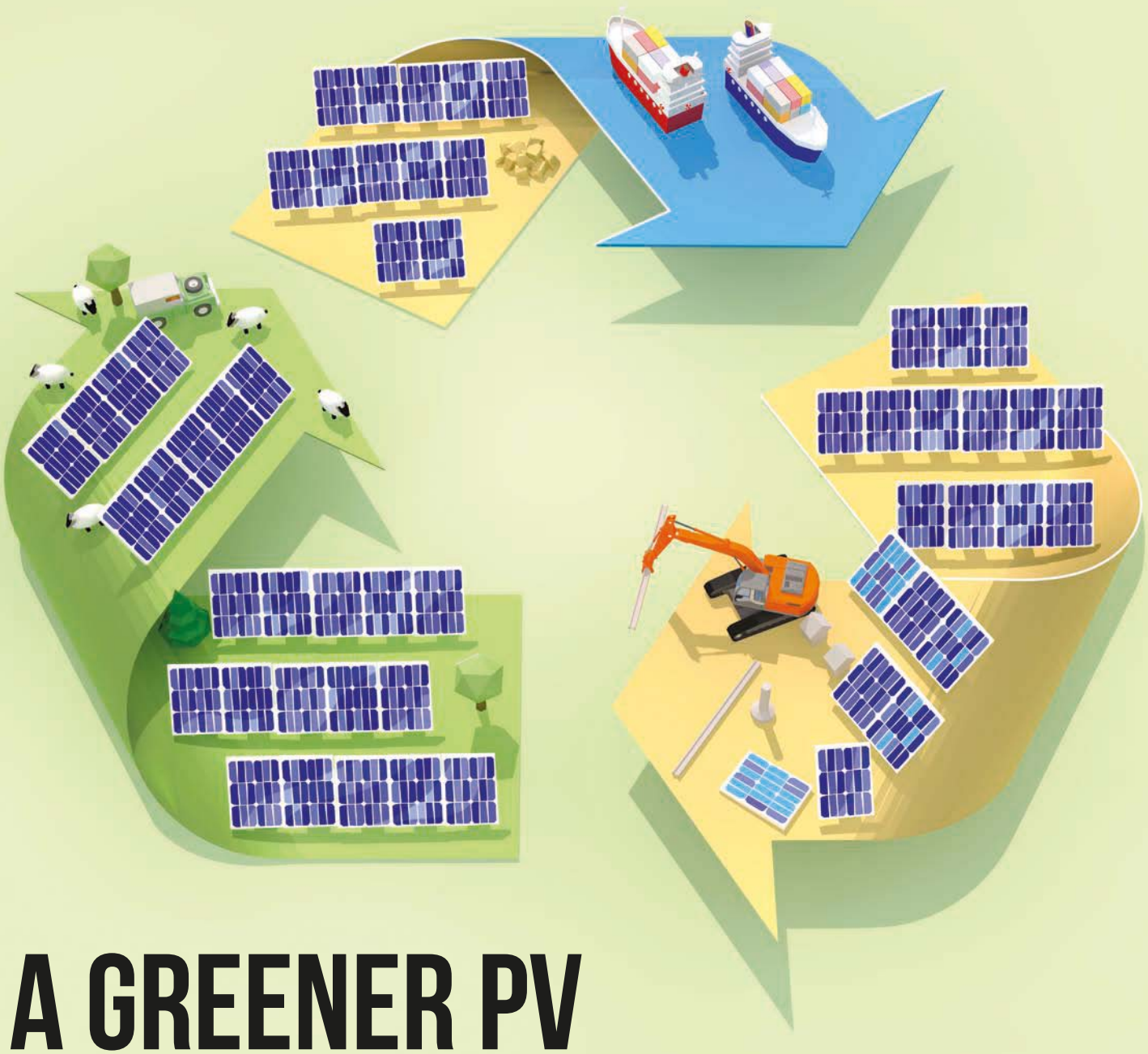
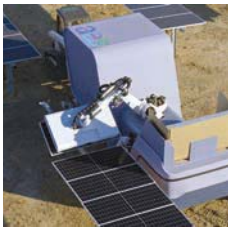
POWER PVTECH

Volume 31 | PV POWER PLANT TECHNOLOGY AND BUSINESS | May 2022



A GREENER PV

How the solar industry is making itself more sustainable, p.19



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Published by
Solar Media Ltd.
123 Buckingham Palace Road
London, SW1W 9SH, UK
Tel: +44 (0) 207 871 0122
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Printed by
Buxton Press Ltd., Derbyshire

PV Tech Power Volume 31, 2022
ISSN: 2057-438X

Brands of Solar Media:

Photovoltaics International
PV TECH
PV TECH PRO 中文专业版
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Cover illustration by Adrian Cartwright, Planet illustration

Introduction

Welcome to PV Tech Power volume 31, produced at a time when the solar industry – and indeed much of the wider world – is in a state of flux. More than two years from the onset of the COVID-19 pandemic and its ructions are still being felt, all the while issues of geopolitical and economical nature are cause for significant concern across the globe.

And yet, it is clear that there remains no greater threat than the climate crisis. The recent Intergovernmental Panel on Climate Change's sixth assessment report warned that it was "now or never" to act on climate change, urging us all to step up climate action or face an unliveable planet. Publishing this volume of PV Tech Power on Earth Day, as we have done this year, hammers that home.

It was also a contributing factor to us focusing on environmental issues in this issue, as if solar PV is to truly play a lead role in decarbonising global economies – and the IPCC report makes it abundantly clear the technology will do much of the heavy lifting – then it too must clean up its act. Our cover story of PV Tech Power volume 31 (p.19) addresses two key issues here; the efforts taken by PV's upstream to ensure the modules installed are manufactured as cleanly as possible, and the necessary efforts underway to ensure the solar economy is as circular as possible throughout the rest of this decade.

We also explore the nature of – well, nature – in a piece that documents the efforts developers are taking to not just mitigate impacts on biodiversity of solar construction, but to enhance and better the sites solar is installed on for decades to come (p.64).

In Market Watch, we profile three markets in particular to have responded to the energy crisis gripping Europe with promised acceleration of solar development this decade. Between Germany (p. 28), Italy (p.32) and the UK (p.26) tens of gigawatts of solar are to be installed each year between now and 2035 if their respective governments have their way, indicating the sheer scale at which this industry must strive to in a short timeframe.

And that scale will be aided by advancements in automated construction practices (p.61), robotic solar cleaning technologies (p.54) and the continued success of colocated solar-storage projects (p.94), all of which are detailed in the pages of PV Tech Power volume 31.

Two years of near constant turbulence has no doubt been exhausting and disorientating. But if this edition of our journal has one overriding message, it's that the energy transition is heading in the right direction in spite of the instability. Thank you for reading, and we hope you enjoy PV Tech Power volume 31.

Liam Stoker
Editor in chief
Solar Media

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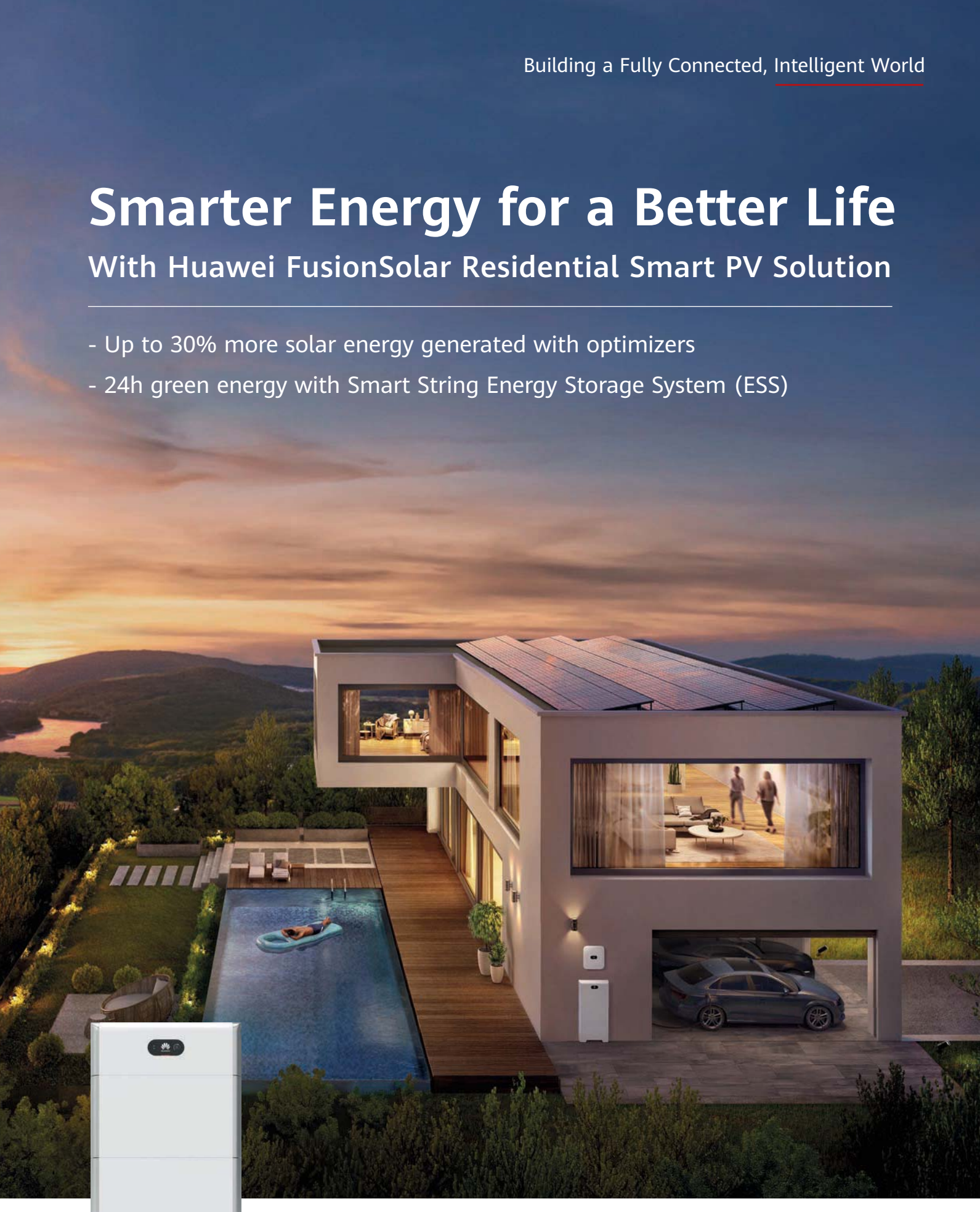
- 24h green energy with Smart String Energy Storage System (ESS)

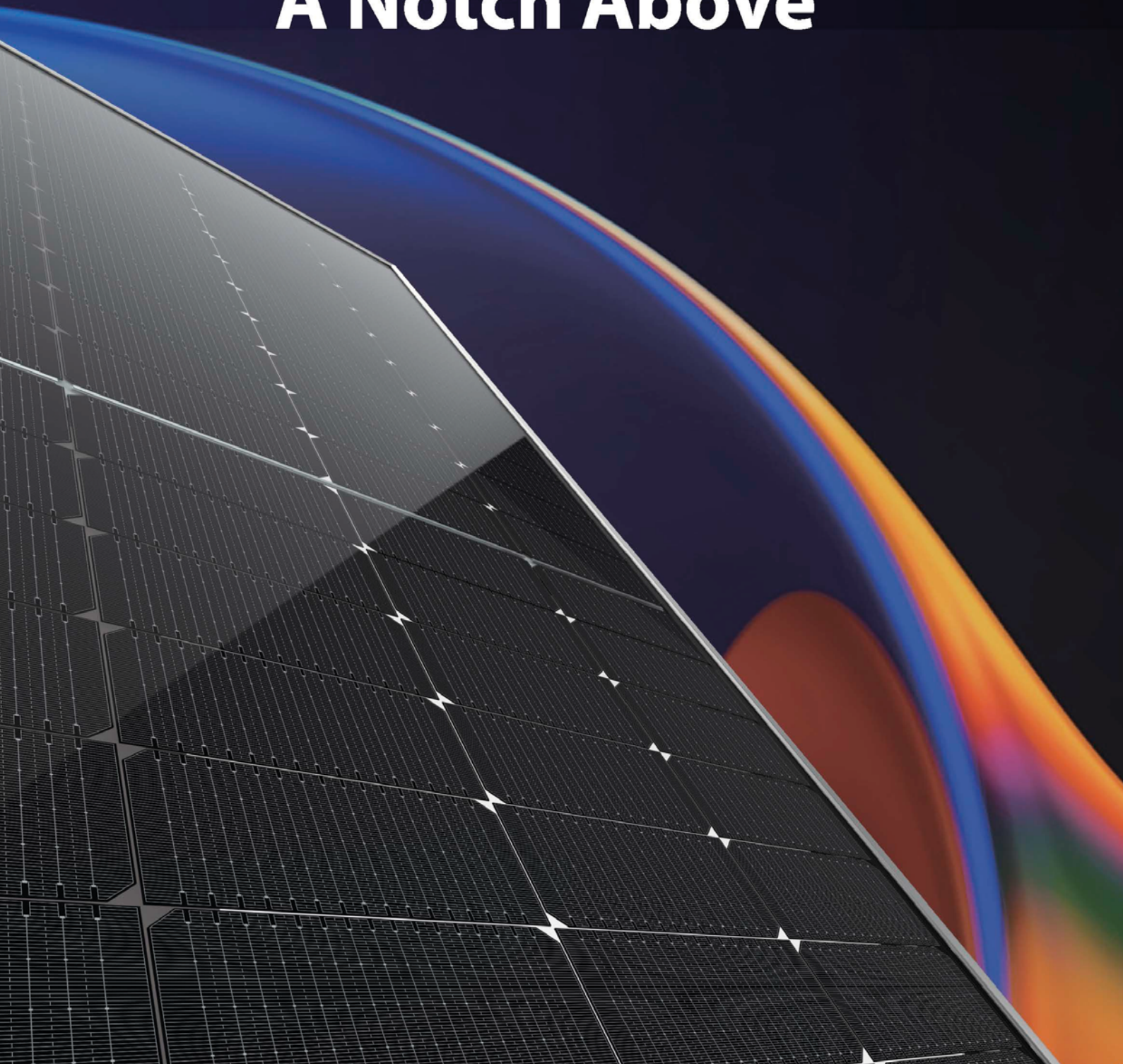


HUAWEI

JinKO Solar

TIGER Neo · 620W

A Notch Above



EUROPE

EU

EU to accelerate renewables 'at lightning speed', cutting dependence on Russian gas

The European Commission (EC) will look to simplify renewables permitting as part of a new strategy aimed at increasing the EU's energy independence while ending its reliance on Russian gas before 2030. Following Moscow's invasion of Ukraine, the case for a rapid clean energy transition "has never been stronger and clearer", the EC said as it unveiled the REPowerEU strategy, which will see the EU reduce demand for Russian gas by two-thirds before the end of 2022. "Let's dash into renewable energy at lightning speed," EU climate policy chief Frans Timmermans said. With lengthy administrative procedures identified as one of the key obstacles for investments in renewables, the strategy will look at how regulatory bottlenecks can be eased to speed up renewables permitting and minimise the time for rollout of projects and grid infrastructure improvements.

UK

UK to relax planning laws as new energy strategy sets out hope of five-fold increase in PV capacity by 2035

The UK government has committed to a major ramp-up of solar capacity in the country as part of a new energy strategy. Amongst plans to significantly increase the capacity of the country's nuclear and offshore wind portfolio, the strategy also states the UK's intent to expand its existing 14GW capacity of solar PV, indicating that this could grow "up to five times" by 2035. Such an increase would see the UK's solar capacity reach 70GW, which trade body Solar Energy UK said had the potential to support up to 60,000 industry jobs. The full strategy commits the government to consulting on changes to planning laws in the UK which will "strengthen policy in favour of development" on non-protected land – i.e. land of low agricultural value and non-greenbelt sites.

Iberia

Portugal brings forward 80% renewables target to 2026, holds floating PV auction

Portugal will aim to increase the share of renewables in electricity production to 80% by 2026, four years earlier than previously planned, its new government announced days before the country's floating solar auction took place. The target represents a significant acceleration in decarbonising the country's power sector; between 2010 and 2022, the share of renewables in electricity production increased from 41% to 58%. Portugal's environment ministry announced it awarded 183MW of floating PV capacity in the country's third solar auction, with EDF picking up 70MW and posting the lowest price of -€4.13/MWh (-US$4.51/MWh). The utility said that alongside the contract-backed floating PV, the grid connection it secured through the auction will also allow it to deploy an additional 14MW of solar and 70MW of wind.

Credit: EDP.

A 220kWp floating solar pilot project from EDP at the Alto Rabagão dam in the north of Portugal.

Spain to fast-track solar permits in bid to tackle energy crisis

Spain will fast-track solar PV projects with generation capacities of up to 150MW as part of a suite of measures the government has enacted to help ease the country's energy crisis. Set to be in place until the end of 2024, the new policy will only apply to plants adjudged to have a low or medium impact on the surrounding environment, and any projects located in the 'Red Natura 2000' zone – a network of protected areas mandated by the EU – will not be eligible. The government also announced plans to free up around 10% of the country's grid capacity to allow for up to 7GW of distributed energy generation to connect between 2023 and 2025.

Green hydrogen

War in Ukraine to 'turbocharge' green hydrogen production

The war in Ukraine will "turbocharge" the global green hydrogen sector as the cost of alternatives soar by more than 70% and Europe seeks to reduce its reliance on Russian gas with a series a financial packages, according to Rystad Energy. The consultancy said the economics of green hydrogen have become "increasingly attractive", with production costs of US$4/kg witnessed in the Iberian Peninsula, compared to US$14/kg for blue and US$12/kg for grey hydrogen in other parts of Europe. Green hydrogen promises energy security as well as potential new regional economies for renewable energy, Rystad said.

Netherlands' first solar-powered green hydrogen plant opened

A green hydrogen plant powered by a 50MWp solar farm has been commissioned in the Netherlands, as the partners behind the installation look to explore how the technology can ease grid congestion. A collaboration between BayWa r.e. subsidiary GroenLeven and electricity and gas distribution network company Alliander, the pilot project is the Netherlands' first hydrogen plant powered by solar PV, according to the companies. They will now test the extent to which a hydrogen electrolyser can follow the generation profile of the solar plant.

M&A

Macquarie-led consortium acquires French IPP Reden Solar for US$2.7bn

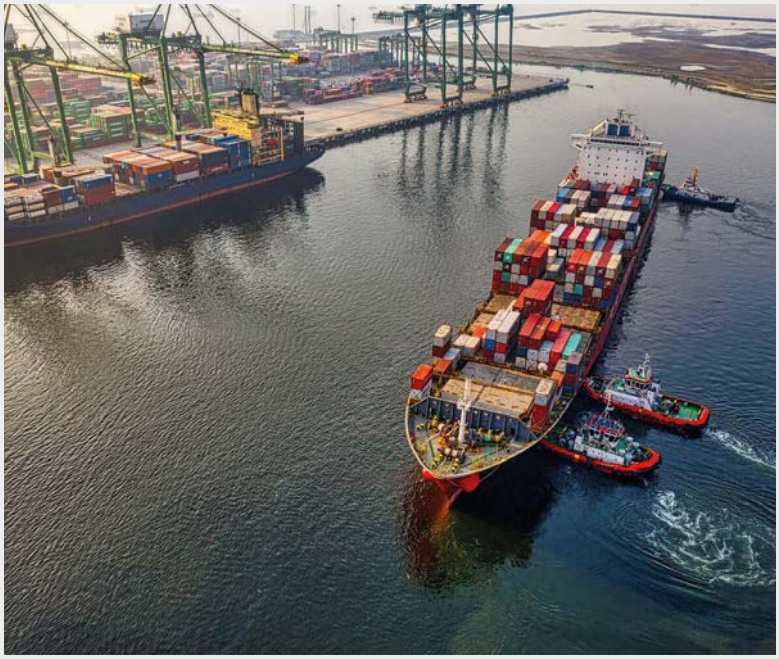
A consortium led by Macquarie Asset Management is acquiring French independent power producer (IPP) Reden Solar for an enterprise value of €2.5 billion (US$2.7 billion). Active in eight European and Latin American countries – including its core markets of France and Spain – Reden develops, builds and operates PV plants, with a 762MW operational portfolio and a 15GW development pipeline. Having recently expanded its footprint into Greece and Italy, the Toulouse-headquartered company is now looking to enter additional markets.

AMERICAS

Trade tariffs

US DOC launches investigation into alleged solar AD/CVD circumvention

The US Department of Commerce (DOC) is to investigate alleged circumvention of antidumping and countervailing duties (AD/CVD) by solar manufacturers in Cambodia, Malaysia, Thailand and Vietnam following a petition filed in February by US manufacturer Auxin Solar. The DOC will conduct country-wide proceedings to determine whether or not solar cells and/or modules made in the Southeast Asian nations use parts originating from China, flouting AD/CVD tariffs. The DOC has said questionnaires will be sent to companies in the above countries regarding their shipments of cells and modules to the US and the origin of inputs for those shipments. The decision has attracted the immediate ire of some in the US solar industry, with more than 90% of respondents to a Solar Energy Industries Association (SEIA) survey saying that the decision to investigate alleged AD/CVD is having a "severe or devastating impact" on their business.



Credit: Unsplash

The Commerce Department's decision to initiate the AD/CVD investigation has been widely criticised by US solar developers

Policy

Pressure mounts on US lawmakers to pass PV manufacturing tax breaks

More than 100 clean energy manufacturers and developers have addressed a letter to US President Joe Biden, Congress leader Chuck Schumer, speaker Nancy Pelosi and chairs of the Committee on Finance and Ways and Means Committee calling for tax incentives to be passed within federal budget reconciliation legislation. Signed by the likes of First Solar, Maxeon Solar, Enphase Energy, Q CELLS and Silfab Solar, alongside US-based producers of steel, polysilicon and other key components, the letter states the companies' support for a swift passage of tax provisions which they say will strengthen the US' manufacturing and production of clean energy.

California's democrats write to CPUC to slam NEM 3.0 and demand policy shift

A group of 26 California Congress Members have written to the California Public Utilities Commission (CPUC) urging it to rethink its contentious and already delayed net metering changes for the state and demanding a "dramatically revised policy". Signatories to the letter urged the CPUC to "use the time to look at options that do not harm existing residential solar adopters while achieving an equitable solution for adopters as well as all customers". NEM 3.0 would cut solar export credits by about 80% and add a US$57 per month fixed charge for the average residential system, which research firm Wood Mackenzie said would cut California's rooftop sector in half by 2024.

Green hydrogen

60GW green hydrogen hub planned for Texas

US developer Green Hydrogen International (GHI) plans to create a green hydrogen hub in Texas that will be powered by 60GW of solar and wind energy and produce over 2.5 billion kilograms of green hydrogen per year. Dubbed Hydrogen City, the project will be built in different phases with the first one set to be operational in 2026 with 2GW of production and two storage caverns. GHI said there was the possibility to further increase that number to over 50 caverns providing up to 6TWh of energy storage.

Technology

SunPower, First Solar in late stage discussions to develop 'world changing' residential module

US residential solar installer SunPower is in late-stage discussions with US thin film manufacturer First Solar to develop the "world's most advanced residential solar panel". The module will employ a dual technology approach, with First Solar's thin film technology sitting atop a layer of crystalline silicon cells. First Solar would manufacturer the module with SunPower becoming the exclusive provider. The product could become available within two years.

MIT develops waterless, contactless solar PV cleaning solution

Researchers at Massachusetts Institute of Technology (MIT) have developed a waterless and contactless solution which they says can clean the dust off solar panels without compromising the panels efficiency. The solution uses an electric field, created by an electrode passing over the panels, to give a charge to dust particles, with a subsequent opposite charge then repels particles from the surface. The researchers said water cleaning can make up 10% of opex costs and that their technology would allow to reduce those costs while improving the power output by augmenting the cleaning frequency.

UL, NREL unveils DERs cyber security report and calls for greater industry safeguards

Safety and certification company UL and the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) have released a report into the cybersecurity of US distributed energy resources (DERs). It pointed to a "market shift from utility-scale to distributed generation", meaning greater protection of distributed energy resources (DERs) is required to ensure the security of those assets and the wider US grid system from cyberattacks. It said the advanced computer systems DERs rely on were susceptible to a range of common cyberattacks.

