLC/RTU, internet-connected gadget and so on in the network is used for.

Even the running software services and open physical/logic ports on the devices should be scrutinised, assessed and evaluated with critical eyes. Otherwise, assessing cyber risk may focus too narrowly on the confidentiality, integrity and availability of information, without adequately considering consequences related to safety,

The network topology

Typically a drawing, it may include network segments, switches, servers, routers, workstations, laptops, tablets, smartphones communication protocols, type of wired cables used, device specific information like OS version, IP address, MAC address, the number/type of physical ports, etc. and other details. Operational technology includes any software/hardware interacting with sensors, actuators and controllers, such as programmable logic circuits (PLCs) and human-machine interfaces (HMIs). An asset inventory of all hardware (e.g. inverters) and software running on it is also needed. If the topology and/or inventory is likely to change frequently, generating the inventory dynamically can ensure it is always updated when changes occur. If the system is complex, break it down to several network topographies and have these available before calling in cyber experts such as DNV to assist with actions such as risk assessment, gap analysis and penetration testing. These experts can also assist the development of a network topology.

Log4Shell shows supply-chain risk

The widely reported Log4Shell vulnerability for the popular Java programming language exemplifies risk originating in a supply chain. It was discovered in 2021, in a tool used in cloud servers and enterprise software globally, and in both IT and OT. Hackers could remotely exploit it without needing authentication or special access privileges to servers. Energy sector companies quickly patched and created workarounds for Log4Shell and to safeguard their IT and OT environments. But many may have been slower to assure that their equipment vendors and system suppliers were also taking appropriate action.

reliability and productivity of the assets. For example, a fire in a BSS deliberately overloaded by hackers could have safety and environmental effects and damage assets.

Knowing where your infrastructure has physical vulnerabilities is as important as knowing where you are digitally exposed. Hackers have been known to seek physical access to substations, servers and switches to gain control of critical infrastructure. Physical security therefore also needs continuous mapping, checking and improvement. Investing in proper routines and procedures for both cyber and physical security is imperative to any organisation that values its tangible and non-tangible assets.

Maintain focus on your supply chain

Undiscovered vulnerabilities along the supply chain can completely undermine a solar PV operator's in-house cybersecurity effort. *The Cyber Priority* highlights supply-chain blind spots creating cyber risk. Less than a third of energy professionals working with OT say their company invests in cybersecurity of supply chains and equipment vendors. Just 12% with OT rank such oversight as a core area of maturity.

Many energy companies apply industry standards and recommended practices to help ensure cyber-secure OT/IT implementations. For instance, DNV advises operators and supplies on best practice to ensure conformity to IEC 62443 standards.

Cybersecurity of power grid protection devices

DNV Recommended Practice (RP) DNV-RP-0575 is applicable to companies involved in operating, managing and securing existing (second and third generation) substations. The RP describes 45 risk-reducing measures, covering people, processes and technology, to minimise attack surfaces and counter threats to power systems. These measures are based on a comprehensive review of current EU and US legislation, and currently applicable standards and guidelines on cybersecurity in operational technology. The RP is free to download from the DNV website.

Accurate cyber risk assessment across the solar value chain is also needed to write adequate cybersecurity requirements into contracts with suppliers and subcontractors.

At DNV, we recommend that supply chain audits and vendor cybersecurity requirements are implemented during procurement, installation and operation of equipment, systems and software. Getting a comprehensive view of internal and external risk includes assessing cybersecurity service vendors and cyber risk from other product/service vendors, including systems as highlighted in the 2022 cyberattack incident in Germany (see Table 1). Vendors should also assess their cybersecurity risk to customers.

Regulatory change and lack of common regulations and standards mean energy industries need internal and/or external experts who can anticipate and keep up with what is happening. Closing off cyber vulnerabilities requires cybersecurity leaders with holistic understanding of IT, engineering, health, safety, environment and quality, in the organisation and the specific industry.

Similar considerations apply when assessing other vendor types. DNV has deep knowledge of these through its long record of providing domain-specific cybersecurity verification services for third-party suppliers' components in energy infrastructure. This has involved simulating cyberattacks on converging OT and IT environments to assess for vulnerabilities.

Vendors must also protect themselves and their customers; for example, by knowing what cybersecurity measures are needed to comply with when tendering for or working to contract. Vendors should know if they can comply with terms and conditions agreed with customers, whether they are doing so and, if not, what they are doing about it. Otherwise, a vendor could be exposed to significant liabilities. Vendors should also ask what their approach to cybersecurity says to existing and potential customers about a vendor's cyber vulnerabilities and trustworthiness on other security issues such as data or commercially sensitive documents.

Invest in people

A company's workforce is the first line of defence against cyberattacks. Encouragingly, 78% of energy professionals report their organisation making education/training a priority in cybersecurity budgets. However, when asked where their organisation is most mature in its cybersecurity, they cited upgrades to core IT systems and software (59%) more than training (41%) or introducing cybersecurity expertise (25%). Only 31% of energy professionals are confident they know exactly what to do if they were concerned about a potential cyber risk or threat on their organisation.

One explanation for these findings is that businesses had to focus on widespread, urgent upgrades (e.g., patches and firewalls) to existing and aging technology infrastructure to block hackers. The industry now needs to invest more evenly across the people and technology disciplines of cybersecurity. Companies should not cut investment in technology upgrades, but need to expand workforce training while exploring what specialist knowledge needs bringing in.

For robust cyber defence, businesses also need deep understanding of each energy domain, whether solar, wind, nuclear, or oil and gas, and assurance that cyber processes will not impact production or their long-term goals around the energy transition. The cyber vulnerabilities of IT and OT environments need understanding both separately and in combination, and always in the relevant industrial context. ■

References

1. 'Germany unveils plan to tackle cyberattacks on satellites', theregister.com, 5 July 2022
2. 'Hackers breached Colonial Pipeline using compromised password', bloomberg.com, 4 June 2021
3. 'First-of-a-kind U.S. grid cyberattack hit wind, solar', governorswindandenergycoalition.org, 3 November 2019
4. 'Cyber attack on Kudankulam nuclear power plant – A wake up call', PK Mallick, Publ. Vivekananda International Foundation, 2019, ISBN: 978-81-943795-2-2
5. 'Russian hackers tried to bring down Ukraine's power grid to help the invasion', MIT Technology Review, 12 April 2022, www.technologyreview.com

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Hydrogen's role in easing solar curtailment

Green hydrogen | Curtailment is a rising threat to solar PV, exacerbated by antiquated grids and a power system in transition. But green hydrogen electrolysis is emerging as a potential solution to the problem, taking excess solar and converting it into hydrogen for either long-duration storage or use by other industries, writes Alissa Tripp, senior research and commercial analyst at Octopus Hydrogen.

Credit: BayWa r.e.

A solar farm from BayWa r.e. in the UK. Octopus Hydrogen announced a green hydrogen partnership with BayWa r.e. earlier this year.

As the UK charts a course towards net zero, renewable power from wind and solar farms will increasingly weigh on an antiquated grid until the system is transformed into one that can handle significant volumes of intermittent generation.

To date, curtailment has been a key tool for managing grid constraints and locational issues around generation. However, developers such as Octopus Hydrogen are driving forward the nascent green hydrogen market and presenting a potential solution to these problems. Here we explore how electrolysers co-located with solar installations can be mutually beneficial as we transition towards a zero-carbon grid.

The role for green hydrogen

Electrolysis is the process of using electricity to split water into hydrogen and oxygen. If low-carbon or renewable electricity is used then the hydrogen produced is considered green. With current technology it takes roughly 60kWh to produce 1kg of green hydrogen, but when it's used in a fuel cell it achieves roughly 30kWh out. This round-trip-efficiency means green hydrogen isn't suitable for all applications; it makes much more commercial sense to electrify sectors such as cars and domestic heating, for example.

However, green hydrogen plays a key role in many countries' decarbonisation plans. Its benefits can be particularly felt in hard-to-abate sectors such as heavy goods vehicles (HGV) and out-of-town bus routes, where the weight of lithium-ion batteries rules out electrification. Aviation and shipping are other sectors where green hydrogen fuel replacement is being explored, and in heavy industry such as steel production green hydrogen is a promising replacement for coking coal.

How does an electrolyser benefit a solar farm?

When embarking on a green hydrogen project, developers must decide on the

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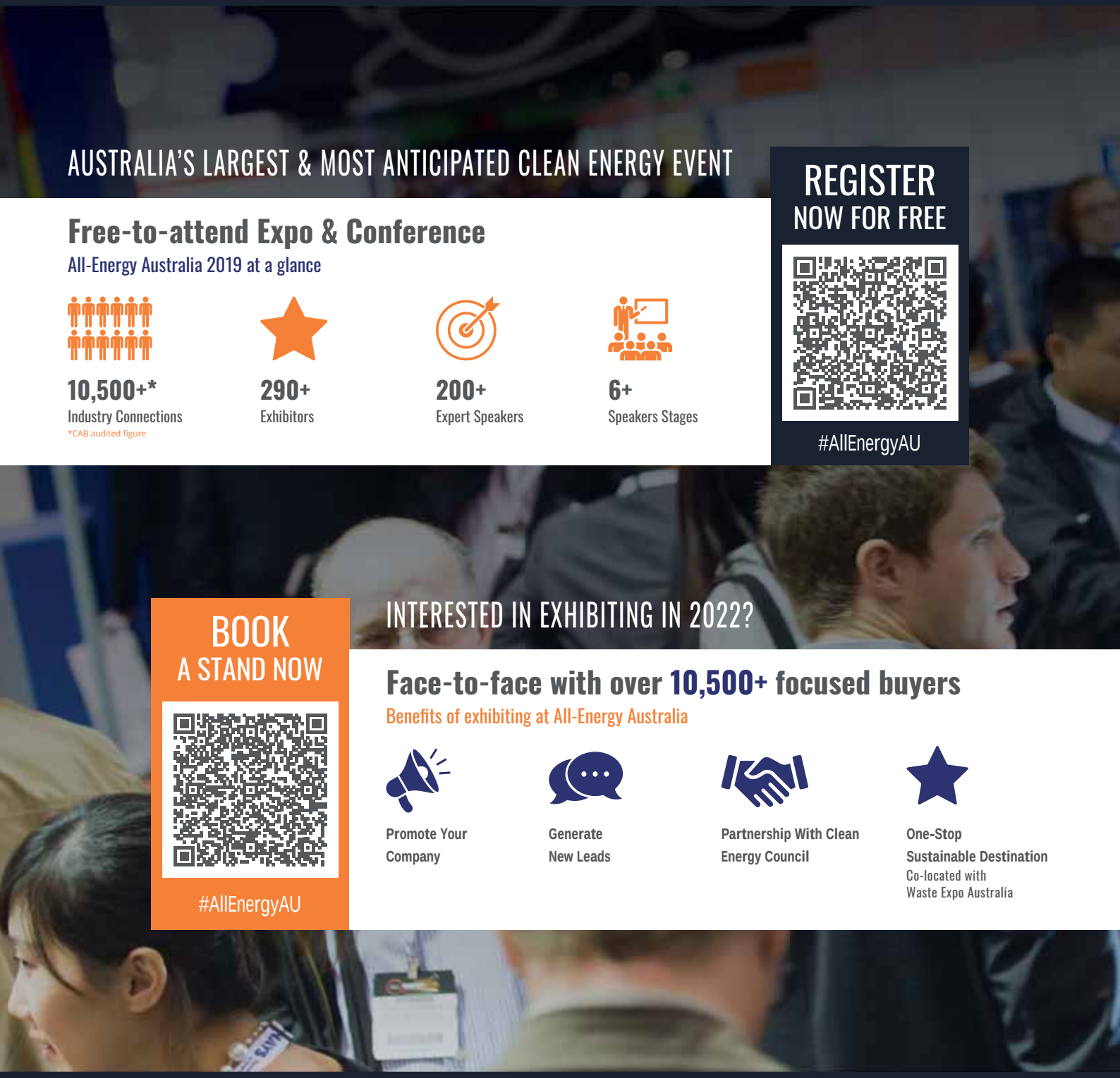

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renewable power source. Co-location with wind produces more green hydrogen than with solar due to higher load factors, but in the UK that likely means production in Scotland. This introduces higher logistics costs to move the gas south, and potentially also higher development costs due to the terrain and isolation of some Scottish wind farms.

Solar already tends to be located in the south of the UK close to where demand is likely to emerge, resulting in more attractive logistics costs. Both wind and solar co-location require generation forecasting, but it's easier to have an idea of the shape of solar generation in an upcoming week than it is for wind. This lends itself to scheduling of gas production. However, for a project to go live it must be beneficial to both the electrolyser and solar developer – which begs the question: what value can an electrolyser add to a solar farm?

Overcoming network constraints

Solar farms are often forgoing revenue due to active network management (ANM), where they agree to the local distribution network operator (DNO) controlling how much power they can output at certain times. This is known as curtailment, and is the option many solar developers opt for in the development phase because the alternative is reinforcing the local grid, which can be expensive and have a long lead time.

The result of ANM is that during these times of curtailment solar farms will not be exporting as much energy as they are capable of, and because payment is on exported volume the solar farm's revenue stream is reduced.

Looking forwards, with an increasing number of intermittent generation connections, and particularly on local grids where a 'last in, first out' approach is used by DNOs to assign ANM connections, curtailment will increasingly eat into the potential revenue of solar farms. As solar farms are added to the grid and without systemic grid transformation, curtailment for these new developments could be anything from a few percent of expected annual export to tens of percent.

This is where electrolysers can come in: electrolysers can be directly connected via a private wire to the solar farm, with a modest import grid connection to satisfy power demand at times when the solar isn't generating. With well-planned commercial structuring the electrolyser can have no impact on the price the solar developer sells its exported power for; indeed, it could even provide more competitive pricing.

The behind-the-meter connection allows the electrolyser to use power that can't be exported due to the ANM connection, i.e. curtailed power. This provides the solar farm with access to a pricing mechanism for its curtailed power, restoring some of the revenue stream lost to ANM. As curtailment is generally still a modest subset of total production this alone isn't enough to make a solar project viable in the development phase. But it's a helpful and non-negligible revenue stream that only increases in value as curtailment on the distribution grids increases. Solar farms are currently being commissioned without revenue for curtailed power, so this is pure upside for the solar developer.

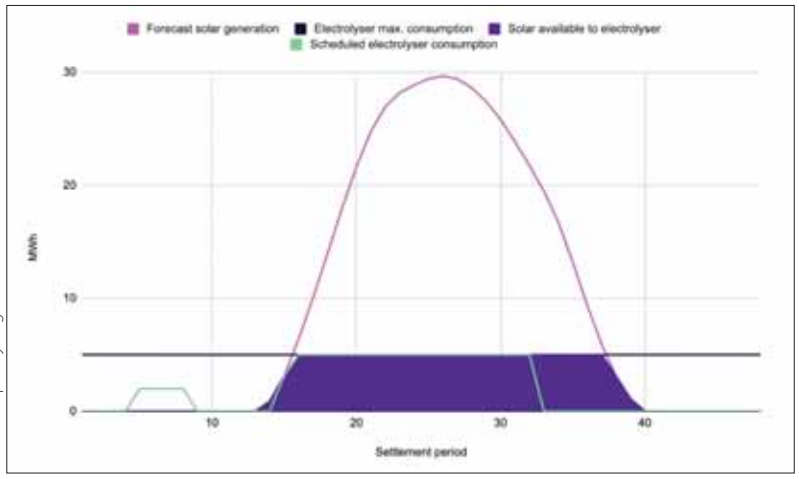
Achieving the best balance

The optimal configuration of solar and electrolyser is not to have them at the same capacity, but to scale back the electrolyser to best balance power from the solar and power from the grid. Take a 70MW solar farm as an example: if this was connected to a 70MW electrolyser then only during solar peak in summer would there be enough solar generation to come close to making use of the electrolyser capacity. The rest of the time the electrolyser would either be idle or drawing power from the grid, incurring expensive grid charges.

A more suitable alternative would be to connect a 10MW electrolyser to the 70MW solar farm via private wire, with a grid import connection of perhaps 2 – 4MW. The electrolyser would then draw the first 10MW of generation from the solar and the rest of its power from the grid. This results in the electrolyser using approximately 40% of the solar farm's annual generation, with the remaining 60% exported to grid. Octopus Hydrogen has assessed alternative structures, such as a simple off-grid solar and electrolysis setup but concludes that this is the optimal configuration.

Hydrogen storage and dispensing stations from NanoSUN.

Credit: Octopus Hydrogen.



Credit: Octopus Hydrogen.

An example electrolyser schedule for 10MW of electrolysis connected to 70MW of solar. The schedule is for an example April day and takes into account both expected renewable generation from the solar farm and forecast power prices for the day.

It allows the solar developer to achieve maximal prices for power whilst preserving flexibility in how the electrolyser can be run.

When it comes to utilisation of the electrolyser, it turns out that the best value is not achieved by running it at 100% and maximising the gas production. This is because the price of power is roughly two-thirds of the cost stack when it comes to producing green hydrogen. Power prices vary greatly by half hour just before delivery and it turns out that 40 – 50% average utilisation is the best way to run an electrolyser, turning it up in times of high wind and solar generation, and switching it off during expensive peak periods. Through winter the electrolyser will be drawing relatively more power from the grid than the solar farm, so it's important to have an import connection that will suffice for the required level of hydrogen production.

Equipment and expertise

To paint a picture of the physical set up, a 10MW electrolyser and its associated kit would require about an acre of land, with enough space for an HGV turning circle. The main pieces of equipment required are an electrolyser with a water supply, a compressor to compress the gas to the required pressure for the offtaker, and either mobile or static storage. If offtakers are coming to the site to refuel directly then a refuelling unit will also be required, though this can be combined with the storage. Supply chain lead times can be up to 12 months, and the configuration of all this kit and the tailoring of it to specific solar projects requires a high level of engineering expertise.

The obstacles to achieving planning permission are not dissimilar to those faced by battery projects. However, unlike batteries, which overwhelmingly attain their revenue streams via ancillary services, a deeper knowledge of energy markets is required to make an electrolysis project viable. This is because the bulk of the returns made on an electrolyser depend on how effectively demand is shifted throughout the day, rather than in frequency response. Octopus Hydrogen has utilised its UK power expertise to build software that allows remote controlling and optimal scheduling of hydrogen production. This allows a hydrogen producer to minimise the cost of power and maximise the greenness of gas produced.

> "Electrolysers of 5 – 20MW scale provide an ideal complement to solar farms of up to 100MW, providing a much-welcome revenue stream for some of the power that would otherwise have been curtailed."

Limits to retrofitting

In terms of physical feasibility, it is perfectly possible for electrolysers to be retrofitted to existing solar developments, but in practice this is unlikely to happen due to the requirements of green hydrogen subsidies. One such subsidy comes from the Renewable Transport Fuel Obligation (RTFO), whereby certificates are awarded for green hydrogen sold into transport. Similar to the UK's Renewable Obligation Certificates, these can be sold into the market of participants who must comply with the RTFO.

This subsidy has an 'additionality' requirement on the power used in the electrolysis, dictating that it must be from new-build renewable connections. Curtailed power from existing farms does also qualify, but the level of curtailment most existing sites are subject to provides an insufficient load factor to make the commercials of an electrolyser project there stack up. Other subsidy schemes such as the Hydrogen Business Model also include additionality criteria as part of their assessment of applications, but it's not a requirement.

Solar to play a key role in green hydrogen production

The UK's plans for decarbonisation rely on building more and more wind and solar, which consequently comes with ever higher levels of curtailment. Electrolysers of 5 – 20MW scale provide an ideal complement to solar farms of up to 100MW, providing a much-welcome revenue stream for some of the power that would otherwise have been curtailed.

At the outset of the green hydrogen industry the combination of renewable generation location and offtaker demand will dictate where the projects are within the UK. As the market matures and logistics can be handled at scale it is likely that more production will come online abroad. In addition to locations being skewed towards demand hubs, places with an abundance of space and cheaper, more reliable renewable energy are strong contenders to become green hydrogen production hotspots, where electrolysers can be installed in the hundreds of megawatts.

Solar will play a key role in fuelling the production of green hydrogen. Though the benefit electrolysis can offer solar farms today mainly revolves around providing revenue for curtailed power, in the future green hydrogen will play a much more central role in the commercials of newbuild solar. ■

Author

Alissa Tripp is the senior research and commercial analyst for Octopus Hydrogen, responsible for research into global hydrogen subsidies and energy systems, and analytics to assess the commercial viability of electrolysis projects. She has a background in renewable energy trading and interest rates strategy.

String versus central versus modular: what's next for inverter technology?

Inverters | Inverters are essentially the brains of a PV plant and while their key function remains the conversion of DC power to AC, their design and configuration is continually evolving. So are the strategies of the companies making this important piece of kit, writes Jonathan Touriño Jacobo.

For many years, the utility-scale solar PV market has been dominated by central and string inverters, with each claimed to have its own benefits for utility-scale solar applications. Lately, modular inverters have also entered the scene, claiming to combine the benefits of both string and central inverters. This feature will explore different uses of each of these technologies, the current technology trends for inverters and how they have adapted to different types of environments ranging from desert areas to floating PV. There is also the fact that more and more utility-scale projects are developed with energy storage in mind, either to be co-located at the same time or with the possibility to add it at a later point. This is something that inverter suppliers have been working around as demand increases. Finally, we look at how inverter suppliers are preparing themselves for the introduction of 600/700W+ modules in the solar market.

String and central inverters are still favoured over modular

With modular inverters claimed to combine the strengths of string and central inverters with a modular design, manufacturers have started to embrace that new technology. Modularity allows Spanish manufacturer Power Electronics to improve efficiency and availability, says Maribel Trenzano, the company's solar & storage product & applications manager. "The efficiency improves because depending on the available power, only the necessary modules will need to operate. The availability increases because the system can keep working even if some modules are failing, and the power of the faulty module could be redistributed with the working modules."

Ginlong's inverter brand Solis meanwhile continues to specialise in string inverters which are flexible and suitable for various scenarios, says Lucy Lu, the manufacturer's global marketing director. "With solar PV projects increasing in size and types, application scenario is more and more complex, it [design] needs to consider inverter devices for higher environmental adaptability and security." For agricultural or mountain terrain PV projects, higher maximum power point tracking (MPPT) is needed and better algorithms for inverters to increase power generation. Meanwhile for desert areas, Solis takes into consideration both wind and sand resistance with better heat dissipation, adds Lu.

If some suppliers are advancing on modular inverters, for German developer BayWa r.e., this is still not an option it is envisioning to use as they are still too expensive, says Tino Weiss, head of purchasing and product development. If possible, the developer would rather opt for string inverters. "Because we are one of the drivers of string technology. So, whatever we built, if we have the chance to change from central to string, we will go for string," adds Weiss. The company sees a big advantage for string inverters in terms of operations and maintenance (O&M), as they always go with 10-year warranties. "We have a longer period of time without the risk of having additional costs on inverter exchange or replacement costs." For the US, it is a whole different story as central inverters are favoured due to utilities and financing banks not accepting string inverters. "There we still go with central inverters," says Weiss. BayWa r.e. did use modular inverters for one project due to issues related to power differences, to rectify mismatch losses, but its price is still not attractive enough for widespread adoption, according to Weiss.

Credit: Ginlong Solis.

Solis inverter assembly line.

Latest technological trends for inverters

Although the nascent floating PV market includes various new technologies and project configurations, inverters are still of course a key component. Located in water, there has thus been a need to adapt to the different new environment the inverters are being installed in. Chinese inverter maker Sungrow is one of the market leaders in the floating PV market, supplying to more than 1.7GW of floating systems around the world, according to the company.