MIDDLE EAST & AFRICA

South Africa

Norfund, CDC invest US$39m in 2.4GW of South African renewables

Norway's Norfund and UK development finance institution CDC have teamed up to fund 2.4GW of renewable deployment in South Africa through a ZAR600 million (US$39 million) investment in renewables company H1 Capital. Norwegian state-owned investment fund Norfund is providing ZAR360 million, while CDC, which is to be renamed British International Investment (BII), has made ZAR240 million available. Norfund said the investment would support South Africa's clean energy goals and enable H1 Capital to fund the development of 2.4GW of solar and wind projects, generating 6,400GWh a year. H1 Capital was selected because of its "expertise on several renewable power projects and its deep commitment to energy sustainability," said Norfund, which is investing in H1 Capital via Norway's new climate fund announced at COP26 late last year.

Credit: Scatec Solar

Norfund is investing ZAR360 million into South African solar, having already owned a stake in Scatec Solar's Sirius site in the country.

Green ammonia

Scatec, ACME to develop solar-powered green ammonia plant in Oman

Norwegian renewables company Scatec and Indian solar developer ACME Group have signed a joint venture agreement to develop a large-scale green ammonia facility in Oman with an annual capacity of 1.2 million tonnes once fully developed. The facility will be built in different phases, with the first one powered by 500MW of solar, featuring 300MW of electrolyser capacity and expected to produce 100,000 tonnes of green ammonia per year. Raymond Carlsen, CEO of Scatec, said: "Oman has excellent solar resources and a strategic location for production of green ammonia. ACME Group has been in the forefront of green ammonia production with this project, and in Scatec we can capitalise on our expertise in renewables, project structuring and financing, execution and operation to accelerate the decarbonisation of the world."

Scatec bolsters green ammonia prospects with Egypt facility

Norwegian renewables company Scatec has signed a memorandum of understanding with the General Authority for Suez Canal Economic Zone (SCZONE), The Sovereign Fund of Egypt, the Egyptian Electricity Transmission Company and the New and Renewable Energy Authority to develop a large-scale green ammonia plant in Egypt. The green hydrogen and ammonia facility will be the first large-scale project of green ammonia in the country. It will have a production capacity of one million tonnes annually, with a potential expansion to three million tonnes and will be located in the SCZONE in Ain Sokhna Industrial Zone.

Saudi Arabia

Saudi Arabia eyes 15GW of renewables projects after penning new PPAs with ACWA Power, Jinko Power

Solar developers ACWA Power and Jinko Power have both penned power purchase agreements (PPA) in Saudi Arabia, with the country aiming to launch 15GW of projects in the next two years. ACWA Power signed the PPA with the Saudi Power Procurement Company for the 700MW Ar Rass project, which is to be built in the Al Qassim province and is expected to be finalised during Q4 2022. The PPA duration is for 25 years. So far it is the largest PV project awarded by Saudi Arabia's National Renewable Energy Programme, of which ACWA Power will deliver 70% of the 58.7GW goal.

Nextracker lands supply deal for first phase of 450MW Saudi PV project

Nextracker has been selected to supply its smart solar trackers and TrueCapture technology for the first phase of a 450MW PV project in Sudair, Saudi Arabia, which Nextracker said was the country's largest solar plant currently under construction. Nextracker said its TrueCapture technology, which "enables solar panels to track the path of the sun to maximise energy production versus fixed tilt ground mount applications", will help boost the energy generation profile of Sudair solar project. The project is being developed by Public Investment Fund of Saudi Arabia through its subsidiary Badeel/WEHC, Saudi Aramco and ACWA Power. The renewables division of global construction giant Larsen & Toubro has been awarded the EPC contract.

Mining

Total Eren, Chariot to develop 430MW renewables project for Zambian mine in latest collaboration

African energy company Chariot and French renewables developer Total Eren have again teamed up to develop a solar PV project that will be used to offset emissions from mining operations in southern Africa. The two companies have agreed to develop a 430MW solar and wind project for mining company First Quantum Minerals in Zambia, with construction to start in 2023. They are also working together on a 40MW PV project to support the operations of South African mining company Tharisa. First Quantum Minerals said the project would provide it with "competitive and sustainable power for its Zambian mining operations" as it seeks to reduce its carbon footprint by 30% by 2025.

Off-grid

Bboxx launches flexible products for off-grid communities in Africa

Off-grid pay-as-you-go solar provider Bboxx has launched a new service to provide renewable solutions to off-grid communities in Africa. "Flexx by Bboxx" is designed to offer cost effective renewables in remote areas that still lack access to a reliable energy source, with Rwanda and Kenya set to be Bboxx's first markets for the new product range. Bboxx will roll out two products under that banner with an upfront cash version that is a 'plug-and-play' portable solar lantern, while the other will be a 'pay-as-you-go' multi-light system with charging ports that it said was aimed at rural customers "at the bottom of the energy pyramid".

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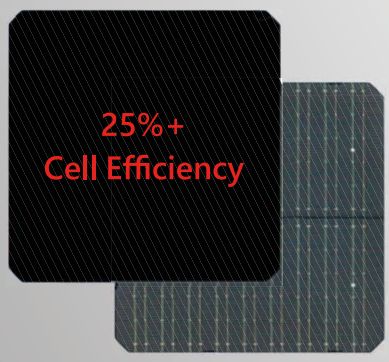

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ASIA-PACIFIC

Partnerships

Ib vogt, ACEN form joint venture to develop utility-scale solar in Asia Pacific

Solar developer ib vogt is partnering with the energy platform of Philippine conglomerate Ayala to develop large-scale PV projects in the Asia Pacific region. The new joint venture (JV) between Germany-headquartered ib vogt and ACEN will develop at least 1GW of renewables capacity in the coming years, with potential for further expansion. The partners will focus on late-stage, shovel-ready projects in markets such as Indonesia, Vietnam, Malaysia, Laos, Bangladesh, as well as other countries in the region, ACEN said. Most projects will stem from ib vogt's Asia development pipeline of more than 5GW, with construction on the first plants due to begin in 2022.

The Philippines

The Philippines set to massively increase solar capacity, project pipeline grows 10-fold in a year

The Philippines looks set to significantly ramp up its solar deployment, according to Fitch Solutions, which has revised up its forecasts for the country's non-hydro renewables sector in line with a rapidly-expanding project pipeline and growing regulatory support. Fitch Solutions said the market's project pipeline for large-scale solar has grown significantly with total solar capacity in the country's pipeline growing more than tenfold from March 2021. As of March 2022, the Philippines had around 13GW of solar in its project pipeline, up from a paltry 1.3GW in March 2021, with wind power also growing substantially.

India

Tata Power commissions 160MW Rajasthan solar project, continues deployment in key Indian states

Tata Power Solar has commissioned a 160MW solar project in the north-western Indian state of Rajasthan as it continues its PV roll-out across the country. The Jetstar project was completed in 15 months and is one of the largest solar projects in the state, according to Tata Power Solar. The announcement comes a day after Tata Power subsidiary Tata Power Renewables Energy commissioned a 300MW solar project in Gujarat, which it claimed was India's largest single-axis solar tracker system.

ArcelorMittal partners Greenko for 975MW 'round the clock' renewable project in India

Steel manufacturer ArcelorMittal has partnered with Indian renewable company Greenko Group to develop a 975MW 'round the clock' wind and solar project in India. The project will be built in Andhra Pradesh and is expected to be fully operational by mid-2024. It will be funded (around US$600 million) and owned by ArcelorMittal, with Greenko taking care of its construction and providing capacity from a pumped hydro energy storage facility to accompany the wind and solar generation.

India's solar PLI scheme may be split to boost participation, reports suggest

India's expanded production-linked incentive (PLI) scheme for solar manufacturing could be altered to encourage more domestic PV players to participate. The INR195 billion (US$2.6 billion) programme is likely to be split into two or three tranches to include various companies, Indian newspaper The Economic Times reported, quoting a government official as saying: "We can divide the PLI into different buckets for polysilicon to module making, wafers to modules and cells to modules manufacturing." With nearly 55GW of bids submitted, the first PLI round was more than four times oversubscribed and closed with transformer manufacturer Shirdi Sai Electricals and Indian conglomerates Reliance Industries and Adani securing funding.

Australia

Australia added 1.2GW of large-scale solar in 2021 but renewables investment slows, report finds

Large-scale solar deployment in Australia jumped 38% year-on-year in 2021 as its three largest PV plants were commissioned, but financial commitments for new renewables projects in the country fell, according to a new report. A total of 1,209MW of solar projects with a capacity of more than 5MW were added in Australia in 2021, making it the sector's second-best year, renewables association the Clean Energy Council (CEC) revealed in its 2022 Clean Energy Australia Report. While renewable energy now accounts for 32.5% of Australia's electricity, CEC chief executive Kane Thornton said the positive results last year are clouded by a significant slowdown in the pipeline for renewables, with the level of financial commitments for new large-scale projects falling by more than 17% between 2020 and 2021.

Credit: Lightsource bp.

Large-scale solar deployment in Australia jumped 38% year-on-year in 2021. Image: Lightsource bp.

Australian climate organisations slam federal budget as a 'massive missed opportunity'

Australia's 2022-23 Federal Budget has "missed the mark" when it comes to supporting the energy transition and has neglected investment in transmission infrastructure over investing in fossil fuels at a critical junction in Australia's decarbonisation journey, said the CEC. The 2022-23 budget reveals that spending on climate change prevention is set to fall from AUS$2 billion 2022-23 financial year to AUS$1.9 billion, AUS$1.5 billion and AUS$1.3 billion in the three years that follow, representing a 35% annual cut in spending over the four years.

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MANUFACTURING

Tongwei investing US$1.9bn in 32GW of new solar cell capacity

Major polysilicon and merchant cell producer Tongwei Group is to invest in an additional 32GW of solar cell capacity through a RMB12 billion (US$1.9 billion) investment in partnership with the government of Meishan City, in Sichuan Province, China. The capacity expansion will be conducted in two 16GW phases, Tongwei said, with the company aiming to bring the first phase of the project online by the end of 2023, after which work on the second phase will begin. Tongwei said in a stock statement that the new facility will be built on Qinglong Street, Tianfu New District, Meishan in cooperation with the local government.

Company news

LONGi warns of profit hit after Yunnan province rows back on power price deal

LONGi Solar has warned of reduced profits after Yunnan Province, where a significant portion of its manufacturing output resides, cancelled a previously-struck power pricing agreement. LONGi said that it had been informed by authorities in Yunnan that the province could no longer honour a preferential power pricing agreement struck between the two parties in 2016. As a result, LONGi will instead pay standard market-based prices for its power consumption, resulting in a material adverse impact on the manufacturer's profits. LONGi further warned that capacity expansion projects that are still ongoing in Yunnan could be revised as a result of the power price revision.

JinkoSolar plots course for 60GW module capacity in 2022

JinkoSolar has confirmed an acceleration to its manufacturing capacity expansion plan on the back of higher than expected demand, despite supply chain constraints continuing to apply pressure on margins. At the manufacturer's FY 2021 results, JinkoSolar announced that it expected to finish this year with around 50GW of wafer, 40GW of cell and 60GW of solar module capacity in what constitutes a significant upgrade compared to previous plans. JinkoSolar finished 2021 with solar wafer, cell and module capacities of 32.5GW, 24GW and 45GW respectively, but had previously guided 2022 capacities to rise to 40GW, 40GW and 50GW respectively. Furthermore, on a conference call with analysts held after the results disclosure, JinkoSolar stated that its capacity expansions would focus solely on its n-type product range.

European manufacturing

Enel signs grant agreement with EU for 3GW bifacial PV module facility in Italy

Enel Green Power (EGP) has signed a grant agreement with the European Commission for a 3GW PV module plant in Catania, Italy, with an R&D commitment to pursue tandem cell production in the coming years. Under the European Union's first Innovation Fund for large-scale projects, it will contribute to the development of TANGO (iTaliAN pv Giga factOry) with a total investment of around €600 million (US$662 million). Additional funding from the EU of €118 million will help increase by 15-fold its current 200MW capacity. and will include the manufacture of bifacial heterojunction PV cells. The 3Sun plant is expected to be fully commissioned by July 2024, with a first line with a capacity of 400MW set to begin production in September 2023.

India is expecting a boom in solar manufacturing capacity in the coming years.

US

Hanwha Solutions unveils 'ambitious plan' to rebuild full US solar supply chain

Hanwha Solutions has an "ambitious plan" to revitalise US solar manufacturing increasing its stake in polysilicon producer REC Silicon, although it has called on the US to pass the Solar Energy Manufacturing Act (SEMA) to help support this. After increasing its stake in REC Silicon to 21.34% in March, Hanwha said its purchase of shares held by Aker Horizons was a "prelude to Hanwha's larger ambition of rebuilding the full US solar supply chain". "Having secured a stable supply of key raw materials for photovoltaic panel production, the company intends to follow up with subsequent investments in virtually every sub-sector of the domestic solar manufacturing industry, ranging from key raw materials like polysilicon to fully assembled solar modules," Hanwha said.

Collaborations

SunPower, First Solar in late-stage discussions to develop 'world changing' residential solar module

US residential solar installer SunPower is in late-stage discussions with US thin film manufacturer First Solar to develop the "world's most advanced residential solar panel", its CEO Peter Faricy revealed. The module will employ a dual technology approach, with First Solar's thin film technology sitting atop a layer of crystalline silicon cells, Faricy said, adding that if completed as envisioned it would be "the most technically advanced residential solar panel in history". First Solar would manufacturer the module with SunPower becoming the exclusive provider. All going well, the product could become available within two years.

Financing

Vikram Solar files for IPO to raise funds for 2GW cell and module manufacturing facility

Vikram Solar has filed draft papers for its initial public offering (IPO) as it looks to raise funds for a 2GW integrated cell and module manufacturing plant in India. Papers filed with the Securities Exchange Board of India reveal Vikram intends to launch a fresh issue of INR 15 billion (US$197 million) worth of shares and offer for sale up to 5 million shares by its existing shareholders and promoters. The company may also consider a pre-IPO placement to raise INR 3 billion. Most of the proceeds will be used for funding capital expenditure for setting the 2GW facility in the Indian state of Tamil Nadu through its wholly owned subsidiary VSL Green Power.

Credit: Vikram Solar

The best of PV Tech Premium

Analysis | PV Tech Premium, our subscription service providing industry-leading insight, analysis and leadership interviews, celebrated its one-year anniversary in April 2022. To commemorate that event, we've made some of our most popular pieces free to read here.

Credit: Qcells.

How US solar manufacturers can compete with China as decentralisation of PV production grows

5 April 2022: US solar manufacturers can compete with Chinese companies for US PV projects given additional import costs and modules making up less than half a project's costs, while also ensuring a secure supply to the US market, lowering the carbon intensity of products and exploiting strong market demand, says Michael Parr, executive director of the Ultra-Low Carbon Solar Alliance (ULCSA).

Module price rises, ongoing supply chain disruption and geopolitical tensions have all made the case for decentralising PV manufacturing even stronger over the past couple of years and Parr believes the world "needs to signal some changes" about how and where solar products are being produced.

The solar manufacturers of today are far more sophisticated than they were five years ago, are highly automated and are taking on expansion projects with much larger capacities, says Parr, allowing US companies to compete with China on price while also lowering the carbon intensity of the final product. Parr notes how modules made in China contain twice as much carbon as elsewhere given much of China's electricity in solar producing regions is derived from coal and other fossil fuels.

And despite cheap energy and substantial government subsidies, Chinese modules have been steadily rising in price for US consumers and now cost around US$0.33c/W for bifacial mono-PERC 440-450W modules, excluding any tax or shipping costs, according to data from PVInfoLink.

Hanwha Solutions' Q CELLS is ramping up module production in the US and will benefit from the restarting of the Moses Lake polysilicon facility.

"On a straight manufacturing cost comparison US labour and other costs make it more expensive to produce things here versus China by some increment," says Parr. "But when you roll shipping costs, tariffs and related factors into the mix, and the fact that modules are only about 40% of project costs, projects with US produced modules are not significantly more expensive than projects with Chinese modules."

"You're competing against imports that have tariffs costs, shipping costs and other costs added on to those. You're not competing with manufacturing costs in China, you're competing with landed price," says Parr.

"And as shipping costs have gone up, the cost differentials have come down. So manufacturing in the US can be more expensive from a human resources

Speakers at the Large Scale Solar Event in March 2022.

perspective but the fact that we're about to double module manufacturing capacity in the US in the next 18 months shows that people believe they can compete."

"And competitiveness is more than just cost equivalence: there are other factors that are considered including quality, longevity, strength of warranty, sustainability and supply reliability that factor into a buying decision," says Parr.

Indeed, there has been much noise lately from the solar industry about trying to establish manufacturing bases for cells, wafers and modules outside of China, with several countries announcing policy support.

The US Biden Administration is under increasing pressure to support the country's PV manufacturing sector through legislation, including the Solar Energy Manufacturing for America (SEMA) Act, which Parr said would "turbocharge" manufacturing growth in the US and act as an effective scaling up incentive.

"Our take [on SEMA] is that the investment logic is there," says Parr. "We're seeing rapid growth today, although from a small-scale, but rapid growth in the US nonetheless. We think policy elements like SEMA would turbocharge that."

Meanwhile, Chinese companies with western customers are thinking seriously about how they could continue to serve those markets, says Parr. He notes how the likes of JinkoSolar, LONGi and Trina Solar are all talking about developing supply chains outside of China. Inside China, companies are increasingly investing in production centres to the East of the country – rather than the mainstays of Inner Mongolia and Xinjiang – that uses roughly 35% cleaner power due to its strong hydropower resources.

The carbon intensity of solar products has been in the spotlight lately and Parr says manufacturers should consider three areas when looking to reduce carbon in their products: the carbon intensity of the grid system in question; energy efficiency in the manufacturing process; and energy efficiency in the power procurement process.

On this last point, Parr says he knows of several US solar manufacturers who are now actively shifting their production schedules to off-peak times and on weekends when more, cheaper renewable power is available.

"You can tailor manufacturing capacity to the power curve," he explains, noting how this reduces costs and the carbon intensity of the final product.

"So, many of the factors that made manufacturing outside of China riskier five or 10 years ago, the industry has now grappled and dealt with," says Parr, adding that the "primary risk" to solar manufacturing in the US an "inconsistency of policy".

That said, solar is becoming less dependent on government policy support as it continues to rise in prominence as a vital source of power and a means of emissions reduction, says Parr.

The US already has 20GW of polysilicon capacity – set to be increased following the announcement that Hanwha Solution is to restart production at Moses Lake – about 8GW of module capacity as well as growing cell capacity, with Parr expecting a wafer announcement soon to complete the supply chain.

"US manufacturers have learnt how to be competitive with China," he says. "And, when you factor in the supply risks associated with the Chinese supply chain, we're in a different world than we were five years ago."

'Fit for 55 can be thrown in the bin': PV players discuss Europe's push to scale up deployment

31 March 2022: Solar players in Europe have called for efforts to accelerate renewables deployment and unlock more corporate power purchase agreement (PPA) volumes in light of the European Union's (EU) push for more energy independence following Russia's invasion of Ukraine.

The European Commission announced earlier this month it would simplify renewables permitting as it unveiled its REPowerEU strategy, which will see the EU reduce demand for Russian gas by two-thirds before the end of the year. That plan follows EU proposals to increase the percentage of renewables in the bloc's energy mix from a previous target of 32% to 40% by 2030 as part of its 'Fit for 55' package.

Russia's invasion of Ukraine means that Fit for 55 is now "something that you can throw in the bin", said Stefan-Jörg Göbel, senior vice president of wind and solar for

Spain and Germany at Statkraft, adding: "I think we have to radically rethink energy policy from A to Z."

Speaking at the Large Scale Solar event, hosted by PV Tech publisher Solar Media, Göbel said that while energy policy has previously been focused on balancing security of supply with environmental concerns and the economy, now it has shifted to "security of supply first, second and third".

"So it's about doing everything possible to bring in more supply into the market via solar, wind, any other technology, including hydrogen, as fast as we can."

Göbel pointed to an announcement by Portugal's secretary of state for energy, João Galamba, who said at the event that the country will no longer require environmental impact assessments for new solar projects with a capacity of under 50MW as the government looks to accelerate PV deployment.

"I think this is the type of radical approach we need to see," Göbel said of the policy.

While the war in Ukraine has prompted a rethink of European energy policy, it was also revealed during the panel discussion that it has also disrupted the solar supply chain.

Gulnara Abdullina, vice-president of Europe at LONGi Solar, said the module manufacturer previously transported connectors from Europe by land, but with some train services stopping because of the war, they now need to be airfreighted. "As a result, they're getting more expensive," she said.

In terms of solar financing, Fit for 55 and accelerated deployment targets in markets across Europe means "a huge pool of capital is needed", according to Anthony Doherty, chief investment officer at Irish renewables investor and asset manager NTR.

While corporate PPAs are becoming more popular across Europe, Doherty warned that there will be a shortage of them as there aren't enough creditworthy counterparties of sufficient size to meet the demand that's needed for the number of projects.

As a result, he called for more support to encourage aggregation. "It would be fantastic if there was some EU backstop in terms of mid-tier corporates that could align together and aggregate. I think that's probably where we are missing a big part is medium-size corporates aggregating and then going out to market."

PV Tech Premium reported earlier this year that there could be an emergence of credit structures that enable smaller and mid-sized corporates in Europe to access renewable PPAs via aggregation.

A recurring theme brought up by speakers at the Large Scale Solar event is the need for the industry to communicate the benefits of solar to local communities.

Manuel Silva, director of project development at investment firm Aquila Capital, said developing solar in Portugal has changed within the last two years, with there now being more scrutiny on new projects. This means developers should engage with local stakeholders and carry out public consultations to understand community concerns and expectations.

"Then comes the important part: which is you need to walk the talk, meaning you need actually to implement some changes in the project, you need to live up to the standards that you are preaching," Silva said. This could mean, for example, reducing the use of concrete foundations, avoiding cutting down trees and creating landscape integration plans that mitigate a project's impact.

"On top of that, you should create a strategy of shared value," Silva added. "You basically need to find initiatives – be it with agriculture, be it with tourism, be it with biodiversity – and create some initiatives locally that present you as an agent of local development and as a long-term partner."

Panic at the Discom: Andhra Pradesh high court ruling sets worrying precedent for Indian utilities

18 March 2022: A high court in the Indian state of Andhra Pradesh has ruled that state distribution companies (Discoms) must honour the power purchase agreements (PPA) they signed with electricity producers and settle any debts within six weeks in a move with potentially huge significance for the country's solar sector.

India's cash-strapped Discoms have long sought to renegotiate signed contracts and are "perennially in financial trouble", so this week's (16 March) ruling is potentially huge for both them and independent power producers (IPPs) in India.

PV Tech Premium spoke with analysts in India and abroad about the ruling and what it means for the country's solar sector.

The ruling

A high court bench of one judge ruled that Discoms must pay power generators the full amount they are owed "in accordance with the PPAs", along with "a late payment surcharge levied as per the terms of the PPAs", according to a court filing on the proceedings.

While the high court had previously ruled that Discoms in the state could make the payments at an interim tariff rate of INR2.43 (US$0.032)-2.44 per unit – instead of the agreed PPA tariff rate of INR5.99/kWh (US$0.079) for the first year – the judge told Discoms to "abide by the terms of the PPAs executed with the [power generators] and make timely payments therein."

Andhra Pradesh's Discoms now must pay back the full PPA tariff rate within six weeks, with an estimated cost of around US$1.4 billion, inclusive of dues arising from the difference between the PPA rate and the interim rate over the last three years.

Girishkumar Kadam, senior vice president of the ICRA rating agency, said the ruling was a "significant positive development for the renewable energy sector and will thus provide major liquidity relief for the affected IPPs in the state."

"The pending resolution of PPA tariff renegotiation has been a key concern for the renewable energy sector and in turn affected the credit profile of wind and solar IPPs in Andhra Pradesh," said Kadam.

A ROTH Capital note said both Azure Power and ReNew Power stood to benefit financially from the ruling. ReNew had previously indicated that it was looking to recover almost US$200 million from Andhra Pradesh, while Azure was chasing around US$24 million of receivables and long-term payments.

"The high court order is a relief for the industry, particularly as it reinforces the basic tenet of contract enforcement," said Vinay Rustagi, managing director of research firm Bridge to India (BOI).

Rustagi added the ruling lays down a "definitive marker" for other states trying to renegotiate PPA contracts.

What it means going forward

While the order will be welcomed by India's solar sector, and ReNew and Azure in particular, it "doesn't deal with the bigger problem of terrible Discom finances, the root cause for states seeking to renegotiate PPAs and delaying payments," said Rustagi.