Jia Zhang, product marketing director for utility-scale PV plants at Sungrow, says that planned location of projects in complex environments "has put forward higher requirements on both hardware and software design of the inverter." With their lifespans being possibly shortened amid higher humidity levels, this requires an ingress protection degree of IP65 and a safe high-level anti-corrosion design.

Adapting to new environments, technologies and PV plant configurations is essential for inverters to keep pace with the industry. Floating solar is a perfect example.

Credit: Sungrow

And given that level of the water where a floating PV, or 'floatovoltaic' system is located will differ during the day, Sungrow has designed inverters that "adopt a lightweight and modular design for easy lifting," adds Zhang. Its newer products, the SG350HX and the 1+X model inverter, have been favoured for floating projects.

Soli's Lucy Lu adds that for floating PV, inverters require more stable and reliable leakage current protection and potential induced degradation (PID) repair function.

Another trend in the inverter market is connected to the increasing energy tariffs across Europe and other regions which ask for higher power generation efficiency of PV systems. "Inverters that have a higher wattage and higher power density have become an irresistible trend," says Zhang.

From a developer point of view, BayWa r.e. is not in favour of string inverters getting bigger and bigger, power wise, with some inverters reaching 350kW. "From our standardisation approach, the bigger the inverter, the more complicated is our standard approach block design because the blocks get too big," says Tino Weiss. Inverters of 500kW are not something Weiss envisages procuring. Instead, improvements need to be delivered from other angles instead.

Some of the issues that BayWa r.e. is currently facing are related to pack controlling, given that if two or more PV plants are connected to the same grid connection, you would need to know which one to shut down first and thus would need a complicated regulation, says Weiss. "If inverters could do this instead of a power controller, this would be I think one of the next step developments for inverter suppliers."

Lowering failure rates and yield reliability of just 0.2% would have a bigger impact than price difference on inverters, adds Weiss. "Yield reliability and failure rate will be the decision factors in the future."

As for the future of inverters, Zheng says that in three or five years, the use of AI technology in inverters could help developers increase their plants' energy production more efficiently.

But probably the most important technology trend for inverters nowadays is the growth of co-located projects. Across the industry, optimising for co-located energy storage seems to be an even more important aspect to figure out than the impact the introduction of modular inverters might have.

Inverter suppliers are adapting to energy storage projects

As more and more projects are built with battery energy storage system (BESS) technology, either at the time of first commissioning or with the option to add it as a retrofit at a later time, inverter suppliers have followed the trend. "Energy storage is the biggest trend," says Lucy Lu, global marketing director at Solis. The company is working on coupling its inverters with energy storage, not only in utility-scale projects, but also in commercial and industrial (C&I) and residential, which takes another dimension if we add chargers for electric vehicles.

Solar PV inverters need to be designed to allow for DC-coupling with batteries to be as easy as it can be, says Power Electronics' Maribel Trenzano. Power Electronics' Bus Plus option allows the connection of various DC/DC converters in parallel with the connection of batteries for solar PV and with a direct channel between the inverter and the converter that allows for simultaneous control of the system. The demand for inverters with batteries in utility-scale projects has increased a lot in 2021, says Trenzano. With some of Power Electronics' Freemaq brand models, the ability to connect up to four independent BESS is working particularly well this year in the US, the UK and Australia. "The future of renewable plants goes through the co-location of energy storage, the demand of hybrid systems is growing, and the regulation is already adapted to it or in the process to [do so] in many countries," Trenzano says.

The use of energy storage co-located with utility-scale solar PV or as a

standalone will keep increasing in the years ahead to integrate variable renewable generation, and thus it is no surprise that for many suppliers it is probably the most important subject nowadays. Sungrow is no exception. "Energy storage is a very popular topic in the last few years," says Zhang. Sungrow's R&D department has invested a lot of resources and time into optimising the connection between inverters and energy storage. This is the case with their latest modular inverter that has a built-in energy storage interface.

"For inverter enterprises, the deployment of integrated optical storage and charging products and solutions will be a new business growth point. Solis is also actively laying out this area and expects to launch related products and solutions in 2023," adds Lu. Some Solis inverters already have in mind the use of energy storage at a later stage, without the need to change existing plant designs, with an "expandable storage interface to accommodate peak saving and provide electricity to support loads and to reduce the overall power supply cost," says Lu.

BayWa r.e.'s strategy for solar PV plants co-located with battery storage so far has not changed its choice of inverter, although "if you have a DC-coupled system, a central inverter could be a good solution," says Weiss. The developer is still looking into aspects of co-located projects but is not sure if it wants to "accept the disadvantages we get through the central inverter compared to the string inverter advantages we have right now," adds Weiss. From a development point of view, what they are already doing is reserving space for battery storage in every project.

Even inverters with small batteries already integrated into them do not seem of interest for BayWa r.e. in terms of utility-scale projects, but they may be suitable for the commercial and industrial (C&I) segment. "If you have rooftops with one or two megawatts, adding hybrid inverters could be doable," says Weiss.

Different ways to adapt to the chip shortage

As more and more technologies rely on the use of semiconductors, or chips, in diverse industries from automotives to video game entertainment and of course solar PV, demand has outpaced supplies. This has been severely affected by the pandemic in 2020 and even in 2021. Inverter manufacturers have not been spared by this ongoing challenge and have replied differently to it. Power Electronics has for example adapted to the changing conditions. "The inverters' design has had to adapt at the same time as the availability of materials," says Maribel Trenzano. While Solis has managed the issue by actively exploring new chip suppliers, "we sincerely hope that outstanding chip enterprises can increase the chip capacity of PV inverters to meet the rapid development of the PV industry," says global marketing director Lucy Lu. And with no end still in sight, inverter manufacturers will still have to cope with the current constraints of the chip shortage affecting many industries.

Increased power output of new modules

As modules are increasing their power output to 600/700W or more, and since inverters are the bridge between the modules and the load, manufacturers have had to increase the power of the conversion components. Manufacturers are actively looking at the increase in power output and optimising their inverters accordingly. In reaction to that change, Solis has optimised the system voltage resistance, component compatibility and system safety, among other features. Solis global marketing director Lucy Lu adds: "At present, affected by the progress of 600W/700W+ modules, inverters with a string current of 15A-20A has become the mainstream."

In the case of Power Electronics, the power of its third generation of 1500V inverters has increased 15.5% in comparison with the previous generation. "This allows to get the highest performance and reduce LCOE of the solar PV plant," says solar & storage product & applications manager at Power Electronics, Maribel Trenzano.

Meanwhile Sungrow has increased the MPPT current of its string inverters from 30 to 40 amperes in response to the module power output increase. "Our modular product performance is not affected by the PV module current change," says Jia Zhang.

Importance of communication between suppliers and developers

One of the "key strengths" of BayWa r.e. is its relationship with inverter manufacturers it works with, to optimise the inverters to best suit each project's needs. Before settling with Huawei and Sungrow, BayWa r.e. had a strong relationship with Italian inverter provider Power One.

"We were deeply involved in the product roadmap and designing their new inverters and of course, we were driving them to design the string inverters to our system design needs, and they followed us quite intensively until a certain period of time when pricing dropped because a lot of new players, Chinese players, came into the market and developed very big string inverters. So, they were not competitive anymore and they followed that route."

When Power One and Baywa r.e. went their separate ways in around 2013-2014, BayWa r.e. decided to work with Huawei, despite the company being a newcomer in the inverter industry; with the caveat that instead of keeping a single source for their inverters, the developer also added a second supplier in Sungrow: "…because a single source in our market dimension is a very big risk," adds Weiss. Such was the case when Huawei was on the US sanction list during the presidency of Donald Trump, which blocked the supply of its inverters for US solar PV projects.

"We have very strong relationships and with very few suppliers. It's similar on everything we do. On modules you have five or six because you need them. For transformer or for switchgear supply, we always have only one or two suppliers we mainly work with. That's one of our strategies, having a close relationship. Being involved in the development and of course, being a big customer to influence development." ■

Credit: Baywa r.e.

Maintaining close partnerships with suppliers really matters, project developer Baywa r.e. says.

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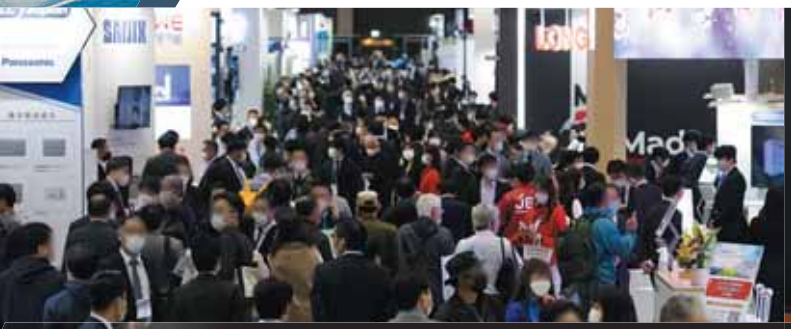

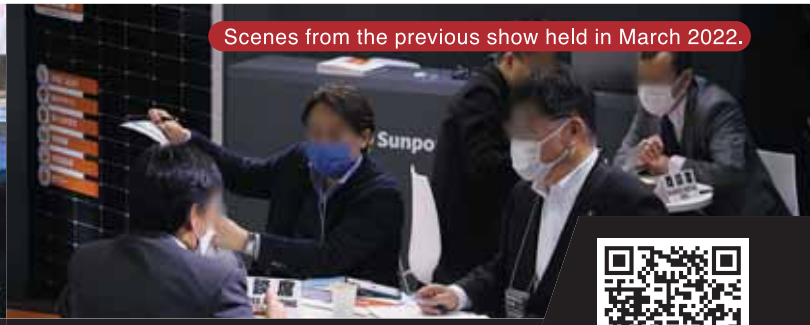

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i2X initiative a 'once-in-a-generation' opportunity to unleash dormant terawatts of clean energy in the US

Grids | The US has a massive interconnection problem, with more than 14TW of clean power sat dormant in its queues. The DOE i2X initiative is seeking to unleash this power and catapult the US closer to its climate targets. But how will it achieve this? Sean Rai-Roche finds out more.

Credit: Unsplash

At the start of June, the US Department of Energy (DOE) launched the Innovation e-Xchange (i2X) initiative to ease the country's enormous interconnection queues, reduce growing wait times and lower grid connection costs.

Terawatts upon terawatts of bulk power are currently sat in US interconnection queues, left unused and unaccommodated by the US grid even as the country targets 80% of its power mix coming from clean energy by 2030.

i2X aims to address this problem by convening interconnection stakeholders from across the country, bringing them together to brainstorm and deliberate on how to revamp the US' ailing grid connection system that has seen queues balloon over the past decade.

A utility-scale PV project's typical duration from connection request to commercial operation increased from roughly 2.1 years for projects built in 2000-2010 to 3.7 years for those built in 2011-2021, Lawrence Berkeley National Laboratory (LBNL) data shows.

A recent LBNL study also found that, among a subset of queues for which data are available, only 23% of the projects seeking connection from 2000 to 2016 were subsequently built and that completion percentages were declining, particularly for wind and solar compared with other resources.

Thus, an initiative like i2X was sorely needed given there is currently more than 14TW of clean energy sat in US interconnection queues, with solar PV making up roughly half of this. And that's just bulk transmission, not to mention distributed generation systems which have also seen queue times increase.

Speaking at the launch of the i2X initiative, US Secretary of Energy Jennifer Granholm said solving the nation's interconnection problem was critical to achieving the US' climate targets and finding a workable solution to the problem could unlock the enormous amount of power currently sat dormant.

Massive grid upgrade costs are putting off many developers in the US.

Granholm called the initiative a "once-in- a-generation opportunity" to make interconnection bottlenecks a thing of the past, urging stakeholders to sign up to the partnership and give their input. At the time of the launch, 193 organisations had already signed up, with this more than doubling to around 430 a few weeks later. It currently sits at 450 according to the DOE.

PV Tech spoke with the DOE's solar team and national laboratories involved in the project to further explore how this important initiative will work, what its aims are and how it intends to achieve them.

The i2X initiative in brief

i2X will address the "core issues surrounding grid connection" through its 'four

pillars of support', which are increasing stakeholder engagement, having better and more transparent data, developing a five-year strategic roadmap and providing technical assistance to partners.

Stakeholders range from grid operators, utilities, state and tribal governments, clean energy developers, energy justice organisations, national research labs and other stakeholders, said the DOE. There is no cut off date for partners to join, while stakeholders will only be invited to conversations around grid reform that pertain to their particular field.

It has come about through US President Joe Biden's Bipartisan Infrastructure Law and is backed by US$3 million in funding for its first year. It is intended as a five-year programme but this will depend on Congress funding and other variables, said Michele Boyd, programme manager of the Strategic Analysis and Institutional Support team in the Solar Energy Technologies Office (SETO) at the DOE, essentially SETO's soft cost department lead.

The DOE will play the role of convener and technical advisor to partners, which Boyd said it had a long and successful history of, while also arranging debates to address each subsection on the US interconnection apparatus. While there has been a "long history of finger pointing" in the sector, Boyd was confident that disparate stakeholders could be convinced to coalesce over an effective strategy.

Data transparency and standardisation

Of the four pillars of its strategy, the DOE has already made good progress on one: stakeholder engagement. Numbers are growing fast. Next, it seeks to tackle the issue of data access and transparency which has hindered the industry for far too long.

Via the initiative, there will be a big push on data transparency and standardisation, said Boyd and Joseph Rand, LBNL's senior scientific engineering associate on the project, who will be supporting the initiative through technical assistance and developing the strategic roadmap. Rand told *PV Tech* that collecting key data, for example on grid upgrade costs, and mapping them over the country to compare between regions was currently very difficult due to a lack of data transparency.

"One quick example [of better data sharing] would be the upgrade cost that developers are allocated or assigned in order to interconnect," says Rand. "It's really important to understand whether those costs to developers [are] increasing over time."

Boyd seconded this, noting that while cost allocation for interconnection was clearly in US Federal Energy Regulatory Commission's (FERC) jurisdiction, this didn't mean the regulator was not interested in i2X's ideas and research on the matter and that the programme would look to support FERC policy on the issue.

Boyd also noted how the interconnection application process can often be "very burdensome" for applicants, even requiring paper forms in some cases, and that i2X would seek to ensure that the "latest technologies are used to make it easier for people to apply".

Moreover, if data are available, they can often be hard to compare between different regions and Rand said i2X would call for greater data standardisation from RTOs and ISOs, which often compile and structure their data in different ways, making it harder to conduct comparisons. Thus, i2X will also urge these entities to standardise their data sets in order to facilitate greater information exchange.

When asked by PV Tech whether ISOs and RTOs would be willing to share this data more freely, Rand said it was unclear given there were already mandates for them to do so but that rules were not always enforced properly, mooting the idea that FERC may decide to step in with new regulations surrounding data exchange.

Plotting a path forward

Meanwhile, the i2X initiative will also establish a 'Strategic Roadmap' for the future that will "inform interconnection process improvements", which will be led by the LBNL as well as the DOE's National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL).

"We have what's called a technical work plan, which is a document we've been developing over the past several months to outline exactly what we plan to do," said Rand, adding that nearly a third of the first year's budget of US$3 million is being provided to LNBL to construct this plan.

And a large part of that plan will be directed at FERC. "We want to be having regular briefings to FERC and ideally engagement from FERC," he said, noting that because of certain rules around what FERC can share and request from LBNL, the plan needs to predict what analysis will be needed to help the regulator make informed decisions.

And it's not just LBNL that is trying to push FERC on potential reforms. Paul Cicio, chair of the Electricity Transmission Competition Coalition, told PV Tech that his organisation was "urging FERC to require that all transmission projects that are 100kV or larger be competitively bid, thereby reducing transmission cost by up to 40%".

"However, the FERC NOPR has rejected competition, despite the fact that competition is a proven anti-inflation policy," Cicio said, adding a Brattle Group study revealed that, when there is no competitive process, the monopoly incumbent utility's costs come in 36% higher than projected costs on average.

In April, FERC issued a Notice of Proposed Rulemaking (NOPR) that aimed to address transmission grid planning and cost allocation, including conducting regional transmission planning on a sufficiently long-term, forward-looking basis to meet transmission needs driven by changes in the resource mix and demand.

It also included rules that "the [interconnection] analyses needs to happen in parallel rather than sequentially" to applications, noted Boyd, who added that the DOE was "really interested in helping people to figure out how to do that and help develop the tools to make that simpler, faster and easier."

Boyd, however, was more sympathetic to the regulator than Cicio, noting how its mandate covers the entire US energy system and that it released the recent NOPR to address interconnection problems, albeit with some key areas – i.e. cost allocation – unaddressed.

Instead, she chooses to focus on "what research needs to happen and what can we do today?". She believes the DOE has assembled the right team to address this mammoth challenge, with many of the experts on the initiative "working on interconnection for decades" and having an extensive knowledge of the issues and barriers at play.

i2X holds the potential to not only unlock the vast amount of dormant power in the US but also pave the way for the more efficient connection of future projects. It's not going to be an easy task and will likely be fraught with competing agendas from disparate stakeholders. But it is vital for the future of US clean energy. Doing nothing is not an option. ■

The importance of understanding the input parameters of PAN files

Data | With numerous markets reporting problems with overly optimistic P50 estimates, attention has also been drawn to similar issues with PAN files. TÜV Rheinland's Yating Zhang and Christos Monokroussos discuss the subject at length.

In both PV research and application areas, people are familiar with PVsyst software which is commonly applied to assess and forecast the energy performance of PV modules and arrays. The simulation results of PVsyst will further influence the financial investment of PV systems.

An energy yield boost of 1% or 2% may bring several million or more revenues for a large system. Therefore, people are realising that the accuracy of PVsyst simulation results is worthy of much attention. Apart from accuracy related to the in-build simulation models and methodology, the accuracy of input parameters for each PV module, the so-called PAN file, results in major discrepancies between simulated and actual energy yield.

The users report that there are many overly optimistic PAN files, and these PAN files lead to overestimated energy yield, which finally increases the risk of investing and trading in the PV area.

Among the input parameters of PAN files, some characteristic data such as STC results, low-light data, incident angle modifier (IAM), temperature coefficient (TC) and light-induced degradation loss (LID) need to be measured according to relevant standards.

For the occasion that the measurement data are not available, some can be retrieved from PV module's datasheets, which are based on measurements that the manufacturer has performed and some default values of these performance parameters are provided by PVsyst.

The first tend to overestimate PV module's performance, while the latter are empirical values concluded either from the theoretical model or measurement results of a significant amount of PV modules. To accurately deal with PAN files, there are several considerations:

1) clarifying the source of input parameters, whether the input parameters are provided by a certified and reputable test laboratory or default values for PVsyst; a reliable source of PAN file input parameters is the base to ensure the accuracy of the simulation results;

2) understanding the definition of each input parameter, such as the series resistance or shunt resistance used in PAN files; the series and shunt resistance are relatively sensitive parameters and whose values may depend on their definition and extraction methods.

In other words, it means that the extracted series resistance or shunt resistance may be correct, however, they may not be the best choice to fit in the modelling methods used in PVsyst. The optimal series resistance or shunt resistance values for PAN files should be extracted from the one-diode model and further optimised through efficiencies under various irradiances to ensure that the accuracy of energy yield prediction is acceptable.

In the following sections, the definition of some important input parameters for PAN files and the comparison of simulation results between using measured and default input parameters will be explained in detail.

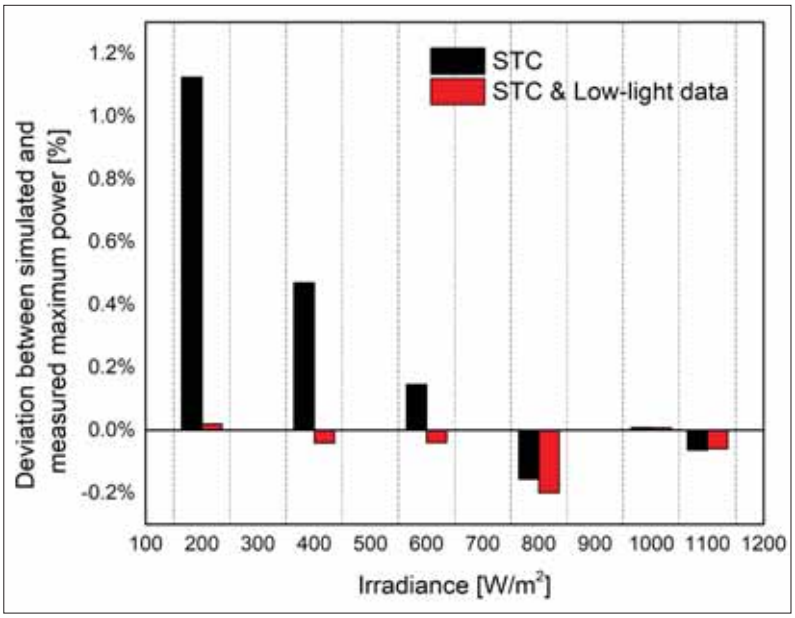
Low-light data

It is known that the PVsyst is modelling PV module performance based on the one-diode circuit model with five unknown parameters (photocurrent, diode inverse saturation current, series resistance, shunt resistance and diode quality factor), and the obligatory input data for determining these unknown parameters are the electrical parameters under STC (short-circuit current, current and voltage at maximum power point and open-circuit voltage).

Under the condition where only STC data are available, operators can only choose the default values of series and shunt resistance, the setting method of which is deduced by PVsyst. The low-light data is an optional input data; nevertheless, it gives essential information about the electrical performance of PV modules under low irradiance and can help optimise the series resistance and shunt resistance according to the actual characteristics of PV modules under various irradiance conditions.

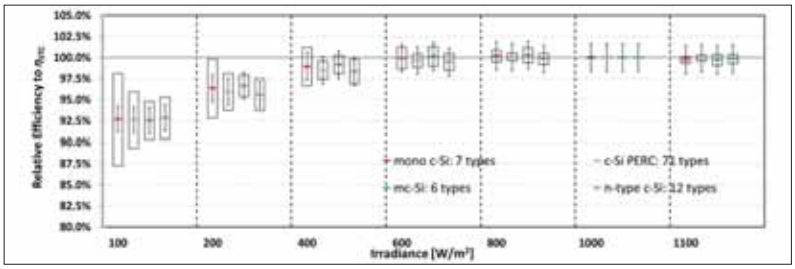
Under different irradiance, the comparison of simulated maximum power values of one mono c-Si PV module extracted with and without low-light data is shown in Figure 1, and the measured maximum power under the corresponding irradiance is the benchmark to estimate the accuracy of simulated maximum power. Some deviations within 0.2% exist for the simulation results extracted with low-light data included. However, it is obvious that the accuracy of simulated maximum power gets worse without inputting low-light data, and simulating deviation as large as 1.1% was observed for the irradiance of 200W/m2.

This simulating deviation may vary with the PV module type, as different PV modules exhibit distinguishable low-light performance. Figure 2 shows abstractly the comparison of approximately 100 PV module types in terms of relative efficiency with the performance at STC as a reference. The results showed that the relative efficiency losses associated with low irradiances below 400W/m2 were observed for all PV types. Even for the same technology group, the variability in the relative efficiency of PV modules can be significant specifically for the low irradiances, with standard deviation of technology variation varying from 2.23%, k=2 for mc-Si PV modules to 5.43%, k=2 for mono c-Si PV modules at 100 W/m2.



Credit: TÜV Rheinland

Comparison of maximum power deviation extracted with and without low-light data. The measured maximum power under various irradiance was used as the reference to calculate the maximum power deviation.