Problems with Discoms' finances are no secret and even the court filing referenced the "financial crisis" of the state's utilities.

"Having run up dues over three years, it is not clear how the Andhra Pradesh Discoms will suddenly find money to pay in six weeks," said Rustagi. "For the long-term health of the power sector, it is imperative that the central government works together with states to find a permanent cure to Discom payment issue."

Raj Prabhu, co-founder and CEO of Mercom Capital, agreed that Discoms were "perennially in financial trouble" but said their search for the cheapest power available may present some significant issues for the solar industry moving forward.

India will introduce a basic customs duty (BCD) on solar modules and cells from 1 April this year. This is expected to push up both cell and modules prices in the short-term, with trade bodies calling on the MNRE to grandfather certain projects or risk up to 10GW of solar deployment.

"If the PPA prices go up after BCD comes into effect, the fear is [Discoms] will not pay more for the same solar power," said Prabhu. "Instead, the fear is that they may delay solar procurement until the prices come back to the lower levels they are used to, which will not be a good thing for the industry."

On top of this, the ruling sets a precedent for other states. Rustagi said the issue of poor Discom finances and the renegotiating of contracts was not endemic to Andhra Pradesh. "There are at least four or five other states which have been delaying payments to power producers for more than a year," he said.

These states – Telangana, Tamil Nadu, Maharashtra, Rajasthan and Karnataka – will be watching proceedings in Andhra Pradesh carefully.

Although the dispute in Andhra Pradesh has been dragging on for the best part of three years, the ruling could have significant repercussions for other Indian states seeking to renegotiate contracts with power producers if other their judicial systems accept it as a precedent.

Inflation, power price volatility and seeking an equilibrium between PV projects and capital

8 March 2022: There's an adage in politics that has grown in popularity of late. It's said there are years when weeks of notable events happen, and weeks when years happen. Sunny Aurora, partner at consultancy firm EY, perhaps best placed into context, moderating the keynote panel at PV Tech publisher Solar Media's Solar Finance & Investment Europe 2022 conference, when he reminded the room that COP26 took place in Glasgow less than six months ago, and a landmark IPCC report was published in early March.

Such have recent events, especially Russia's invasion of Ukraine and its ricocheting effect on energy economics in Europe and beyond, impacted the renewables landscape that it is perhaps difficult to isolate a key theme from the opening day.

But if there is one threat posed to the industry's deployment prospects in the near-term that speakers and delegates were most concerned by, it is that of inflation. The solar industry has contended with incredible price pressures already over the last 12 months in particular and, with sky-high energy prices sending inflation soaring – and that lifting interest rates and other costs of capital – the levelised cost of electricity for renewables projects is being significantly impacted.

Giovanni Terranova of Bluefield suggested that with double-digit inflation a distinct possibility in certain markets, such price pressure would require a significant rethink in the way projects are approached. The increasing cost bases of PV projects would quickly eat up remaining margins and, as Everwood Capital partner Jose Antonio Urquizu stressed, interest rates are already of concern. And that's not considering where interest rates may climb to if inflation worsens.

Inflation and the cost of capital was an ever-present topic on the event's opening day, with much debate over to what extent Europe's soaring wholesale power prices could offset cost increases. One potential consequence could be for asset owners and operators to consider more merchant exposure and adjust the percentage of revenues from power purchase agreements (PPAs) accordingly, a dilemma which Gregor McDonald, head of trading and PPAs at European Energy, described as a "luxury problem" for developers given the spiralling prices on Europe's power markets today.

But even concluding on PPAs in today's market is riskier, despite the inherent benefit for corporate or utility customers looking to hedge their costs. As McDonald said, given the time it takes to conclude on a PPA, especially for corporate customers, coupled with power market volatility, the pricing bandwidth offered at the start of negotiations – and indeed the entire economic basis for the project, given capex costs – could be wildly different by the time counterparties are in a position to sign.

Higher power prices are, however, sending corporate customers into action. Whereas previously corporate customers may have been "buying a PR story" by entering into a PPA with a solar project, triggered by ESG initiatives, McDonald said they are now hedging against power price volatility. And what's more, higher capture prices for PPAs are "allowing creativity" in terms of pricing structures.

This is too creating hope that financing will be plentiful, even if the plethora of headwinds persist. The same may not be said for the number of projects, especially against a backdrop of heightened targets throughout Europe.

As the European Union's RePowerEU strategy reinforced today, total PV generation capacity is expected to reach upwards of 420GW by 2030. Success in Germany will be pivotal for the continent reaching this target, the country having not too long ago increased its deployment target to 200GW by 2030. That will require as much as 9GW of solar PV to be installed each year and while supply chain concerns obviously continue to persist, a greater number of projects will also need to come forward. Tim Kallas, CIO at developer Blue Elephant Energy, said while projects are still economically feasible in spite of inflation, the industry needs to "reach an equilibrium" between project developers and providers of capital.

Terranova echoed Kallas' sentiments by stressing that investors are moving into decarbonisation and clean energy in general and that capital will be available, just not as cheaply as it might have been, The biggest hurdle, Terranova stressed, will be in the availability of projects in which to invest that financing. ■

A greener PV

Decarbonisation | As the world leans on solar PV to decarbonise its power supply, so must the solar industry clean up its act. Jules Scully charts the industry-wide efforts for a greener solar PV industry.

Credit: NexWafe.

Reduced-carbon solar panels might not be top of the wish list of developers and procurement contractors currently struggling with volatile prices and supply chain uncertainty, but as clean energy buyers raise their demands, manufacturers are stepping up by greening the PV value chain through more sustainable production strategies.

While solar manufacturing currently represents a small percentage of global emissions, a business-as-usual approach will see carbon emissions from PV production exceed those of aluminium manufacturing by 2040, according to the Clean Energy Buyers Institute (CEBI). Aluminium is currently the fourth largest industrial commodity from an emissions standpoint, the non-profit organisation said in a recent report.

With PV deployment on track to rapidly scale up in the coming years, those championing a greener solar sector say now is the time to focus on decarbonising the supply chain by reducing the proportion of components produced in areas predominantly powered by coal (or indeed, using more renewable power in the production process) while bringing some manufacturing closer to end markets.

At 50 – 63%, the share of energy required in manufacturing is the most influential factor on the CO2 footprint of a solar module, research from the Fraunhofer Institute for Solar Energy Systems ISE revealed. And in terms of market share, China dominates all stages of module production. Fraunhofer ISE found that as of 2019, China produced 68% of polysilicon, 96% of wafers, 76% of cells and 71% of PV modules.

NexWafe is developing monocrystalline silicon wafers grown directly from a feedstock gas.

Jochen Rentsch, head of the production technology department at Fraunhofer ISE, says that for a solar panel produced in China, the carbon footprint is heavily dominated by the energy-intensive parts of the value chain, such as polysilicon production and ingot growth. "And if you drive these energy-intensive parts with thermal power plants, so basically coal, then of course your carbon footprint is relatively high."

Renewable at the source

German chemical group Wacker Chemie has worked on reducing the environmental impact of its polysilicon by interconnecting all the major steps in the production process, enabling the company to recycle intermediates and byproducts and use them as intermediates or raw materials in other parts of production.

"Another major advantage of our polysilicon production process is the fact that it is almost entirely electrified," says Christian Westermeier, vice president of sales, marketing and application technology at Wacker's polysilicon division. "This means that our process is reducing its already low carbon footprint with every kilowatt of renewable energy that is newly installed in Germany and fed into the power grid."

Westermeier adds that the company also uses a sophisticated energy management scheme that "significantly reduces" energy consumption and, thus, the carbon footprint of its polysilicon.

As it bids to reach net zero by 2045, Wacker is also looking to power more of its operations with clean energy. The company signed an agreement in March with Statkraft that will mean 40% of the electricity needs of its silicon metal production site in Holla, Norway, will be met by hydropower in the future.

Another manufacturer that has been able to benefit from its location to boost the sustainability credentials of its products is Norwegian Crystals, which produces monocrystalline silicon products, such as bricks, wafers and ingots.

Blake Barthelmess, chief operations officer at Norwegian Crystals, says the energy mix where the company's production plant is located in northern Norway is 99% hydropower and 1% wind, while it also benefits from a nearby glacier that provides naturally cool water.

With a focus on circular manufacturing, the company has developed recycling techniques for silicon material. "We don't throw it away, we bring it back through our process and increase overall yield and consumption that way and reduce and eliminate waste," Barthelmess says. "We're trying to focus on all aspects of our footprint."

Norwegian Crystals' reduced-carbon footprint is also boosted by its procurement strategy of sourcing polysilicon from the US and Germany instead of China.

Coal made up 64% of power generation in China last year, the International Energy Agency found. And the majority of the most energy-intensive components of the PV supply chain have been placed in Chinese regions such as Xinjiang and Inner Mongolia, which have predominantly coal-powered grids, according to Michael Parr, executive director of the Ultra Low-Carbon Solar Alliance, which consists of companies and stakeholders committed to accelerating reductions in solar supply chain greenhouse gas emissions.

"The quickest way to have a lower-carbon footprint in solar manufacturing is to build your facility in a geography with a relatively decarbonised grid," says Parr, who believes investments will reorient to lower-carbon manufacturing "and over time the Chinese supply chain will become less carbon-rich as it goes".

Vertically integrated Chinese module manufacturers JinkoSolar and LONGi have committed to sourcing 100% renewable electricity across their global operations by 2025 and 2028, respectively. When JinkoSolar announced that ambition in 2020 it said it would accelerate studies on new and recycled material alternatives while also building new factories in or adjacent to renewables-rich regions.

Questions have been raised, however, about the effectiveness of simply setting up new production facilities in areas with high levels of renewables. "The problem is that if you have a country with a particular energy mix, if one producer is using the hydropower, they're robbing Peter to pay Paul," says Davor Sutija, CEO of wafer producer NexWafe. "Just to say that you are buying hydroelectric-generated electricity, I think is somewhat disingenuous."

A spinoff from Fraunhofer ISE, Germany-headquartered NexWafe is developing monocrystalline silicon wafers grown directly from a feedstock gas through its EpiWafer process, which obviates the need for intermediate steps such as polysilicon production and ingot pulling on which traditional wafer manufacturing relies.

According to a recently commissioned white paper from NexWafe, conventional wafer manufacturing via the Czochralski process has many inherently energy-intensive aspects, including the need to remelt the cropped wings of the ingot and the high levels of silicon waste due to kerf loss. The company believes these issues leave an opportunity for a manufacturing method such as its EpiWafer process to offer significant energy and carbon savings.

"What is different about our process is that independent of the source of electricity, we actually consume 70% less energy and therefore emit 70% less CO2 than the conventional Czochralski methodology," Sutija says. "By going gas to wafer, it's not just green branding, it's actually energy reduction in manufacturing."

Alongside innovations from polysilicon and wafer producers, decarbonisation efforts are also being seen further down

France spearheading policy efforts to decarbonise module supply

French efforts to source more sustainable solar modules for projects backed by tenders have been successful in driving PV manufacturers to decarbonise their supply chains, according to industry observers, amid calls for the policy to be replicated elsewhere.

Obligatory for solar plants with a capacity of more than 100kWp, the policy requires installed modules to have passed a calculation that certifies the life cycle carbon impacts associated with each step of the manufacturing process with a maximum score corresponding to a return on carbon no higher than half of the life cycle of a PV power plant.

With silicon purification and ingot manufacturing being so energy-intensive, the first thing module manufacturers had to do to enter the market was find low carbon wafers, according to France Jonathan, executive director at consultancy Pink Strategy.

She says while this initially gave wafer manufacturers in Norway a head start thanks to the country's green electricity grid, Chinese wafer producers are becoming competitive as a result of reduced energy and argon consumption during manufacturing.

Given the programme's effectiveness, Jonathan says "it is a policy that is interesting to a lot of other countries".

The EU has been preparing the introduction of an Ecodesign and Energy Label for PV modules, inverters and systems, which will include carbon footprint information requirements, according to SolarPower Europe, while the Netherlands and Norway have introduced environmental product declaration requirements for PV modules, which include carbon footprint reporting.

"Each country should probably have a mechanism like France," says Jonathan. "My feeling working with manufacturers and developers mostly is that it is a good and proven way to guarantee continuous improvement of solar panel efficiency in terms of carbon emissions."

Johannes Linder, head of system design and innovation at Belectric, believes the current situation allows manufacturers to simply sort their products for specific markets depending on whether those countries have low carbon requirements. He says: "In the future, if more countries would have certain regulations, for sure the manufacturers would react."

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the PV value chain as some module manufacturers work to green their operations in response to policy drivers, most notably in France.

Progress in greening modules

Modules selected for installation in larger solar projects participating in France's tenders must pass an assessment of their carbon impact. Authorities can require certificates from module suppliers proving the origin of components, according to SolarPower Europe, which said modules with low footprints can collect bonus points and thus afford higher electricity price bids. South Korea introduced a similar system in 2020.

There are indications that there will be more efforts to incentivise ultra-low-carbon solar, similar to France's procurement programme, says Karen Drozdiak, head of ESG and sustainability at thin-film cadmium telluride (CdTe) module manufacturer First Solar. "France's efforts to encourage the use of lower-carbon solar by including a carbon assessment in its tender process sets a benchmark that other countries, such as Spain, could follow."

Between 2008 and 2019, First Solar's carbon intensity decreased by around 46% thanks in part to increased module efficiency, manufacturing throughput and capacity utilisation, decreased emissions intensity of purchased grid electricity and energy conservation initiatives.

Providing around 5% of the global module market, thin-film technologies are an example of low carbon PV solutions, SolarPower Europe said in a report published last year. This is due to a lower amount of energy needed for the upstream processing of raw materials compared with silicon-based PV products and a low amount of semiconductor material required to make modules. The trade association said, therefore, thin-film PV lifecycle emissions "are significantly lower than in silicon-based PV products".

According to First Solar, the carbon footprint of its thin-film modules is 2.5 times lower than that of monocrystalline silicon panels on a life-cycle basis. "Our lower carbon footprint is primarily due to our resource-efficient manufacturing process and avoidance of energy-intensive polysilicon production," says Drozdiak.

Alongside changes to manufacturing processes, module sustainability can be bolstered by adjustments to how panels are assembled and by the replacement of energy-intensive components.

Research published last year by Fraunhofer ISE found that glass-glass modules enable an emissions reduction of 7.5 – 12.5% compared to PV modules with backsheet films, regardless of their production location. The reason for this is not the backsheet itself, but the fact that glass-glass modules do not need an aluminium frame, which is very energy-intensive to produce.

Fraunhofer ISE's Jochen Rentsch says reducing the material input from mounting structures can also contribute. "All parts which are heavily energy dependent, if you reduce the amount in the final panel or the final system, that will help."

Replacing glass and aluminium frames with lightweight polymers is a strategy deployed by Netherlands-based module manufacturer Solarge, which has been able to produce modules that weigh less than half of alternatives while also lowering their carbon footprint. Citing research that suggests as much as 40% of roofs in the Netherlands cannot support traditional modules because of their weight, the company is targeting the country's commercial sector before expanding overseas.

In addition to being fully recyclable – thanks to a reheating step that allows the components to be taken apart from each other without contamination – Solarge modules also have a 25% lower carbon footprint than other solar modules, according to the manufacturer.

Gerard de Leede, co-founder and chief technology officer at Solarge, says the company's decarbonisation strategy is based on three steps: eliminating the use of glass and aluminium, procuring low carbon cells and using plant-based or recycled polymers.

Having been focused on pilot production and certifying its product, Solarge announced in March it secured a €10 million (US$11 million) investment that will enable it to begin the large-scale production of its modules as it works on setting up a 100MW manufacturing plant in the Netherlands that it hopes to increase to 350MW by the end of 2024.

The company then aims to set up production plants in other countries – enabling it to be closer to end markets, rather than supplying from one location – as well as license its technology to other module manufacturers. De Leede says Solarge is currently in discussion with three parties for licensing its technology, adding: "That allows this whole product to grow faster into the market, with the advantage of [being] lightweight and low carbon."

Shipping and sustainable construction

While upstream processes have the biggest carbon impact on solar modules, efforts to regionalise some PV manufacturing outside China – most notably in North America, Europe and India – are gaining momentum, potentially reducing long-haul transportation of goods while lowering their carbon footprint.

Fraunhofer ISE research suggests that for a PV module from China, the CO2 emissions generated during transport to Europe account for about 3% of the total emissions.

Despite this small share, logistics challenges and limited product avail-

Credit: Solarge.

Netherlands-based module manufacturer Solarge has replaced glass and aluminium frames with lightweight polymers.

ability mean some solar components can accumulate significant distances before being put to use in a final product.

Blake Barthelmess of Norwegian Crystals points to the journey sometimes made by quartz, which he says is mined in the US, sent to Norway for further refinement, shipped to China to be pressed and formed into crucibles, before being returned to Norway for consumption. "The number of steps that are introduced and the amount of carbon that is associated with that series of steps in the value chain is insane," he says. "Not only does it cost more, but it's also just inefficient."

Therefore, Barthelmess adds, developing regional supply chain stability "will be fundamental in lowering the overall carbon footprint of the PV industry".

"Not only does it cost more, but it's also just inefficient"

Although there may be demand from some purchasers for more locally manufactured modules, sourcing such panels can prove problematic. "We are highly interested in module alternatives from Chinese supply chains," says Johannes Linder, head of system design and innovation at solar developer Belectric, adding that alternatives become "very thin in the market, especially for utility-scale projects. This is something which is not a healthy situation."

Having built more than 4GW of solar globally to date, Germany-headquartered Belectric is working to green its operations by predominantly using direct ramming in project construction without the need for concrete. While this technique requires more steel, it means it will be easier to bring the site back to its original condition at the end of the project's life.

Belectric is also exploring the potential of dual land use by combining solar with agriculture. With governments across Europe scaling up their solar deployment ambitions, Linder says agriPV could be one solution "because it has certain advantages in terms of sustainability" while also increasing social acceptance of PV as it allows farmers to keep their jobs.

Another form of greening the PV sector is by simply getting the most out of all components and achieving the highest production possible, allowing solar farms to displace as much non-renewable power as possible. "Sustainability is also about profitability," Linder says. "We optimise our projects in a way to make sure that each project can deploy the maximum volume of energy and also for customers the maximum profit."

Demand signals

Efforts are underway to leverage the purchasing power of clean energy buyers to create demand signals that reverberate across the supply chain, possibly spurring solar manufacturers to reduce the carbon impact of their products.

One such programme is the Decarbonizing Industrial Supply Chain Energy (DISC-e) initiative, which supports energy customers with educational resources to develop an understanding of solar PV supply chain emissions and accelerate the uptake of low carbon solar. Launched by CEBI, DISC-e has published a Request for Proposal guide with recommendations for energy customers on how to integrate low carbon preferences into clean energy procurement.

Energy customers have an opportunity to maximise their impact and lead the way to a carbon-free energy future by bringing embodied carbon into the solar PV project selection process, says CEBI senior manager Jen Snook. "As awareness around emissions across the solar PV supply chain and the environmental value of low carbon solar grow, more stakeholders will begin to take the no-cost actions to prioritise it and we expect demand will only continue to increase."

Among the actions clean energy buyers can take include asking PV suppliers for information about the embodied carbon of equipment being employed in projects, which CEBI believes can have a ripple effect in the supply chain, with the information provided fed into databases to improve procurement strategies.

Another tool to assist purchasers is the EPEAT ecolabel, which aims to help clean energy buyers identify and select more sustainable products. Managed by US-based non-profit the Global Electronics Council (GEC), EPEAT addresses the full product life cycle, including managing substances in the product, manufacturing energy and water use, packaging, end-of-life recycling and corporate responsibility.

Having created a solar module and inverter category in its EPEAT registry, GEC is responding to increased market demand for lower-carbon products by adding a new criterion for low embodied carbon that is expected to go live by September. Establishing a carbon threshold, that criterion will be consistent with the methodology used in France's tender.

GEC senior manager Debbie Graham-Clifford says the organisation has been working in recent months to document the demand signals from solar buyers and "let the manufacturers that are considering EPEAT know that the demand is there already, it exists today".

Later this year will also see advocacy organisation the Silicon Valley Toxics Coalition release information on the environmental performance of PV manufacturers as part of its Solar Scorecard initiative, which aims to help customers evaluate purchases based on sustainability.

SVTC science advisor Dustin Mulvaney believes that while it is important to address sustainability challenges early in the solar industry's growth, he is unsure if there will be increased demand for more environmentally friendly PV products. "One would think that as industry grows, it would result in some seeking out more sustainable PV modules, but without widespread campaigns and broader support, this is challenging. Most folks seem to think that PV modules are good enough and don't want to ask hard questions."

A similar view is taken by Jenny Chase, head of solar analysis at research organisation BloombergNEF. "I think people just buy the cheapest solar panels. Especially right now when there is something of a supply shortage, I don't think anyone can be very fussy about it," she says, adding: "I don't see manufacturers trying to establish it as a key differentiator."

Regardless of whether customer demand rises for more sustainable PV products, increased renewables penetration, more efficient manufacturing processes and efforts to recycle a higher percentage of modules will lead to a more decarbonised PV sector.

Michael Parr of the Ultra Low-Carbon Solar Alliance believes there is increased awareness in the market of the levels of embodied carbon in modules. With the projected ramp-up in PV manufacturing as the industry reaches new heights, Parr says there is a "unique opportunity" to help guide that growth "in a more sustainable trajectory that will both reduce carbon emissions in manufacturing, but even more importantly, help de-risk some of the supply constraints in the current supply chain". ■

Is a solar circular economy on the horizon?

Recycling | The solar industry's manufacturing footprint, and indeed the projects themselves, are becoming ever larger, with more panels and other associated equipment being packaged and shipped globally. Now, as Emilie Oxel O'Leary, CEO at Green Clean Solar explains, the industry is getting serious on its end of life obligations and establishing a true circular economy

Credit: Green Clean Solar.

Panels aren't the only recycling consideration for developers, with shipping materials also posing issues.

Expanding solar power production is key to reducing emissions worldwide. The International Energy Agency initially predicted that global solar energy would reach 550TWh in 2030 - that capacity was reached and beat as of 2018.

With greater heights in solar installation come greater needs for efficient and effective waste management of panels and installation by-products. As a rapidly scaling industry, it is inevitable that solar stakeholders begin taking end of life (EOL) panel waste seriously. As of early 2022, we're beginning to see more global leaders address EOL panels as worldwide waste streams brace themselves for the influx.

First wave generation and early EOL

We have about ten more years before we begin to see the first genuine wave of EOL panels. EOL panels have yet to be data-tracked, and waste has not been well documented thus far, making it challenging to know the exact reasons early EOL is taking place beyond breakage. The lack of EOL data is expected to change as major bodies in the US, Asia and Australia have officially expressed formal research plans, albeit well behind the actionable efforts of the European Union.

The first wave of installed solar panels is warrantied to perform about 20-35 years. Currently, there are varying factors that contribute to early EOL for some of these panels. The most common reasons include:

- expected percent breakage during shipping or installation
- manufacturing serial defects
- aging systems
- extreme weather damage
- early upgrades for better efficiency
- tax policies
- installation errors
- high-temperature rooftop and early degradation

These factors highlight our need to implement waste management protocols and cost-effective recycling solutions now, both from a manufacturer responsibility perspective and legislation to help streamline protocols and lower recycling costs.

What we're seeing now is a great need for cost-effective solutions that include logistics and cleanup support, especially for utility-scale projects with a higher rate of expected broken panels per install. Utilities are also commencing more decommissioning projects requiring responsible waste diversion and management. As more aggressive weather systems impact solar farms and natural disasters cause damage to panels and racking systems, recycling effort demand is expected to increase.

Current status quo in solar's circular economy

The solar circular economy is waiting in the wings worldwide as we wrap up the era of status quo landfilling for solar panels and packaging materials. Especially for more extensive commercial, industrial, and utility installs, filling roll-off bins with broken panels and leftover packaging, all destined for the landfill, will soon no longer be the norm. Depending on the recycling outfit, waste diversion for panels can sometimes cost more than a landfill dump. Still, with discussion and movement toward standard practice for EOL panels, costs will be driven downward. The EU, in particular, has been a tremendous example of what's possible when we enact actionable recycling mandates for solar panels.

The EU has primarily led the solar circular economy, with some international companies and non-profits taking the lead. Other countries are now following suit in preparation for an onslaught of first-wave EOL. For example, the US and China had little or no mention of solar PV recycling and material recovery efforts before 2022, and here's where they're at now.