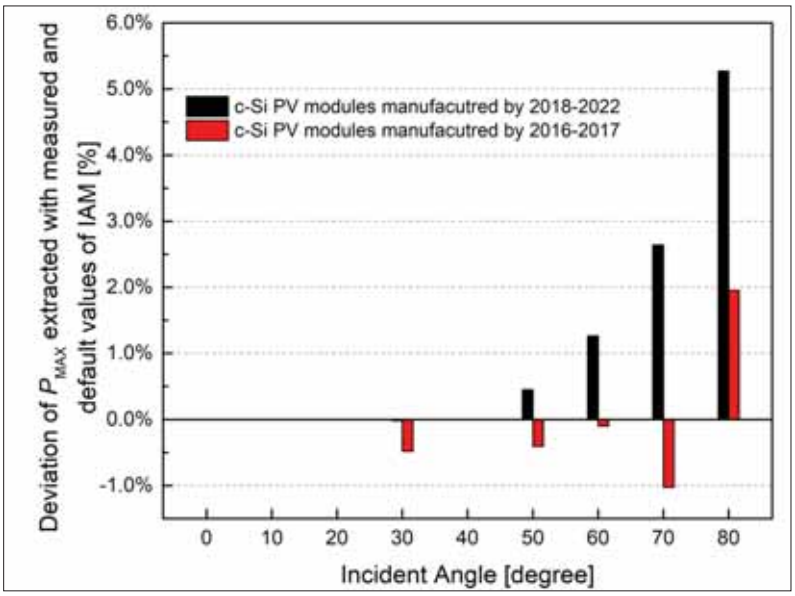
Credit: TÜV Rheinland

Relative efficiency deviation (to STC) against irradiance for different module types at 25°C and spectral distribution of AM1.5G. Boxes represent the standard deviation of technology variation (k=2) and error bars represent the measurement uncertainty (k=2).

Incident angle modifier

IAM is another optional input data for filling the PAN files. When PV modules operate outdoors, they are subject to diffuse angular profiles that may introduce significant optical losses. The power losses due to incidence angles were to be at least 3% for a PV station every year [1, 2]. Since the optical losses are affected by many factors, such as inactive materials (glass or EVA), or the SiNx covering solar cells, the IAM is a unique characteristic for each PV module product. Hence, inputting the measured IAM for each PV module is recommended for increasing the accuracy of the simulation. For the case without measured IAM, PVsyst also provides several sets of default IAM values varied by the type of front surface of PV modules.

Figure 3 shows the discrepancy of simulated maximum power (PMAX) extracted with measured and default values for the AR coating surface. The measured IAM was counted from the measurement data of around 100 c-Si PV modules, and they were additionally sorted by the manufacturing year. The IAM test was performed in the ISO/IEC 17025 accredited PV laboratory of TÜV Rheinland in Shanghai according to the relevant contents in IEC 61853-23 [3]. As Figure 3 shows, there is an increasing tendency of maximum power deviation along with the incident angles. The maximum deviations are around 5.0% and 2.0% for the PV modules manufactured by 2018-2022 and 2016-2017 respectively. This means when the incident angle is 80°, approximately 5.0% power output may be underestimated by using the default IAM for PVsyst. It is also observed that the default IAM is relatively conservative compared with the actual IAM of PV modules manufactured in recent years, so the default IAM for PVsyst should be optimised to match the latest development of PV technologies.



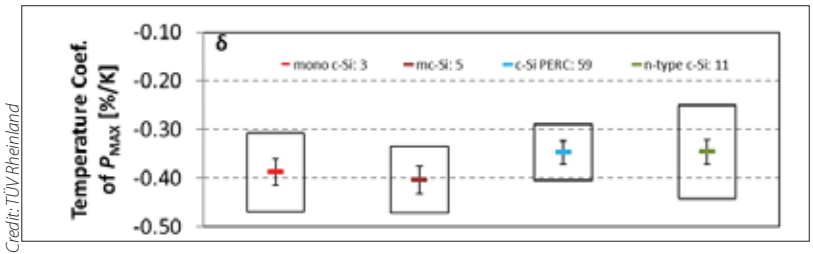
Credit: TÜV Rheinland

Deviation of maximum power extracted with measured and default IAM data. The measured IAM data for black column is the average IAM data of PV modules manufactured by 2018-2022, while the red column represents PV modules manufactured by 2016-2017.

Temperature coefficient

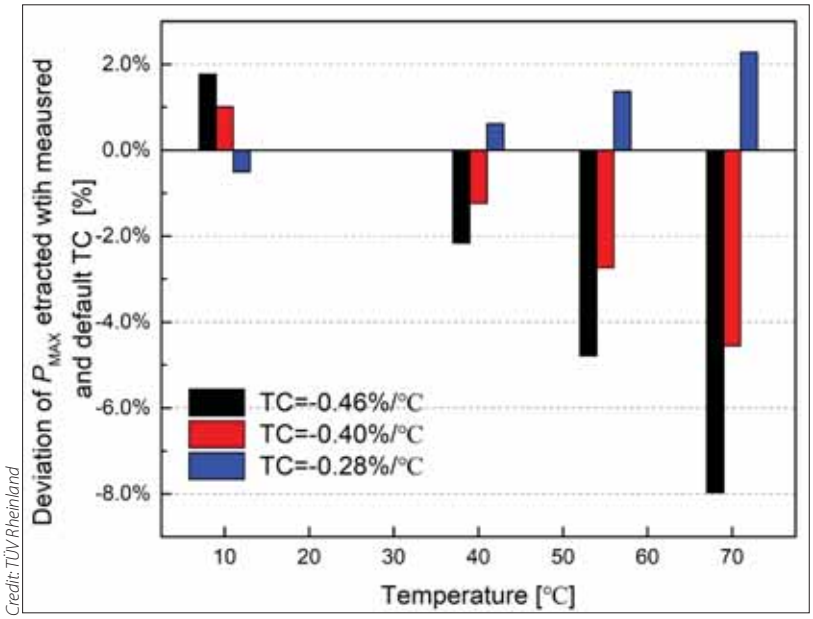
A photovoltaic module in the field is rarely working at a constant temperature. Most of the incident solar energy which fails to be converted into electricity dissipates as heat, leading to an increased module temperature and worsened performance. Temperature coefficients are measured to characterise the effect of thermal behaviour on the performance of PV modules, and they can be further applied to predict the energy output of PV modules under various temperature conditions.

Generally, the temperature coefficients are specifically sorted into the temperature coefficient of ISC, VOC and PMAX. The temperature coefficients of VOC and PMAX are normally negative, while the opposite condition for the temperature coefficient of ISC. According to a significant amount of measurement



Credit: TÜV Rheinland

Temperature coefficients of PMAX for different module types. Boxes represent the standard deviation of technology variation (k=2) and error bars represent the measurement uncertainty (k=2). Differences overlap with the uncertainty in measurement.



Credit: TÜV Rheinland

Deviation of maximum power extracted with measured and default temperature coefficient. The black, red and blue column represent the condition with measured temperature coefficient of -0.46%/°C, -0.40%/°C and -0.28%/°C respectively.

results of c-Si PV modules, the temperature coefficient of ISC mainly distributes between 0.02%/°C and 0.07%/°C, and the range of temperature coefficient of VOC and PMAX are [-0.35, -0.25]%/°C and [-0.48, -0.25]%/°C respectively [4]. The temperature coefficient of PMAX is taken as an example here. Figure 4 shows the temperature coefficients of PMAX for 78 c-Si PV modules measured in the ISO/IEC 17025 accredited PV laboratory of TÜV Rheinland in Shanghai.

Based on the one-diode model for PVsyst, the effect of temperature factor on the power output is projected to the transformation of photocurrent and diode inverse saturation current along with temperature. The mulsc defined as temperature coefficient of ISC in PVsyst is set for the temperature correction of photocurrent. The muPmpp defined as temperature coefficient of PMAX can either be specified by the user or set with the default value for PVsyst. Based on the input muPmpp, the temperature correction factor on diode quality factor (muGamma) would be deduced automatically by PVsyst, and then be applied to simulate the inverse saturation current under various temperature. The default temperature coefficient for PMAX of c-Si PV modules is -0.32%/°C. Figure 5 shows the deviations of maximum power extracted with measured and default temperature coefficient of PMAX. The maximum power discrepancy increases along with the magnitude of temperature deviation from 25°C, and it may be as large as 8% for the temperature of 70°C. Even for the muPmpp of -0.28%/°C which is similar with the default muPmpp value, the deviation of maximum power can increase to around 2% for the temperature of 70°C.

Light-induced degradation loss

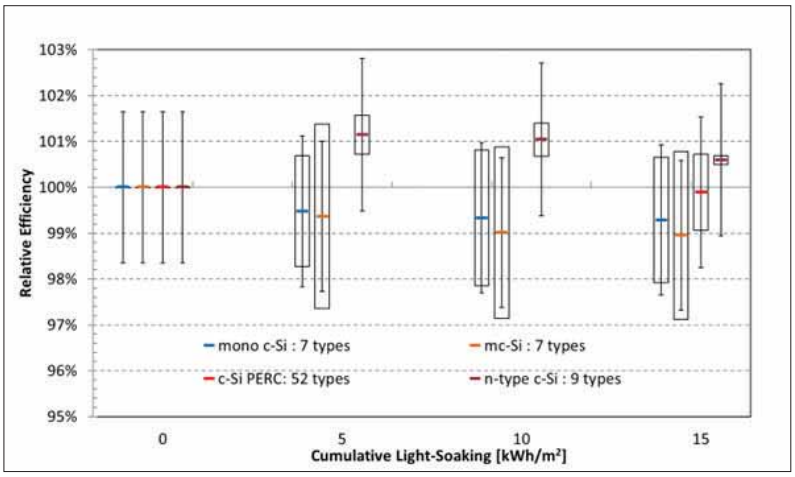
Light-induced degradation (LID) refers to a performance and power loss of solar cells due to the excess carrier injection by illumination or forward biasing [5, 6]. Most industrial c-Si solar cells and modules are suffering from some type of LID. In PVsyst, the LID loss is one type of array losses in PV systems and specified to analyse the PV array losses.

The LID phenomenon has been studied for four decades since it was first observed in Czochralski-grown c-Si devices in the 1970s [7]. Several LID degradation types have been observed such as boron-oxygen complex activation (BO-LID), Copper-related (Cu-LID), iron-boron pair dissociation (FeB-LID) and mc-PERC LID [8-10]. Among these degradation types, BO-LID is the mostly recognised degradation effect, which is usually observed in clean boron-doped Cz-Si. In recent years, gallium has been introduced as a dopant instead of boron, which results in lower LID losses. In contrast to the degradation caused by light exposure, a metastable relative efficiency increase appears in HJT solar cells with doped a-Si:H/c-Si structures under light soaking [11].

The results of relative efficiency (to initial) against cumulative irradiation dose for different module types at STC are illustrated in Figure 6. The relative efficiency losses of all the PV modules due to LID stays within 3.5% after light soaking of 15 kWh/m2. Mono c-Si, mc-Si, and c-Si PERC samples showed an average LID of 0.70%, 1.10%, and 0.11% respectively. N-type c-Si samples, the majority of which are HJT technologies with n-type Cz-Si wafer, showed an average 0.60% relative efficiency increase. The standard deviation within technology groups was calculated as coefficient of variation (CoV). It is worth noting that the module-to-module variation within certain technology was more significant than the difference between technology types except for n-type c-Si types. This indicates that even for similar technology types, large dispersion would exist due to both wafer quality and manufacturing processes employed.

Summary

The PAN files for PVsyst integrate most characteristics of PV modules that are necessary for energy yield prediction under different climatic conditions. Nowadays, a significant amount of PAN files, which are widely used in the industry contain inaccurate information, which is overly optimistic of the actual PV module performance. In order to acquire accurate PAN files, there are some suggestions below.



Light-induced degradation (LID) expressed as relative efficiency (to initial) against cumulative irradiation dose for different module types at STC. Boxes represent the standard deviation of technology variation (k=2) and error bars represent the measurement uncertainty (k=2).

Firstly, understanding the modelling strategy and how input parameters are defined is a fundamental step. Secondly, the performance measurement of PV modules should be performed according to relevant standards such as IEC 61215-1 [12] and IEC 61853-1,-23, [13]. Thirdly, it is recommended that tests are performed by an accredited and reputable laboratory. Lastly, it is suggested to have a third-party organisation performing regular surveillance for PAN files information. A third-party organisation can help check the accuracy of PAN files, and if necessary, sample PV modules and carry performance characterisation to verify the accuracy of input parameters.

References

[1] N. Martin, and J.M. Ruiz., "Calculation of the PV modules angular losses under field conditions by means of an analytical model", Sol. Energy Mater. Sol. Cells, 70 (1), 2001.

[2] M. Schweiger, W. Herrmann, A. Gerber and U. Rau, "Understanding the energy yield of photovoltaic modules in different climates by linear performance loss analysis of the module performance ratio", IET Renew. Power Gener., 11: 558-565.

[3] IEC 61853-2: 2016, Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements.

[4] C. Monokroussos, Y. Zhang, Eleanor W. Lee and et al., "Energy performance of commercial c-Si PV modules in accordance with IEC 61853-1, -2 and impact on the annual specific yield", EPJ of Photo., to be submitted.

[5] H. Hashigami, Y. Itakura, T. Saitoh, "Effect of illumination conditions on Czochralski-grown silicon solar cell degradation", J. Appl. Phys. 93, 7 (2003).

[6] J. Knobloch, S.W. Glunz et al., "Solar cells with efficiencies above 21% processed from Czochralski grown silicon" in Proceedings of 25th IEEE Photovoltaic Specialists Conference, 1996, pp.405-408.

[7] R.L. Crabb, "Photon induced degradation of electron irradiated silicon solar cells", in Proceedings of 9th IEEE Photovoltaic Specialists Conference, IEEE, Silver Springs, MD, USA, 1972, pp. 243-249.

[8] B. Sopori, P. Basnyat, S. Devayajanam, S. Shet, V. Mehta, J. Binns, "Understanding Light-Induced Degradation of c-Si Solar Cells", J. Appel in Proceedings of 2012 IEEE Photovoltaic Specialists Conference, Austin, 2012.

[9] T. Luka, C. Hagendorf, M. Turek., "Multicrystalline PERC solar cells: Is light-induced degradation challenging the efficiency gain of rear passivation?", Photovolt. Int. 32 (2016), pp. 37-44.

[10] K. Ramspeck, S. Zimmermann, H. Nagel, A. Metz, Y. Gassenbauer, B. Birkmann, "Light Induced Degradation of Rear Passivated mc-Si Solar Cells", A. Seidl., in Proceedings of 27th European Photovoltaic Solar Energy Conference and Exhibition. Frankfurt, 2012.

[11] E. Kobayashi et al., "Light-induced performance increase of silicon heterojunction solar cells", Appl. Physics Letters, 109(15), 2016.

[12] IEC 61215-1: 2016, Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements.

[13] IEC 61853-1: 2011, Photovoltaic (PV) module performance testing and energy rating - Part 1: Irradiance and temperature performance measurements and power rating.

LCOE analysis of PERC, TOPCon and HJT

LCOE | Using an in-house tool and PVsyst simulation software, a team from Chint New Energy Technology Co. analyse the LCOE of utility-scale solar systems in various countries based on three technologies: PERC, TOPCon and HJT.

Credit: Chint New Energy Technology Co.

A manufacturing facility from Chint New Energy Technology Co.

Nowadays, renewable energy is playing an increasingly significant role in the global context. It reduces dependence on fossil fuels and provides value in energy supply security and global warming mitigation. More importantly, the substantial cost reduction of renewable energy technologies enables the transition from subsidies to grid price parity with conventional electricity sources and actualises its market-driven expansion. According to figures produced this year by the International Renewable Energy Agency (IRENA), global renewable generation capacity increased by 257GW in 2021, with solar energy contributing to 52% of this increase. [1]

The PV industry is currently on the cusp of n-type technology evolution in pursuit of higher energy efficiency as the dominant technology, passivated emitter and rear cell (PERC) almost reaching its limited theoretical efficiency. New technologies including tunnel oxide passivated contact (TOPCon) and heterojunction (HJT) provide chances

Location	Global horizontal iradiation kWh/m^2.year	Diffuse horizontal iradation kWh/m^2.year	DHI/GHI	Annual avg. temperature °C
Golmud	1935.4	598.3	31%	6.6
Berlin	1052.7	553.2	53%	10.3
Jinan	1337.2	812.3	61%	14.8
Dallas	1785.1	705.7	40%	19.4
Dubai	2000.4	822.3	41%	28.0

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$$LCOE = \frac{Initial\ investment - \sum_{n=1}^{N} \frac{Depreciation^n}{(1+Discount\ rate)^n} \times Tax\ rate + \sum_{n=1}^{N} \frac{Annual\ costs}{(1+Discount\ rate)^n} \times (1-Tax\ rate) - \frac{Residual\ value}{(1+Discount\ rate)^n}}{\sum_{n=1}^{N} \frac{Initial\ enery\ generation \times (1-System\ degradation\ rate)^n}{(1+Discount\ rate)^n}} \quad (1)$$

of lowering the levelised cost of energy (LCOE), even based on the fact that the price of n-type modules is currently higher than PERC. There have been a lot of studies on the LCOE of TOPCon and HJT for different purposes, however most of them are based on limited scenarios, and the boundaries may not be defined clearly. Whereas an LCOE assessment is sensitive to module performance, solar resource, system design, labour cost, etc., it is meaningful to make LCOE analysis for PV technologies based on a variety of scenarios.

Methodology

In this paper, we compare the LCOE of TOPCon and HJT with PERC in different scenarios as follows. We chose five project locations with typical climate features, irradiance levels and balance of system (BOS) cost levels. We also include a range of albedos from 10% to 30% at each location. For each scenario, the DC/AC ratio is optimised to reach the lowest LCOE of each selected PV technology. Finally, a premium in price of TOPCon and HJT relative to PERC is calculated for each scenario when different technologies reach the same LCOE.

Module type	PERC	TOPCon	HJT
Wafer size (mm)	210	210	210
Ce1 (half-aut) quartity	132	132	132
Module length (mm)	2384	2384	2384
Module width (mm)	1303	1303	1303
Nominal power (W)	660	680	685
Module eff.	21.25%	21.89%	22.05%
Voc (V)	45.9	47.1	49.4
Bifaciality	0.7	0.8	0.9
Power temp. coefficient	-0.35%	-0.30%	-0.25%
Rel. eff.@200w	-	↑ 0.5%	↑ 0.5%
1st year degadation	2%	1%	1%
Annual degradation	0.45%	0.40%	0.40%

PV module information.

Location	Albedo	Optimized DC/AC ratio		
		PERC	TOPcon	HJT
Golmud	10%	1.18	1.16	1.14
	20%	1.16	1.14	1.12
	30%	1.14	1.12	1.10
Berlin	10%	1.60	1.58	1.58
	20%	1.58	1.54	1.54
	30%	1.56	1.52	1.52
Jinan	10%	1.56	1.54	1.52
	20%	1.54	1.52	1.50
	30%	1.50	1.46	1.44
Dallas	10%	1.36	1.34	1.34
	20%	1.36	1.34	1.32
	30%	1.32	1.28	1.28
Dubai	10%	1.42	1.40	1.36
	20%	1.40	1.36	1.33
	30%	1.36	1.33	1.32

DC/AC ratios, optimised based on the lowest LCOE for each scenario.

Energy generation

Energy generation is simulated with the PVsyst software. The TOPCon PAN file is based on the actual performance of Chint New Energy Technology Co.'s module product – ASTRO N – meanwhile the PAN files of PERC and HJT are based on a general industry-wide performance level.

Locations

We chose five typical locations, including Golmud (China), Berlin (Germany), Jinan (China), Dallas County (US) and Dubai (UAE). Their global horizontal irradiance (GHI), diffuse horizontal irradiance (DHI) and annual average temperature are listed in table 2.1. The level of irradiance and the temperature have a great impact on the energy yield, and PV modules generally generate more energy with high irradiance levels and low temperatures. The ratio of DHI and GHI influences the bifacial gain of energy generation, as a high proportion of DHI means more light can be received at the rear of the module. Albedos of 10%, 20% and 30% are applied to the simulation at each location. The energy yield gain of TOPCon and HJT is calculated as a relative value to PERC.

BOS cost

Note that the BOS costs are not the same for different technologies and for different albedos, even at the same location because the DC/AC ratio will be slightly changed. The BOS cost includes module installation, tracker material and installation, DC electrical parts such as wire and combiner boxes, AC electrical parts such as inverters, wire and transformer substation, system design, permission and licensing fee and overhead. Berlin and Dallas County represent locations with relatively high BOS cost, while Dubai and Jinan/Golmud represent locations with relatively moderate and relatively low BOS cost, respectively.

LCOE

The calculation for LCOE is the net present value of total life cycle costs of the project, divided by the net present value of energy produced over the system's lifetime. The total life cycle costs can be disaggregated as initial investment, annual cost, depreciation tax benefit and system residual value. [2] The initial investment (US$/Wdc) is the sum of the BOS cost and the module price.

Premium

Module prices of the three PV technologies are assumed to be the same. The premium refers to the additional price of TOPCon/HJT relative to the price of PERC when they achieve the same LCOE results.

System design

Since the industry is moving towards large-format modules, we compare the 210mm wafer 132 half-cell bifacial modules of three technologies. The detailed information is listed in table 2.

The AC capacity of the utility-scale plant is designed to be 100.8MW. The system voltage is 1500V. The number of modules per string is determined by the lowest temperature at each location. The system configuration is a horizontal single-axis tracker system, with two strings of modules on each tracker. The site area is assumed to be unlimited, the ground coverage ratio calibrated at 33.3%, and the land cost is also considered. The system lifetime is set for 30 years.

In real projects, high DC/AC ratios increase the overload energy loss in inverters at peak generation, and at the same time it decreases BOS cost. Therefore, DC/AC ratio should be optimised to balance between the two. In this study, we optimised the DC/AC ratios for each combination of PV technologies, project

Location	Albedo	BOS (USC/Wdc)	Premium (USC/Wdc)	
			TOPcon	HJT
Golmud	10%	35.1	1.49	1.63
	20%	35.4	1.66	1.67
	30%	35.7	1.78	1.69
Berlin	10%	46.6	2.58	3.00
	20%	47.0	2.78	3.14
	30%	47.3	3.03	3.30
Jinan	10%	30.7	1.78	2.15
	20%	30.9	1.94	2.24
	30%	31.2	2.15	2.38
Dallas	10%	49.9	2.68	2.99
	20%	50.3	2.84	3.03
	30%	51.1	3.09	3.12
Dubai	10%	40.2	2.44	3.69
	20%	40.5	2.63	4.04
	30%	41.2	2.79	4.27

Lifetime energy yield gain of TOPCon and HJT relative to PERC. Note: Lifetime energy yield gain = (Lifetime energy yield of TOPCon/HJT – Lifetime energy yield of PERC) / Lifetime energy yield of PERC.

Location	Albedo	Lifetime energy yield (MWh/kWdc)	
		TOPcon	HJT
Golmud	10%	2.34%	3.06%
	20%	2.77%	3.14%
	30%	2.94%	3.17%
Berlin	10%	2.74%	2.95%
	20%	3.19%	3.43%
	30%	3.42%	3.58%
Jinan	10%	2.78%	3.49%
	20%	3.01%	3.71%
	30%	3.63%	4.23%
Dallas	10%	3.24%	3.75%
	20%	2.85%	3.94%
	30%	3.62%	4.01%
Dubai	10%	3.00%	5.27%
	20%	3.70%	5.89%
	30%	3.73%	5.92%

BOS cost and premium of TOPCon and HJT relative to PERC

locations and albedo values, based on the lowest LCOE point. The optimised results are listed in table 3.1. It generally follows rules that the optimum DC/AC ratio in high solar resource regions, with high albedo and high energy generation performance, is lower than that for low solar resource regions with low albedo and low energy generation performance.