Asia & Australia

A 2021 report from the Global Energy Interconnection Development and Cooperation Organization estimated that China may witness 1.05 million tonnes of retired components and solar panels entering

SNEC
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SNEC(2022)国际储能和氢能与燃料电池(上海)技术大会暨展览会

SNEC (2022) International Energy Storage and Hydrogen & Fuel Cell Technology Conference & Exhibition

因上海疫情防控，原定于2022年5月24-26日举行的SNEC展会延期至2022年9月13-15日举行。

According to the anti-epidemic measures in Shanghai, the SNEC tradeshow, originally scheduled on 24-26 May 2022, is now postponed to 13-15 September 2022.

SNEC
Dialogue & Conference & Exhibition

SNEC第十六届(2022)国际太阳能光伏与智慧能源(上海)大会暨展览会

SNEC 16th (2022) International Photovoltaic Power Generation and Smart Energy Conference & Exhibition

时间：2022年9月13-15日
地点：国家会展中心(上海)
（上海市崧泽大道333号）

September 13-15, 2022
National Exhibition and Convention Center (Shanghai)
(333 Songze Avenue, Shanghai)

http://www.snec.org.cn

the waste stream by 2025. In February, China's policymakers formally addressed the impending renewable energy waste management need with new policy plans to develop technologies for reuse and recycling.

In particular, the Chinese policy aims for "cross-sector utilisation" of materials such as silicon recovered from solar panels to be used in other non-solar sector electronics and components. As far as it's understood, this is the first time the Chinese government has addressed the issue as an urgent matter requiring new technologies and directives for waste management and encompassing solar panels, wind turbines, and EV batteries. China, Japan, and Korea contributed to the rush in 178-plus filed patents aimed to solve module recyclability, focusing primarily on crystalline silicon (c-Si) technology.

Australia has also chosen early 2022 to announce shifts to deal with solar panel waste. So far, efforts have varied across regions, with some considering solar panels e-waste. As it stands, the solar recycling services in Australia can only recover about 17% of the materials from a panel, leaving the remaining 83%, including glass, silicon, and polymer back sheeting on the market for export or headed to the landfill.

European Union

Since 2012, EOL solar panels have been under the scope of the Waste from Electrical and Electronic Equipment in the EU (WEEE). WEEE regulations require 85% collection and 80% recycling of the materials used in PV panels. The policy uses a fund or tax incentive for the repair, reuse, or refurbishment of panels. It includes right to repair laws and enlists policies to minimise new fossil fuel infrastructures. These measures, which have been in place for about a decade now, have effectively lowered the costs of recycling to create a profitable solar recycling market.

The EU's solar panel recycling body, PV Cycle, has been widely used to fulfill WEEE compliance. The EU has been a worldwide beacon for EOL solar panel handling and recycling legislation.

Africa

As solar power scales in Sub-saharan Africa, various African countries' EOL solar PV standards are starting to be addressed. The topic has been discussed in research and best practices in Ghana and South Africa.

In Ghana, a hybrid public-private strategy focuses on technical solutions and delivers clear roles to all actors, including government, business, and end-users. The goal of Ghana's EOL plan is to achieve reduction, reuse, repair, and recycling that will benefit all stakeholders and promote education around sustainability and lifecycle knowledge on solar panels.

North America

There is no set national law for recycling solar panels thus far. The US's closest to a national directive is the Department of Energy's Solar Energy Technologies Office (SETO) Photovoltaics End-of-Life Action Plan, released in March 2022. SETO outlined an 18-page Action Plan aiming to better understand the state of EOL panels through the development of a database that tracks materials, quantity, age, location, cause of EOL, and handling methods for modules. In addition the directive aims to reduce panel recycling costs by more than half by 2030.

Currently, costs are on average US$15 - $45 to recycle one module, with the more well-known and mainstream PV recycling companies charging upwards of US$58 per panel at the higher end. It will be key to drive these costs down as landfill fees average about US$1 - $5 per module. The National Renewable Energy Laboratory (NREL) has suggested that we could have a profitable solar module recycling industry by 2032, with a US$10 - 18 per panel subsidy. These combined figures would result in the goals of SETO to reach a US$3 per panel recycling rate by 2030.

California leads the US by categorising all solar panels as universal waste, the first in the country to do so. Listing panels as such reduces the management burden and facilitates the recycling of the panels by necessary means. The mandate started on 1 January 2021, and declared that decommissioned solar panels would be regulated like other universal waste, including batteries, cathode ray tubes, mercury-containing equipment, electronic devices, and lamps.

Canada

Canada's Ministry of Environment and Climate Change Strategy announced a recycling guide; however, facilities are too limited in scope to actualise solar panel recycling under current circumstances. For now, manufacturers can become members of the PV Cycle to support recycling efforts.

South America

Brazil's massive electronics industry has paved the way for panel recycling which has launched in 2021 by SunR. For Brazil, it's not so much the recycling capabilities; those are in place, and recycling is much more cost-effective than incineration or landfilling. The larger issue is logistics in getting panels to the proper recycling facilities.

The company estimates that for every 500,000 tons of panels installed, about 40,000 tons of materials are discarded, putting the value of this market at around US$3.8million.

What percentage of panels go to landfills?

Solar Panel recycling laws and rates vary from region to region across the globe. One of the highest known recycling rates is within the EU.

Europe

According to PV Cycle, the EU is hovering at a 94.7% recovery rate of crystalline silicon-based PV modules, which exceeds WEEE's recovery rate directive of 85%. In 2008, the first full-scale solar panel recycling plant opened in France, which handles large-scale quantities of PV panels for the region. PV Cycle has partnered with solar manufacturers under the EU WEEE regulations and offers manufacturers that operate within the region recycling and compliance support.

North America

Panel recycling rates in the US are around 10%, leaving the remaining 90% destined for landfills, according to estimates from NREL.

Worldwide

The global e-waste recycling rate is estimated to be around 17.4% - that is collected and recycled properly. With looming waste recovery from the solar sector, if mandates and incentives are put in place and panels are officially designated as e-waste worldwide, solar panel recycling rates can begin having a global framework and likely a higher recycling rate than the global e-waste rates.

What can be recycled, and what is recycled?

By mass, the ratio of each panel is about 70% glass, 15% aluminum, 10% silicon, silver, indium, gallium account for 4%, and other rare metals account for about

1%. Around 99% of PV materials are non-hazardous, and about 95% of the materials are recoverable using currently available technologies. Recyclable parts of panels, installation materials, and packaging include:

- aluminum frame
- copper wire
- plastic junction box
- ground mounts
- trackers
- wiring
- inverters
- racking
- battery backup systems
- wood crates
- cardboard

When it comes to panels, the general process for recycling them should aim to recover as much material as possible. While there is no standardised process yet, there are three core phases for recovering as much material as possible from each panel.

Phase 1: Frame and junction box removal

Phase 2: Chemical, thermal, or mechanical separation of the silicon wafer from the glass

Phase 3: Chemical and electrical methods for separating and purifying silicon cells and metals (copper, lead, tin, silver)

These materials aren't the only things that need recycling. Tons of wood crates, plastic, and cardboard at a rate of about 40 pounds per pallet require diversion and management protocols.

How is the industry ramping up its efforts to boost recycling?

Panel recycling efforts across the solar industry have been sporadic, with some proactive manufacturers taking charge, others beginning research and a large majority waiting until guidelines, subsidies, and mandates move forward on recycling plans. We are witnessing a transition toward a circular solar economy thanks to varying degrees of effort and action.

Producer responsibility

Responsibility on the part of solar manufacturers is currently voluntary, and those who are acting ahead of the mandate curve are developing a model for improving their environmental and customer relations now. Early waste diversion adoption is helping these manufacturers remain relevant to their customers, especially ESG-minded businesses.

A handful of these manufacturers in the solar industry are gearing up efforts for boosting the recovery of solar materials. One manufacturer, in particular, has already established a producer responsibility model. First Solar is one of the premier manufacturers with a recycling program integrated into its contracts. Recovery is performed with a takeback approach; broken or unusable panels are sent back to the manufacturer. The company reports a 90% reuse rate for semiconductors and a 90% reuse rate for glass - materials are reimplemented into manufacturing new panels.

There are also racking companies exploring the best practices for their product and packaging supply chains. As ESG reporting becomes increasingly important and tied to both solar installs and waste - tracking recycling metrics on solar is becoming more pressing on the producer end.

ESG reporting pressures

While most manufacturers are still on the sidelines, legislation and ESG reporting are quickly putting manufacturers in a reactive position when it comes to producer responsibility. The proactive manufacturers, implementing recycling and take-back efforts, are getting ahead of best practices.

Responsible solar manufacturers delivering solutions to their customers for material recovery and waste diversion are quickly gaining leverage. ESG reporting encompasses the adoption of solar panels to combat carbon emissions; historically, solar energy installation and waste reporting were not mentioned in the same categories. Now that reporting and verifiable metrics are the expected environmental norm, waste outcomes of every advancement must be addressed. We're seeing these reports more and more, and the data must incorporate waste reduction efforts, validated by recycling reports and receipts from the recycling plant.

New markets for secondary solar products

Depending on the quality of a panel at EOL, it can be reused as a whole or for parts, refurbished, or recycled, and any materials that cannot be treated under one of these conditions can either be stored until future needs or solutions arise, or sent to the landfill as a last resort.

Solar panels that are decommissioned early or can be refurbished or repaired have an opportunity to be resold at a discounted rate for things like community solar projects or anywhere where solar costs have held people back from implementing solar. A solar panel refurbishment market is ramping up efforts; research and development have been going on since around 2017. Grants have been issued in the US for developing a full-functioning submarket for second-hand panels, parts, and components.

One of these organisations is EnergyBin, which in 2017 received federal funding to build a feasibility case for an online marketplace that supplied overstocked and hard-to-find components and decommissioned materials for the solar industry.

Within the next 10 years, we will see a solar industry that treats panels and packaging materials in a cradle-to-cradle manner

Energy Bin operates as a member platform dedicated to moving otherwise warehoused items and getting them back on the market to decrease costs for engineering, procurement, construction, manufacturers, distributors and other firms to sell overstock.

Designing for end of life

Ultimately we will need to see actionable measures for increasing global recycling and refurbishing infrastructure coupled with better design on the front end and optimised supply chain choices to create a lasting circular economy for the solar industry. This direction is inevitable, and it's apparent that the solar industry wants to do the right thing and scale toward a decarbonised future. There are a lot of improvements to make, and the efforts and acknowledgments that have been made public by large countries and organisations are a sneak peek of the recovery efforts in the works. Within the next 10 years, we will see a solar industry that treats panels and packaging materials in a cradle-to-cradle manner. Now is the time for solar industry leaders to roll up their sleeves and get us there. ■

Author

Emilie Oxel O'Leary is the CEO/Owner of Green Clean Solar, based in Marietta, Georgia. She has a strong passion and expertise in the solar industry, focusing on waste management and landfill diversion services while building a diverse workforce.

Hitting the accelerator: Germany's race to 215GW

Germany | Germany's new rainbow coalition has hit the accelerator on solar deployment in the country, setting the ambitious aim of reaching 215GW of installed capacity by 2030. Jules Scully speaks to policy makers and developers alike to discover just how the market can reach that goal.

Credit: Enerparc.

A 30MW solar project from Enerparc in Germany.

With already more than one-third of the European Union's (EU) installed solar capacity, Germany is set to supercharge PV deployment in the coming decade as the new government seeks to accelerate the decarbonisation of the country's electricity sector while lowering energy imports.

Before the new coalition government – comprising the centre-left Social Democrats (SPD), Greens and neoliberal Free Democrats (FDP) – was sworn in in December, its plans to speed up the energy transition had already been revealed, including a target of having 200GW of solar installed by 2030, by which time renewables should provide 80% of the country's electricity.

The government has since raised that goal even higher, aiming for 215GW of deployed solar by 2030 as part of measures included in the so-called Easter package.

The initial 200GW target was warmly welcomed by the country's renewables industry, with the managing director of solar trade body Bundesverband Solarwirtschaft (BSW), Carsten Körnig, at the time describing the coalition's agreement as a "solid launchpad for the successful solarisation of Germany's energy supply".

Having deployed 4.8GW of solar in 2020, Germany added 5.3GW last year, taking the country's total installed capacity up to 59GW, according to figures from BSW. Some 22GW will need to be added annually by 2030 to reach the government's new target.

Attention has now shifted to the policies required to support the PV sector reach the new deployment ambition amid a heightened focus on energy security following Russia's invasion of Ukraine.

A recent report from SolarPower Europe (SPE) revealed that Germany's solar sector has been experiencing a second boost as of 2018, thanks in part to self-consumption with attractive feed-in premiums for medium- to large-scale commercial systems and auctions for projects up to 10MW.

The country currently has two tenders for larger solar projects: one for ground-mounted plants between 750kW and 20MW and another for rooftop systems between 300 – 750kW. Christophe Lits, junior market analyst at SPE, says the ground-mount tenders are supporting the higher growth, having awarded 1.6GW of capacity in 2021 and planning to allocate a further 3.6GW this year.

In addition to those, the country also has a technology-neutral innovation tender and a solar innovation tender, for segments such as floating PV, carports and agriPV.

After the government recently revealed it would bring forward plans for renewables to account for all of Germany's electricity needs by 2035 as well as speed up the passage of the country's Renewable Energy Sources Act (EEG) through parliament, there have been solar industry calls for an increase in auction volumes to support new projects.

Tender volumes

David Johann, head of sales Europe and new markets at solar developer and EPC provider Belectric, says the target means Germany "must go back to a more subsidised market to give the security to the financing banks and to the investors". He believes the proportion of solar projects in the country backed by auctions will increase.

With recent rising costs, Johann says project Capex is now comparable to 2018. "And at that time, we had higher subsidies to achieve lower targets."

According to Stefan Müller, COO at developer Enerparc, companies without much equity tend to participate more in Germany's solar auctions, which he says are "easy to finance because the government backs you up with the amount which you participate. So that means here you see a lot of energy communities" taking part.

In terms of projects with power purchase agreements (PPAs), Müller says these are generally suited to players with strong equity back-up, "such as Vattenfall, EnBW, Statkraft, all the big utilities".

As well as posting winning bids in auctions, Enerparc has secured PPAs for PV projects in Germany in recent years, with offtakers including Statkraft and utility RWE. The latter deal, announced in December, will see RWE market electricity

Credit: Belectric.

produced from a 57MW solar project from Enerparc in the state of Hesse, with the companies touting the potential of PPAs to allow more flexibility in terms of location while speeding up development.

As of this year, RWE is also sourcing electricity from a solar project in the northern state of Mecklenburg-Western Pomerania and supplying it to Volkswagen through a ten-year PPA.

In a statement sent to PV Tech Power, RWE said that as Germany is the only industrialised country where both nuclear energy and coal will be replaced, the company sees "huge potential" for its renewables sector. In the short term, the utility is planning to open seven new offices and hire 200 employees who will work exclusively on project development.

Lits of SPE says large-scale solar PPAs remain an "emerging trend" in Germany. "However, as many utilities and investors are active in the segment, we can anticipate that it will grow and become a pillar for solar PV's development in the country in the coming years."

Indeed, German renewables developer BayWa r.e. recently announced that one of its targets for 2022 will be an increased focus on subsidy-free projects, set to be realised through PPAs with corporations.

Germany may also launch a contracts for difference (CfD) scheme, which "is probably for investors who want to think a bit bigger, but want to be on the safe side", says Enerparc's Müller. He believes the mix of auctions, PPAs and CfDs "is a good combination because this will attract international investors because they know what CfDs are".

Belectric's 172MWp Tramm-Göthen project in the state of Mecklenburg-Western Pomerania.

The outlook for merchant solar in Germany isn't as promising as other options, according to Johann of Belectric, who believes project financing could be an issue for that segment. In general, he says solar equity and debt capital providers "need securities to keep or lower their return expectations" and become less risk-averse, adding: "It's a big challenge. If there is no change, then that target will not be achieved."

Hurdles to overcome

As in other markets across Europe, solar project permitting in Germany remains a headwind that proves problematic for developers aiming to speed up deployment.

In a recent press release from the Association of Energy Market Innovators (BNE) welcoming that new draft legislation aims to decarbonise the electricity sector by 2035, the trade body called for a significant increase in tender volumes as well as faster grid registration and connection for new PV plants. "It is unacceptable that you have to wait months for a PV system to be connected to the grid," BNE CEO Robert Busch said at the time, adding that a maximum of four weeks is "acceptable".

Solar permitting processes, however, have been accelerated in some areas given the increased focus on energy security following Russia's invasion of Ukraine.

While developers such as Enerparc previously encountered some opposition to new PV plants from local residents aiming to block their construction, Müller says such opposition "is off the table from one day to another" since the war began in February.

"We've had community hearings and even mayors calling us now and saying, 'In the last hearing a few people were against it, but this is different, we want to be part of being independent from Russia, so you can have this piece of land.' This is really great."

Despite this positive development for the industry, other solar players in Germany contacted by PV Tech Power have yet to witness such efforts to speed up project permitting.

According to Johann, while people often say they want to contribute to tackling climate change and increasing climate security, when it comes to permitting "there are many people against" authorising new projects. This is said to be an issue especially impacting ground-mount installations.

Belectric has yet to see a change in mindset among German municipal governments in terms of solar permitting, Johann says, adding that opposition to new projects can come from environmentalists, archaeologists and even hunting organisations concerned about the impact a PV plant might have on animals. "It's unbelievable" that so many other things are considered more important than clean energy, he says.

Alongside struggling to secure consent for new projects, Johann believes the main

challenge for Germany's solar sector will be grid infrastructure, with upgrades already too slow to keep up with current levels of deployment. "We get sites where we have a very long transmission line – 10km to the next grid connection point – so we cannot use the closest one, and that makes grid costs expensive."

An additional challenge the sector faces is a skills gap, as solar companies battle to secure the best talent from a limited pool of qualified candidates. SPE research published last year revealed that Germany had 79,000 full-time equivalent (FTE) solar jobs in 2020, the majority of which worked in the rooftop segment. The report's medium scenario forecasts that the country will have 137,000 FTE solar jobs by 2025, when a significantly higher proportion will be employed in the utility-scale sector.

Workforce development is an issue that people tend to underestimate, according to Müller, who says "it's really difficult to find good people". As a result, Enerparc has stopped its activities in some Nordic markets, instead opting to focus on five countries: Germany, France, Spain, the Netherlands and Portugal.

As of February, Germany's unemployment rate was just 3.1%, compared with 11.9% in Greece and 12.6% in Spain, according to European Union figures. This means it can be difficult to get workers in Germany to change jobs, says Vittorio Van Ginderdeuren, director for Germany at developer ib vogt, who has called on the country's solar sector to educate people about the PV industry and encourage them to join its growing workforce.

"We find it very challenging to find enough people, either to hire or to work with," he says. "We have a restricted pool of people that we're trying to tap into, and the challenge is to grow that pool of people to be able to increase the speed of development." Positions such as project managers and originators are said to be especially difficult to find candidates for.

Van Ginderdeuren, however, is bullish about the ability of Germany's solar sector to secure enough land to reach the government's solar target, thanks to regulations that allow for projects backed by PPAs to be constructed on low-value agricultural land. "For example, in the Brandenburg area you have huge areas of land which is very sandy, and that's perfect land for PV."

Earlier this year Germany's government launched an initiative to support the dual use of some areas for both power production and agriculture. Under the proposals, moorland used for agriculture could be used to install solar projects as long as the land is eventually restored.

AgriPV and rooftop systems

Among its ten solar predictions for 2022, BloombergNEF (BNEF) forecasted that agriPV will start to properly be understood for commercial purposes. While noting that such projects make planting and harvesting more difficult, the research organisation said agrivoltaics is currently "something of a buzzword in solar circles" as it predicted progress will be made this year in choosing optimal applications.

Miguel Herrero, senior policy advisor at SPE, believes the most important part of Germany's new agriPV push is a proposal to allow multiple land use to be possible with PV projects. He says many EU member states don't recognise that agriPV projects should be eligible for Common Agricultural Policy subsidies for the reason that the project is no longer considered agricultural land.

> "the challenge is to grow that pool of people to be able to increase the speed of development"

If it is recognised in law that PV plants can also be agricultural land, Herrero says this will give developers and farmers "the clarity and the legal and investment certainty that they will actually be able to go ahead with their project".

Despite the significant potential of using more agricultural land for solar, concerns have been raised that Germany's tender mechanism will bundle agriPV and traditional ground-mount projects together.

BSW generally welcomed the government's agriPV proposals, but said that due to the additional costs when constructing plants on farmland, auctions should be separate. A similar view is taken by the German Renewable Energy Federation (BEE), the umbrella organisation for renewables associations in Germany, which said agriPV would have no chance to compete if bundled with conventional PV in auctions.

BEE head of politics Sandra Rostek says that although the proposal to combine agriculture with solar is a "very positive development", bureaucratic hurdles mean that for the time being "no more than 1GW per year will come from this segment, which is good, but it's obviously not enough".

Amid potential challenges in securing suitable land, BSW estimates that less than 1% of Germany's area will be required for ground-mount projects to meet the government targets. The trade body predicts that about half of the solar expansion by 2030 will come from ground-based plants and half from rooftop solar.

As well as pledging to slash red tape for rooftop PV, the three parties said in their coalition agreement last year that "all suitable roof areas are to be used for solar energy in the future", making it mandatory to install PV on new commercial buildings and the norm for new private buildings.

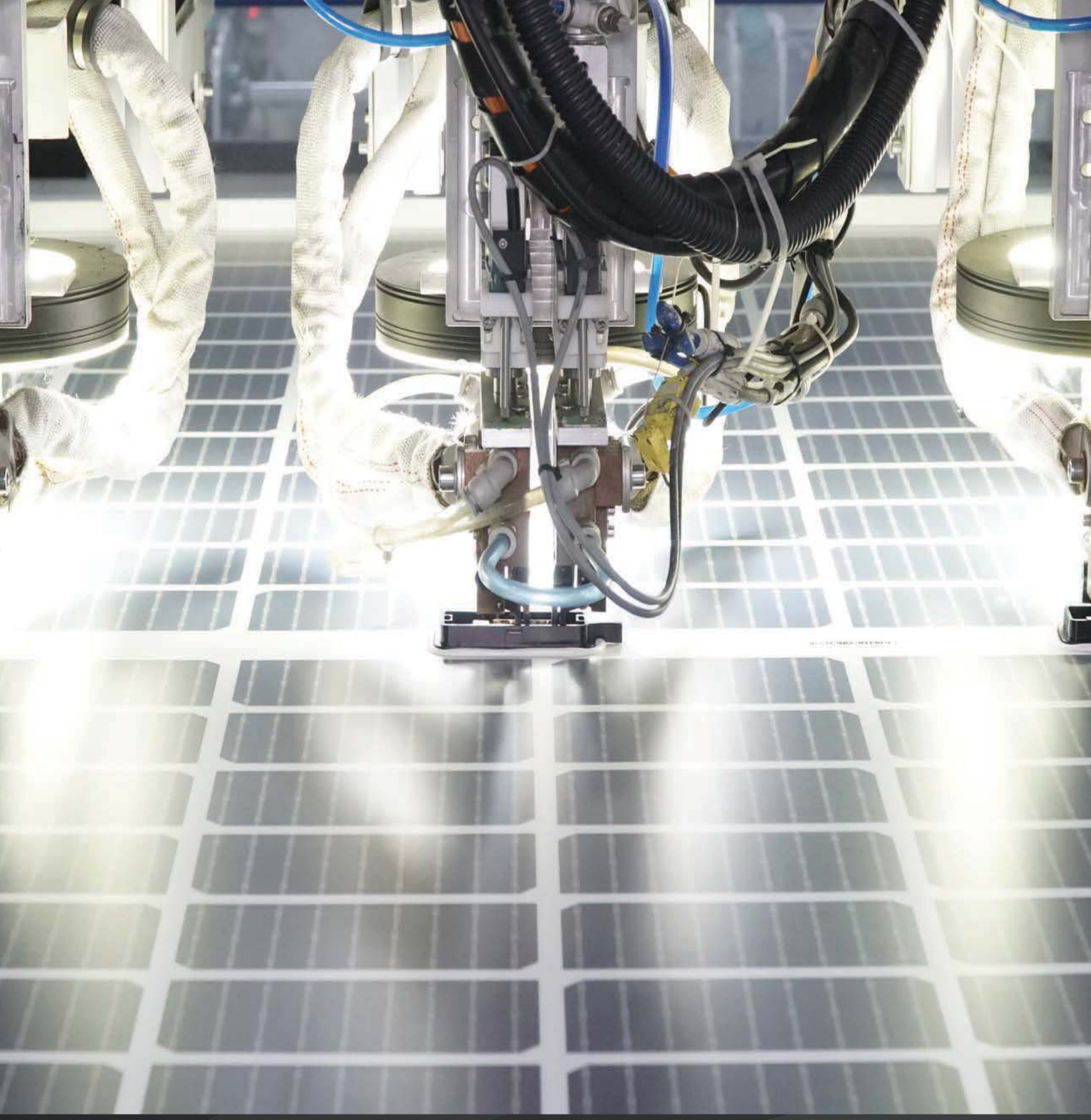
According to SPE, law changes last year made investments in residential and small commercial systems more attractive after a self-consumption levy was removed. The residential segment is expected to grow at a "reasonable pace", says SPE's Lits, adding: "The increase in solar system's price is somewhat counterbalanced by the rise in electricity price and we see households are willing to make the investment to reduce their electricity bill."