Results

The lifetime energy yield gain at our modelled Dubai project provides the upper limit due to n-type's outstanding performance at high temperature. In contrast, the plateau-climate features of low temperature in Golmud result in the lower limit. Energy yield gain at the two locations with different albedos is broken down to the contributions as shown in Fig. 1. The three PV technologies exhibit different performance in energy generation due to their differences in bifacial factors, temperature coefficients and first-year degradation values which can be primarily attributed to light-induced degradation (LID). Bifacial gain is larger at locations with high albedo, and the temperature loss difference is more obvious in places with hotter climates.

The BOS cost and premium of TOPCon and HJT relative to PERC are shown in table 5. The BOS refers to that of the PERC system at 20% albedo. It should be pointed out that the module prices of the three technologies are assumed to be the same in LCOE analysis to calculate the premium. TOPCon and HJT are more competitive with high BOS cost levels, high temperature and high ground albedo in most cases. For example, HJT in Dubai with 30% albedo results in a very high premium of US$0.043/Wdc, and this is because HJT has a low temperature coefficient which allows it to perform well at high temperatures throughout the year. On the other hand, Jinan and Berlin have similar solar resource levels and temperatures, hence similar energy yield gain, but the premium in two locations is quite different. This is mainly because Berlin has a comparatively higher BOS cost than Jinan, and this makes the energy gain in Berlin more valuable.

Furthermore, it is meaningful to compare the premium between TOPCon and HJT and provide a range of price difference in order to determine the economical priority. As shown in Fig. 5, the premium differences are within a range of 0.01 – 1.42 US$ cents per watt based on the typical albedo environment. In cold and mild regions, the premium differences are less than 0.36 US$ cents per watt.

Conclusion

Regarding energy generation, HJT is the top performer amongst the three PV module technologies, while TOPCon is the second, especially in hot and sunny regions with high albedo. This is due to their advantage of low temperature coefficient and high bifaciality.

On the other hand, high energy generation ability reduces the optimum DC/AC ratio required to reduce the inverter's overload power loss. This is the reason for HJT systems to be designed with a smaller DC/AC ratio. As a result, reduced DC/AC ratio increases the BOS cost on the AC side. In LCOE analysis, we compromise the energy yield and the BOS cost to pursue the lowest LCOE for each technology. Therefore, the results of premium do not fully comply with the results of energy yield gain.

In LCOE analysis, the prices of the three technologies are assumed to be identical, while in real-world projects of today, the prices of TOPCon and HJT modules are ~1-2 US cents per watt and ~3 US cents per watt higher than the price of PERC, respectively. Considering the price differences, TOPCon has the highest priorities in most mild climate regions. In hot regions like Dubai, the choice between TOPCon and HJT depends more on the price. ■

References

1. Renewable capacity highlights. (2022). [online] Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Apr/IRENA_-RE_Capacity_Highlights_2022.pdf?la=en&hash=6122BF5666A36BECD5AAA2050B011ECE255B3BC7.
2. Campbell, Matthew. Levelized Cost of Energy for Utility-Scale Photovoltaics. Solar Cells and Their Applications, 4 Aug. 2010, pp. 251–270.

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Wei Zhang, vice president, Chint New Energy Technology Co. Wei Zhang started his career in the PV industry in 2007, after working for Huawei for five years. With over ten years of experience in sales, investment, and management, he has a thorough understanding of the PV market's development and customer demand.

TRACKER LAUNCHED FOR PV TESTING IN DESERT CONDITIONS

The Qatar Environment & Energy Research Institute (QEERI), part of Hamad Bin Khalifa University (HBKU), has launched a 7-row horizontal-axis tracker to test PV modules in harsh desert conditions. The HSAT system, located at QEERI's Outdoor Test Facility, currently has 13 PV module technologies, with space for more. It is one of the largest PV trackers in the world operated by a scientific institute for module testing and research.

Field testing at high temperatures, irradiation and albedo

Bifacial PV modules with horizontal-axis tracking generate the lowest-cost solar energy in the world today. Computer simulations are useful, but rear-side irradiation on trackers is complex, so it is essential to validate simulations with real-world tests. It is particularly important in the case of harsh desert climates such as Qatar's, which has module temperatures of over 70°C, albedo above 40% and high humidity and soiling.

QEERI's HSAT provides such field testing. Coming online in March this year, the tracker has 7 rows with different spacings (pitches), ranging from 8.7m to 12m. This provides a precise understanding of the effect of row spacing on rear-side albedo, irradiation uniformity and PV generation across different seasons. The tracker is 2P, allowing for tests with different East/West string layouts. Finally, multiple modern PV technologies are being studied side-by-side for energy yield and degradation.

Solar Consortium: researchers and industry collaborate on desert PV

QEERI's HSAT system is part of its Solar Consortium, an international group for solar energy manufacturers, developers and authorities. Current members include Hanwha Q Cells, Kahramaa, Maxeon Solar, Soltec, TotalEnergies and QEERI itself. Companies in the Solar Consortium receive confidential test data on their own equipment, plus results from group research projects such as robotic cleaning and trackers.

The Solar Consortium and Outdoor Test Facility are ideal for companies to validate their PV technology in harsh desert conditions.

To find out more, please visit
www.hbku.edu.qa/en/qeeri-solar-consortium

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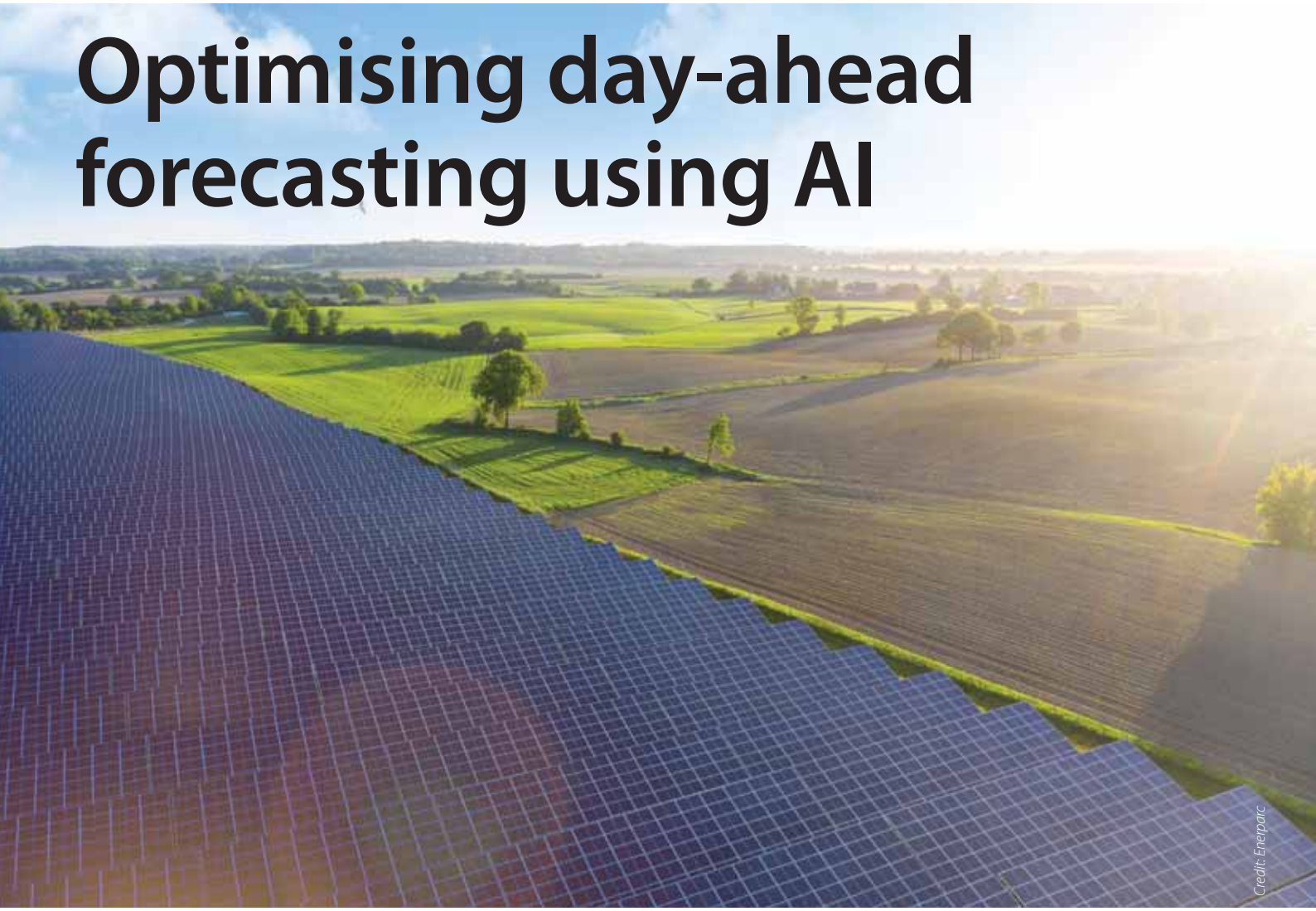
Optimising day-ahead forecasting using AI



Credit: Enerparc

Forecasting | With accurate power forecasting becoming more essential than ever for solar asset owners, Yoojin Lee, a systems engineer and power forecast specialist at Enerparc, reveals how the company's artificial intelligence approaches are used to make day-ahead forecasts more accurate.

Three years ago, Enerparc started developing a solar PV power forecasting tool as a pilot project in the form of a master thesis from Yoojin Lee, a systems engineer/power forecast specialist at the company. It started as a simple tool for a couple of power plants in Enerparc's solar PV portfolio and evolved within three years into operational software with a convincing forecasting accuracy.

In several research papers and publications, the advantage of hybrid models was often addressed to combine two inheritably different models. On this account, the project was designed using a physical model and one machine learning model which was up to date, feasible and appropriate for time series forecasting and combining those two in the end.

The physical model is formed to calculate power output at the grid connection point as accurately as possible, by applying Enerparc's specific system design details and taking possible power losses into account from PV arrays to the grid. The power output from the physical model is fed into the machine learning model as one of the input parameters.

The adopted machine learning model is called the 'Long Short-Term Memory (LSTM)' network as a type of recurrent neural network (RNN), which can model complex multivariate input sequences of observations. The LSTM network has already been very popularly deployed in time series forecasting applications. Meanwhile, many new types of deep learning models have been developed and introduced, therefore it is always important to keep an eye on recent findings and to exchange with people in the field to stay up to date.

A 28MW solar PV plant from Enerparc in Germany.

AI approaches used by Enerparc

Enerparc harnesses the multivariate LSTM model for time series forecasting. Specifically, multiple variables are put together as input to the model, and only the solar power output variable is predicted as output. The LSTM model is trained based on historical data for each power plant, meaning that Enerparc has 300 different AI models for 300 large-scale solar power plants in Germany.

It is decisive to calculate an accurate physical power forecast variable as part

of input parameters to run prediction with an AI model. It may sound contradictory to have to calculate physical power to predict a power with AI. The physical power mentioned first is a result of the physical model and is used as one of the input parameters for the AI model. The physical power must be given before being able to harness the AI model. And the final power value from the AI model is the result of prediction after running the trained AI model.

One of the challenges lies in getting physical power as accurate as possible. Enerparc's solution was to calculate power output values with an internally further developed physical model, based on an academically published power output model. In short, the solar PV power forecasting project harnesses a hybrid model in a combination of a physical model with a multivariate LSTM model.

How have they been assimilated into the company's operations

Once the prediction performance of the hybrid model was validated, the next step was to establish a sustainable and secure environment of operations with the help of IT experts. There is a long list of tasks to achieve a certain level of reliable operation. For example, a test programming environment should be separated and isolated from an as-built environment, where a tiny change affects the current running operation directly. Logging and notification systems have to be implemented in the case of any possible failure during operations to manage, detect, and analyse issues.

In the beginning, there were many learnings from a variety of errors over time during operations, because building a sustainable environment required specific IT expertise, which was a challenge to learn and implement in a short time. For this reason, it was rather a recurring processing of problem-solving with each new error. However, after receiving the appropriate support and expertise from Enerparc's IT team this power forecast project could finally be running in a reliable, secure and sustainable environment. Accordingly, regular improvements were gradually made to improve the overall operation of the power forecasting model within a couple of years.

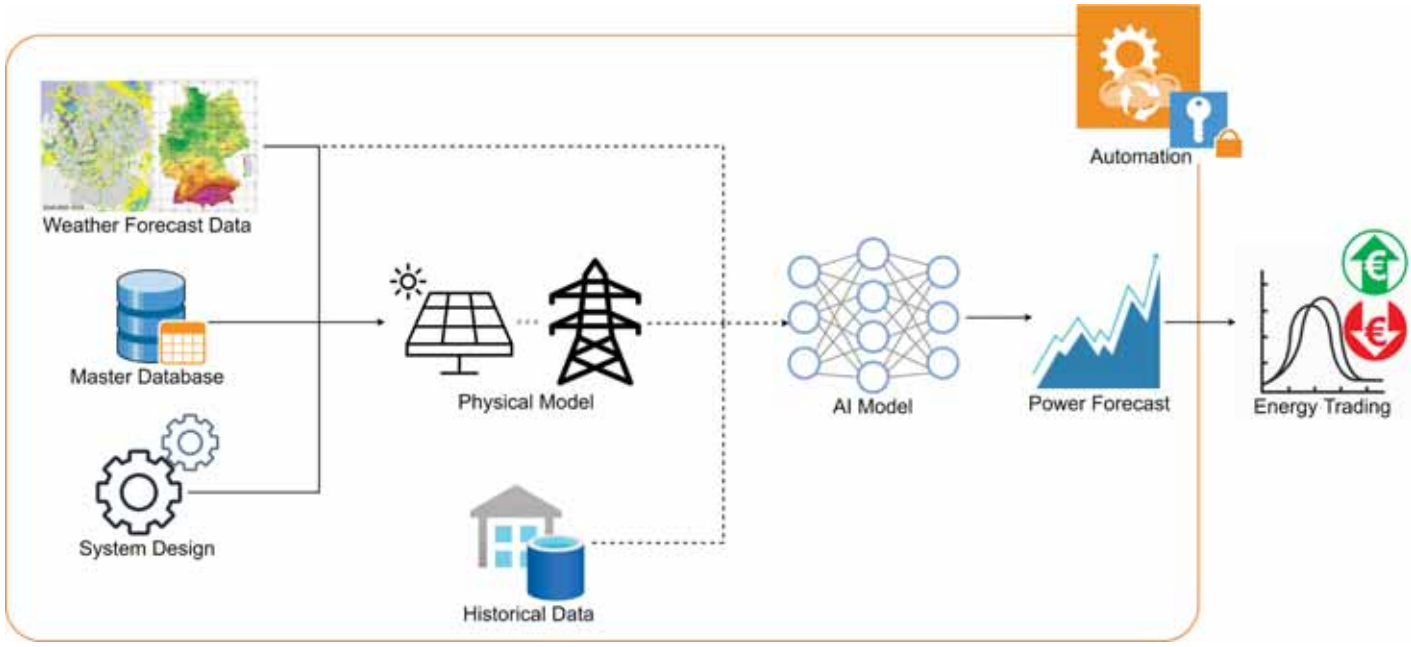
Data used for AI

With the forecast of a clear-sky day, it can be easily assumed that a large amount of solar PV energy will be generated. How do humans know the relation between clear sky day and high solar PV energy generation? That is because it has been observed and remembered from the past. For a deep learning model to know and learn the same relation as humans, it needs to learn from the past observations that are being fed into the model. On this account, it is important to feed the right input data into the AI model, which is well-prepared power and weather input variables data in this case.

At first, the input dataset consisted of power generation and a couple of weather parameters. In the meantime, temporal and installed capacity parameters were being added to clarify the nature of data inputs more explicitly, so that each AI model is trained based on more distinct information about each time series data. Especially the installed capacity information was necessary for power plants, which were extended after a while additionally next to the existing power plants. Then the new extended power plant will feed electricity into the same grid point as the previously installed grid point for the existing power plant. The AI model will be able to be trained better with this increasing installed capacity history because it provides a reason why the historical power profile shows bigger values from a certain point.

Importance of central master data

When a portfolio grows over time and a physical model requires more detailed system design information for each power plant, the central master data gets longer and grows exponentially at the same time. Therefore it is absolutely necessary to maintain around-the-clock, up-to-date master data. For example, newly commissioned power plants should be added to the master data as soon as possible, so that power forecasting covers the increased actual portfolio as well. If an installed capacity for a power plant is mistyped in the



Credit: Enerparc.

Project overview describing physical power used as one of the data inputs for an AI model together with weather forecast and historical data.

master data, it will end up overestimating or underestimating the power plant consistently, without knowing why it happens. It makes it even worse in the case of large power plants. That is why it is so important to regularly update and maintain the master data.

Benefits of AI

Power forecasting with AI techniques provides more accurate output in comparison to a single physical model prediction, by learning correlations between input variables and output variables from the historical behaviours. There is a clear limitation on the use of a physical model only for time series forecasting. A physical model is calculating the power generation from a mathematical equation with relevant weather forecast parameters. Even if a physical model is formed with numerous variables either in an experimental or theoretical way as accurately as possible, it is incapable of solving an arbitrary complex nonlinear relation between input and output variables. That is why AI, specifically deep learning neural networks, are becoming such powerful and popular tools.

Enerparc's day-ahead solar PV power forecasting has demonstrated promising and impressive outcomes for its portfolio in comparison to other external power forecasting providers. It led the energy trading team of Sunnic Lighthouse, a subsidiary of Enerparc, to reduce the number of external power forecasting providers from three to two since 2020 by substituting the third best provider with Enerparc's forecasting.

Apart from that, it is extremely valuable to own an independent in-house power forecasting product and technology since an accurate power forecasting capability has become more essential than ever before.

Moreover, there are a few dominant power forecasting players in the German market. No matter how big or well-known the companies are, no one is immune from delivering less accurate forecasting results some days or even frequently for some power plants. In other words, it is possible, and it happens from time to time, that every energy trading company overestimates or underestimates power generation by a large margin for the next day, causing massive chaos for all traders, because they all referred to the forecast data from the same well-known forecasting company. However, Enerparc will be less dependent on such a dominant player once the power forecasting technology lies in its hands and delivers an additional reliable reference.

At the moment it is being optimised further regarding the forecasting results by comparing a forecast outcome to the real-time power measurement values, which are accessible from Enerparc's internal database to increase the forecasting accuracy.

Insights gained from the AI project

Before starting to work on an AI project, three elements are truly essential: good quality of data, an optimised deep learning model and a good team with expertise.

Good quality of data

Data cannot be regarded as separate from any kind of AI project. A good result of an AI project is consequentially preceded by the high quality of input data, which is finely prepared after collection. In the case of power forecasting, there are two main datasets: historical data and weather forecast data. Once historical time series data for desired input variables are collected, the very first step is to identify, clean, filter and handle missing and wrong data. This is one of the most time-consuming tasks but very important to get the most out of the given data. Secondly, weather forecast data is the main source to achieve an accurate power forecast. Many weather forecasting providers are harnessing their machine learning models to optimise weather forecast data from different sources. In Enerparc's case, weather forecast data is being used from DWD's (German Weather Service) open data FTP server for its solar PV power plants in Germany.

"It is extremely valuable to own an independent in-house power forecasting product and technology since an accurate power forecasting capability has become more essential than ever"

An optimised deep learning model

Building a deep learning model is one thing and optimising it is another. Even if two different companies apply the same type of deep learning model, it can generate a completely divergent consequence. There are numerous hyperparameters to optimise deep learning models, which characterise each model and determine the quality of prediction capability. For example, the number of hidden layers, the number of neurons for each layer, the type of activation function for the hidden and dense layers, and the learning rate are part of hyperparameters. Random search or grid search can be used for model hyperparameter optimisation, which is available in the scikit-learn Python library. If there are multiple power plants in a portfolio, it is recommended to train a deep learning model for each power plant, rather than to apply a general model for all different plants.

A good team with expertise

The high quality of an AI project for power forecasting can be realised from the synergy of experienced engineers, data scientists and people standing on the border between them. Data scientists play a very decisive role to bring such a project up to a professional level of operation and result in discoveries that haven't been noticed before. However, when talking about AI projects, it often tends to be highlighted for jobs of data scientists too much, because it is an unfamiliar and little-known area to many people. Any AI project can also be approached purely statistically without knowledge of the data, and it can work out well enough. However, at least in the solar PV power forecasting field, it is very important to work in a team who have a deep understanding of data in context and correlation with other parameters. For example, how solar PV power can be calculated with meteorological variables and technical system design, what kind of weather parameters can influence power production and what could be the cause for a short sudden drop in power generation during the day, and so forth. In addition, a person being able to speak and understand both languages of engineering and data science plays a huge role because this person can be the bridge to connect two different worlds into one together.

A 10MW solar PV plant from Enerparc in Germany.

Credit: Enerparc

Today's challenges

Is weather forecast data the best among others?

In general, there are many big steps to finally obtain a power forecast result, starting from collecting data to delivering power forecast data to an end user. Since each step is so closely connected, there are always high chances to accumulate errors consecutively. The first step all starts with weather forecast data. Just like really good food is made from high-quality ingredients, good weather forecast data is highly significant for accurate power forecasting. One of today's challenges is to find out such good weather forecast data. There are various weather forecast models from different sources in the market that allow access to numerical weather prediction models, offering forecast horizons up to several days ahead. Until now, Enerparc has been applying weather forecast data from DWD exclusively for power forecasting. At the same time, current weather forecast data is being verified and alternative models are being searched for, which have the potential to perform better than what has been used so far

Is there any other input data to add to the AI model?

It is a challenging task to form and structure an input dataset for the AI model. Historical power values are the results of many complex dynamic circumstances that have to be interpreted in the right way. It is very important to be aware of all the possible factors, which influence the power value. That is because it is directly related to shaping input data for the AI model to forecast power output.

When a power plant is extended additionally after a certain period or it is partially disconnected from the grid for repair, component replacement, or inspection, or requested not to feed into the grid for a while to maintain grid stability, the AI model can generate and train a better prediction model, if such information is provided as an input data as well. Besides, a weather input variable can also have a meaningful impact on the power output variable, which is not discovered and experimented with so far. Therefore, Enerparc is working on brainstorming and integrating additional input variables to enable AI models to train and predict more accurate power output results.

With the further development of power forecasting, Enerparc is committed to improving the reliability and predictability of renewable energies which play an increasingly important role in a stable power supply with rapidly increasing green power sources. ■

Author

Yoojin Lee is a systems engineer and power forecast specialist at Hamburg-based Enerparc. She works on the development and operation of a power forecasting project as well as on the BOS analysis, inverter selection and battery design tool development. Born in Seoul in 1991, Yoojin studied a bachelor's degree in Mechanical Engineering at the Korea Advanced Institute of Science and Technology (KAIST). She then moved to Germany to deepen her knowledge of power plant engineering and electricity generation through a Master of Science in Power Engineering at the Technical University of Munich.

How is AI evolving PV site selection and design?

Software | As solar becomes more sophisticated, the industry is leaning on more advanced software and AI to determine the best sites and optimum system designs. Molly Lempriere explores the role AI and other advanced techniques are playing in solar development.

Credit: Glint Solar

Glint's software allows developers to explore elements such as irradiation, distance to interconnection and topography.

In recent years, the potential for artificial intelligence (AI) and other advanced software technologies for the rollout of solar power has started to be realised. As the scale of the sites has grown, so too has the importance of their placement and design, requiring more elements to be considered than ever before.

"To us it's surprising how many very sophisticated solar developers are still using the old way of sourcing land: reactively waiting for someone to recommend a piece of land or guessing by looking at Google Earth," says Even J. Kvelland, co-founder and chief operating officer of solar AI company Glint Solar.

"Given how ambitious plans virtually all developers have, they increasingly must be proactive about site screening and we're proud to finally offer them a software for this important task."

So how is AI stepping up to ease not just site selection, but design and development?

Software to streamline solar site selection

Advances in software are allowing developers to assess a vast range of elements faster than ever, from the very early stages of site selection right through the development.

According to the Solar Energy Industries Association, depending on the specific technology, a utility-scale solar power plant can require between five and ten acres per megawatt of generating technology. The land this is then developed on will generally require some grading of land and clearing for vegetation. Solar PV can be built on land with a slope and no water access, but there are considerations around shading and topology amongst others.

With solar farms now being developed by the tens of megawatts, this is often a huge amount of land that needs to be assessed.

"We've built a very intuitive yet powerful software-as-a-service (SaaS) platform where the solar developer themselves identify and analyse potential project sites," explains Kvelland.

"They can for instance identify specific

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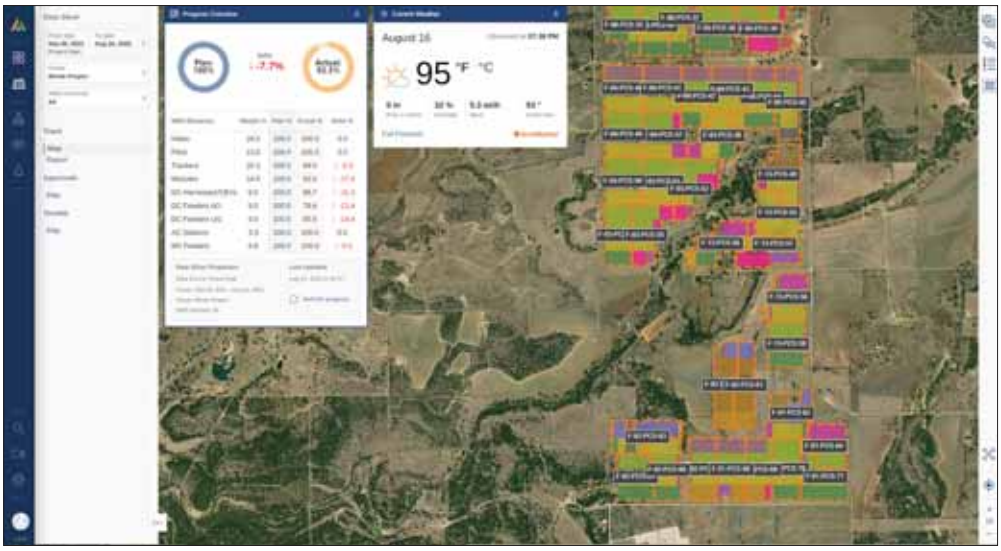

Credit: TeraBase.

types of land, such as industrial zones or pasture or identify relevant parcels where you can for example build min. 10MWp and is no more than 3km from a grid interconnection point. From there they can analyse topography and run more in-depth technical and financial analyses. In sum, we are streamlining the early screening work to quicker build a robust project pipeline."

Glint's software for example allows solar developers to explore a number of elements of site selection, but Kvelland says the most common are a combination of irradiation, distance to interconnection, topography, and environmental constraints.

"We are attempting to pull in as much relevant insight in the early planning stages as possible to give our customers – the solar developers – the best possible foundation for optimising their pipelines," continues Kvelland.

"Knowing which projects to kill and which to go for is tremendously important from an efficiency point of view. AI can be used to detect what type of land satellite imagery is showing, if a waterbody for floating PV is natural or man-made and we have been working on an AI model to assess the bathymetry of lakes from satellite images based on how much light is reflected from the bottom."

On a residential scale too, AI is stepping in to help provide accurate and rapid estimates for the solar potential of homes. Numerous software programs are able to offer installation designs that demonstrate how to maximise the roof space available to generate the most power.

Oil and gas giant Total and Google Cloud for example launched an AI tool dubbed Solar Mapper to help accelerate the deployment of residential solar panels in 2020.

TeraBase looks to use automation and digitalisation to ease the rollout of utility-scale solar.

Using AI to ease grid connections

It is no secret that one of the biggest challenges for the rollout of clean energy technologies like solar is network capacity. In the US, a Lawrence Berkeley National Laboratory analysis in April 2022 found that there was almost 1TW of renewable energy capacity – of which 700GW was solar PV – in interconnection queues as of the end of 2021.

A similar story is true in other markets, with long connection times in countries like the UK and Spain for example. Here too, AI is stepping up to help tackle challenges around grid capacity however.

> "Knowing which projects to kill and which to go for is tremendously important from an efficiency point of view"

"There are a number of ways in which AI can really benefit the further development of solar," says Kvelland.

"In the early stages, one can apply various AI algorithms to do more advanced assessments of capex and opex with regards to choosing specific sites and the plant design at those sites. One can run prediction algorithms on future power prices and where to build and how to feed into the grid in combination with storage."

Grid connection challenges impact the rollout of solar power at all levels, from the largest mega-projects to individual residential connections. One project looking to use AI to improve grid connections in the US is being run by a team at Stanford University, who have developed an algorithm that allows them to map residential solar across the country, and in doing so, understand its impact on networks.

Using satellite imagery from Google, the team – led by Ram Rajagopal, associate professor of Civil and Environmental Engineering at Stanford University – has been able to track the widespread adoption of both rooftop PV systems and grid-scale solar, digging into what change is needed from system operators, utilities and solar system providers to manage and plan ahead for new deployments.

"One of the main issues [utilities are] having is they need to do the planning for the short, medium term and long term," says Rajagopal.

"And one of their big concerns is what if there's too much solar behind a particular transformer or which region solar is going to come in. So when they do their ten-year plans, they take those things as inputs, and they really like the power adoption curves. Because solar is very concentrated in certain locations, and as costs come down and incentives change, suddenly locations are having onset. When you have an onset, your previous data is not really a good predictor of what's going to happen in the future."

The sophisticated software easing construction

Once a site is selected, taking into account all major inputs such as the quality of the land and the availability of a grid connection, software is also stepping up to help with the construction of solar sites as well, with the process becoming increasingly automated to maximise efficiencies.

One company that is looking to employ advanced software in the next stages of solar site development is TeraBase. Born out of a digitalisation program at SunPower, the company looks to use automation and digitalisation to ease the rollout of utility-scale solar power.

"The first thing we do is we create a digital twin of the plant," explains Matt

TeraBase builds a factory on site, that then automatically constructs the solar system.

Campbell, CEO of TeraBase, which then acts as a full, 3D plan for the site.

"We have a pop-up factory where we bring in steel structures, cables, panels, and then we use a combination of robotics and manufacturing machines to assemble everything. So we build these structures that are about 13-metres long, and then have a special vehicle, which will be autonomous - it's not autonomous today, but it will be - and that delivers the structures to the field and installs them. So we have a fleet of vehicles, and they're just in constant operation, almost like ants just following the path."

The company has now completed its first beta project and is starting to unpick the benefits of automation and digitalisation for the construction of solar power farms.

This includes numerous health and safety benefits, as well as efficiency of rollout and environmental improvements. The company's beta project is in central Texas where developers are contending with 38°C heat, rattlesnakes and dust storms, making health and safety a particularly key consideration. By automating the construction, workers could minimise the time spent outside at the mercy of such elements, as well as avoiding "lifting these 40kg panels all day".

Intelligent optimisation once operational

Once the site is selected and developed, AI and other advanced software can also come into play to optimise the operation of the assets. Back in 2019, a project from National Grid ESO in the UK found AI could improve its solar forecasting by 33%.

Other initiatives are emerging to explore the use of AI for optimisation of solar sites, with Kvelland pointing to collaboration between IBM and the US Department of Energy, which "looked into self-learning weather models, sensors and satellite imagery and was able to achieve 30% better solar forecasting."

"AI will also be very important not just on the supply side, but also on the demand side and how to balance the two. Once built, one can use AI to improve cleaning and maintenance, which is especially very attractive on large PV plants."

From cradle to grave, AI and other advanced software platforms are easing the rollout and operation of solar power. Whilst there are still undoubtedly challenges around the availability of data, the integration of processes and the development of the hardware to match it, AI looks set to play a key role in solar design going forwards. ■

What the new era of inflation means for investments in the global energy transition

Markets | Consistently high levels of inflations seen across the world are impacting all industries in different ways. And solar PV is no exception. Alexa Capital examines the risk and reward profiles for different company structures and moots than greater market consolidation may be on the way.

Soaring commodity prices have brought inflation back to Western markets that had not seen significant cost-of-living increases in decades. In July 2022, the US consumer price index climbed 9.1% year on year, the biggest rise since 1981. Meanwhile Euro area inflation was up to 8.6% in June 2022. In the UK, the Consumer Prices Index including owner occupiers' housing costs was at 8.2% in June, the highest point since March 1991. For investors, this has put the brakes on markets and dramatically slowed the velocity of capital. For investors in the energy transition, this inflationary landscape is an entirely new environment – where there remains an imperative to invest, but with risks managed through a different lens.

The large-scale deployment of clean technologies has only really ramped up in the last couple of decades. Until now, funding deployment has been underpinned by low-inflation macroeconomic conditions. So, what does the current environment mean for investors? Before answering this question, it is worth considering the outlook for inflation in Western economies. How long are today's inflationary pressures set to last?

Although it is impossible to foretell the future, it is important to note that the long end of the yield curve has not changed much in recent months. This is significant given that many renewable energy projects are funded with seven to 10-year debt. Look at 10-year and 30-year UK government bonds, for example – the longer-term bonds are usually more expensive, reflecting a greater uncertainty around repayment.

But this year the spread between the two has all but vanished, with rates for both short term and long term bonds at around 2% in July 2022. This can be explained by a popular belief among investors that inflation will soon be brought under control. Indeed, several central banks have begun taking action to stem the rise in cost of living. In July, for instance, the European Central Bank posted its first interest rate rise in 11 years, pushing its base rate up 0.5%. The US Federal Reserve has been more aggressive, upping rates in increasingly large increments since March. The Bank of England raised its rate to 1.25% in June.

These are all positive signals to contain inflation. Even under the most optimistic scenarios, however, it seems likely inflation could remain high for at least another year or two. And these are set to be critical years for energy transition investment, not only with continued growth of investment into renewable energy projects but also for critical investment into ancillary segments such as low-carbon hydrogen, energy storage, EV charging infrastructure and flexibility services.

Price of 10-year and 30-year UK government bonds

So, what should investors be aware of in the current environment? Fundamentally, there are three things to consider:

- How inflation affects project revenues.
- How inflation affects project costs.
- Which businesses are least prone to see negative impacts from the above.

How inflation affects project revenues

Inflation is generally bad for any business that gets a fixed, non-index-linked amount of money for a given product or service. The value of that money depreciates over time, effectively leading to lower revenues. Some renewable energy projects may indeed operate on such a business model, but these are almost certainly a minority.

With companies that do get a fixed price per kilowatt-hour, for example through corporate power-purchase agreements (PPAs), it would be a poorly negotiated contract indeed that did not include some index linkage or price hedging mechanism. In addition, many renewable energy projects typically include some level of spot market exposure, either at the end of a PPA term or as an additional revenue stream to PPAs. These projects are benefiting from a major and likely short-term increase in their revenue and profits as global energy markets head skywards currently.

Regional wholesale electricity benchmark prices in European day-ahead markets have risen from less than €50/MWh in 2019 and 2020 to between €150-€250/MWh in the first quarter of 2022. In projects that are fully amortised, this revenue translates almost entirely into pre-tax profits because

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the sources of renewable energy involved—wind or solar in most cases—are free. It is fair to say these projects were pioneers and took considerable risks for which they are being compensated (noting that non-dispatchable renewable energy have suffered from low dispatch prices due to the "duck curve" in recent years).

How inflation affects project costs

On project costs, the picture is not so rosy. The supply pressures at the root of current high inflation rates are hitting renewables as much as any other industry, with raw material cost increases pushing up solar module prices more than 20% in the last year. These increases, which are also being seen in the wind and battery storage sectors, are a completely new phenomenon in industries that until now have been noteworthy for their steep and sustained reductions in cost.

Price increases pose a problem for developers that have committed to projects relying on razor-thin margins for profitability, such as plants that have been awarded through government tenders. The owners of such projects have often reduced all cost components as far as they can and are therefore unlikely to be able to offset material and component pricing increases through further reductions in other line items. Hence, they have three realistic courses of action.

The first is to renegotiate their offtake agreements, which will depend on the counterparty. A corporate PPA customer may be willing to pay a bit more for electricity in the current environment because they could still likely make a saving compared to buying energy from wholesale markets. The second option is to try to secure additional revenue streams. As noted above, there is considerable upside in today's energy markets, but this is only available to projects that have not committed all their generation to an offtaker. Another revenue source, already of prime importance to storage projects and increasingly too for wind and solar assets, is to tap into ancillary services and/or flexibility markets. But for companies that cannot go down any of these routes, the only realistic prospect is to pause or cancel the project. Analysts have been warning of project delays and cancellations in the solar industry since last year. There will certainly be many renewable projects that get postponed.

It is important to note, too, that concerns about project delivery are not just related to the cost of materials and components. Their availability is an issue, too, and transport costs and delays are another major challenge. The upshot is that even companies that have locked in competitive supplies may face problems in completing projects on time and on budget. In addition, supply chains are being re-oriented from global to regional, and there are likely to be sourcing issues for some time to come.

Which businesses are least prone to negative impacts?

Given the points above, it should be evident that companies with mature asset portfolios and little exposure to government auctions and similar offtake structures are well placed to benefit from current economic conditions. In contrast, those that are caught up in the delivery of projects with low, fixed-price contracts could struggle. We are also seeing that present conditions are tending to favour larger players because they usually have more robust supply chains (and more buying power).

When faced with delivery constraints, original equipment manufacturers—most of which are in Asia—are naturally keen to prioritise supplies to their major customers. This puts smaller developers at a disadvantage. Larger players are also more able to weather the current storm because they are more likely to have diverse, integrated portfolios and professional trading desks, which allow them to access a range of market opportunities.

These large players can tap into capital markets efficiently, further improving their competitive position compared to smaller companies. One obvious implication of this is that the market could be set for consolidation, with large portfolio holders looking to expand their reach through the acquisition of smaller rivals. These market trends aside, the fundamentals underlying the energy transition remain solid.

Although until recently progress in the US is perhaps not as rapid as some in the administration might like, energy infrastructure development has broad bipartisan support and steps such as the Federal Energy Regulatory Commission's decision to reform regional transmission planning have been praised. In Europe, meanwhile, Russia's invasion of Ukraine has led to a Pearl Harbour moment whereby the energy transition has become a matter of national and regional security.

The European Union's REPowerEU plan, unveiled in May, explicitly links the ending of Russian fossil fuel dependence with progress in the energy transition. The European Commission has proposed increasing Europe's 2030 renewables target from 40% to 45% of total supply by 2030, along with plans to double solar PV capacity by 2025 and tackle permitting delays that are currently hampering the growth of the market.

Another feature of REPowerEU is a target of 10 million tonnes of domestic renewable hydrogen production, plus 10 million tonnes of imports, by 2030. All this means that, in Europe at least, not only have renewable energy asset owners never had it so good, but never has their outlook been so positive as well. There are, perhaps, just a couple of minor areas of concern for investors.

One is what happens if, despite all estimates and efforts, inflation continues to be high for the foreseeable future. If this is the case, it will be important to understand the causes of the inflation, although it is safe to say that renewable power is likely to remain one of the safer investment asset classes regardless of market conditions—it is hard to envisage a situation where people stop needing electricity.

Another, more realistic challenge is that progress on the energy transition is hampered by restricted supplies from Asia. It is no secret that China has a stranglehold on manufacturing for the energy transition. The country controls 50% of global wind turbine capacity, almost 70% of solar module output and 90% of lithium-ion battery production.

Without China, there is no energy transition. But Western policymakers recognise this—which is why we can expect to see significant support for reshoring and nearshoring of manufacturing capability. Yet again, this can only be a good thing as far as investors are concerned—regardless of the impact of inflation.

The bottom line is that new development is at high risk of slowing down if markets believe inflation cannot be contained, and if supply lines do not stabilise. We are medium term and long term optimistic, but appreciate that the next few quarters will have some tough trading. ■

Author

Bruce Huber is CEO of Alexa Capital. Throughout his career, he has advised on hundreds of capital markets and M&A transactions, including IPOs, follow-ons, convertible & debt, energy project financing, as well as corporate finance, including public and private M&A. He was previously a member of the board at Jefferies International where he helped found and build the #1 global industry equities, research and investment banking platform in the new energy sector, with substantial activities financing renewable energy and circular economy businesses.

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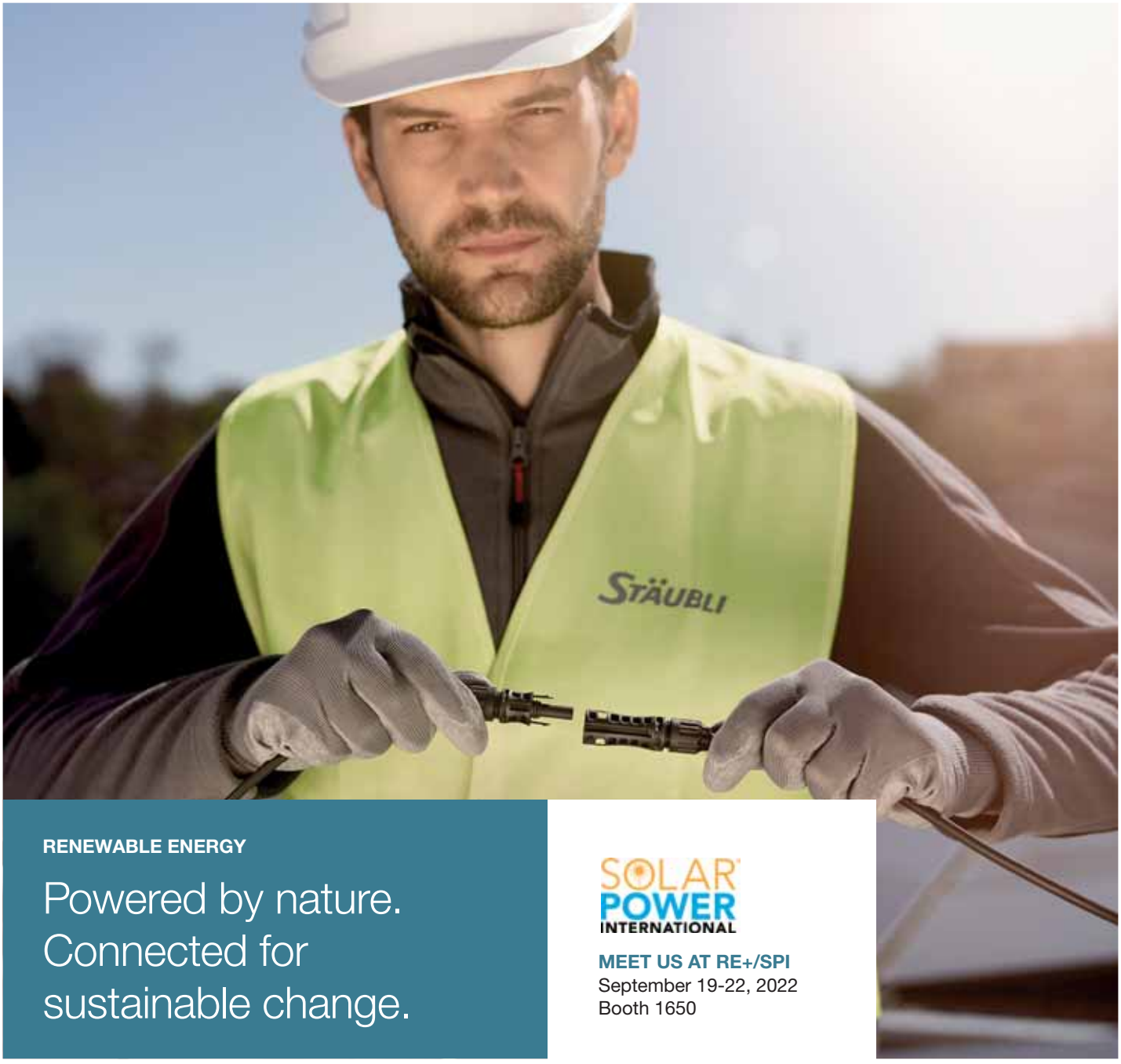

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Prickly procurement: How the manufacturer-developer relationship has changed

Procurement | Manufacturers and developers alike have felt the pain of supply chain constraints of the last two years but, amidst sky-high prices and contractual disputes, how have relations between manufacturers, distributors and developers changed? Liam Stoker reports.

Credit LONGi Solar.

Sky-high material and component prices have forced module costs upwards by as much as 20% in recent years.

Supply chain constraints of the last 18 months, while perhaps not unlike anything seen before given the cyclical nature of solar PV manufacturing, have caused major concern.

Manufacturers have felt the brunt of this turbulence, with polysilicon prices at ten-year highs and reverberating down the value chain. Prices have often risen by 3 – 4% in the space of a week, with those price spikes then being passed onto the customer.

Module prices have risen by up to 20% over the course of the past two years, with the most recent forecasts suggesting European developers can expect to pay up to US$0.30c/W for modules. The average price for modules bound for the US is around the US$0.36c/W mark, however prices have fluctuated in the extreme considering recent policy and tariff risks.

Such price hikes, coupled with the weekly uncertainty and changing goalposts, have placed considerable strain on the supplier-developer relationship, with both having to navigate sensitive and often fraught negotiations.

Frank Niendorf, general manager for Europe at Solar Module Super League (SMSL) member JinkoSolar, says that for module makers in particular, "a lot of challenges have come all in parallel", which has made the situation difficult to handle.

Jeff Waters, chief executive officer at manufacturer Maxeon Solar Technologies, says the last 18 months of turbulence has "tested our resilience" when it has come to honouring contracts.

"We really do put a high emphasis on integrity in our relationships, and part of it is, frankly, out of necessity. We're a NASDAQ-listed company, we have investors watching over us, we're domiciled in Singapore so, if somebody wants to sue us, they can sue us," he says.

As a result, Waters says contractual situations have "created some pain" in recent months. "I can think of some deals where we had fixed contracts with customers and we've honoured them… but if I could have waved a magic wand and made those contracts go away or raise the prices, I would have. But we abide by our contracts," he says.

The need for transparency

Relationships between developers and manufacturers have had to change over the last two years and, according to Niendorf, the answer has been for JinkoSolar to be more transparent as to pricing, delays and availability. When this information comes up front and the customer is aware, they can be altogether more accepting that the situation is a point of pain for all involved.

"We are used to being flexible and improvise as good as we can. And customers, they do understand that currently it's not a normal market situation, not a normal supply/demand situation, not a normal logistics situation, and they show understanding. But it's challenging," Niendorf says.

Waters agrees, stating that in the discussions Maxeon has had with customers of late there is a greater understanding as to the reasons behind cost increases. This has grown even further since Russia's invasion of Ukraine sent another shockwave through the global economy, developing an altogether more comprehensive understanding of the impact economic shocks can have on pricing generally.

"The customer is never going to tell you they're happy with prices increase, but they do understand it now. I can point to 30% cost increases in the supply chain and they get it. What we're hearing more now is 'hey, we get it, increase the prices, but just get us the panels'," Waters says.