The commercial and industrial (C&I) segment, however, has been penalised by the introduction of a new rooftop tender as of last year, which led to a decline in installations. According to Lits, discussions are now underway to increase the threshold under which rooftop systems must participate in the tender.

BSW has warned current government proposals to support rooftop PV fall short, while Enerparc's Müller says that although the C&I segment is quite untapped, the market "at the moment is really very challenging for company owners who want to focus on own consumption because the bureaucracy is very high".

Measures to boost both rooftop and ground-mount solar were included in the government's Easter package. But while industry players continue to push for additional policy support, there is a recognition that the government is helping to set up the industry for significant growth.

"They are very dedicated. And I must say, I'm really positively surprised that they're not just talking, but they're really doing," says BEE's Rostek, who believes more work still needs to be done on the policy front. "We're not yet 100% convinced that the measures that have been taken will be enough." ■



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Italy's PV balancing act

Italy | Italy's solar sector is a market in flux, with moves by the government to ease development clashing with a clawback of solar profits hampering international investor confidence. Molly Lempriere takes a look at what the new market potential for Italy is and where it goes from here?

Credit: NextEnergy Capital.

Italy's government has set a target of 52GW of operational solar capacity by 2030.

Italy was once amongst the leading PV markets in Europe, with early growth spurred by its high levels of irradiation and the launch of a number of government support mechanisms. But bureaucratic challenges and changes in policy support has led it to lag behind other European markets.

As power prices have surged throughout Europe on the back of gas shortages and geopolitical tensions, focus is again turning to the fastest ways to grow the clean energy sector. Italy's National Integrated Energy and Climate Plan (PNIEC) set out a target of 55% of its power generation coming from renewables by 2030, including a 52GW solar capacity target, up from 22GW currently.

To meet this goal the country needs to triple the amount of solar it rolls out annually, and must therefore tackle core challenges such as the country's permitting process and land availability. But while positive steps have been made towards easing these, a recent move to clawback profits from operational solar power plants has risked deferring investment.

So what is the market potential of Italy, and does more need to be done to ensure the market is attractive?

Clawing back solar's success

In January 2022, the Italian government announced a new law to limit the windfall profits of some Conto Energia feed-in tariff (FiT) backed solar power plants. Conto Energia was first launched in 2005 to support the rollout of renewable technologies by guaranteeing revenues for up to 20 years. The clawback forms part of article 16 of the Law Decree 04/2022, and is set to impact geothermal, hydro, photovoltaic and wind merchant power plants with a capacity above 20kW.

For solar, this could be as much as 13GW of generating projects according to research from energy trading company EGO Energy. From 1 February, "extra profits" from these plants will have to be paid back to the country's energy management agency Gestore dei Servizi Energetici (GSE) as part of a €1.7 billion (US$1.9 billion) energy package designed to curb surging energy bills.

The move has been condemned by the country's solar trade association, Italia Solare as it "inexplicably modifies previous agreements to which the operators have legitimately relied, a change even more unacceptable considering that there has been no consultation with the operators", Paolo Rocco Viscontini, president of the association, wrote in a letter sent to Italian Prime Minister Mario Draghi in January.

Speaking to PV Tech, Viscontini highlighted that the criticism doesn't stem from the move to secure economic support where possible within an energy crisis, but from the lack of consultation and inconsistency between the impact of government policies on renewables in comparison to fossil fuels.

"Fossil energies have been touched in a much different way more recently with a new decree, but this is really unfair because it's very confused and seems a much lower level of intervention in terms of funds that are taken by the state from fossil fuels, a much lower percentage than for renewables where it is 100% of the extra price, whereas for the fossil companies it is 10% practically. With a system of calculation that is complicated and it seems that some companies will even avoid paying," says Viscontini.

The clawback is designed to raise €1.5 billion, and will work together with other measures introduced by the government such as a levy on energy companies profits to help cushion the impact of surging prices. Currently the Conto Energia subsidy costs consumers €6 billion per year.

The threat to investor confidence

Whilst the clawback may be seen as a blow to solar projects developed under the Conto Energia scheme, whether the move impacts investor confidence in the Italian market remains to be seen.

Viscontini says this was a key concern, because if the state can decide when a company is earning too much and intervene, it creates "very strong uncertainty [in the] investment atmosphere".

"At the same time, there is such a high interest and availability of capital and liquidity to invest in the sector, we still see a huge interest in investing in Italy. I expect that the IRR targets will increase to absorb this risk. It's a traditional, standard financial rule, the higher the risk, the higher will be the IRR expectation," he says.

Given the strong market fundamentals and continued push to move away from gas and towards renewable energy boosting investment prospects, many developers remain undeterred by the move. This sentiment is echoed by Richard Braakenburg, head of the equity investments team

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at SUSI Partners, who said for his team, the long-term trends in the Italian market remained favourable.

"That's also why we look at projects that aren't subsidised, because they have to stand on their own two feet," he adds. "So we're obviously tracking this carefully, but we still believe the fundamentals are there, and we're cracking on."

Others in the solar energy sector in Italy flagged that this is a short term measure, minimising the overall impact. Michele Governatori, the energy lead at ECCO, describes the measure as "old stuff already" and instead highlighted that with current prices, subsidies are not a problem.

The benefits of maintaining a stable investment environment are clear, but so too is the need for action from the government to manage the current energy crisis. Italian household electricity prices jumped 55% in the first quarter of 2022 despite the government providing €3.8 billion to cushion the blow, on the back of a 41.8% increase in gas prices.

"The government is trying to address and react to challenges never seen before. And what they are operating now is in actually through leverages that are within their control, for example taxation, and nobody ever said that taxes will never change," says Aldo Beolchini, CFO of NextEnergy Capital.

"So this is why I am not in favour of the immediate opposition [to the clawback] that came up from some parts of the industry, where they are saying, 'Oh, this is absolutely damaging the industry.' And you see investors know, when they enter into markets that some regulations might change, tax regimes can always change, energy markets are dynamic. And in our age, they are even more dynamic, in the last couple of months they've been upset by exceptional events as well."

> "The core question of what we do with agricultural land is still there"

Driving solar forward

Whilst the government is looking to utilise surging profits in the solar sector to boost the resilience of the market more broadly, it has also made moves to further support its expansion, most notably through its Simplification Decree. The Decreto Semplificazioni Bis (Act No. 108 of 29 July 2021) looks to ease the planning process allowing more solar PV projects to come online faster, tackling one of the most significant barriers in the sector.

The Simplification Decree forms part of the Italian Recovery Plan, and is expected to take advantage of €191 billion (US$227 billion) of EU funds. There are a number of tenets to it, including a new State Environmental Impact Assessment (EIA) procedure, impacting solar photovoltaic plants with a capacity greater than 10MW and a simplified authorisation procedure for power plants up to 20MW in industrial, production or commercial areas.

"We will measure the effectiveness of the Simplification Decree in the coming months," said trade association Electricity Futura president Re Rebaudengo when it was released in 2021. "Our country risks continuing to have long authorisation times and high bureaucratic costs. We hope that our fears are not confirmed ".

Additionally, the decree makes it possible for solar developers to apply for state incentives under Legislative Decree 28/2011 to construct ground-mounted projects on agricultural land. Along with planning permission, the availability of land is often seen as one of the key barriers to development in Italy, by opening up further agricultural land for PV developments, the government has recognised a potentially significant area of opportunity for the solar sector.

Across Europe, agriphotovoltaics (agriPV) is gaining increasing attention as countries look to balance clean energy targets and land scarcity. The advancement of the sector was one of eight key actions suggested by SolarPower Europe in March 2021, designed to help Europe accelerate solar deployment to reach a total capacity of 1TW by 2030 and reduce its reliance on Russian fossil fuel imports.

While the overarching aims of the Simplification Decree, and more specifically the move to open up agricultural land for development, have been welcomed by the sector, there are a number of points that remain unclear.

"There's always a bit of fine tuning clarification required," says SUSI's Braakenburg. "Those new regulations are probably working around at the edges. So we haven't quite addressed the core of that question. Designating certain areas of land, like disused quarries and various other brownfield land as developable is helpful, but it just nibbles around at the edge. The core question of what we do with agricultural land is still there, I think."

Italia Solare has called for additional details on the use of agriPV, in particular around the area of land that is used for PV and how this is defined

"These laws are still a little confused without a proper definition," says Viscontini. "So, they are exposed to interpretations that is something that we don't want, because for instance they say that both agriphotovoltaics or standard ground installed PV plants can have access to a fixed tariff for 20 years, even if this must be renovated."

The opportunity within the agriPV space in Italy is clear, and already companies are looking to take advantage of it. NextEnergy Capital recently unveiled a project that includes seven kinds of crops, working collectively for the most efficient production of power and resources.

"We have created an innovative methodology of developing projects in conjunction with the farmers unions, so that they have actually identified, what were the typical crops they wanted to grow," says NextEnergy Capital's Beolchini.

"An example is some of the land was contaminated by previous industrial and landfill processes. So we devised a part of the site to be used to grow hemp, which is a type of crop you're not going to eat. But it can be actually a fantastic replacement for plastic in insulation materials, but also has the advantage of filtering and cleaning the land over the years. So it's a natural regenerating agent for a site."

Beyond this, Statkraft Italy recently signed a four-year research agreement with the Department of Agro-Environmental and Territorial Sciences at the University of Bari Aldo Moro in April 2022, to explore the potential of agriPV in Italy and beyond.

In addition to these moves by government to spur solar power development, the country's grid operator Terna announced €10 billion of investment in March, with the intention of improving the country's national transmission grid and building more cross-border interconnections, paving the way for easier access for renewables.

"Our capital expenditure... will allow us to integrate renewable sources and electrify consumption and to guarantee ever greater security and efficiency of supply, a system that is fit for purpose and improved quality of service, whilst cutting costs for consumers and businesses," said Stefano Donnarumma, CEO of Terna, at the time.

How do investors see the market?

So has the flux in the Italian market hurt its investment prospects? Given the growing demand for clean energy it seems unlikely, especially given the strong economics of solar power meaning that beyond subsidised projects there is positive movement in the sector.

On the back of this, the power purchase agreement (PPA) market is seeing an exceptionally strong period, with Italy accounting for the second largest share of agreements in Europe at 27% according to LevelTen's Energy Marketplace. It found that Italian P25 solar PPA prices have jumped by more than 23% year-on-year between 2021 and 2022, and now sit at €51.5/MWh.

"It's interesting, because you end up in a bit of a conundrum actually, do you want to sign a PPA now, a long-term PPA at prices that the corporates won't necessarily want to do that at this level. And equally a lot of [power] producers would be well served by just being merchant at the moment," says SUSI's Braakenburg.

> "A lot of [power] producers would be well served by just being merchant at the moment"

"So I think the PPA debate is probably in a little bit of a hiatus, simply whilst we wait for these volatile times to shake out a little bit. But I think that markets will still be there."

In addition to growth in this space, there is also Contracts for Difference (CfD) auctions offering support for utility-scale solar. Italian energy agency the GSE awarded 710.2MW of solar capacity across 60 locations as part of the seventh round of the scheme. Companies including German developer Juwi, Italian developers ERG and Enel and Portuguese utility EDP won contracts for the development of solar projects under the scheme.

The combination of a push towards green energy, efforts to streamline the planning process and open up additional land, a strong PPA market and the CfD's mean despite challenges in the sector, momentum is building. But as Italy looks to expand and decarbonise its energy sector, it is important that solar is centred as a key solution to both energy security and climate action, in order to continue to strengthen as a sector.

"I think we all need to be aware of the fact that renewable energy is an emerging industry, and we're also facing a clash with the incumbent energy generators, the oil and gas majors," says Beolchini.

"When it comes to redistributing the pain, I think it is important actually to remember that the operators in the renewable energy industry are the ones that are building the future energy system. And so it was important that these costs are located right, taking into account who's part of the solution."

While the Italian market is experiencing a level of flux, it seems unlikely that this will stop the growth of solar power, with the question just remaining as to whether it will be enough to meet 2030's targets.

But, as Braakenburg says, "the arrows are all pointing in the right direction." ■

A very British solar renaissance

UK | Having witnessed its utility-scale solar boom peak in 2015, the UK is primed for a return to large-scale solar buildout. Liam Stoker explores the pipeline, the drivers and the role of the country's new energy security strategy in driving new solar deployment.

Credit: Anesco.

Anesco's Drayton Manor site has a capacity of 52.5MW.

Back in 2015, the UK was perhaps if not the jewel in the crown of European solar, then certainly one of the industry's solid-gold markets. Amidst a rush under the country's Renewables Obligation (RO) scheme, which awarded certificates for renewable power that meant projects were rewarded handsomely, around 4GW of solar PV was installed in one year.

Such was the frenzy of deployment that, at the time, there were tales of independent connection providers being helicoptered from site to site in the run-up to the 31 March connection deadlines as there was too much work and too few high voltage engineers.

But there was a spectre at the feast. The UK's Conservative Party swept to a majority government victory in May 2015 and, in the absence of their Liberal Democrat coalition partners of the previous five years, ripped through the then-named Department of Energy and Climate Change's green initiatives. If then-Prime Minister David Cameron truly did want to "cut the green crap", as he was alleged to have said privately, then his cabinet truly delivered.

The RO was almost immediately cancelled to new applicants and save for a limited number of grace period-compliant projects, development of utility-scale solar in the UK slowed significantly.

Now, however, times are different. Developers in the country have been jointly amassing a pipeline of projects that now stands at nearly 40GW, costs have fallen to the extent that even the most risk-averse investors are chasing shovel-ready assets and with the country's government keen to arrest an energy crisis exacerbated by Russia's invasion of Ukraine, the policy envelope could yet swing back in solar PV's favour.

What's in the pipeline?

PV Tech Power publisher Solar Media's in-house market research team has been tracking the UK's utility-scale solar pipeline for more than seven years, identifying projects right the way through from a tentative scoping or grid connection application to shovel-ready status. As of January 2022, the country's pipeline had swollen to some 37GWdc, spread across more than 900 individual projects at differing stages of the planning cycle.

But while that figure may seem enough to sate the UK's demand for solar PV, it's important to delve deeper than the headline statistics. As Finlay Colville, head of market research at Solar Media has suggested, many of these project applications – 77 projects, totalling just under 15GWdc of capacity – are at the tentative planning stage or have a grid connection offer in place. Colville affords this grouping of projects just a 10% chance of ever generating.

In fact, of that total pipeline figure, a total of 435 sites totalling just under 10GWdc of solar PV has submitted a formal planning application, thus implying a desire by the applicant to proceed with the project in earnest. Whilst this pipeline continues to grow and projects move through the planning sphere, it's evident

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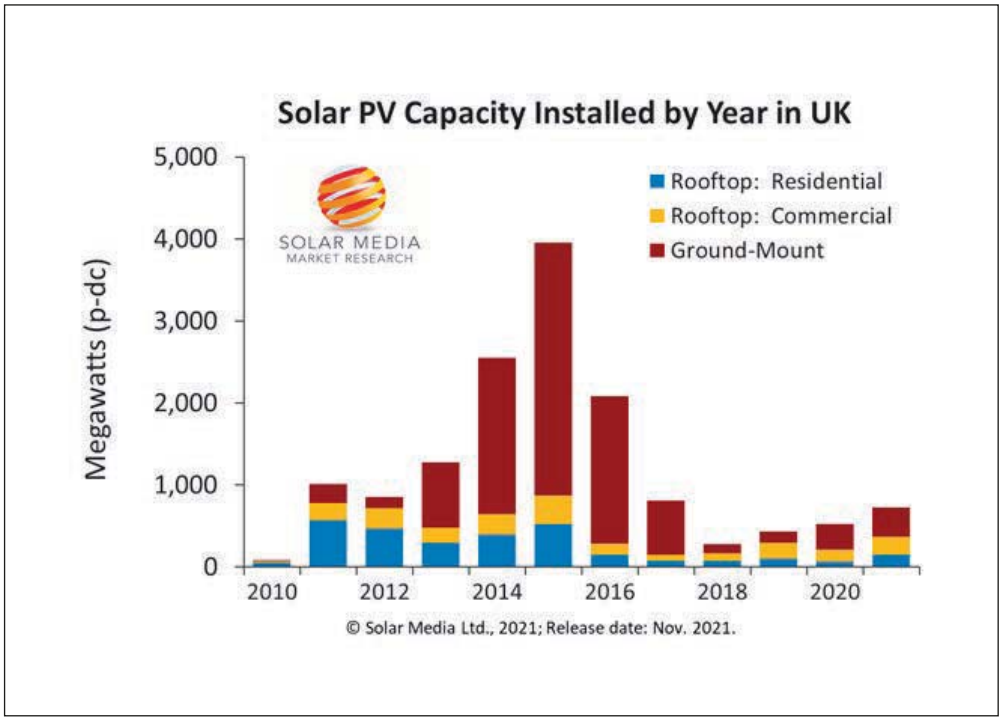

Credit: Solar Media Market Research.

that considerable progress will need to be made by industry stakeholders if average annual installs are to approach the 4GW figure necessitated by the projection included within the government's recent energy strategy (see box out).

Solar Energy UK, the country's trade association for solar PV, states there to be around 5GW of utility-scale solar projects that are shovel-ready today with another 5 – 6GW making progress through the country's planning system. Of that, a small number of projects – those with capacities in excess of 50MW – are passing through the UK's Nationally Significant Infrastructure Project route, which requires government consent.

But the significant majority of projects are navigating planning at a local level, posing the first major stumbling block for the country's solar market.

Historically, planning consent for solar farms has not been a typically time-intensive process. Mark Futyan, chief executive at UK-based solar developer Anesco, says the company used to bank on a timeframe of around three months for consent to be granted or denied by a local planning authority. Post-pandemic, this is taking significantly longer.

Chris Hewett, chief executive at Solar Energy UK, says local planning portals are now moving far slower than the industry would like. "That's not just for solar, that's for all projects. The resources within the local planning system are stretched," he says. Futyan goes one further, suggesting that planning authorities are now "overwhelmed" by the backlog of planning requests entering the system.

Solar deployment in the UK peaked in 2015 before falling after support mechanisms were cut.

Planning is, of course, just one piece of the puzzle. For a project to advance it requires a grid connection agreement and, crucially, components. Project economics were then built to those timelines and, historically at least, all three elements were more predictable than not. Futyan says that now, all three components are "extremely difficult". But while the planning system may indeed be overwhelmed, it's the UK's power networks where developers are finding more concern.

Brits turn against queuing

While the old saying goes that the British love to queue, solar developers in the country are quickly turning against the practice. Of the 14GW of operational solar capacity in the UK, much of that is developed in the country's south, leading to capacity constraints and periods of curtailment. Hewett says some of Solar Energy UK's members have warned that such is the extent of grid connection queues in the country that estimated connection dates are now falling into 2028 and beyond.

This has led many developers – or at least those with the required skilled workforce – to seek to connect to the transmission grid, operated by the government's appointed transmission system operator National Grid ET, rather than the distribution grid, which is managed by six regulated distribu-

What's in the British energy security strategy?

Launched in response to Russia's invasion of Ukraine and the impact it had on already-spiralling energy prices, the UK's Department for Business, Energy and Industrial Strategy unveiled the British energy security strategy in early April 2022, aimed at increasing the country's energy independence whilst simultaneously transitioning to cleaner sources of generation. Noting that the UK's solar capacity currently stands at around 14GW, BEIS suggested that it "expects" – note the cautious wording here – a five-fold increase in deployment by 2035, implying a total generation capacity of around 70GW. For this to occur, an average of around 4GW of solar would need to be installed each year out to 2035, a rate which trade body Solar Energy UK said at the time would support up to 60,000 jobs.

To achieve this, BEIS said it is to consult on amendments to existing planning rules in the country to "strengthen policy in favour of development on non-protected land", with the caveat that communities would continue to contribute to decision making procedures. Environmental protections will remain in place, unlike other European jurisdictions which have relaxed those to streamline permitting. Large-scale solar projects are to be encouraged on previously-developed or lower value land, such as landfill sites, and projects will be asked to "avoid, mitigate, and where necessary, compensate" for the impacts of developing on greenfield sites.

Co-located projects will also be supported, while the strategy also mentions a "radical" simplifying of planning processes for rooftop solar PV, teasing the launch of a consultation on relevant permitted development rights. Commercial rooftop solar projects up to 1MW in capacity already benefit from permitted development rights following a decision taken by the government in 2015, however.

tion network operators (DNOs). To do so requires the skills and qualifications to work at the high voltages of that particular network of 400kV. If you can navigate that particular hurdle, you can be rewarded with a shorter lead time to energisation.

This has, however, led to some unfortunate and unintended circumstances of projects being able to jump connection queues, owing to a quirk in the planning system. Those connecting to the (lower voltage, but more constrained) distribution grid are often placed into batches by DNOs, who then submit those to National Grid ESO – the national electricity system operator – to determine the need for any prospective reinforcement works in the local area. This can be a timely process and, all the while, connection agreements at the transmission level can be issued. On at least one occasion, National Grid ESO has denied immediate connection requests – despite the DNO accepting grid connection requests years prior – citing there to be limited available capacity after awarding transmission capacity in the same area.

"There's a distortion in the DNO and National Grid interplay," says Futyan, whose company has recently been offered grid connection dates for solar projects in the UK as far out as 2031, with some energisation dates even being changed just months before they were due to occur.

The discrepancy also serves to highlight the grid issues identified by developers in the UK, which have become more acute since the market's 2015 heyday. Hewett says capacity constraints, and the extent to which they can be addressed, is the biggest concern for the industry in both the short- and medium-term.

In the immediate timeframe, most DNOs now offer more flexible connection agreements – offering limited export capacity, for instance – in exchange for shorter lead times. DNOs are able to free up capacity in local grids flexibly under what's been termed a regional development project, or RDP, as long as developers can adapt their own plans.

But the industry is imploring lawmakers and regulators to intervene, placing a great deal of hope on wording within the recent energy security strategy around grid reinforcement to enable renewable developments and streamline the planning, permitting and grid connection process.

Futyan says that while the strategy was big on targets, it was light on detail and this must be addressed with an unblocking of the grid connection process in the country.

> "There's just no answers for the industry specifics of how do you make that target a reality… the interventions that will get us there, I think are absent"

"There's just no answers for the industry specifics of how do you make that target a reality… the interventions that will get us there, I think are absent," he says, adding that the grid needs "better prioritisation" when it comes to handling connection requests, while planning laws around greenbelt development need both simplifying and streamlining so they are better understood.

The industry also faces a potentially worrying trend in NIMBYism, with opposition to renewables projects – admittedly large ones – becoming more vocal than it has previously been. Hewett says this appears to be more a case of a small number of groups shouting louder, and recent surveys suggest those who actually live adjacent to solar arrays in particular are more favourable of them than those who do not.

Flipping the model

Delays across planning, grid connections and the supply chain – the UK is, of course, not immune to issues felt globally – are further impacting the financial models assets owners are entertaining when financing projects. There's an inherent risk with signing a power purchase agreement (PPA) with a specific energisation date that if the project slips, there's a financial risk hanging over it.

PPAs are too falling out of fashion as a result of the huge lifts seen at the front end of price curves, indicating that electricity generators can make supply chain volatility-busting returns by going merchant. "When investors look at the proposition now, their investment returns on a subsidy-free basis are just much better than they were a year or 18 months ago. Even though costs have gone up, the price spike in wholesale prices is lifting the revenue side. "Either way, the investment equation works," Futyan says, indicating a "huge amount of interest" that has been expressed in Anesco's pipeline.

Some developers are also eyeing up the prospect of the UK's Contracts for Difference auctions – now running at least yearly, with solar and other 'established technologies' welcomed back as of Allocation Round 4, the results of which are to be released this summer – which offer 15-year contracts designed to offer certainty to investors.

The route to which projects are financed will ultimately depend on the investor and their appetite, Futyan says, with there being no shortage of investors willing to finance solar projects – and colocated solar-storage assets, for that matter – on British shores as it stands.

Cause for optimism

The British energy security strategy was the first time this Conservative government, which has now been in uninterrupted and unchecked power since 2015, has mentioned a specific solar PV capacity target or ambition. And at 70GW by 2035, the expectation is even greater than the industry had suggested.

But that's not to say the sector is fazed by that stated aim. "I think if we can solve the grid issue, it's absolutely doable… that's the order of magnitude that people will start to accept as likely for solar," says Hewett, noting that the UK's residential and commercial rooftop sectors are now operating "at capacity", with an influx of customers willing to go solar.

Futyan concurs. "You can't build projects as quickly or as cheaply as you used to be able to, but neither of those are fundamental barriers. You can just take longer or have a bigger budget [given the wholesale power prices]," he says.

With a sizeable and growing pipeline of projects, a booming residential and commercial rooftop market and a healthy history of deployment experience and ingenuity to lean on, the UK solar market is ready to return once again to the gigawatt-scale club after a five-year absence.

If it is to realise its true potential, however, political and regulatory intervention is required, one that will address the technical issues raised by developers quickly and succinctly, without obfuscation or delay. With the spectre at 2015's feast still there – at least at the time of writing – those asks may be taller than they need to be. ■

Product reviews

Inverters — Huayu New Energy launches world's thinnest microinverter for AC modules

Product outline: Huayu New Energy has launched an upgraded version of its single-module microinverter series, the HY-300/400/500-Plus, which professes to be the world's thinnest microinverter at 25mm.

Problem: Increasing module power outputs and efficiencies are placing new technical demands on inverters, especially in the rooftop market which is witnessing a considerable increase in this area. This places strain on an inverter's performance and heat dissipation, with microinverters having to balance these demands alongside the need to comply with specific design and installation size constraints.

Solution: Huayu New Energy's R&D efforts centred on the optimal design for microinverters and combination of both software and hardware, selecting components and electric circuits – from transformers, capacitors and switches – before testing those combinations to

determine the right fit for a microinverter that must be both small in size while ensuring sufficient heat dissipation under an ambient temperature of 65 degrees Celsius and operating temperature of 85 degrees Celsius throughout a 25-year warranty.

Applications: Rooftop solar installations.

Platform: The HY-300/400/500-Plus is 25mm thick, placing it as the world's thinnest microinverter. It weighs 2.2kg and has 1.54m AC cables and AC connectors integrated within its design. Four screw holes are designed besides two sides of the product rather than the mounting plate for easier assembly both in factories and on site, with the thickness allowing for a sufficient gap between the backsheet of the solar panel and the microinverter for improved airflow. This is also achieved while keeping the whole of the microinverter's body within the module frame. The HY-300/400/500-Plus is compatible with modules featuring power outputs of 300W to 750W. The product range features a maximum DC input voltage of 60Vdc with a built-in rapid shutdown mode, reducing the risk of arc faults. IP67 waterproof enclosure rating and protection glue injected for PCBAs also extends the lifetime of the product when installed outdoors.

Availability: Available now in specific markets.

Modules — Seraphim releasing its n-type S3 module series to deliver higher efficiencies, better bifaciality and reduced degradation

Product outline: Solar module manufacturer Seraphim is to display its next-generation n-type module product, the n-type S3, at this year's Intersolar Europe exhibition. The n-type S3 delivers power outputs of 475 – 490W, uses 166mm wafers and has module efficiencies of between 21.85% and 22.54%.

Problem: After years of material increases in cell efficiency and a rapid large-scale manufacturing capacity expansion, mono PERC is showing signs of reaching the limits of its technology. But the end market's pursuit of higher efficiency products and lower costs remains. To better prepare for this shift to next-generation technologies, Seraphim began its research and development of n-type products years and is now showcasing its latest findings to meet the European market's needs.

Solution: The n-type S3 module combines n-type cells with multi-busbar and half-cut cell technologies to reach higher product efficiencies and better temperature co-efficiency. The new module enjoys better bifaciality, which generates higher power outputs whilst simultaneously reducing balance of system costs. In addition, it has a lower power attenuation rate, with only 1% degradation in the first year and 0.4% in subsequent years. Moreover, Seraphim is providing a 30-year warranty for this new product.

Application: Rooftop and utility-scale, ground-mount solar PV projects.

Platform: The n-type S3 comes in a 72-cell format with dimensions of 2094 x 1038 x 30mm. It weighs around 28 kilograms, uses 2.0mm-thick semi-tempered glass with an anti-reflective coating and an anodised aluminium alloy frame. The S3 series has received ISO9001, ISO14001 and ISO45001 certifications and has passed stringent operating environment condition testing by PVEL relating to sand, acid, salt and hail stone weather conditions as well as high wind and snow loads.

Availability: Available in 2022.

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SOFARSOLAR putting power into the hands of consumers

Energy storage | As rooftop solar proliferates, energy storage is perfectly placed to put more control into the hands of consumers. SOFARSOLAR has launched its modular energy storage solution, the SOFAR PowerAll, to achieve just that.

SOFARSOLAR has been dedicated to the development of power electronics products for many years, focusing on key areas of technology research and product development in the field of energy storage.

These R&D efforts have focused on expanding the capabilities of energy storage inverters and battery products while independently developing and producing battery management systems, intelligent lithium batteries and hybrid energy storage systems to provide customers with reliable, safe and efficient 'one-stop-shop' household energy storage system solutions.

In response to the problems experienced by the current residential energy storage industry, SOFARSOLAR has integrated energy storage batteries with power electronics technology and launched an intelligent household energy storage system solution.

The SOFAR PowerAll adopts key technologies such as independent balance management, modularization and integrated design among battery packs to enhance the balance capability between energy storage battery packs, increase the available capacity of the system and improve the battery cycle life, reliability and flexibility.

The PowerAll comprises a smart lithium battery unit which is comprised of a low-voltage battery pack, battery management unit (BMU) and a power control unit (PCU). Through the PCU, the battery can independently adjust the output voltage and current, which serves to automatically balance the capacities between battery packs according to the battery's state of charge.

This improvement to the battery capacity mismatch effectively increases the battery's available capacity, supports the use of both old and new battery units which can be expanded in stages, allows for easy maintenance and results in extremely low self-consumption of power by the battery. Furthermore, the system can be updated remotely and monitored through the use of a mobile application.

Its all-in-one design allows for a highly integrated lithium battery and energy storage inverter, whilst also possessing the advantages of a smaller footprint and design, allowing the PowerAll to be suitable for numerous installation scenarios.

The PowerAll comes with standardized accessories and quick-plug connectors, removing the need for on-site wiring. Only simple wiring and fixing operations are required and two people can complete an installation of the entire system – which includes three battery modules and one inverter module – within 30 minutes. Furthermore the battery module also has electrical and physical isolation, posing major safety benefits to the equipment and personnel installing it, while the battery is also has a zero-voltage mode, making it safer to transport and operate.

Platform specifics

- Inverter module size: 708 x 170 x 410mm
- Battery module size: 708 x 170 x 420mm
- Each battery storage module adds 5kWh of energy storage capacity, with a nominal power output of 2,500W
- One battery and one inverter module weighs 74.5kg, with each additional battery storage module weighing 50kg

Key characteristics

Intelligent management and efficient operation and maintenance;

- Built-in PCU, which automatically adjusts output voltage and current, self-balances management between battery packs and improves capacity mismatch;
- Remote system upgrade and real-time monitoring, including a mobile application that directly manage the system;
- Supports the mixed use of old and new batteries. When the battery is abnormal, the new battery can be replaced directly, plug and play;
- It can be expanded in stages, reducing the initial investment cost and high return on investment.

Modular design, applicable to all scenarios

- Fully modular design, convenient transportation and handling, stacking installation, flexible configuration
- Standardized accessories, quick-plug connectors, easy to install.
- EPS output, seamless switching, applicable to all scenarios

Safe and reliable, stable protection

- Lithium-iron phosphate battery for safe energy storage
- Electrical and physical double isolation to ensure the battery is safer
- In the process of transportation, installation and maintenance, the battery pack is in a dormant state and the port has zero voltage output for safer installation

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Product reviews

Energy storage

Sungrow's ST2752UX liquid-cooled battery energy storage system reduces system costs for hybrid solar-storage projects

Product outline: Sungrow has launched its latest ST2752UX liquid-cooled battery energy storage system with an AC-/DC-coupling solution for utility-scale power plants across the world. The new system offers minimalised system costs, higher dischargeable energy capacity, more flexibility and improved safety.

Problem: With the rapid development of renewable energy technologies, the proportion of solar, wind and other renewable energy in electricity systems all over the world is increasing. Accordingly, the demand for energy storage systems is also becoming greater while, at the same time, utility-scale energy storage systems face several problems and challenges, such as high Capex costs, low energy output, low flexibility and safety issues. Until now, the vast majority of battery storage systems have used HVAC for air cooling and direct parallel connection of multiple battery racks to increase energy density. This has led to numerous problems, such as high auxiliary power consumption, inefficient heat dissipation and severe barrel effect, resulting in lower project revenue.

Solution: Sungrow's ST2752UX battery storage system, with its advanced liquid-cooled heat dissipation technology, can dissipate heat more evenly from the batteries, while the system requires less auxiliary power consumption for cooling because the thermal conductivity of the coolant is much greater than that of air. In addition, the battery racks are connected to their own DC/DC so that different racks in the same cabinet can be controlled individually, thus reducing the barrel effect and increasing the dischargeable capacity. With temperature, smoke and combustible gas detectors, active exhaust systems and water fire-fighting systems, the possibility of accidents can be reduced to a minimum.

Applications: Utility-scale energy storage and hybrid renewables-storage power plants

Platform: The ST2752UX liquid-cooled battery cabinet, with a maximum capacity of 2752kWh, includes a liquid cooling unit, 48 battery modules (64 cells per module), 4 DC/DC (0.25C, 4 hours system) or 8 DC/DC (0.5C, 2 hours system) and a firefighting system. Its total weight is around 26 tons with dimensions of 9340*2600*1730mm (W*H*D). Depending on customer requirements, the total energy capacity of each battery cabinet can be reduced to achieve the optimum economy for a specific project.

Availability: Currently available.

Modules

Trina Solar's Vertex S+ module boosts power output for rooftop solar PV

Product outline: Trina Solar has boosted the power output of its high-performance range of rooftop solar modules, taking outputs to 425Wp while offering an extended 25-year product warranty and 30-year performance warranty.

Problem: Appetite for rooftop solar PV amidst consumers and corporates is growing at a time when power demand is surging and wholesale energy prices are skyrocketing, placing a more concentrated need for high-power solar modules suitable for rooftop installations.

Solution: The Vertex S+ module builds on the success of the Vertex S series, taking power outputs to 425Wp compared to the 405Wp of the previous model. The new Vertex S+ achieves this by incorporating n-type cells, with a module efficiency of 21.9%. The Vertex S+ comes in a dual-glass design with two options; a transparent version with bifacial cells and an option with white encapsulant. The portfolio is aimed as a premium solution for residential and commercial rooftops, featuring a black frame with dark cells for aesthetics.

Applications: Residential and commercial rooftop markets

Platform: The Vertex S+ is designed to be highly compatible with mainstream inverters, optimisers and rooftop mounting systems. It uses 1.6mm heat-strengthened glass to reduce its weight by 2.5kg compared to industry standard dual-glass products whilst maintaining its ability to withstand wind and snow loads. The Vertex S+ has received a class A + C fire rating according to IEC 61730:2016 standard. Trina Solar offers an extended 25-year product warranty and 30-year performance warranty with a best-in-class maximum annual degradation of 0.4%.

Availability: Available soon from distribution partners in Europe, available now in other jurisdictions such as Australia.

The runners and riders of green hydrogen electrolysis

Green hydrogen | The race for green hydrogen dominance is on, with global markets ramping up the scale of their ambition in terms of deployment. But this too is causing a further fight for market share among the three core electrolysis technologies, as Jonathan Tourino Jacobo learns.

Until not so long ago, green hydrogen was considered an exorbitantly expensive cousin of its fossil fuel counterparts, so-called blue and grey hydrogen. But the conflict in Ukraine and the need for the European Union to reduce its reliance on Russian gas has significantly increased the price of production of grey and blue hydrogen, making the once-costly green counterpart seem a lot more cost efficient, and cleaner too.

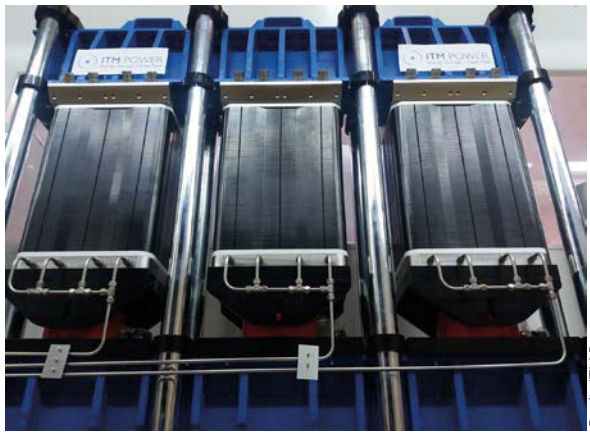
With production costs from green hydrogen expected to be lower in certain European countries than fossil fuels, it's simply a matter of time before the scale of green hydrogen projects grows. For that, production of electrolysers will have to increase if the sector is to cope with demand.

Water-based electrolysis is currently the most common way to produce hydrogen given its capacity to produce hydrogen with purities in excess of 99.9%, and there are three core technologies leading the way: alkaline, proton exchange membrane or polymer electrolyte membrane (PEM) and solid oxide electrolysis cell (SOEC). Which one to choose can depend on different factors as each technology has its specificities and particularities that need to be taken into consideration.

PV Tech Power spoke with analysts and manufacturers to examine how electrolysis technologies work, what differentiates them from each other, what they are best suited for and which one is best placed to dominate the green hydrogen market in the future.

Alkaline electrolysis offering maturity

Out of the three core electrolysis technologies, alkaline electrolysis is the most mature, with the basic principles of the technology having been used for more than a century. It relies on the use of the alkaline being a liquid electrolyte, with an asbestos diaphragm that separates the electrodes used to split oxygen and hydrogen from water. The reaction further generates heat, which can be harnessed to increase the reaction's efficiency.



Credit: ITM Power

A PEM electrolyser developed by ITM Power.

With alkaline electrolysers, since the water is non-conductive, the process to separate hydrogen and oxygen needs the use of a further chemical, normally potassium hydroxide. This is used as a liquid electrolyte to increase the ionic conductivity in the cell stack. Other processes can use sodium hydroxide or sodium chloride as electrolytes, but potassium hydroxide is the most commonly used. However, this makes alkaline electrolysers highly corrosive due to the liquid state of the electrolyte and requires more components in order to clean, raising its maintenance cost.

Alkaline electrolysis is, however, limited by the fact a more permanent and stable power source is needed. Alkaline-based electrolysers take time to start and cannot be stopped instantly, meaning variable source of power such as wind and solar PV are more complicated to be used as a direct source of electricity. This has lent weight to developers assessing other technologies that could, at least in theory, be better suited towards green hydrogen production.

Partnering with PEM

Even though PEM technology is more recent than alkaline, the structure of the electrolyser is quite similar given how it works at a low temperature – between 30 – 80 degrees Celsisus – with electrolysers not passing the 100ºC threshold.

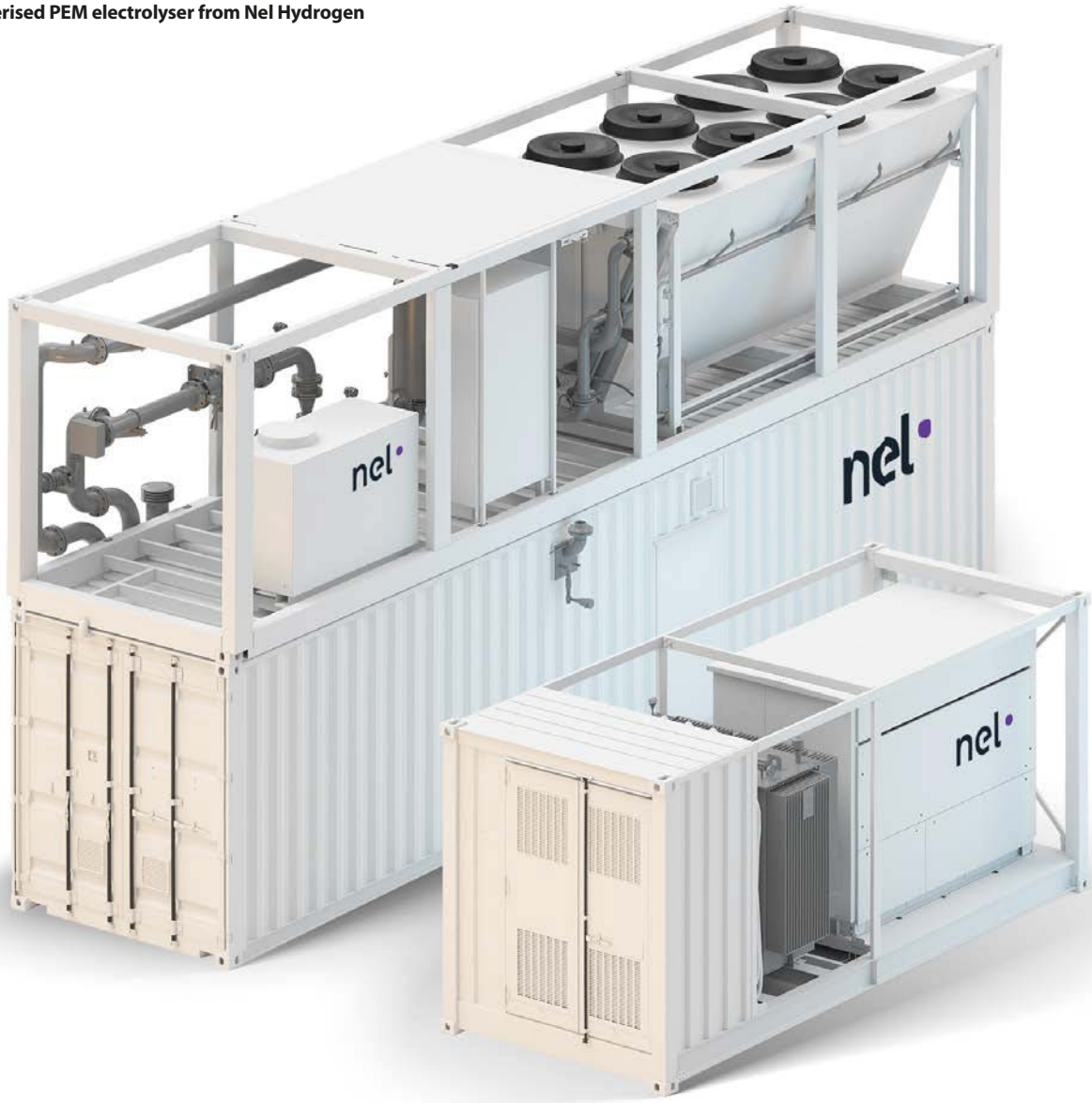
The main difference between PEM and alkaline electrolysers is the former uses a solid polymer membrane electrolyte to absorb the water, creating a physical barrier between the two electrodes instead of a liquid solution such as potassium hydroxide. This means you can generate high pressure hydrogen, says Graham Cooley, CEO at ITM Power, which has been manufacturing PEM electrolysers in the UK for the past two decades.

The physical barrier prevents gases from mixing and only lets through positively-charged hydrogen, avoiding at the same time any corrosion that would incur higher maintenance costs. Cooley adds that the presence of a physical barrier also allows PEM technology to be easily turned on and off without any disruption as it does not create any turbulence in the bottom strings, which at the same time allows for the use of fluctuating power supply such as solar PV or wind.

> "I don't think there's any limit to what projects you can do with PEM electrolysis"

While in operation the electrolysis can cause a decrease in moisture, and it is necessary to control the presence of water, but PEM technology can work with differential pressure and can be directly set to a specific pressure, given the equipment can be stabilised quite fast. It's claimed PEM electrolysis also has a smaller physical footprint, as it can

A containerised PEM electrolyser from Nel Hydrogen



Credit: Nel Hydrogen

produce more kilograms of hydrogen per m3 of cell stack and needs far fewer components than alkaline electrolysis. As for the type of projects PEM can be used for, Cooley says: "I don't think there's any limit to what projects you can do with PEM electrolysis."

He adds that even though in the past ITM Power wasn't able to get the same modular scale required, now ITM Power is able to make modules in 2MW and 5MW capacities that can be stacked up, as evidenced by the fact the company's largest electrolyser project underway has a planned capacity of 100MW.

Using steam to produce hydrogen with SOEC

The process for solid oxide electrolysers (SOEC) is quite different from the previous two in the sense that the electrolyte uses a solid ceramic material, making it compact with a fast response time, and also conducts a negatively charged oxygen ion membrane.

While alkaline and PEM both operate at temperatures no higher than 100°C, solid oxide electrolysis works with higher temperatures ranging from 500 – 1,000°C, which in itself increases the electrolysis efficiency rate as it is able to use the heat generated by the temperature and reduce the amount of electricity that's required to break the water into hydrogen and oxygen, says Chris Ball, head of technology advocacy at solid oxide manufacturer Bloom Energy.

This higher temperature also permits SOEC to use industrial waste heat from other sources, using steam as an energy input that can in itself be used in the process instead of water, reducing further the electricity needed to produce hydrogen in comparison with other electrolysers.

Similar to PEM technology, SOEC has so far been used mainly for smaller-scale projects and its higher temperature can cause a greater degradation and corrosion of the metals, resulting in an increase in maintenance costs, similar to alkaline electrolysers.

"I don't think that there's a real difference between the different technologies as far as how the projects are built," Bloom Energy's Ball says, adding: "I think it's more about the hydrogen economy what's needed. Certainly, large-scale, purpose built hydrogen facilities are going to be the most cost effective."

Be project specific

When confronted with the choice of different electrolyser technologies, many factors

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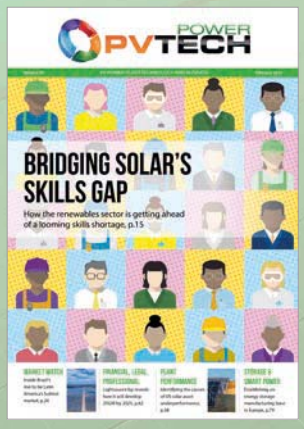

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must therefore be taken into consideration. Is this for a small- or large-scale project? Do the technology requirements dictate that only the highest-efficiency technology will suffice, or is it more a question of the project capex and its return on investment?

At the moment there is not a single approach capable of ticking all the industry's boxes, meaning that it remains a case-by-case basis when it comes to technology selection. There is no "universal tendency" to prefer one technology across the board, Stephen Szymanski, director of business development at Nel Hydrogen, says.

However Mollie McCorkindale, market analyst at PV Tech Power publisher Solar Media's market research division, suggests that PEM technology is currently favoured for green hydrogen applications given how it operates alongside variable power supplies – negating the need for a constant power source or to be paired with battery energy storage systems – and the added fact that PEM electrolysers have more simple maintenance procedures and fewer component parts.

But if projects are viewed in terms of capital cost, Szymanski notes that alkaline electrolyser technologies – when viewed a cost-per-kilowatt basis – is around US$1/kW lower than that of PEM electrolysers at the moment, increasing the technology's appeal to projects operating on more of a budget. Alkaline is also favoured when factoring the scale of the project, McCorkindale notes, pointing in particular to how green hydrogen projects coming forward in the UK using PEM are mostly of a smaller scale.

This is perhaps why the efficiency of the three technologies is under the microscope. "[It's] where the real differences are between the technologies," Ball says, adding that the fact SOEC uses less electricity offers that technology class a competitive edge.

"With a high temperature electrolyser we're using less electricity, electricity being the most expensive part of electrolysis, that's really important," says Ball. When using electricity as the sole input, Ball says SOEC technologies can achieve a 15% efficiency advantage compared to alkaline or PEM. When the use of steam is also factored in, that efficiency increases even further. "Our efficiency goes up to 30% when you have steam because again you're using less electricity, so we have an efficiency advantage," adds Ball.