One international solar distributor spoken to for this article concurred that honesty really is the best policy when it comes to shifting prices and confirmed the notion that manufacturers were certainly being more transparent than they perhaps were before.

But transparency is not a panacea for the solar industry's present constraints, and distributors have had to adapt in kind. Contractual frameworks have changed and become more commonplace, while orders are now being placed months ahead of where they were previously. More diversified product ranges have had to be adopted to tackle limited availability of certain products in specific markets too, some manufacturers carefully selecting where module supply goes, and to whom.

Contract constraints

It is perhaps understandable then that relations have become strained and, in some instances, ultimately broken down. Maxeon's Waters describes the number of suppliers that he has heard of walking away from contracts as "stunning".

In July sister publication PV Tech broke news that Totalenergies' renewables division had launched a lawsuit against Trina Solar in the US, alleging fraud and breach of contract in relation to Master Service Agreements signed for four specific projects in the US. Totalenergies agreed to pay around US$300 million – including US$8.75 million in deposit payments – to secure delivery of nearly 1GW of solar modules between February and September 2022. The price and delivery schedules were, Totalenergies claims, locked in at the time of contract signing.

However as the upstream solar landscape shifted, both in terms of pricing and policy barriers to trade, Totalenergies alleges that Trina tried on three occasions to renegotiate the terms of the contract, eventually declaring force majeure. Totalenergies rejected the claim for force majeure, insisting that because Trina had suggested specific PV capacity was reserved upon signing of the contract, there were insufficient grounds.

Trina disputes Totalenergies' version of events and in a statement issued to PV Tech, rejected "completely and utterly, any allegation of 'breach of contract' or 'fraud'" before insisting it will "defend its position in the appropriate manner". PV Tech Power understands that there is no timeline attached to any resolution to the dispute, with meetings between the parties expected later this year.

One distributor spoken to for this article said that it is now not unusual for prices or quantities to change in spite of sales contracts having been signed, some many months in advance of delivery. Whereas this was "previously unheard of", it is now considered far more common, with manufacturers being able to adopt a "take it or leave it approach", safe in the knowledge that someone, somewhere will probably accept those terms.

Evidently, certain parts of the solar value chain will be at loggerheads over what grounds, exactly, constitute force majeure. The pace of change within solar's upstream – the industry average price for polysilicon increased by more than 18% in just three months between May and July this year – has also meant that a contract signed one month could be uneconomical the very next.

This much has been borne out in manufacturer results. The last two years have seen module manufacturers battling to maintain supply margins at a somewhat comparable level to what has historically been achieved, with differing results.

> "The customer is never going to tell you they're happy with prices increase, but they do understand it now."

As such, contracts are now being drawn up in such a way that protects manufacturers from significant fluctuations not just in the price of raw materials and components, but policy risk too. At the manufacturer's Q1 2022 results disclosure in May this year, Canadian Solar revealed – to some surprise – that it was still shipping to the US market from facilities based in Southeast Asia despite the continued uncertainty surrounding the anti-dumping and countervailing investigation launched by the Department of Commerce. The results of that investigation had the potential to see tariffs of up to 250% imposed retrospectively, leading many manufacturers to cease shipments to the US altogether.

Rather than cease shipments, Canadian Solar altered contractual conditions to share elements of that risk, with US developers paying premium prices. Canadian Solar also included a clause which states that the manufacturer can terminate shipments altogether if tariffs veered "outside of certain lines". The risk premium paid by manufacturers varied, but served to protect Canadian Solar from uneconomical contracts while allowing developers to secure module supply at an incredibly fraught time, albeit at a price that may have hit their bottom lines.

With module prices on the up and contractual terms rewritten, Canadian Solar witnessed the margin of its upstream division rise by five percentage points year-on-year in Q1 2022 to 14.5%, a figure which is broadly expected to remain the same throughout this financial year.

A seller's market

Soaring demand coupled with a constrained supply has led the solar market to flip to a seller's market almost overnight. PV Tech head of market research Finlay Colville has written extensively on the subject this year, stating that whereas previous annual solar install figures were dictated largely by demand for modules – driven in turn largely by national policy – for the foreseeable future it will be driven entirely by the industry's total manufacturing output.

"It's very clearly a seller's market at the global level, and it lays bare the power dynamics at play in the industry globally, and the limitations of influence within that at times," one industry stakeholder, who wished to remain anonymous, says. That more significant industry players have been able to secure supply – as evidenced by contract announcements of the last year – would be testament to how module procurement is quickly becoming limited to those with balance sheets to buy gigawatts, and not just megawatts, at a time.

The unfortunate conclusion to reach is that these dynamics will be in place for at least the short-term, or as long as it takes significant polysilicon capacity to come onstream and – in the medium-term – supply chains to be established outside of China.

There are signs of encouragement, however. That manufacturers, developers and distributors alike all speak of healthier, more transparent relationships being formed throughout the last 18 months can only be a source of optimism. ■

ESG strategy for PV development: essential considerations for the solar industry

ESG | ESG is now at the centre of many investor requirements when it comes to finalising deals, and while solar is obviously a destination of choice from an environmental perspective, that is only part of the puzzle. Galp's head of Renewable Energy Innovation Centre Emilien Simonot and its environment and CSR manager Claudia Montenegro detail the essential considerations for the solar industry from an ESG perspective.

Credit: Galp Energia.

Livestock grazing next to a solar project from Galp in Spain.

The importance of environmental, social and governance (ESG) strategy for businesses worldwide has gained higher relevance in recent years, due to the growing importance of non-financial metrics in qualifying projects, companies or initiatives.

While renewables in general and solar PV in particular are already well positioned to contribute to the energy transition, they are not without their own challenges. The sector is working towards the incorporation of better practices however, especially as renewable project development is speeding up. In this context the PV value chain is experiencing a series of challenges both globally and locally with regards to ESG.

PV sector ESG challenges

In the past, the acceleration of PV installation rates in all segments, utility-scale solar or self-consumption, has come together with the necessary development of the supply chains for PV equipment as well as the adequate global logistics network. This has led to several situations and challenges related to the supply of equipment and, in particular, modules, where buyers and end users, especially in the EU have become vulnerable to changes in delivery conditions, all in all affecting the profitability of the projects and increasing risks.

As PV has now become a strategic value chain for the future of energy supply globally, triggered by the current and short-term fossil energy market challenges and their longer term expected phasing out, governments and policymakers should act accordingly to reduce the current vulnerability of supply chains and to develop more resilient options.

On the other side, with PV ramping up strongly and becoming a mainstream power generation technology, it is to be noted that the current socio-environmental footprint has also recently raised questions that must be considered as countries and the private sector are developing the future supply chain needed to cover a market that will keep growing in all geographies. Questions like resilience of supply, CO2 footprint, natural resources, biodiversity and labour conditions will all contribute to the competitiveness and reputation of the whole PV value chain.

At the other end of the value chain, PV power plants and solar farms are being deployed at a high pace, often representing the materialisation of government and private sector commitment to mitigate global warming impacts. Those industrial projects are very strictly regulated and required to be duly authorised from several administrations. While the first plants were celebrated under the prisms of innovation or climate action, the real and material switch from fossil-based generation to low carbon and renewables will require a massive deployment of distributed infrastructure across rural territories, not only the vast areas of land to be used for renewable generation but also the necessary evacuation infrastructure, like power lines. In countries where the PV sector is most advanced, like southern European countries, these sometimes-rapid developments start to generate some rejection from local communities concerned about the social or biodiversity impacts.

Galp's approach to ESG

Galp is a recent player in the field, having started deployment of renewable capacity in 2019, but is already a top three operator of PV installations in the Iberian Peninsula with a development pipeline across the EU and Latin America.

In our last strategy refresh, the accent was put on the integration of fundamental principles of sustainability into our culture, strategy, management and activities as well as in refreshing our relationship with society and communities and providing innovative energy solutions and technological development, whilst caring for the people and the planet.

A consequence of this is the integration of ESG requirements into our decision-making processes through all our organisational units that are associated with the development stages across the full project lifecycle

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in order to ensure alignment with sustainability strategy, commitments and targets.

These commitments answer the material issues and Sustainable Development Goals (SDGs), particularly those which Galp's operations impact the most, since they are shared and integrated in its everyday activity: (SDG7) affordable and clean energy, (SDG8) decent work and economic growth, (SDG9) industry, innovation and infrastructure, (SDG12) responsible consumption and production, (SDG13) climate action and (SDG17) partnerships for the goals.

Applying sustainability principles to everything we do is the responsible way in which we want to operate in the renewables business. We are developing projects that promote social and environmental positive impact and improve stakeholder engagement. At the same time, we are reinforcing the internal corporate culture of environmental and social responsibility, helping to consolidate Galp's reputation for sustainable development and energy transition.

At the governance level, we integrate sustainability principles into the Galp Group management process, promoting industry best practices in all of its activities, with a view to long-term value creation. Galp has several specialised committees that assist the company's day-to-day management by implementing and ensuring certain practices and principles underlying our corporate strategy, including sustainability and innovation.

We also work in partnerships, sharing the value we create with society. Galp believes that it is well positioned for the future, guided by its sustainability commitments, approved by senior management and understood throughout our organisation.

Answers to solar's ESG challenges

Based on our ESG approach, we are building a general sustainability strategy, which will apply to all portfolios of renewables projects. This strategy is sponsored by top management and supported by a multi-disciplinary team. A special focus is put on innovation to continuously enrich the approach and develop initiatives enabled by third parties that can add values, skills and competencies, with the goal to create value for the communities in a structured, systematic and replicable way.

The strategy is articulated along the following dimensions:

- Creation of shared value for our host communities to achieve a just energy transition
- Ecosystem respect and integration of our activities
- Supply chain excellence approach promoting circularity principles and good practices
- Innovation: we truly believe that we can develop, test and incorporate new solutions to enrich our vision and practices

For this we are acting in different fields, leveraging science, education and training, access to clean and reliable energy solutions and improving the application of circularity principles beyond others. This work is a unique opportunity to diversify our understanding of our projects and portfolio: besides the classical financial and technical perspectives, we now have also understanding of our impacts on the local economy, biodiversity and social dynamics and we can develop solutions and concepts for mitigation actions (no net loss) with the ambition to reach net gain (i.e. proactive biodiversity improvement actions)

An important part of our strategy is its structured approach and its "replicability by design". Especially when it comes to our work with communities, replicability is a key parameter to ensure an impact everywhere we go and at scale. For this, we consider the following areas of work:

- Access to sustainable energy solutions: as an integrated energy company developing and commercialising products in the whole energy value chain, we develop specific actions and special offers to ensure that our host communities can access them: solar rooftop self-consumption installations, low-carbon mobility solutions, etc.
- Education and capacity building in a win-win approach as the massive deployment of renewables will bring strong needs for trained staff.
- Ecosystem integration through the elaboration and incorporation of best-in-class renaturalisation techniques in partnership with local specialists (universities and research centres) as well as the testing of agrivoltaics solutions

Besides these, we also acknowledge that every community is different and has its own needs. Therefore, our local managers have the mandate to interact with local authorities or entities (associations, charities, etc.) to identify meaningful projects aligned with our goal to "promote a fair and just energy transition". Galp aims to raise awareness and enable local communities to understand what a just and fair energy transition means at their level; in their context and the changes it supposes in their daily life. This empowers them to understand the changes needed and the shift to action. Proposing support along this process and materialising it through real and concrete projects turned Galp into a change originator.

Regarding the value chain challenges, Galp does consider them as an extremely relevant area that requires action. Galp is already including high selection standards in its procurement processes for PV equipment, but we acknowledge that individual and isolated initiatives will not bring significant solutions in the timeframe needed. We are supportive of the diversification of the supply chain to mitigate the current risks linked to supply, and we observe with interest policy-making moves for the reshoring of the value chain in geographies like the US or the EU.

PV is becoming a mainstream source of power generation, as it is the cheapest source of energy on earth, it is adaptable and highly scalable. While it is variable, it can be hybridised with wind or storage technologies to deliver clean power at scale. For PV to have it all, the ESG challenges addressed in this piece must be applicable throughout the whole life cycle of projects so they do not convert into business risks that could hinder the swift development of this amazing power generation technologies.

While we have reviewed how a company like Galp is approaching those challenges, we also acknowledge the limitations of an isolated approach as those challenges have to be solved by the sector as a whole, including not only companies and private sector but also policy makers and society as a whole. ■

Authors

Claudia Montenegro has more than 20 years of experience working in the energy industry. Claudia is currently environmental and social responsibility manager at Galp Renewables, having had a diversified set of roles in Galp related to sustainability, climate change challenges, environment and biodiversity protection, circular economy and social responsibility. Before that she worked as project engineer, coordinating and executing industrial and environmental licensing processes for large scale industrial facilities, and being responsible for the implementation of safety, health and environmental management systems.

Emilien Simonot is head of Galp's Renewable Energy Innovation Centre. Before joining the company in 2021, he occupied several positions at the crossroads of innovation and sustainable energy across the EU. Emilien pushes the competitiveness of existing renewables and enables new sustainability energy solutions, from power generation, storage to end use.

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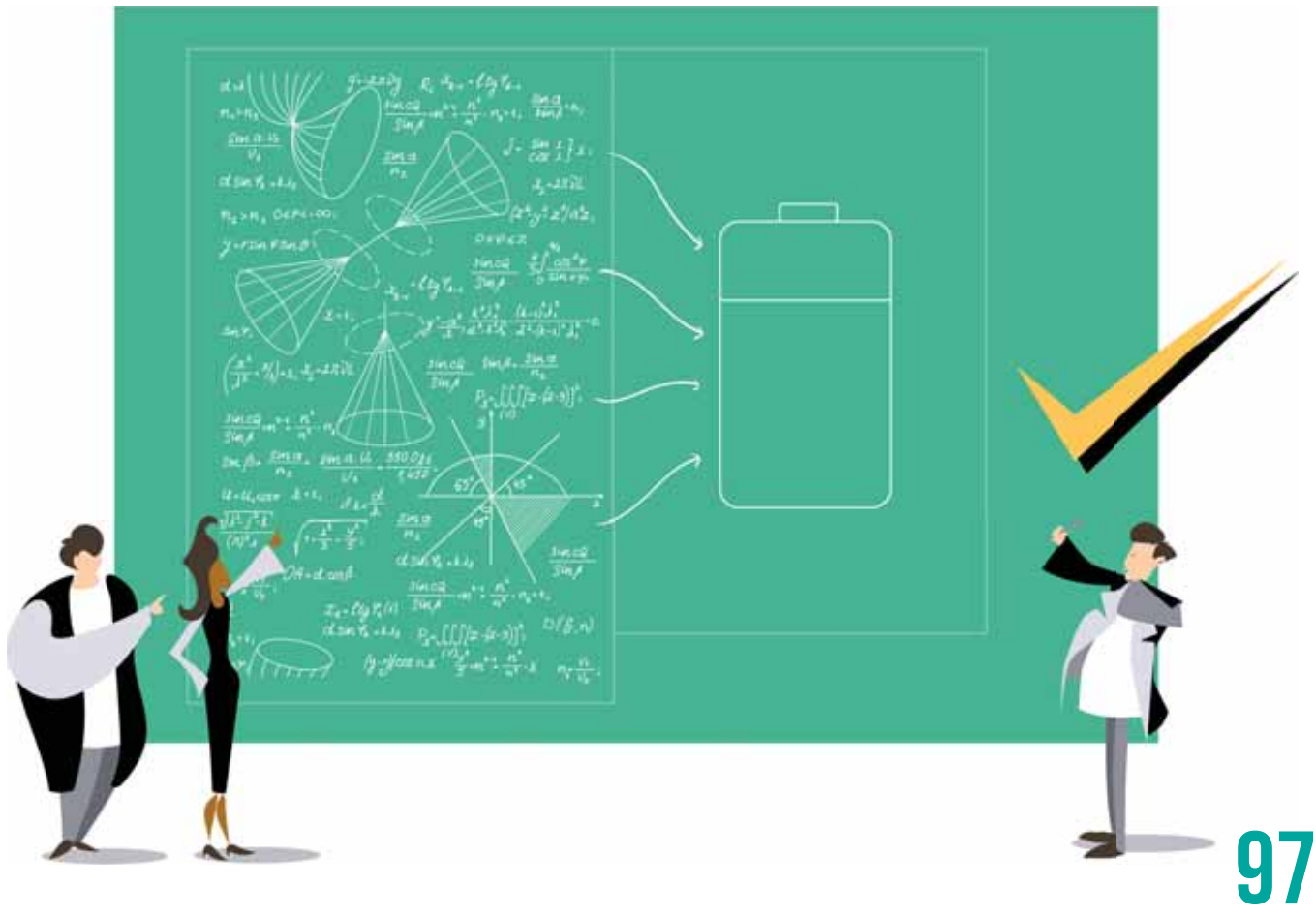

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Introduction

Welcome to another edition of Storage & Smart Power, brought to you by the team at Energy-Storage.news.

As journalists, we're traditionally accustomed to describing August as 'silly season'. In almost every industry, the flow of news slows down as the peak of the northern hemisphere's summer arrives. Newspapers give over precious column inches to stories of cats stuck in trees and other things that they'd normally never consider printing.

For the last two years, that hasn't happened for us at all. Everything has kept going. Contracts are being signed with utilities and other off-takers, projects continue to be announced and innovation and R&D departments keep innovating, researching, and developing.

Part of that perhaps is the pandemic having disrupted the ordinary rhythms and ways of working we were used to. But a bigger part is that the energy transition never sleeps and it rarely if ever takes a vacation.

This July and August saw possibly the biggest story roll through that I've covered in my nine years with Solar Media, certainly the biggest in terms of US news. I'm talking of course about the Inflation Reduction Act and the way it has finally brought about the one thing I've consistently heard the US industry ask for the most: the standalone energy storage investment tax credit (ITC).

I think it's fair to say we're all excited about that, although there is still the matter of the details of how the ITC and the other billions of dollars-worth of clean energy support in the Act will be applied. We look forward to engaging with you, the industry, to learn what you think about it, how it will affect your business plans and ultimately to see if it delivers on the anti-inflationary, clean air, climate crisis mitigation and energy security promises made.

The excitement in these months has not been limited to the US by any means. We're seeing immense pick up in activity in India and Australia and expecting great things to come in markets like Southeast Asia, Japan, and Latin America. Energy storage has a role to play in every energy transition, in every country.

Speaking of which, in this edition, Energy-Storage.news reporter Cameron Murray looks at what's happening in Germany. After a strong early lead in solar PV was followed up by early adopter interest in grid-scale batteries, activity in the market has gone very quiet. Now however, as Cameron finds out in his article, many are tipping Germany to make a return to action, with new market opportunities and a more welcoming regulatory and policy space.

Following on from my look at the 'great disconnect' between raw materials supply and battery storage deployment in Volume 31, in this issue I speak to various commentators and experts about how the dynamics will play out over the longer term, and what is being done to mitigate constraints that have caused costs to rise and projects to be delayed.

Finally, Dr Kai-Philipp Kairies from ACCURE Battery Intelligence explains the role that battery analytics play in making lithium-ion a safer technology to work with. ACCURE has worked directly with manufacturers and integrators in both stationary storage and electric mobility and Dr Kai-Philipp has been able to draw on those real-world experiences in shaping his article.

I'd like to take this opportunity to thank everyone that worked with our team to bring these articles to you, from interviewees to contributors.

As mentioned elsewhere in Jules Scully's introduction to the main journal, our editor-in-chief Liam Stoker has left to work in pastures new and I'd also like to thank Liam for his leadership and hard work over the years.

To paraphrase a quote from Noel Bakhtian of Berkeley Lab, the climate crisis has no borders. Water and air have no borders. These problems we face as a species and a planet are not unique to any one of us or any one group of people. As an industry, as human beings, we are capable of facing them together. Together we are also better equipped to face them.

Andy Colthorpe
Solar Media

Biden's signature brings standalone storage ITC to life

US President Joe Biden signed the Inflation Reduction Act on 16 August, bringing with it tax incentives and other measures widely expected to significantly boost prospects for energy storage deployment.

Its US$369 billion investment in energy security and climate change mitigation targets a 40% reduction in greenhouse gas (GHG) levels by 2030, supporting electric vehicles (EVs), energy efficiency and building electrification, wind, solar PV, green hydrogen, battery storage and other technologies.

Most directly relevant to the downstream energy storage industry is the introduction of an investment tax credit (ITC) for standalone energy storage. That can lower the capital cost of equipment by about 30%, although under some prevailing conditions it will be more or less, depending on, for example, use of local unionised labour.

Credit: NASA

Enervenue is commercialising a low-cost version of nickel-hydrogen batteries used at the International Space Station (pictured).

Metal-hydrogen battery going into high-volume production

Startup Enervenue has already got 5GWh of customer orders for its metal-hydrogen battery for stationary storage, with a 25GWh opportunity pipeline in North America alone.

The company is rapidly commercialising its batteries, which are a low-cost, durable version of a technology used in space applications like on the International Space Station and the Hubble telescope.

High-volume production is expected to begin before the end of this year and a gigafactory is being planned, mass producing 1.2kWh vessels which can be stacked together to make systems for grid-scale or distributed energy applications.

Claimed advantages include the ability to operate in ambient temperatures from -40°C to 60°C for a 30-year lifespan or roughly 30,000 cycles without degradation and at charge and discharge rates from C/10+ to 5C.

World's biggest battery storage system back online

Moss Landing Energy Storage Facility, at 400MW/1,600MWh the world's biggest battery energy storage system (BESS) project so far, is back online.

Owner Vistra Energy had called a temporary halt to its operation and market participation after battery overheating incidents at both phases of the project.

The 300MW/1,200MWh Phase I, commissioned in December 2020, went out of action after a September 2021 incident, while Phase II's separate 100MW output and 400MWh of capacity went online a month before that incident, only to be also switched off in February this year.

Vistra said in July that a successful restart had been carried out with more than 98% of the total 400MW storing energy and releasing it to California's CAISO grid.

BESS cost base 'has gone up 25% year-on-year'

Battery energy storage systems (BESS) cost base has increased 25% in the past year, according to the head of storage for global energy technology group Wärtsilä.

"We're looking at a 25% (+/-) increase in the cost base of BESS systems versus one year ago. There are inflationary pressures across the whole system, but this magnitude of increase is really being driven by the battery cells," said Wärtsilä's VP energy storage & optimisation Andy Tang in mid-July.

Tang characterised the ongoing issues as the result of a confluence of multiple events. The jump in battery cell prices has affected the cost structure of a typical BESS solution too. Taking last year's costs as a baseline, battery cells increase to close to 70% of balance of plant (BOP) costs when a lithium-ion BESS goes to four hours' duration.

First grid-connected utility-scale solar-plus-storage project in Sub-Saharan Africa

A solar and storage project totalling 20MW has entered commercial operation in Malawi, claimed as the first grid-connected utility-scale co-located project to do so in sub-Saharan Africa.

Independent power producer JCM Power and infrastructure investor InfraCo Africa brought the Golomoti Solar PV and Battery Energy Storage project in the Dedza district of the country online in a little under 12 months of construction.

The project pairs a 28.5MWp solar farm with a 5MW/10MWh lithium-ion battery energy storage system (BESS) supplied by Sungrow. The BESS portion of the project received financial support from the Energy Catalyst programme of Innovate UK, the UK's innovation agency. It will smooth out intermittency of the solar farm as well as provide frequency response services to the grid.

First phase of 800MWh world biggest flow battery commissioned in China

Commissioning has taken place of a 100MW/400MWh vanadium redox flow battery (VRFB) energy storage system in Dalian, China.