Scale and the race to the top

With the three core electrolysis technologies possessing different competitive advantages, the key battleground for green hydrogen dominance could well be scale. With numerous markets establishing sizeable targets for green hydrogen development – further increasing in the wake of Russia's invasion of Ukraine – gigawatts of electrolysers will need to be manufactured and installed this decade. Szymanski says Nel Hydrogen's alkaline electrolyser plant in Herøya, Norway, has an existing output of 500MW per year, although this could expanded with the addition of up to four production lines, taking its output to 2GW. The company is also looking into scaling up production of its PEM technology in the US. The reason the company is currently prioritising alkaline, Szymanski says, is due to the fact larger projects would, at the moment, have a bigger demand for alkaline electrolysers over PEM.

> "Cost reductions will mean that alkaline electrolysis will find it difficult to find a market"

Cooley says ITM Power, meanwhile, currently has a 1GW production facility in the UK, and the company is already building a second facility of 1.5GW output, consistent with a strategy to reach 5GW per year by the end of 2024.

Bloom Energy is currently building a new factory in California for its solid oxide fuel cells that is close to 1GW, which Ball says could be converted to manufacture electrolysers in response to market demand. That switch would equate to around 2.4GW of capacity.

The race for scale is therefore clearly on, and other companies have announced they are to accelerate the manufacture of electrolysers to reach the gigawatt-scale production needed.

Market demand is proving to be a major driver in this regard. The need to faster increase green hydrogen production is increasing globally. In March 2022 the European Union revised its plans for the decarbonisation of its region and updated its goals through the REPowerEU programme. Whilst before the bloc estimated that around 5MT of green hydrogen was needed by 2030, that number rose to 20MT in the programme's recent revision, increasing the need for electrolysers from 80GW to more than 200GW in less than eight years. A report from McKinsey & Company in February 2021 estimated worldwide investments would reach US$300 billion by the end of this decade, with almost half of it coming from Europe.

In the shorter term alkaline electrolysers might still be favoured for large-scale projects, as perhaps evidenced by Nel Hydrogen's manufacturing capacity being larger for that technology than PEM and as Szymanski alludes to, market demand is higher for this technology. At the beginning of this year, BloombergNEF published its prediction for hydrogen in 2022, expecting alkaline to increase its market share over the other technologies and account for 75-78% of shipments. The research firm cited its lower cost and the fact it is best suited for large-scale projects for its increased dominance.

But as costs continue to fall in the coming years, PEM will be able to compete with alkaline, Cooley believes. "Cost reductions will mean that alkaline electrolysis will find it difficult to find a market," he says. If the UK is any suggestion to what might happen, alkaline might still be favoured for large-scale projects at the moment, with PEM being used for those of smaller scale, as McCorkindale says. But that might change in the future if manufacturing costs of PEM electrolysers continue dropping.

Moreover, providing we can rule out the entrance of a new technology that could have the capacity to disrupt the market before the end of this decade, PEM technology is expected to be best suited to dominate the market in the long run when producing green hydrogen, providing the cost of manufacturing continues to fall in line with expectations. Its advantages of no counter-effect from power fluctuation coming from renewable sources and a lower maintenance cost looks set to position it on top.

While that does remain subject to some debate in the industry, it is without doubt that electricity remains the largest cost of hydrogen production, making up to 80% of the levelised cost. It's for that reason that green hydrogen's aim of reaching its coveted production cost of US$1.50/kg – one that will see it outcompete blue and grey hydrogen – does still rely on the cost of power production, and therefore solar PV and wind, to find further cost reductions this decade. ■

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Standardisation in PV and associated inverter trends

Standardisation | Standardising PV modules will help reduce developer uncertainty, while at the same time, larger more efficient modules help reduce the size of photovoltaic plants, which continues to be one of the industry's biggest challenges, writes Victor Navarrete, grid connection manager at Atlas Renewable Energy.

As announced by several major PV module manufacturers, photovoltaic modules will now have a standard size; 182/210mm. This will be applied to different module designs, such as cell type or half-cell. The standardisation of modules will help to reduce uncertainty for large-scale renewable energy developers, who design massive projects and need to make sure that all components in the design of the project, such as trackers and inverters, are compatible with the modules. Having a standard size makes designing and developing sizable solar plants much more effective and efficient.

The standardisation of PV modules is as revolutionary as the debut of bifacial panels. Larger modules imply better use of the surface of large-scale projects and represents an improvement in efficiency and overall better production of photovoltaic plants. Larger, more efficient modules means that these large solar plants won't need to be as big as before and allow renewable energy developers to innovate and find creative solutions.

With new larger and standardised PV modules, we must also think about finding ways to update inverters, which are one of the most fundamental components of a photovoltaic plant. Larger panels imply more power, which can be reflected in an increase in the maximum power current (Imp, Maximum Power Current) and short-circuit current (Ish, Short-Circuit Current).

More power could cause a problem for traditional string inverters because they are multistring and/or multi–Maximum Power Point Tracking (MPPT), which mostly share two string inputs per MPPT, where each input has a maximum capacity of 30 Amperes (15 Amperes per string input).

This is a problem when using 182/210 mm panels, with currents up to 13.5 Amperes, without considering the extra contribution of bifacial technology, which under good environmental conditions could raise the current above 15 Amperes. When this is the case, the inverter limits the generation to keep the current under the 15 Amp limit, which would represent an energy production waste when using larger solar panels.

Credit: Sungrow.

Inverter technologies and capacities are adapting to module trends.

This represents an opportunity for inverter manufacturers to adapt to new trends in PV modules – those being larger, more powerful panels – and energy generation. Recently, new inverters have been launched that consider a higher current capacity per string input, reaching up to 40 Ampere (20 Amperes per string input), which are now challenging traditional string inverters.

With this new capacity, it is possible to take advantage of the extra power generated by the larger solar panels and the possibility of energy curtailment is minimised. From the point of view of a large-scale project developer increasing the capacity of the string inputs is a good solution, as it helps to reduce uncertainty in the face of the urgent need to close panel purchase contracts with the manufacturers.

Another tendency that has caught the eye of the market for a while now has been central inverters. Depending on the model, these inverters have one or two Maximum Power Point Tracking (MPPT) and do not have the input current restrictions of string inverters; in this case the restriction is for the maximum input current, which depending on the power of the inverter, can withstand 4,000 Amperes DC or more, thus achieving greater flexibility to work with large panels and take advantage of the extra power they deliver, which reduces the possibility of power cuts in the inverter itself.

It is evident that panel manufacturing technology will continue to advance, making them increasingly larger and more powerful, which requires inverters to evolve at a similar pace, becoming more flexible and allowing the best use of the photovoltaic resource.

The trend among inverter manufacturers seems to be to produce higher capacity string inverters and very flexible central inverters for large panel size applications. There is also a tendency to build increasingly modular equipment, reducing operating and maintenance costs and shortening replacement times in the event of failure. Overall, it is estimated that larger panels and modular inverters will significantly lower balance of system and levelised cost of energy costs, which will ultimately result in a boost to PV economics.

At Atlas Renewable Energy, we've stayed on top of these trends to push forward future photovoltaic project developments that could help heavy energy consumers to reduce their CO2 emissions, while at the same time reducing costs of energy for the long-term benefit of the environment. ■

Author

Victor Navarrete: Victor is responsible for the review and compliance with grid code requirements applicable to the company's photovoltaic and wind projects. Before joining Atlas Renewable Energy, Victor worked at Acciona Energy for five years as Interconnection Manager for LatAm. Prior to that time, Victor spent 6 years in different companies in the energy transmission sector, mainly focused on the development of electrical studies and the integration of renewable energy into the Chilean electricity grid. Victor holds an Electric Engineering degree from Universidad de La Frontera de Chile.

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Cross-connection of PV connectors – a fact check

Connectors | Solar PV connectors provider Stäubli discusses the risks of cross-mating PV connectors, examines the pitfalls of individual testing and details the international standards all solar PV professionals should know.

Damage to photovoltaic systems caused by cross-mating of different PV connector brands is a recurring issue. and one that holds the potential to pose significant problems for solar installations, as this article will explain. Often there are reports from testing institutes about tests regarding the combinations of PV connectors from differentmanufacturers, which lead to a false interpretation of compatibility. In this context, it's useful to know the difference between type approval certificates and individual testing. Far more, it is also important to be aware of the consequences from both a technical and legal perspective.

Test institutes are regularly commissioned to test combinations of PV connectors from different manufacturers. Such kinds of tests are solely being done based on the requirements of the commissioning customer. Based on those individual test reports it's misleading to conclude a safe and long-term operation regarding the combination of PV connectors from different manufacturers in a PV system based on such individual test reports.

Test reports from individual testing

One-time analysis for individual testing of the combination of PV connectors of different manufacturers are performed on individual samples. The customer decides at the time of application what is to be tested and how. A test report from such individual testing describes the actual state of the existing sample, without taking into account the production processes, the handling of raw material or the manufacturer's quality management. These individual tests are not comparable with a type approval certificate, which is far more comprehensive, repeated at regular intervals and verified by spot-checks and factory inspections. With such individual tests as a basis, no statement can be made about the long-term safety of a product combination.

A PV connector is designed and manufactured to guarantee uninterrupted operation for more than 25 years. These smallest PV components are transmitting very high currents and high voltages, which also means that the contact elements have to ensure constant low contact resistance, even in challenging environmental influences. This means that plug and socket in the connection have to be capable of withstanding high solar irradiation, temperatures ranging from below –40°C and in excess of 100° C, heavy rains and thunderstorms, winds and snow.

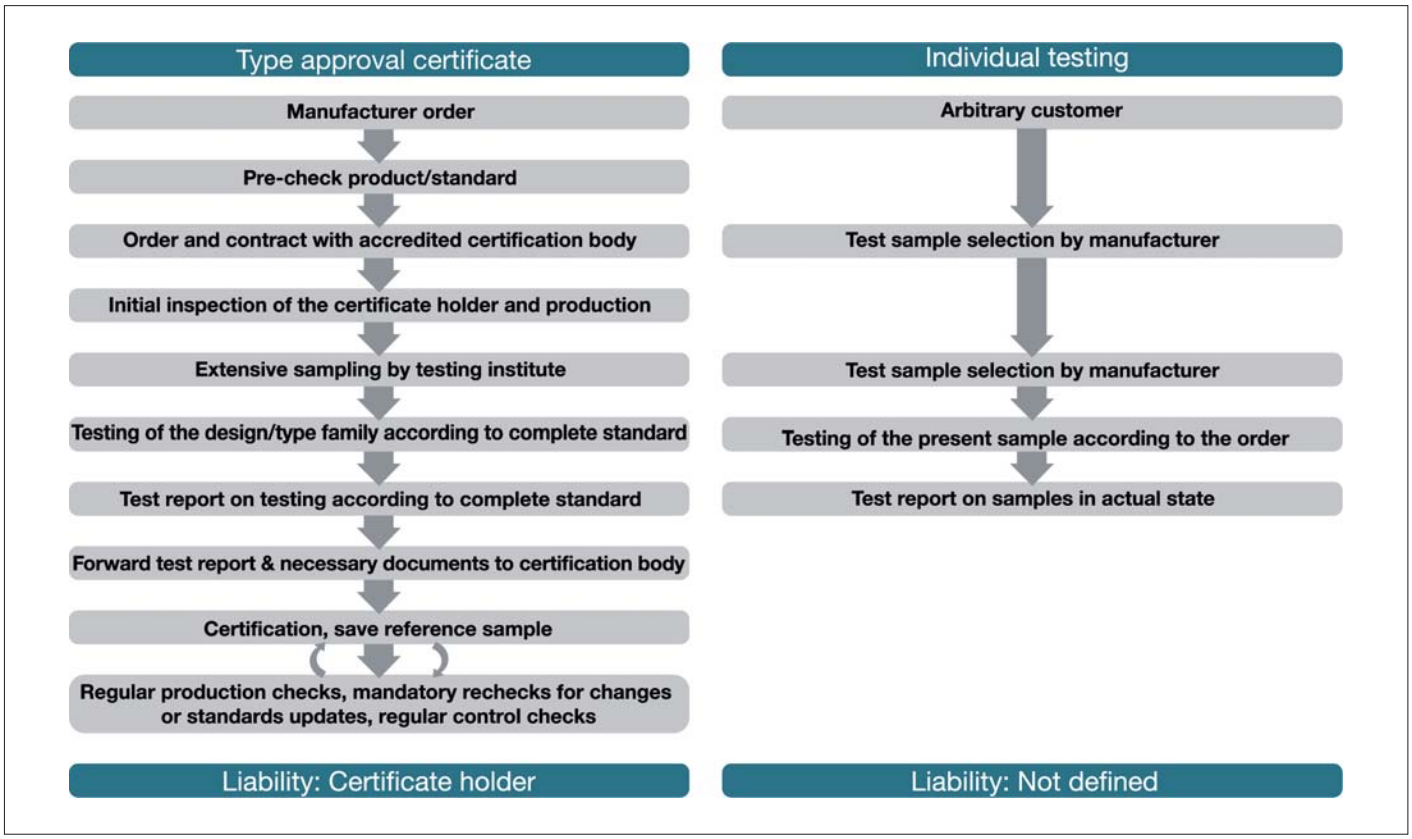
And in installations at high elevations, they also have to meet the requirements for clearances because of lower air pressure. The quality of a long-lasting connection depends on other factors including, but not limited to, the functionality of the contact technology on the inside of the plug and socket, the mutual influence of different plastic or metal alloy materials, the manufacturing process and the monitoring of consistent quality.

All these points must be considered during the development of connectors and the final type tests. Therefore, it is dangerous to conclude from the results of individual testing based on particular samples that PV connectors from different manufacturers can be safely combined in a PV system and operated safely over the long term.

The international standards

There are established standards in the PV industry; product standards such as IEC 62852:2014 + A1:2020 or UL6703, and installation standards IEC 62548 or IEC 60364-7-712. Type approval certifications are carried out based on these existing standards. These established standards were written for connectors of the same type or type family from one manufacturer. They refer to the tested connection of socket and plug within a type family and not to the respective individual parts of a connector. Therefore, they are not suitable to make a statement about the

Avoid cross-mating of PV connectors from different manufacturers and only couple same brand connectors



safety of combinations of PV connectors from different manufacturers.

This fact also applies that if two manufacturers designate their connectors as compatible on the condition that they inform each other of safety-relevant changes to the product. Even the smallest modifications can have a significant impact on the long-term function of the connection. For example, a chemical incompatibility or differing thermal expansion parameters of the metal contact can lead to contact corrosion after some time. Under such circumstances, not only are the project and the PV system at risk, but also people and the surrounding infrastructure and environment. The question then arises as to who is responsible for such damage. The manufacturers of connectors are not liable if they exclude the combination with third-party products. The PV system is implemented by the installer, which is why they can be held responsible in most cases.

Type approval certificate

A type approval certificate verifies the tested safety and quality of an entire type series. Besides the safety tests, a broad range of additional aspects is inspected and considered, such as the production process, the handling of the raw materials, and also the quality management of the respective manufacturer.

This extensive testing is repeated regularly and performed on large sample quantities that are usually selected by the expert of the testing institute. This procedure ensures a consistent quality of the products. The relevant applicable testing standards describe the minimum requirements for the safety of PV connectors, from which indications for liability can also be derived in the event of damage. Based on these existing standards the notified bodies or accredited certification institutes are signaling the tested and certified safety and quality of a type series of products for long-lasting operation in a PV plant.

A test report for individual testing is not the same as a type approval certificate, and deriving compatibility from it is deceptive. No statements regarding the safety of products and product families can be made based on the test report from individual testing. Only the status of the existing sample at the time of the respective individual testing can be evaluated. In the event of damage, product liability is not regulated, and responsibility usually lies with the installing party. Both the manufacturer and the testing institute have noted a disclaimer.

The currently valid product safety standards and installation standards of the IEC prohibit cross-connection. There are also international studies and a large number of claims showing that cross-mating different connector brands hugely increases the technical, but also the legal risk of a PV system.

Relying on individual testing reports to legitimize the cross-mating of PV connectors of different manufacturers can lead to significant risks such as loss of safety to the environment, life, and limb, as well as loss of performance with critical consequences regarding the project and financial success. ■

Table showing the difference between type approval certificate and individual testing

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PV cleaning robots: new test methods for a new technology

O&M | With PV cleaning robots posing significant advantages for solar O&M, Ben Figgis of the Qatar Environment & Energy Research Institute of Hamad bin Khalifa University, explores recent developments of standards in the field.

Credit: QEERI.

A robotic cleaning system in operation.

The robots are coming. And so are their test standards.

It is now common to use machines to clean large-scale PV plants in desert regions. Soiling losses can reach 1% per day, and it is impractical to clean kilometres of PV arrays every few days by hand. Meanwhile the technology of robotics has improved while costs have fallen. But PV cleaning robots raise new questions, such as how often to run them, whether or not to use water and abrasion of the modules' anti-reflective coating (ARC).

ARC abrasion is a particular concern. The coating increases light transmittance — and hence module power — by around 2-3%, and up to 5% at high irradiance angles. Yet it has a finite life even without contact cleaning, between one and 15 years according to a recent estimate (arxiv.org/abs/2101.05446v1).

Some commercial cleaning robots use water to reduce potential abrasion, while others use dry brushing for simplicity and to avoid the use of scare water in desert environments. The question is how fast the ARC degrades depending on the brush type, cleaning frequency and wet/dry option.

To predict ARC lifetime, a combination of laboratory and real-world tests are needed. Accelerated lab tests provide results quickly and in controlled conditions. Real-world tests validate the accelerated-test simulations, and allow effects other than abrasion to be studied, such as module micro-cracking. Of course it is desirable for accelerated-test results to be repeatable and "apples-to-apples" between different labs, hence abrasion test standards have been developed specifically for PV coatings (both anti-reflective and anti-soiling).

Abrasion test standards were a major theme of the recent PV Robot Cleaning Workshop, organised by the Qatar Environment & Energy Research Institute of Hamad bin Khalifa University. Two open standards were published this year, and at least one PV module manufacturer is developing its own in-house test protocol.

Standard development

The US National Renewable Energy Laboratory led the development of IEC 62788-7-3, published in February 2022, motivated by the fact that existing abrasion standards from other industries did not adequately simulate PV soiling and cleaning. By default the standard uses medium Arizona test dust as the abrasive for the brush test methods, although other compositions can be used for local studies.

It is primarily designed for testing coupons — samples can be as small as 7.5cm square — though in principle full-size PV modules or cover glass can also be used. The standard also covers many different abrasion scenarios: linear and/or rotating brushes, in wet or dry operation with test dust, as well as falling or blowing sand. The closest simulation of large-scale PV plant cleaning is a rotating brush with linear motion, although as the standard notes, "there is no existing commercial test equipment" for this set-up.

The other standard launched this year, DIN SPEC 4867:2022-04, came from a consortium led by Fraunhofer CSP in Germany. It is focused on simulating real-world PV module cleaning. Samples must be "original format" (full-size) modules or glass samples, to achieve industrial-grade

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ARC fabrication and coating properties. The cleaning mechanism is a linearly-moving rotating brush, with tools and cleaning characteristics typical of commercial products. For consistency, the default abrasive is feldspar, which is applied only as a wet slurry. The standard has two "modes": comparing durability of different ARCs, and comparing abrasion by different cleaning parameters such as brushes. Unlike the IEC standard, the DIN one specifies in detail how the resulting ARC abrasion is to be measured and calculated, using a reflectance photometer.

These standards will help achieve repeatable and comparable laboratory abrasion tests. They are especially useful for "A vs. B" tests, for example comparing the durability of different ARC candidates or brush types. Another potential use may be to fast-track approval to use a certain robot with a certain module. For example, if a robot is already approved to be used with module X, and a standard test shows that module Y has the same abrasion resistance as module X, then the robot could be safely approved for module Y.

Rise of the robots

The workshop also discussed comparative robot testing. Jinko Solar presented their Dust Cleaning Robot Testing Project; the company says it is the first module supplier to conduct such abrasion tests. The program field-tests robots proposed for a specific PV project during the planning stage, with results validated by Jinko, the EPC and "third parties". The tests inspect not only ARC abrasion but also the robot's movement — tracker crossing, obstacle resilience and emergency stopping.

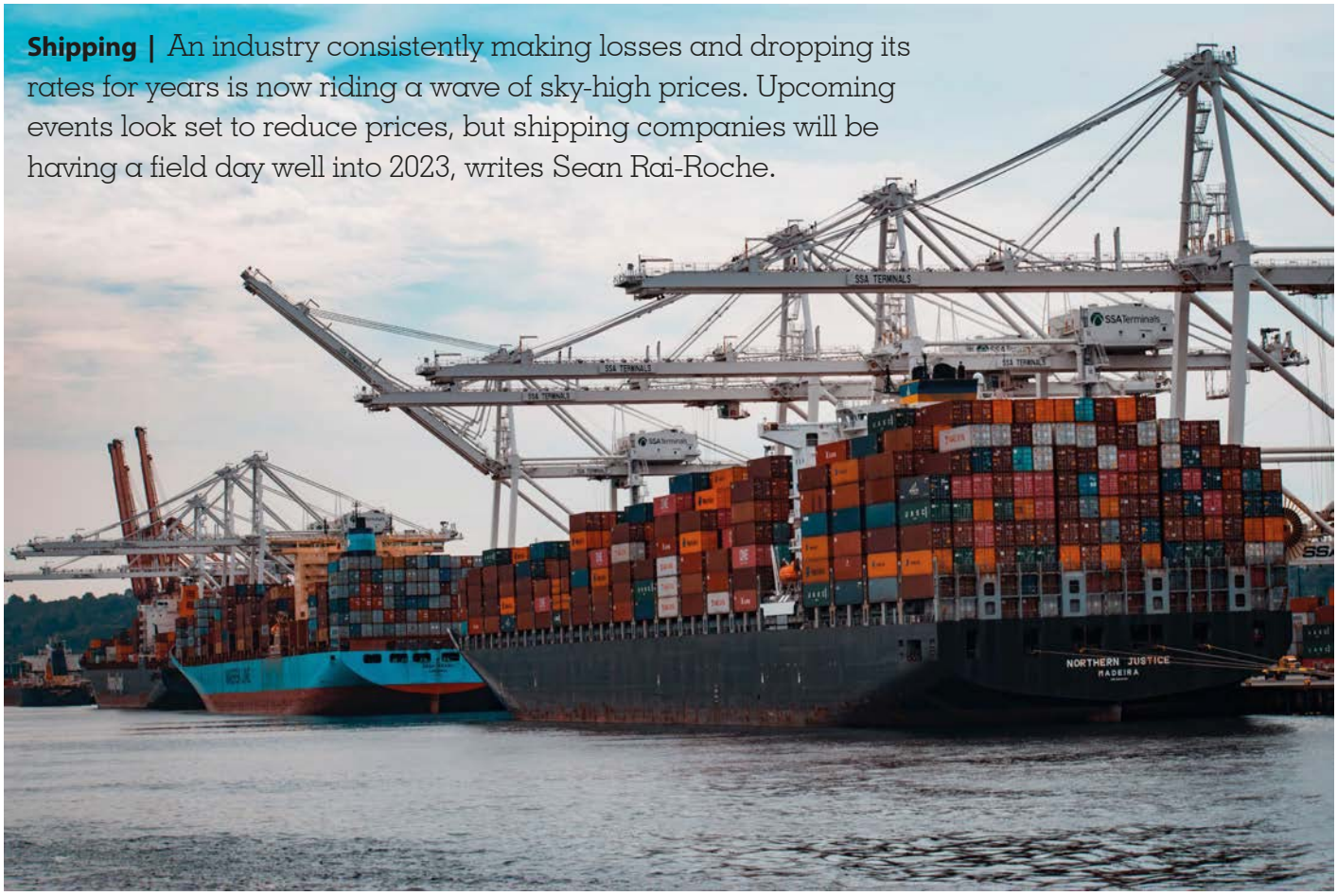
Much testing has been conducted with Jinko's Tiger-Neo n-type modules, to confirm that the modules' power rating is minimally affected. Robots run on an accelerated schedule of 10,000 passes, simulating 30 years of operation. So far Jinko has tested robots from five manufacturers. Eventually it aims to run the tests for other PV manufacturers and to release the protocol as an industry standard.

A key question is how well laboratory tests simulate the mechanics of real-world module abrasion over the long term, and whether one brush cycle in the lab equals one brush cycle in the field. A main difference is that in the field, dust accumulates over one or more days between cleanings, during which dew, humidity and high temperatures on PV modules can affect the dust properties. Therefore it is useful to validate results from indoor tests with outdoor field testing. Such indoor/outdoor comparisons will also help tailor accelerated tests for local dust types and sticking mechanisms.