The biggest project of its type in the world today, the VRFB project's planning, design and construction has taken six years. It was connected to the Dalian grid in late May. It will contribute to lowering the peak load on the grid in Dalian City and could even play a role at provincial level, improving power supply and the capability to connect new generation sources like renewable energy to the grid.

VRFB developer and manufacturer Rongke Power, a spin-off from the Dalian Institute of Chemical Physics of the Chinese Academy of Sciences supplied the battery. A demonstration project and part of a wave of large-scale VRFBs China is looking to deploy, a second phase will bring it up to 200MW/800MWh.

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Is the German utility-scale energy storage market set to take off?

Germany | Germany's early lead among Europe's battery storage adopters is now long gone. But with the urgency to deploy renewable energy compounded by the need for greater energy independence, some industry players and experts see change coming on the horizon, Cameron Murray writes.

As by far Europe's largest economy, the German market is usually on the radar of businesses in any fast-growing and internationalising sector. But when it comes to large-scale front-of-meter battery storage projects, its deployment figures for 2021 lagged far behind the UK, Ireland and France.

The residential sector has conversely always been very strong, as homeowners increasingly seek to back up their home PV systems. But just 32MW of utility-scale (1MW-plus) projects were installed in the country in 2021, according to a recent report by a group of RWTH Aachen University-based and spinout organisations. However, the situation is starting to change, one of its authors tells *PV Tech Power*.

"The large-scale market is gaining traction, with different drivers from previous years. You have big Innovation Tenders for co-located sites, you have many industrial sites installing MW-plus systems and you also have the Grid Boosters which will provide a huge boost to the market," says Jan Figgener, head of grid integration and storage system analysis at ISEA RWTH Aachen University.

People see the German market now as 'boiling' and want to be there early, adds Florian Mayr, partner at clean energy finance and strategy consultancy Apricum.

Two companies which were part of the start of the energy storage boom in the UK, investor Gore Street Capital and renewables developer Anesco, entered the German market in quarter one 2022. In June, Swiss Life Asset Managers, which has US$290 billion of investments, joined them when it acquired a platform with a 220MW BESS pipeline.

But this bullishness isn't necessarily widely shared. Claus Urbanke, head of wind and solar Germany for Norwegian hydropower company Statkraft, says that the short-term storage needs of the market are limited and that Statkraft does not currently see a commercial case for standalone battery energy storage, although it is participating in the Innovation Tenders from federal network operator Bundesnetzagentur for co-location, explained later.

Jorg Blaurock, partner at 3Energie Consulting which produces annual reports on the storage sector for national storage association BVES, agrees to an extent. He says that Germany does not need any more energy storage for grid stability as its needs are already well served by existing assets and interconnection with other countries, and that the main driver is opportunities in the wholesale energy market capitalising on increased volatility.

Where are we today?

One big reason why the German battery energy storage market has not taken off yet is because of a relatively small grid frequency services market, typically the first driver for battery storage because of its stable revenue guarantees. This relates to Germany's greater array of options for grid flexibility, including numerous interconnectors to other national grids.

Value stacking is also more difficult due to unfavourable regulatory conditions. This stems from the existing regulatory definitions for storage assets being inadequate according to BVES, although should change going forward after new definitions were brought into German law in May 2022.

Frequency containment reserve (FCR) is the main ancillary service for batteries to play in, but the 550-600MW market is close to saturation with around 600MW of utility-scale battery energy storage installed at the time of writing, according to project developer ECO STOR.

FCR will soon be replaced by aFRR, which will help make the service more international amongst Europe's interconnected markets, although will not on its own increase the size of the market, points out Statkraft's Urbanke.

"There was a short time when these (short duration storage) projects were commercially viable in primary reserve (FCR), but since this is such a small segment of the market which got exploited quickly, this opportunity doesn't exist anymore," he says.

Credit: RWE

A 4.5MWh BESS using Audi EV batteries brought online by RWE in January 2022.

The period he refers to is around 2018 when nearly 200MW of utility-scale battery storage was installed according to Delta-EE, a record year for the sector. But the market slowed substantially in 2020 and 2021 as FCR was increasingly saturated.

The largest operational battery storage system in Germany today is the Lausitz Battery Energy Storage System at 60MW/52MWh, attached to a coal plant operated by power plant operator and utility LEAG. LEAG, RWE and other large utilities have been the main players installing large systems to-date, says Lars Fallant, COO of project developer Tricera Energy.

These are market-driven projects, he adds, capitalising on grid frequency services and trading opportunities. These, plus the Innovation Tenders incentivising co-located storage projects and a handful of massive 'Grid Booster' storage tenders are the main drivers of the market going forward, according to all the sources we interviewed.

'Ukraine has amplified the drivers': ancillary services and short-term trading

Along with the rest of the European Union, Germany recently upped its renewable energy targets for 2030 to reduce reliance more quickly on Russian fossil fuels after its

Credit: Smart Power.

The Smareg 4 project in Eisenach, Germany, developed by Smart Power and recently acquired by BCP Battery

invasion of Ukraine. Energy storage will be needed to integrate those new resources onto the grid.

"The invasion amplified the existing factors driving the storage market, especially for big industrial sites and other renewable energy installations as everyone knows now we need independence from Russian gas. And those renewable energy assets will need batteries," says Figgener.

To achieve a renewable mix of 80% by 2030, the new target, Germany will need 84GWh of additional energy storage, all batteries, according to the Fraunhofer Institute for Solar Energy Systems.

As more renewable resources come onto the grid, this will increase market volatility which in turn creates an opportunity for battery storage to capitalise in short-term trading markets. Delta-EE anticipates that this ramp-up in storage will start in 2025 although the numbers it is expecting are still far below what is needed. It expects around 450MW of additions in 2025 growing (with a dip in 2026) to around 800MW in 2030.

But even before any ramp-up of renewable resource deployment happens - it's still early days - the existing revenue opportunities for storage have increased substantially, says Georg Gallmetzer, managing director of ECO STOR. And that is despite a revenue source that has historically made up half of the value stack for big batteries no longer being available for projects being commissioned after 2022.

He says that the prices in the auxiliary (ancillary) service markets and spreads in short-term trading have multiplied so much recently that the business model is stronger than last year, even with a 30% increase in material costs due to supply chain constraints (lithium-ion batteries, transformers, concrete and building work etc).

Fallant partially agrees: "The frequency response and energy trading markets have increased recently, but most owners go for frequency response because it ages the battery less quickly because of shallower cycling. But the outlook is that batteries will do more energy trading, although no one knows exactly where the prices will go."

Gallmetzer agrees that most systems focus on frequency response because of the less heavy cycling. But heavy cycling activities like energy trading will increasingly deliver higher profits and investor returns over time, he claims.

Because growth in energy storage will never keep up with growth in renewables, according to Gallmetzer, opportunities for storage in trading and grid services will continue to increase until the 2030s or 2040s when batteries may eventually begin to cannibalise their revenue opportunities.

Innovation Tenders

Another driver of the storage market is the Innovation Tender mentioned earlier, which was first brought in for renewable generation but recent ones for projects that combine two different clean energy resources will see the first winning sites commissioned in 2023. All the winners from the tenders in May and August 2021 were solar-plus-storage projects.

Winning projects get an additional fixed market premium per kWh of energy provided to offset technology investment costs. Statkraft is deploying a 20MW solar, 7MW lithium-ion storage project through the tender and will participate in others.

"The storage project for the Innovation Tender will effectively be a peak shaver function for the PV plant because, and this is due to the way the tender is designed, you can only inject the storage system with kilowatt-hours which are produced by the PV plant. So, every day you would inject the cheapest hours and then you would dispatch to the grid during the most expensive hours when the plant doesn't produce any more, so typically during the evening," Urbanke said.

But, he added, the requirement for storage to only charge from the generation asset was not the most optimal solution.

Fallant agreed, saying it was a "...big disadvantage as the usability of the battery

Credit: TESVOLT.

German ESS maker TESVOLT mainly targets the C&I market. Behind-the-meter residential and commercial continue to outshine the utility-scale segment.

storage is very limited for this application". Nonetheless, these tenders have been called a bright spot in the relatively subdued German market.

Grid Boosters

Two of Germany's big four transmission grid operators, TenneT and TransnetBW, have announced plans to launch 'Grid Booster' ('Netzbooster' in German) projects in which large battery storage systems will be installed at vulnerable locations on the grid.

The aim of these is to reduce redispatch costs and defer some of the mass of new cable investments the country needs to integrate new renewable energy resources. In general, Germany's renewable generation is in the windy north while consumer needs are in the more densely populated south.

Batteries can help mitigate the issues in ensuring the smooth shift of energy across the country by, for example, being placed at both ends of a grid congestion point, acting as a virtual power line.

According to the latest announcements, Transnet's will be 250MW while TenneT is planning two of 100MW each (all one-hour systems). They are set to be commissioned in 2025 although project development tenders or firm dates have not yet been announced.

Figgener expects these tenders to happen in 2023 and points out that although they are few in number, they will significantly boost the utility-scale storage market. If they went online today, they would increase the size of the utility-scale battery storage market by two-thirds in one swoop.

Looking forward

"Why do you think Germany doesn't have 100-200MW projects like the UK, and when do you think it will?" was a question put to the PV Tech Power team by a German delegate at Intersolar Munich in May this year, to which the short answer was 'very soon'.

Gallmetzer says the move to larger projects has simply needed investors to try smaller projects first, to get experience in the sector before scaling up. Siemens and Fluence announced plans to build a 100MW/200MWh battery in Wunsiedel although have not given a delivery date. RWE expects a 72MW project to come online in late 2022 while ECO STOR will build a 100MW/200MWh system for commissioning in 2024.

Gallmetzer tells PV Tech Power that the main limitation for Germany achieving its storage deployment targets is not finance, nor materials, nor grid access.

"The actual limitation of growth of the German storage market is the number of teams and players on the market and their output capability for developing and deploying large-scale storage projects," he says.

"I think with the existing players we could get to 30-50GWh by 2030, but not 100GWh. But even with 40-45% renewable share today batteries see a tremendous profit opportunity on the short term (trading) markets."

The entry of international investors and developers like Gore Street Capital and Anesco should help here but the expected shortfall based on ECO STOR and Delta-EE's numbers seems insurmountable by battery storage alone.

Some of that shortfall could be made up for by green hydrogen, which we hear the energy community in Germany is very bullish on, although this is mostly focusing on using it as feedstock for industry. A second use will be for transportation and then lastly using it for power-to-gas-to-power electricity energy storage will be considered, although the economics of this don't yet stack up.

Germany is so bullish on the technology that buyers of energy storage solutions (ESS) do not even consider flow batteries as an option for medium-to-long duration solutions, according to one provider who was speaking anonymously.

New definition for energy storage

In recent news, the German parliament amended several laws relating to energy and the electricity grid which officially recognised energy storage as a resource where the "final use of electrical energy is postponed to a later point in time than when it was generated" (a direct translation).

This may finally mark the end of energy storage assets being treated as a generating resource when discharging and a consumer of electricity when charging, although the immediate effect is negligible or unclear.

The significance of it is that future regulations can be formulated to be much more friendly to energy storage. Until now, sources have described Germany's regulatory framework for storage as unfavourable, complex and full of hurdles and insecurity, as rules were always defined for traditional energy assets.

Credit: Cameron Murray / Solar Media.

Tricera Energy exhibiting at Intersolar / ees Europe in Munich in May 2022.

But Gallmetzer says it is difficult to evaluate the significance of the move because of the complexity of the topic and the fact its contents may change as it passes through the Bundesrat.

Residential, commercial & industrial to continue dominating the market, but to what extent?

All reports providing forward forecasts on the German energy storage market estimate that the residential and commercial & industrial (C&I) sectors will continue to account for the vast majority of storage deployments.

Blaurock says that one driver of households and businesses wanting to become energy-independent is the negative reputation that big energy groups have developed, due to windfall profits whilst energy prices have been high.

Another is that solar energy is relatively cheap, and regulators have simplified the process for installing on-site solar resources, which has in turn helped the associated on-site energy storage market to kick on.

Although it's to be expected, BESS developers say that the utility-scale storage market's future growth is being underestimated. This is both because of difficulties in forecasting the opportunities in energy trading several years down the line, and an under-reporting of planned projects.

Conclusion

It's clear that Germany's need for energy storage is likely to grow substantially as more renewable resources are integrated into the grid. Whether there is enough capital, grid access and development capacity to deliver the quantity of utility-scale projects is far from certain, however.

Unless we start to see a lot more project developers enter the market, the sector is likely to continue to be driven by small-scale projects purchased by homes and businesses and may fall well short of the sorts of figures industry actors claim are needed. ■

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Bridging the gap between battery supply and energy storage demand

Supply chain | The mismatch between supply and demand for lithium batteries presents a challenge to the global transition to sustainable energy and the role energy storage will play in it. Andy Colthorpe hears how the dynamics are playing out, and how the challenge can be overcome.

Credit: Imperial County Executive Board.

In the last edition of PV Tech Power, we took a dive into how various factors, both expected and unexpected, have caused disruptions in the supply chain for stationary energy storage.

Coupled with global economic and political factors, phenomenal rise in demand for lithium batteries, led primarily by the electric mobility sector, is leading to constraints, in turn delaying projects and investment decisions.

This time, we ask what mitigating strategies can be taken, from startups looking to deploy storage, to politicians looking to support the growth of economies based around clean energy.

The big picture

As second half of this year began, lithium carbonate pricing remained the main concern, according to Cormac O'Laire, senior manager for market intelligence with Clean Energy Associates (CEA). Even as additional lithium mining projects come online in Q4 2022, CEA expects supply will remain tight.

"To address potential lithium shortages, battery and nickel manganese cobalt (NMC) cathode makers are entering into long-term agreements with lithium miners. The price of commodity metals such as nickel and cobalt have begun to ease following significant volatility after Russia's invasion of Ukraine sparked nickel and copper supply fears," O'Laire says.

California's Salton Sea holds an opportunity to develop geothermal brine extraction from a region dubbed 'Lithium Valley'. Credit: Imperial County Board of Supervisors.

Credit: Controlled Thermal Resources.

Artist impression of how co-located geothermal power generation and lithium extraction could look in Lithium Valley.

While the price trends of those commodity metals are expected to "remain flat until the end of the year," investment in battery raw materials mining in general is "woefully underfunded," with CEA forecasting that about US$5 billion will have been spent in this area during 2022 worldwide.

Whereas, to quote Battery Metals Review analyst Matt Fernley's forecasted figures, US$15 billion annual investment is required to meet battery demand just from electric vehicles (EVs) by 2030.

"More investment in raw materials, and particularly in lithium, is required by both governments and the private sector to resolve looming supply-demand constraints," O'Laire says.

Further downstream, in China, battery energy storage system-specific (BESS) cell factories are being built that will take the country's annual production capacity to more than 200GWh, which "should be enough" to meet global demand up to 2025. In Europe and the US however, BESS cell projects are taking place, but to a much smaller extent and would not be able to meet demand independent of China, according to the analyst.

Meanwhile, over 5 million tonnes of lithium iron phosphate (LFP) BESS cathode active material (CAM) capacity expansions have been announced in China, about 2TWh of CAM, which will far exceed projected demand by 2025. So, there's a chance, a "serious possibility" even, that LFP will be a surplus market as early as 2024, O'Laire says.

Startups vs big players

Some industry players believe the situation is beginning to ease, especially regarding the impact of COVID-19 on logistics.

Some calming of price volatility makes it likely BESS project developers will start to be able to consider Final Investment Decisions during Q3 2022, CEA analysis has indicated.

After some of the biggest price increases in years, prices for key battery metals like cobalt, lithium and nickel have "turned the corner". With lithium chemical prices having the greatest impact among those commodity costs, CEA is expecting lithium prices to remain relatively flat, below the highs that were seen earlier this year, for at least the rest of 2022.

Supply-demand balance will remain precarious however, from Q4 into Q1 2023, and that could drive prices up into the New Year, according to Cormac O'Laire and his team.

The short-term disruption means the storage industry has had to swallow rising costs of batteries or pass them onto customers.

The good news appears to be that not many report a fall in demand, despite some introducing raw material index (RMI) based pricing, following the lead of the EV industry.

"Index-based pricing is a tool that was used in the past when lithium prices and demand were low to protect lithium miners. More recently battery manufacturers and miners are using index contracts alike to share price risks and secure supply," O'Laire says.

Index pricing helps protect developers against securing long-term contracts at high pricing, but that also makes it difficult for them to get visibility over their medium-term pricing forecasts or long-term purchase agreements.

Yet index-based pricing is likely to be in place in supply contracts across the industry for the foreseeable future, and in the US industry, that means BESS investors and stakeholders will need to develop finance strategies that include indexed agreements, CEA believes.

The impacts will likely affect bigger players in very different ways to startups. The likes of Fluence, Powin Energy and Honeywell, among the bigger system integrator and BESS manufacturers in the non-Chinese industry, have locked in deals for multiple gigawatt-hours of cell supply over several years. For smaller players, the scramble continues.

"Whoever is a small consumer of battery cells, is very much in a pickle at the moment," Dr Nicolo Campagnol, solution manager for McKinsey Battery Insights, says.

There's a need to think outside the box. One interesting thing is that companies developing second life battery solutions, repackaging used battery cells and packs from EVs into ESS applications, are flourishing, as are various second- and third-tier battery makers.

China's CATL has identified a commercialisation opportunity for sodium-ion batteries.

It's not just ESS companies. It's also in consumer electronics and even two-wheeled mobility applications. Anyone who isn't looking to buy about a gigawatt-hour of cells per year has to be agile in sourcing them and many are asking after second life or non-Tier One products, Campagnol says.

That's a freedom the smaller players and startups have that the bigger companies don't. Big, established players are still of a mindset that they need to use new, Top Tier, batteries. Yet second life batteries will have their place in the BESS sector. It may not be a dominant technology set by any means, but the McKinsey Battery Insights solution manager says it would be wrong to underplay its role, which may account for at least double-digit percentages of installations in the coming years.

Right technologies for the job

LFP is increasingly the cell chemistry of choice for BESS. In PV Tech Power Vol.31, we heard that the growing popularity of LFP for electric cars, particularly for shorter range, lower priced vehicles, erodes availability of cells for stationary storage.

Historically, NMC had been "the Gold Standard," for BESS, says Nicolo Campagnol, but this gave way to a recognition both in China and elsewhere that the less energy-dense, but cheaper, LFP could be a "great idea" for stationary storage. As CEA's Cormac O'Laire points out, China has even banned NMC for grid-scale storage over safety concerns.

Yet LFP requires a higher proportion of lithium in the cell than NMC, and lithium carbonate price rises affect LFP more than other chemistries, while growing demand from mobility means less LFP – at least until more LFP factories come online.

Unhappy with paying so much or being unable to get cells, the BESS industry and other consumers see innovation and diversification as an answer.

Some players are developing and commercialising sodium-ion cells, for example. Potentially cheaper and decoupled from demand from the EV sector, McKinsey sees the huge potential of this technology, yet, as for many other new products, only time will show whether claims of lower costs will hold true as R&D progresses and production capacity ramps up.

Looking further ahead, diversification in the BESS sector might be led by a different practical consideration, according to Steve Eglash, director of the Applied Energy Division of SLAC National Accelerator Laboratory.

SLAC, based at Stanford University, is one of three US National Laboratories based in the California Bay Area collaborating to accelerate the US battery industry.

The challenge facing stationary energy storage battery supply chains is fundamentally down to its symbiotic marriage of convenience with EVs, Eglash says. With many gigawatt-hours of batteries being made for cars, the BESS industry benefitted from the EV sector's cost reduction curves and scale.

"My feeling is that while the batteries being manufactured today are quite good, and more than sufficient for EVs, and that's why we're seeing the rapid expansion of EVs, they're still not quite what's needed for stationary storage," Eglash says.

"The thing that's limiting a more rapid growth of stationary storage is not the supply chain, but rather that we don't quite yet have the right batteries for stationary storage."

That means batteries that "maximise power density versus dollars, rather than power density versus weight, because weight matters for a vehicle, it doesn't matter for stationary [applications]," Eglash says, as well as batteries that discharge over much longer durations, anywhere from 12 to 24 or even 96 hours. Those will come, he believes, but they're not commercialised at scale yet today.

As Clean Energy Associates' Cormac O'Laire explains, the primary defining characteristic for EV batteries is energy density (watt-hours per kg) versus volumetric energy (watt-hours per litre) for ESS batteries. As the table below O'Laire provided shows, there are other differences in requirements for each application.

Battery manufacturers produce cells specific to EVs or ESS. The same cells are not used interchangeably, and Cormac O'Laire notes that even for LFP cells, the cathode

	EV batteries	ESS batteries
Service Life	5-8 years	20 years
Cycle Life	2,000	<4,000
Safety	High	Very high
Cost	Higher (80% of pack)	Lower cost (60% of BESS system)

Requirements

active material (CAM) used will differ in of terms electrolyte formation, material performance, cell capacity and charge/discharge rates. The increase in factories serving the stationary storage sector is likely to erode competition between EV and ESS from 2024 onwards.

"ESS-specific plants may alleviate current supply issues such as unfilled or cancelled supply agreements," O'Laire says.

However, both applications compete for the many of same raw materials. Higher profitability in electric cars may also steer more market actors in that direction.

Driven by a differing need, the increase in demand for long-duration energy storage, CEA thinks it likely there will be more ESS-specific energy storage technologies going forwards. Those technologies would struggle to compete for cost and scale with lithium in shorter duration applications. However, for applications that require "significantly more than four hours of storage," non-lithium technologies will have their best shot.

And ongoing lithium materials shortages and high prices mean some customers already ask Clean Energy Associates about alternatives including sodium-ion, sodium sulfur (NAS) batteries and flow batteries, particularly vanadium redox flow batteries (VRFB).

Away from China

The pandemic caused shipping delays and other logistical issues that showed how dependent global industry is on Chinese factories, technologies, and supply chains.

For the US, that's a concern given rocky relations between the two countries. But in a wider sense, dependency on any one region ties industry to a single point of failure. In the US and in Europe, there's also a desire to claw back economic competitiveness and bring at least some of the IP and manufacturing at home, or closer to home.

McKinsey Battery Insights' Nicolo Campagnol says there's a desire to onshore or nearshore production at various stages of the value chain. Fluence recently announced the opening of an ESS assembly plant in Utah, Powin Energy has partnered with a contract manufacturer based in Mexico. While many of the cells will be produced in Asia, both system integrators see it as a major step in bringing production closer to a major customer base at home.

Tony Van Buuren, deputy associate director Lawrence Livermore National Laboratory, one of the other two Bay Area national laboratories collaborating with SLAC – the other is Lawrence Berkeley (Berkeley Lab) – says innovating in the next generation of battery technologies is the best way to establish longer-term competitiveness.

"If you invest in technologies that are already going, lithium-ion technologies that are primarily in Asia right now, that is no way to repatriate. We need to innovate what the next generation of energy storage batteries are going to be," Van Buuren says.

The key word is 'leapfrog,' says Noel Bakhtian, director of Berkeley Lab Energy Storage Center. The three labs are working out how to "avoid having to spend decades on developing something" all the way from new material to commercialised product because of the manufacturing gap in-between.

One longstanding veteran of Europe's energy storage industry, Bo Normark, a strategist at European Union-backed innovation hub EITInnoEnergy said a while back that competing with China for market share is an unrealistic aim. However, Normark said, it should be unacceptable or unthinkable that Europe will capture no market share at all.

Berkeley Lab's Noel Bakhtian points out that the EU's European Battery Alliance (EBA) has already put billions into developing the continent's manufacturing ecosystem. Dozens of gigafactories are in construction or development in Europe and it's a lead Bakhtian hopes the US can follow.

European Union Commissioner Maros Sefkovic, a founder of the EBA, recently visited counterparts in Washington DC and there was talk of stronger collaboration. In the US, even before Joe Biden became president the White House's previous occupant signed off legislation to foster Critical Materials supply chains and launched the Energy Storage Grand Challenge, a competitive funding opportunity for promising long-duration energy storage tech.

Efforts have picked up pace since Biden took office. Around US$7 billion funding for batteries was unlocked by the Bipartisan Infrastructure Law. SLAC's Steve Eglash says that's "an order of magnitude greater" than existing R&D efforts in that area and emphasises that the money will go largely to industry, with the national laboratories "playing a supporting role".

There are numerous other policy initiatives, none of them bigger than the US' biggest-ever climate investment, as Biden has described it: the Inflation Reduction Act. Along with a standalone investment tax credit (ITC) to stimulate downstream demand, that key legislation will unlock support for manufacturing and R&D and includes a total US$369 billion of climate crisis mitigation and energy security pledges.

In the last edition of the journal, we heard about the "great disconnect" between raw materials supply and battery manufacturing plans, from Benchmark Mineral Intelligence analyst Caspar Rawles. There simply is no easy fix for that, but the fact is that investing in lithium and other raw materials supply is in the money, which is ironically driven by the same challenging conditions facing the market.

Today, there are efforts to develop direct lithium extraction from brine in Germany and California, to name just two examples. Lithium can be extracted in many ways, McKinsey's Nicolo Campagnol says, and through methods that have a lower footprint than others, such as geothermal brine.

"It's beautiful to see all these different technologies coming up, and many of them are actually very feasible," Campagnol says.

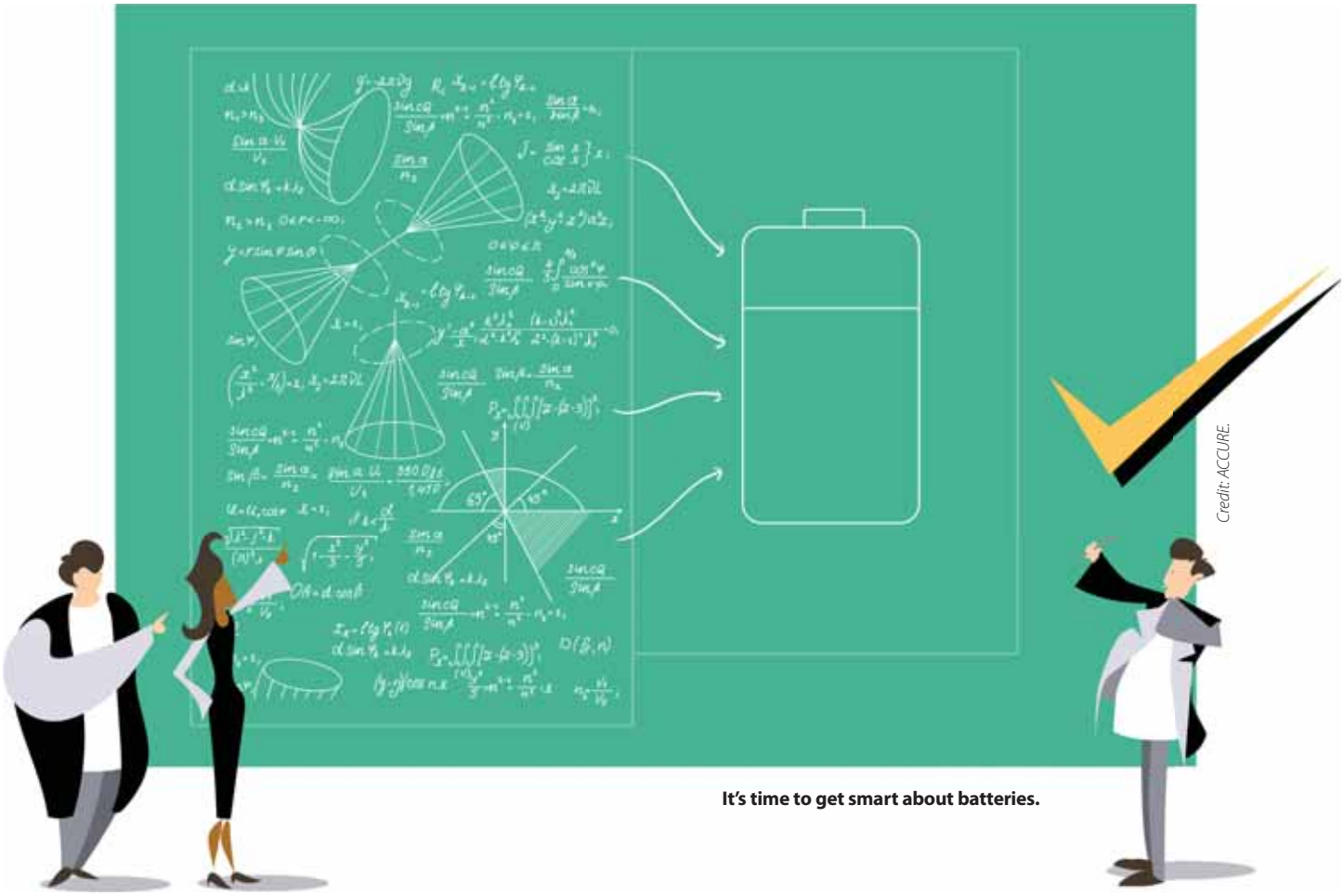
"On the other hand, not all elements can be done like this," he says, citing the example of cobalt.

"And so not all of the raw material 'basket', can be tackled with the same things. Obviously high prices will [have an] influence in general, but some elements are more prone to find a solution quicker than others."

As Noel Bakhtian from Berkeley Lab points out, the climate crisis has no borders. Water and air have no borders. Ultimately, these problems facing the energy transition are for all the world to solve together, no matter who might take the lead at any one time. ■

Battery safety - why it's important and what we can do about it

Safety | With the great demand for lithium batteries comes great responsibility to install and use them safely. Although much of that responsibility lies with manufacturers, Dr Kai-Philipp Kairies of ACCURE Battery Intelligence discusses how a combination of data gathered from the field and analytics embedded in software can make batteries safer to operate while maximising value.



Credit: ACCURE.

It's time to get smart about batteries.

The incredible success story of LIB…

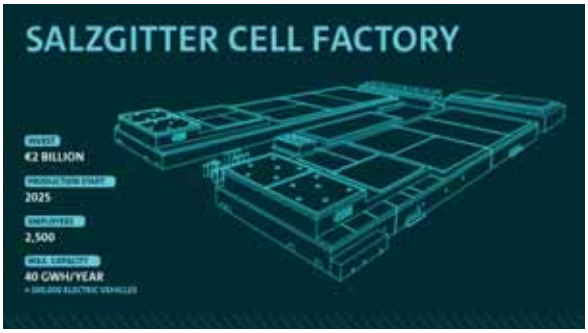
The energy and mobility world are accelerating on the path to decarbonisation. One of the most important assets for this transition are energy storage systems, particularly lithium-ion batteries (LIB). To put the incredible success of this young technology into perspective, the annual production capacity of the recently announced Volkswagen SalzGiga factory (40GWh) in Salzgitter, Germany, will be larger than the world's total LIB demand in 2013. Just let that sink in for a moment.

There are many reasons for the dominance of LIB in the energy and mobility world. One major advantage over other battery technologies is the flexibility. LIB cell types have been successfully used in electric cars, ships, buses and large-scale storage systems, allowing for synergies and scaling effects. But certainly, the strongest drivers of LIB were the stark increases in energy density and the (until recently) continuously falling prices.

…and why we need to talk about safety

The focus on ever-increasing battery energy densities and cost reductions, combined with a dizzyingly fast ramp-up of global production capacities has brought LIB into countless applications. As more industry players enter the market and deploy at a rapid pace, safety incidents also increase. Battery fires and explosions have become a regular sight in the news and on social media. Three events that caught worldwide attention:

- In 2019, a cell failure in a battery system at an APS facility in McMicken, Arizona led to a thermal runaway and ultimately caused an explosion that injured several first responders.
- Between April 2021 and May 2022,



Credit: Volkswagen.

Automaker Volkswagen's factory Germany will have annual production capacity equivalent to 2013's total global demand for lithium-ion batteries.

over 80 electric buses and 4 bus depots burned down across France, Germany, and the UK.

- Since 2020 thousands of electric scooters have caught fire around the world – some in private homes, some in warehouses.

While everyone in the industry agrees that battery safety should be the top priority, the reality is that the expectations and pressures relating to growth create conflicting priorities, in addition to the pressures to commercialise new, innovative technologies. Higher energy densities, for example, inevitably mean more energy that can fuel the fire during a failure. So, what are our options to prevent critical failures and make batteries—and clean energy—as safe as possible?

Three options for safer batteries

There are three main areas that engineers can work on to improve battery safety. These are:

1. **Production quality**
2. **System design**
3. **Cloud analytics**

In this article, we will take a quick look at production quality and system designs but take a deeper dive into cloud analytics because of the immediate results they deliver for battery safety. Their ability to go beyond the limitations of system design, the preventative advantages during battery operation, and the ease with which cloud analytics can be implemented means the benefits are highly accessible to battery operators and system integrators today. We will cover what a cloud-based battery analytics solution does, how it can be implemented and where it's used in real-world applications.

1 Production quality

To operate safely, batteries need to be produced with the utmost care and precision, from processing active materials to manufacturing the cells to assembling the pack. Any production defect can lead to unexpected (and sometimes critical) behavior years later.

The only solution to control manufacturing defects is rigorous quality management – so tighten your six-sigma black belt and dive into everything from incoming goods control to end of line testing. But there are two major challenges: For one, most mid-stream companies in the energy storage space have neither the full information about, nor the ability to impact the quality of the cells and packs they buy. On the contrary, in today's market, the sheer ability to buy batteries from a supplier weighs heavier than any quality management (QM) certification.

On top of that, even the most rigorous quality management will never catch 100% of the failures. And at giga-scale, even the tiniest slips become real problems. To reiterate on the recently announced Volkswagen Gigafactory: a failure that only happens once in a million will happen at least five times every month in this factory.

2 System design

Battery systems are equipped with several layers of protection. These protective measures are meant to keep the battery in its intended window of operation, shield it from external harm, and minimise the impact of a single-cell failure.

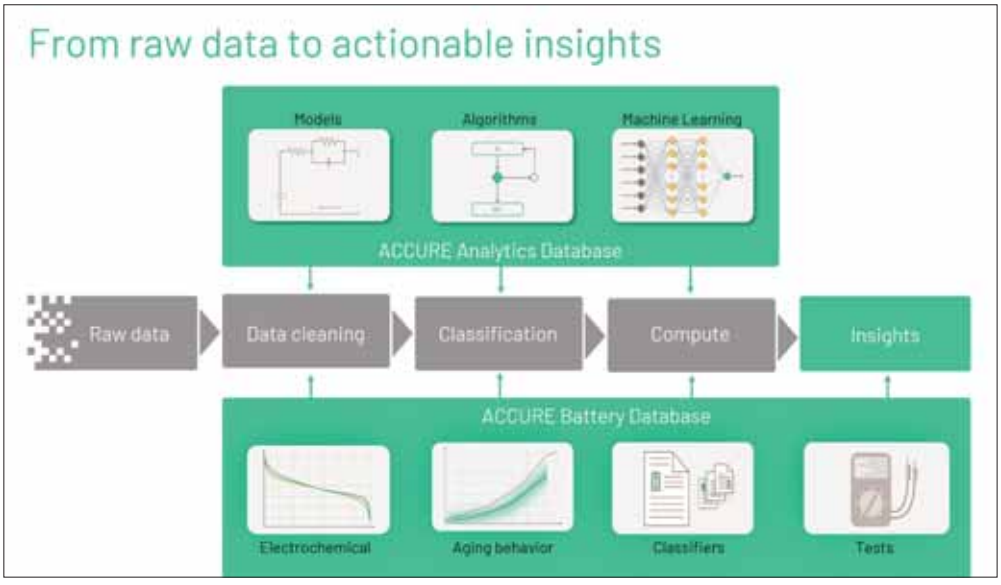
Passive safety components: LIB systems usually contain several passive components to ensure the safety of the overall system. However, passive safety components are last resorts to minimise the damage from critical situations that are already happening. In many cases they cannot prevent safety incidents.

Battery management systems (BMS) are electronic circuits containing sensors, logical units, actors, and a communication interface. BMS make sure that a battery is operated within its specifications. A basic BMS constantly monitors the status of voltage, current and temperature of the battery system via sensor measurements, calculates and monitors the states of the system such as SOC and SOH and performs cell balancing by selectively discharging cells over resistors. The BMS is also responsible to bring the system to a safe state when boundary conditions of temperature, voltage, current, etc. are exceeded.

While BMS are crucial to the safety of LIB, they also have noticeable shortcomings: They only see the cells within the corresponding battery pack, have little to no access to historic data or data from other battery systems and, importantly: they are limited in their computing power. Due to these limitations, BMS capabilities to detect edge-case anomalies, run deep analytics, and predict long-term trends are slim to none.

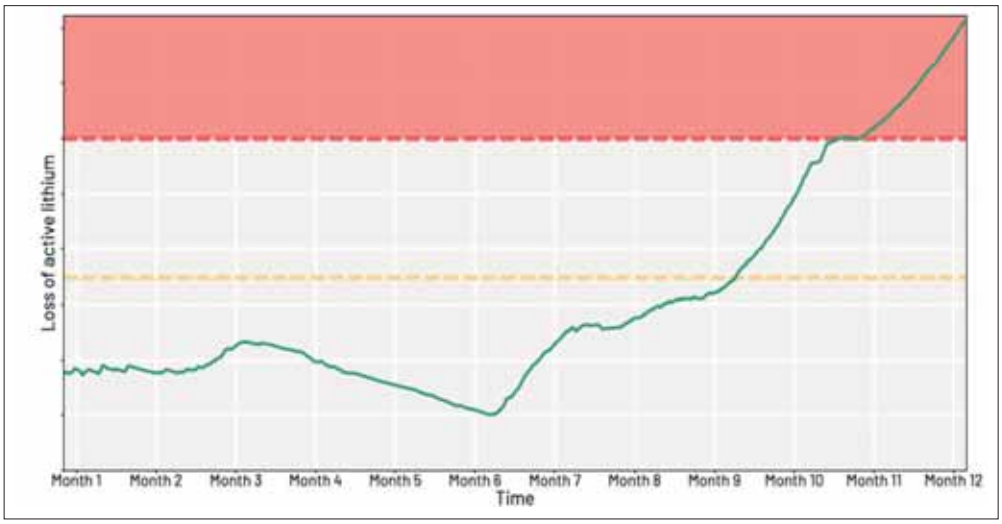
3 Cloud-based analytics

A proven strategy to improve battery safety is the use of cloud-based analytics. By detecting critical faults at an early stage using more sophisticated and modern analytical methods, battery operators can act before any damage is done. Diagnostics based on existing field data streams can be applied to any LIB system without the need for any product modification.



Credit: ACCURE.

Figure 1: Schematic workflow of ACCURE's predictive diagnostics.



Credit: ACCURE.

Figure 2: Model-based safety diagnostics track the loss of active lithium over time and give automated warnings if thresholds are reached.

The concept of cloud-based analytics is presented in Figure 1 and summarised in the following.

Step 1: Data acquisition

The starting point for all cloud analytics is the continuous stream of measurements from the BMS ("raw data"). This raw data is passed to the communication bus and then pushed to the cloud where it can be stored, consolidated, and analysed by the battery operator or a third-party service provider.

Step 2: Data pre-processing

To leverage the raw data, extensive data cleaning needs to be performed. For one, outliers and systematic measurement errors in the raw data need to be detected and flagged as such, to avoid false interpretations. But, more generally speaking, every BMS has its own (systematic and statistical) errors and idiosyncrasies that need to be understood to make sense of the data. If you plan to evaluate a cloud-based analytics solution, then make sure it works with any kind of input data and is able draw the right conclusions from every new data point. This pays off in terms of scalability for diverse BMS's.

Step 3: Fault detection

Fault detection algorithms scrutinise the battery data to check for potential faults. A fault can be identified through changes in primary parameters such as voltage, temperature, and current or in secondary parameters such as impedance, a shift in the open circuit voltage curve, or the amount of active lithium in each cell. To track secondary parameters, model-based algorithms, which consider reduced order physical-/chemical processes through mathematical equations are used. Identifying and tracking specific patterns in these parameters for the millions of similar cells, which are in operation, enables these algorithms to find anomalies before they become dangerous.

Credit: Metropolitan Transportation Authority of New York via Flickr.

Electric buses present an opportunity to decarbonise and reduce air pollution, but are assets that need to be managed safely.

Step 4: Reporting

If a battery is identified as dangerous by the cloud analytics, automated warning notifications are generated to allow the operator to act – by bringing the system into a safe state and arranging for maintenance or replacement.

A technical example of one of 20 safety indicators

There are many ways field data can reveal safety-critical battery behavior. In fact, there are at least 20 safety indicators a robust cloud analytics solution should track multiple times per day. They are based on electrical, thermal and mechanistic models empowered by machine learning. The algorithms mirror electrochemical relationships and processes, revealing insights about the internal states of the battery. In Figure 3, an analysis of the loss of lithium inventory, a process closely linked to lithium plating, is presented.

Lithium plating, where metallic lithium gathers on the outside of the anode, has been a major headache in the LIB world for decades. It mainly occurs when a battery is charged with high current rates at low temperatures but can also happen under "normal" operating conditions. Not only does it quickly degrade a battery's capacity, but it can also become a safety threat by forming metallic dendrites and triggering side reactions such as gassing. It manifests itself in a decrease of the lithium inventory which is no longer available for the main reaction.

Cloud-based safety algorithms, among other things, must closely track the loss of active lithium to accurately predict safety critical events.

Two real-world cases of cloud-based safety monitoring

At ACCURE Battery Intelligence a team of 70 battery experts applies cloud analytics to optimise the safety, reliability, and lifetime of currently 1.6GWh of battery assets. Among our customers are companies that have experienced battery fires and other safety incidents, which are not often publicised, before coming to us.

One public example, however, is Senec, a residential PV+Storage provider with over 65,000 installations across Europe and Australia. In March 2022, Senec experienced three battery fires within two weeks. After contracting ACCURE and transferring its historic operation data to our cloud, we were able to show that our cloud-based safety monitoring would have predicted all three incidents and together implemented a powerful new safety solution, the "Senec Safeguard 2.0." This combination of BMS and cloud-based algorithms now performs daily check-ups to ensure maximum safety.

Another example is the Berlin Transport Authority (BVG) who will transition their entire fleet to electric vehicles by 2030 – a total of 1,600 buses. After several battery fires in e-buses across Europe, BVG decided to be proactive about safety and started to use ACCURE's cloud-based safety monitoring on a part of their fleet.

Take control of battery safety

Battery safety is a complex topic spanning many stakeholders. With novel technology variants launched every month and new suppliers entering the market, it becomes increasingly difficult for battery system integrators and operators to manage their risks and optimise their upside.

The main levers to improve battery safety are production quality, system design and cloud analytics. As many companies do not have full insights into or even impact on the production quality and system design, cloud analytics are oftentimes the best way to manage risks today. While even the most advanced analytics cannot replace high production quality and a robust system design, they are proven to prevent critical failures and drastically improve the agency of battery owners and operators. Implementing advanced cloud analytics is a no-regret solution for companies – whether using their own resources or by partnering with a trusted analytics software provider. ■

Author

Dr. Kai-Philipp Kairies is a scientist and entrepreneur focusing on innovative battery energy storage solutions. He worked as a battery researcher and consultant in Germany, Singapore, and California. Since 2020, he is CEO of ACCURE Battery Intelligence, a battery analytics solution provider that supports companies in understanding and improving their batteries' safety and longevity to reduce risk and increase value and sustainability.

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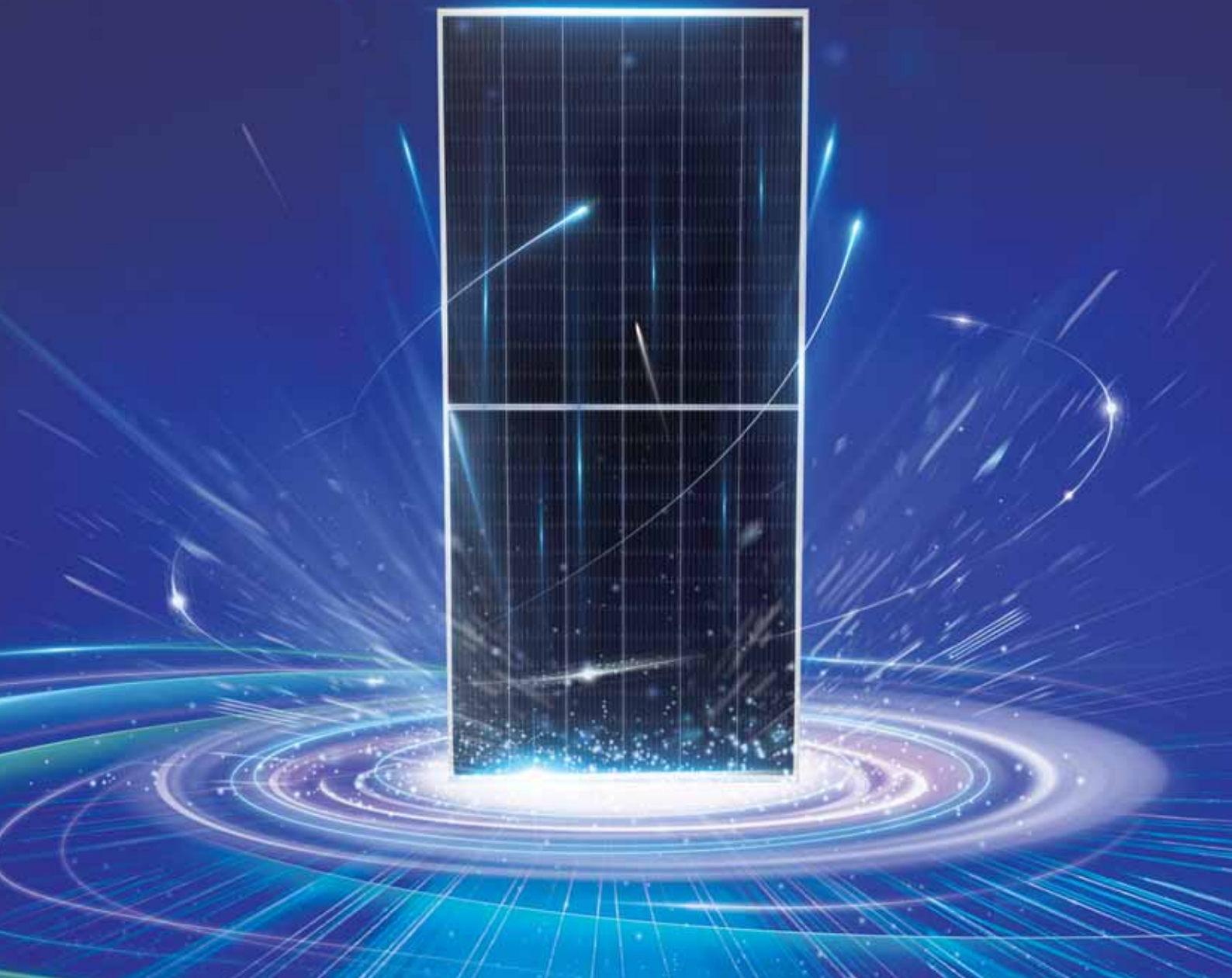

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