At the workshop QEERI presented its outdoor robot testing program, part of its Solar Consortium industry group. The project has been using a dry-brush cleaning robot on the same PV modules and coupons at the Outdoor Test Facility continuously since 2020. Uniquely, the tests are non-accelerated — samples are cleaned either once per day, once per week, or not at all. Although this approach takes years to yield results (final measurements are due late 2022), it will provide highly realistic data on robot PV abrasion in desert conditions. ■

Waves in the shipping industry and what they mean for solar PV

Shipping | An industry consistently making losses and dropping its rates for years is now riding a wave of sky-high prices. Upcoming events look set to reduce prices, but shipping companies will be having a field day well into 2023, writes Sean Rai-Roche.



Credit: Andy Li/Unsplash

The COVID-19 pandemic has been catastrophic for so many people and changed the world in myriad ways, from nationwide lockdowns to the shift to remote working and the rise of virtual business environments. But perhaps no industry has been impacted quite so much as the global shipping industry. Fear in March of 2020 was supplanted by sky high profits, with Q4 2020 reportedly the most profitable in container shipping history.

Since the highs of 2020, prices have not come down in a material sense and still represent a massive extra cost for importers of solar products in the US and Europe, helping to push up the price of modules and in turn raise project capex costs. While significant supply additions are upcoming, it is unclear if this will lead to a dramatic reduction in freight costs. What is clear, however, is prices will never come down to the triple digit level seen in early 2020, while a number of regulatory and geopolitical decisions could compound the situation further.

PV Tech has been tracking the shipping industry and its price impact on solar products for the best part of a year. Here, we draw on various sources to provide an exhaustive analysis on the container shipping sector, its impact on solar projects, what prices are expected to do moving forwards and the key factors that could cast the sector into further uncertainty.

A brief history of shipping prices

Cast your mind back to before the pandemic. In January and February 2020, container shipping companies were charging around US$1,650 for 40-foot containers from Asia to Europe and around US$3,000 to the West coast of the US, according to George Griffiths, global pricing specialist at S&P Global Platts. Some couriers were even charging triple digit rates to capture demand and many shipping firms were making losses year after year.

Shipping costs have soared since the COVID-19 pandemic, placing strain on solar PV project LCOEs.

Then, COVID-19 hit. Economies shut down, demand collapsed and global commerce ground to a standstill as countries desperately tried to protect their populations with national lockdowns and social distancing measures. Consumer demand for home improvement goods and shipments of personal protective equipment (PPE) were the only thing keeping the industry alive. Moreover, local lockdowns and COVID-19 outbreaks saw containers dispersed around the world, rather than being returned quickly to vital export hubs.

Compounding the situation further were a series of alliances made by shipping firms in 2013 and 2014 to streamline their operations that saw fewer ships being used to transport the same amount of goods, which again had the effect of reducing the supply pool, says Griffiths.

As economies started to open back up and global trade resumed, demand soared. But this was not matched by an increase in supply. The result was a massive rise in the cost of shipping. The harpex index, which aggregates world charter rates for containers, is today up roughly 800% from April 2020. In 2021 alone, when most major economies were back in full swing and container prices were at their highest, shipping companies made profits for the year in the region of US$200-250 billion after years of losses.

Anna Larson, communications director of the World Shipping Council (WSC), summarises the situation. "The current supply chain congestion is due to pandemic-induced extreme demand coupled with operational disruptions as manufacturers have closed plants, and ports and inland logistics are overloaded, tying up capacity and reducing supply. With these supply restrictions and the high demand, rates are pushed up."

However, Larson says it is important to understand that the sensational rates published in media are not representative. "They are normally spot rates, whereas, depending on the trade, the majority of the volumes transported go under contract rates agreed between shippers and carriers for longer periods based on mutual commitments."

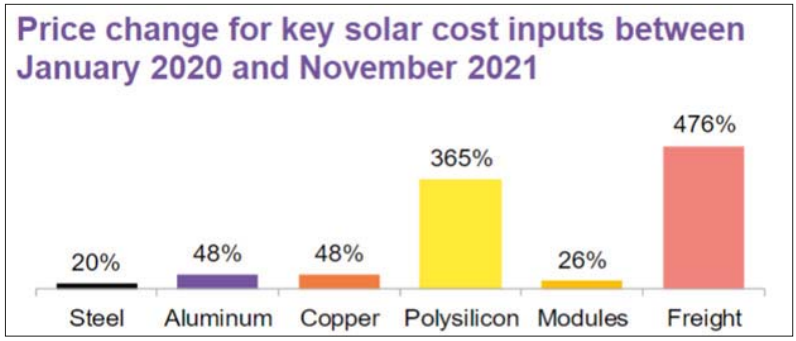
That said, in the solar industry, there have been numerous reports of couriers reneging on contracts as higher offers come in and demand intensifies. Some are even offering 'premium' rates to ensure on-time deliveries. Moreover, the increased cost of shipping gets baked into the final cost of modules for developers, resulting in a meaningful impact on a project's capex costs and LCOE.

Impact on solar projects

The average price of shipping containers from Asia rose by 597% from mid-2020, with this particularly relevant for power components manufactured in China such as solar panels, inverters or batteries, noted BloombergNEF's (BNEF) 2H 2021 levelised cost of energy (LCOE) update.

A 40-foot container can hold about 840 modules, and if each module is rated at around 445W, there's the equivalent of about 374kW in each container. BNEF's analysis shows that while freight costs have been a negligible factor in total solar project capex in the past, accounting for just US$0.01 – 0.02c/W. However now they are at US$0.04 – 0.06c/W, representing about 8% of BNEF's total capex benchmark last year.

The price of freight as an input for key solar products has increased by more than that of polysilicon.



Credit: Bloomberg Terminal, BNEF, LME, PV Infolink, Shanghai SteelHome E-Commerce, Antaike and Shanghai Metals Exchange.

BNEF's global capex benchmark for fixed-axis PV is now US$690,000/MW, some 10% up from US$630,000/MW on average in 2020. "This is the first time in more than a decade that our capex estimate increases," said the report.

BNEF's head of solar analysis Jenny Chase told PV Tech that she expects freight rates to remain flat in the near-term, meaning capex costs should not be subject to further upticks moving forward.

Meanwhile, fierce demand and port congestion have resulted in significant order delays, with a knock on effect on PV projects, particularly in the US and Europe. Late delivery of modules or other PV equipment can cause project delays, pushing back commencement of operations and disrupting companies' financials along the way.

In October 2021, the backlog of ships waiting outside the key twin ports of Los Angeles and Long Beach reached an all-time high of 112. In January, a Covid outbreak did cause another spike in congestion with 91 ships in the queue, but this number has steadily been falling and Griffiths believes the industry may have reached "peak delays".

"Delays on US West coast ports are starting to ease, with the vessel queue at the ports of Los Angeles and Long Beach falling from their January spike, however these delays and queues have begun building up at East Coast ports, in particular Charleston," says Griffiths.

An average of 18-day delays in October has now come down to roughly seven to 10 days from Asia to the US and Europe, says Griffiths. He expects delays to reduce by a couple of days every month from now on, although this is dependent on no more major disruptions to the sector.

Where are shipping prices headed?

Shipping costs remain relatively flat with some upwards and downwards movements and solar importers can expect this trend to continue through 2022 and into 2023, when some major changes are set to occur. That said, project planning and financial forecasts should not expect shipping costs to plummet back down to early-2020 levels, instead reducing slowly but surely, meaning the impact on projects' LCOE will be minimal.

A 40-foot container from the key Chinese port of Shanghai to Europe's largest port of Rotterdam now costs around US$11,100, down from a high of US$14,800 in October 2021, according to data from the World Container Index. Meanwhile spot rates from Shanghai to New York stand at roughly US$12,000 (down from US$16,000 in September 2021) and US$9,000 to Los Angeles (down from a high of US$12,500 in September).

S&P Global Commodity Insights forecasts that Asia to Europe freight rates will peak at US$14,000 for a 40-foot equivalent unit (FEU) in July, up from around US$12,500 at the start of April. Asia to East coast North America will peak at US$12,000/FEU in May, before falling slightly into July at US$10,500/FEU, with West coast rates falling gently into the middle of the year from US$8,000/FEU at the start of April to US$6,500/FEU by June, says Griffiths.

Elsewhere, the cost of leasing vessels and hiring charter vessels has soared alongside traditional container line prices. Michelle Wiese Bockmann, markets editor at Lloyd's List, says the industry was paying five times more for a "clapped-out" old ship than it was a year ago, while short distance charter vessels were charging around US$250,000, up from US$25,000 last year, adding that long term contracts being negotiated now were roughly 400% higher than they were a year ago.

While it is unlikely freight rates will ease in the short-term, there is a growing tendency for fast freight forwarders and container lines to lock in longer term contracts at higher prices, says Bockmann.

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This can be read in a couple of ways. Either the sustained high prices could be a signal that shipping companies don't expect prices to come down anytime soon or they predict that upcoming capacity additions will drive down prices and therefore want to lock in lucrative contracts, say both Griffiths and Bockmann.

Nonetheless, all analysts PV Tech spoke with expect prices to come down in 2023. This is because there is a substantial amount of containership orders in the works, with an additional 20% of the capacity of the current global fleet scheduled to come online, says Griffiths.

Bockmann says the current orderbook is around 800 ships with total twenty-foot equivalent unit (TEU) capacity of 6.3 million, adding that the current fleet in service is roughly 5500 ships and 24.7 million TEU.

"The volumes of capacity of new container ships that have been ordered in the last 18 months have been at record breaking levels," explains Bockmann. "Most of the orders were 18 months ago and lead times for shipbuilding is about two years," she says, reinforcing the idea that 2023 is when big changes are set to occur.

Falling prices at risk from external shocks

While analysts and experts are broadly agreed on the trajectory of the shipping industry and where prices are headed, they all expressed caveats to the above predictions. First and foremost, the ongoing threat of COVID-19 outbreaks in ports and key transport hubs could complicate price predictions, while China's zero COVID policy could cause further lockdowns in crucial manufacturing centres, which could again cause demand and delay spikes.

"At the moment, all eyes are on China which is currently undergoing a series of COVID-related lockdowns, so should that result in some closed ports, there could be a significant build up in demand and delays spreading across the exporting region, tying up capacity and containers themselves," says Griffiths.

Bockmann places the greater risk on China's zero-COVID policies, which have seen entire cities shutdown due to a few cases. "It's not actually the pandemic anymore," she says, "it's that policy and the shutdowns. At the moment, we're not seeing any immediate impact but it's kind of like a slow moving car crash because you know what's coming, you're going to see ships building up while they wait to collect."

> "…it's kind of like a slow moving car crash because you know what's coming, you're going to see ships building up while they wait to collect"

"Obviously manufacturing will be compromised," she continues. "Then you'll have delays at the port and a repeat, probably on a lesser scale, of what happened at the beginning of the pandemic because there's interruption to manufacturing."

On top on this, the shipping industry's drive to decarbonise may also cause extra delays and upward pressure on prices.

The International Maritime Organisation (IMO) has set decarbonisation targets for 2030 and 2050, with the 2030 target being a cut in the carbon intensity of all ships by 40%. This means more money for research and development and some older ships being taken out of circulation or travelling slower.

"The challenge for deep sea shipping is that there are no zero carbon technologies and fuels available for use, and significant investments and regulatory progress is needed on a global level to decarbonise the industry," says Larson.

Liquified natural gas (LNG) could be a potential stop-gap that complies with IMO 2030 regulations but it won't be accepted under 2050 conditions, so a long-term solution is needed with ammonia and methanol being potential options albeit ones already in high demand.

"Individual carriers are investing in research and technology development around future low and zero carbon fuels, and WSC is working for regulation and multilateral dialogue through the IMO," adds Larson.

At the same time some older, more polluting ships will also need to travel slower in order to reach the new emissions goals, which will likely result in longer transit times in a market which is already struggling with reliability, says Griffiths.

Shipping to remain a thorn in solar's side

The solar sector knows all too well the disruption that can be caused from crises in the shipping industry, from increased module prices to project delays. While solar companies should be anticipating a decline in shipping prices moving forward, nothing is set in stone. A number of factors threaten to block the downwards trajectory of prices and unforeseen geopolitical events could compound the situation further still. Companies may have to make some difficult decisions moving forward – i.e. whether to lock in long-term contracts at today's rates or continue to use spot market prices – that will depend on their business model and operational needs. That said, while the days of three-figure rates are well and truly behind us, there is reason to hope that prices will move steadily down this year, with 2023 set to change the game further as the shipping industry's fleet gets a 20% bump.

2022 will certainly be an improvement on last year, with 2023 set to ease pricing pressures considerably further. But, as we all know, a year is a long time in solar and prudent companies will have multiple contingency plans in place. ■

Source: World Container Index via Drewry Supply Chain Advisors

Shipping costs from Shanghai to major western ports have continued to rise through 2021, although there are signals that rates may come down.

Accelerating solar through robotics

Automation | Late last year AES Corportation unveiled the Atlas, an automated solar deployment robot the company claimed to be a first of its kind. Here, AES gives PV Tech Power the full story of its development.

Credit: AES.

AES' Atlas robot uses advanced techniques to install panels along tracker torque tubes.

To address the most significant challenges posed by climate change, the world must achieve net zero emissions by 2050. To reach that goal, governments, businesses and communities need to change the approach to seven emission-emitting infrastructure systems: energy, industry, mobility, buildings, agriculture, forestry, and waste. Accelerating the deployment of renewable power at scale is an essential part of this change, and this requires reimagining the way we install solar. At AES, we are rising to this challenge, increasing the speed of solar deployments, addressing workforce shortages, and promoting safety and inclusivity with Atlas, our recently launched automated solar installation robot. We are also addressing land constraints and construction timelines with our investment in 5B, a clean tech innovator focusing on prefabricated solar technology.

Unprecedented solar growth

Today, the power sector accounts for about 30% of global CO2 emissions. To achieve net zero by 2050, nearly all this power must be generated by renewable energy. Moreover, the systems that are currently powered by fossil fuels—particularly mobility, industry, and buildings—will need to transition to electricity. In some cases, this will happen directly through the adoption of new products and technologies like electric vehicles and heat pumps, whereas other systems will electrify indirectly, consuming fuels that are produced from electrically generated feedstocks such as green hydrogen.

As a result, by 2050, the demand for electricity will increase to two to three times what it is today[1] — and that increased demand will primarily be met by solar energy. This represents an unprecedented opportunity for solar expansion and necessitates fast paced construction of large-scale solar facilities. The Solar Energy Industries Association (SEIA) estimates that in the US alone, achieving the Biden administration's goal of 100% clean electricity by 2035 will require the annual deployment of more than 130GW of solar, a five-times increase from the 24GW added in 2021. Globally, the International Energy Agency (IEA) estimates that annual solar deployment will need to increase from the 183GW installed in 2021 to more than 630GW by the end of this decade[2].

We need to change how we do things

This poses significant challenges — and opportunities — in a construction industry that is already facing workforce shortages[3]. In the absence of changes in the ways solar photovoltaic plants are installed, the segment of US workforce dedicated to solar construction will need to quadruple, from the 230,000 solar workers today to more than 900,000 workers by 2035.[4] A single utility solar plant may require the installation of several hundred thousand solar panels. Staging, placing, and securing panels onto mounting structures represents some of the most repetitive and time-consuming processes in solar installation. Atlas was designed to assist the already-stretched workforce by completing these tasks, increasing the installation rate to enable shorter construction timelines, all while growing high-quality installation jobs.

In addition to this material workforce expansion, the solar industry will need to manage increasing safety constraints in the coming years, which automated installation can mitigate. The solar industry is moving towards larger, high-capacity modules. New module manufacturing standards will help to improve efficiency and delivering the optimised project economics that are needed to support the acceleration of solar expansion.

However, although larger modules save labor expenses, balance of plant cost, and allow for a more efficient use of land, they also add considerable weight. New module standards weigh up to 50% more than the previous industry standard and create a 60% larger surface area that makes them harder to lift and handle[5]. Atlas does this heavy lifting for solar installers, increasing safety and supporting inclusivity by reducing physical strength requirements for solar installers.

Apart from heavier lifting, solar install-

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ers are also likely to face hotter installation conditions[6,7]. By mid-century, the National Weather Service estimates that four times as many US cities will experience 30 or more 100+-Heat-Index-days, and that extreme heat waves are likely to become more frequent[8].

Given that high-insolation sites with little shade produce optimal solar output, solar is often deployed in harsh-weather, high-temperature areas. As a result, our industry employs significant protective measures to prevent heat-related illness. In the coming years, such efforts to keep the solar construction workforce safe from heat-related illness will become increasingly important, impacting construction operations and project timelines.

Safety is our number one priority, and by automating the panel installation process, we can limit personnel exposure and strenuous activities in high heat index conditions, while accelerating the pace of deployment and shortening the construction timeline.

Driving automation

AES' purpose is to accelerate the future of energy, together. We set out to reimagine solar installation to make it safer, faster, more affordable, accessible, efficient and scalable. This led us to develop Atlas, a first-of-its-kind artificial intelligence-enabled solar panel installation robot. We designed Atlas through a multi-year innovation process and built it in cooperation with our partner Calvary Robotics, along with other third parties.

Atlas is a tool to assist the solar installation workforce; it automates the repetitive and manual steps of the solar panel installation process. Atlas installs solar panels in half the time required for current fully manual methods. This reduces construction timelines while improving safety by minimising heavy lifting and creating better working conditions in harsh climates.

Automation in controlled and structured environments, such as factories, has been around for decades. In the solar industry, robotics and advanced manufacturing techniques have been used in the four steps of module manufacturing: silicon ingots, wafers, cells, and modules. In the field, simple robotic applications such as robotic automated mowers and photovoltaic module cleaning robots are increasingly common (see p.54).

In recent years, advancements in artificial intelligence, computer vision, mobile robotics, and advanced sensing for navigation, positioning and detection in dynamic environments have enabled advanced robotics and automation applications that would not have been possible just a few years ago. From self-driving cars to autonomous agricultural and construction machinery, outdoor automation in unstructured environments is now a reality.

We evaluated these technological advancements, tracked them over time, and incorporated advanced robotics and computer vision into Atlas. Rather than starting with the simplest installation tasks, we focused on the most repetitive steps in the process. Our aim was to prove that Atlas could overcome the most difficult challenges, helping to boost confidence and enabling Atlas to scale.

> "From self-driving cars to autonomous agricultural and construction machinery, outdoor automation in unstructured environments is now a reality"

This first-generation of Atlas robots are comprised of one robotic arm that picks and places the photovoltaic modules onto the solar structures and their respective clamps. Its computer vision system enables Atlas to "see" the solar structure and clamps. It then calculates its position relative to the torque tubes and determines where to place and secure the module. Atlas' second robotic arm finalises the installation process by locating and torquing the bobtail of the clamp, allowing for a complete installation of the solar panel.

The Atlas robot was designed to be PV structure and photovoltaic module agnostic; its artificial intelligence allows it to be trained on different solar structure and panel combinations. Solar panel mounting hardware is designed for humans, not robots. We designed Atlas to work with these existing, commercially available mounting systems, rather than developing a new tracker and clamp design for optimal automated deployment.

Although developing such a tracker would have simplified Atlas' design and operation, it would have required solar developers and installers to introduce a new mounting product, creating complexity and constraining Atlas' reach. As we scale, we may be able to further accelerate by influencing the supply chain to provide mounting hardware that is optimised for automated installation.

Together with our partners, we are further developing Atlas' capabilities by rolling it out within AES' solar pipeline. Atlas will continue to gather experience, expanding the module and tracker system combinations that it can work with. Improvements in performance is one of the key focus areas to continue challenging Atlas to meet our vision. Atlas' capacity and versatility will continue to grow as it builds more solar projects across a greater variety of topologies. We are executing on Atlas' technology roadmap, and in collaboration with talented teams to iterate and improve Atlas. We will continue to expand the fleet to take on more and larger projects. We are committed to our purpose of accelerating the future of energy, together, and we are excited to bring Atlas to the solar industry to help unlock the speed of solar deployment the world needs to meet net zero emissions. ■

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Deise Yumi Asami, solar transformational designs director, AES

Alvaro Creixell, solar construction innovation project manager, AES

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Cohabitation necessary: what's new in combining solar PV with animal habitats

Wildlife | More than ever before, solar developers are implementing measures to support animal habitats and improve the biodiversity of their sites. Alice Grundy explores how this cohabitation can be encouraged - and the challenges left to tackle.

Solar farms have significant potential to create habitats for wildlife and deliver substantial net gains for biodiversity, and many developers pride themselves on the benefits that can achieved.

As is the case for many areas of the industry, some of the biodiversity benefits that can be achieved are driven by regulation. Environmental impact assessments (EIA) are a common feature of planning regulations, although not every country requires them.

As part of an EIA, developers will need to appoint consultants to conduct surveys of the land and produce an environment statement. This document works through the relevant environmental factors on a site and categorises them according to impact. The steps needed to mitigate any impacts on the environment will then be determined.

But not every site will require an EIA, with certain criteria - whether physical changes will need to be made to the site, the presence of protected areas and the use of natural resources among other factors - all determining whether one is needed.

The purpose of an EIA is to establish the base position of a site, according to Christian Silk, head of infrastructure planning at law firm Foot Anstey, and then understanding what impact a development will have on that. "EIA is much more around mitigating the impacts on environmental matters, particularly ecology and wildlife, as opposed to necessarily enhancement. It can identify opportunities for enhancement, but that isn't its key purpose," he says.

In the UK, new regulations – the Environment Act 2021, to be specific – are to require solar developers to achieve a 10% biodiversity net gain on their sites, although these have yet to come into force.

Credit: G Parker, NextEnergy Emberton 2019

Wildflower meadows are one of many ways to enhance solar sites, providing benefits to pollinators such as bees.

Many developers in the country are, however, going above and beyond that requirement. Indeed, UK-headquartered renewables developer and service provider Anesco is expecting to achieve a 173% biodiversity net gain at its 10MW High Meadow 2 site and a 216% net gain at its 25MW Moat Farm site, both of which are located in the UK.

Sarah Webb, Anesco's director of development and technical, says that the level of net gain that can be achieved depends on a number of factors, including the size of the site itself. With larger sites, there's more room to implement extra trees and ponds.

Alona Armstrong, senior lecturer in energy and environmental sciences at Lancaster University, adds: "At some sites, just because of their underlying characteristics, there's more potential for biodiversity than there is at others. It's not a level playing field of where you start."

However, Webb says that most developers will always try and make the most of every site and make sure they're putting in as many reasonable measures to increase biodiversity as they can.

Progression versus regression

What about those countries that don't require EIAs and have weaker wildlife

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protection laws? Tris Allinson, senior global science officer at non-governmental organisation (NGO) BirdLife International, says that there is a "regulation vacuum" in countries such as India, where land that appears to be empty – as in not used for agricultural or other purposes – is often being used for solar, however these are often important habitats for local wildlife.

In Brazil, meanwhile, some renewable developers are looking to cut a scrub habitat home to birds such as the Lear's macaw, while the increasing levels of solar and wind development in the Western Rajasthan area of India is posing a real threat to the great Indian bustard, a critically endangered bird that due to poor eyesight is prone to collision with powerlines. With more solar and wind – and the associated powerlines – being built in its native habitat, renewables are posing a real threat. There are only around 100 of these birds left in the wild, with it estimated that between ten and 15 of the birds are striking powerlines every year.

"You have the incredibly tragic situation that before we lose any species to climate change, we could lose one to renewable energy," Allinson says.

To avoid situations like this, Allinson says the first step is to see if a solar site can be located elsewhere. If that's not possible, steps can be taken to mitigate the risk of powerlines through designs that do not incur electrocution risk to birds, as well as ensuring there are bird flight diverters. In the most sensitive of areas, burial of powerlines is also an option.

If there's still going to be damage incurred, Allinson says that the NGO will work with companies to offset that by creating additional habitats elsewhere.

Other animals at risk from the buildout of solar include ground nesting birds, with species such as skylarks requiring wide open areas to feel safe enough to nest. However, Guy Parker, founder and co-director of Wychwood Biodiversity, says that even with the habitat lost, these birds will often use the farms to forage, while wide open areas around solar farms can be incorporated either around or inside the solar farm to mitigate the loss.

While the physical space solar farms take up can result in a loss of habitat, the construction phase can also pose a risk to wildlife. "In a wet winter a site can get really damaged. You lose your grass cover, there can be soil compaction and flooding," Parker says. However, if an EPC provider is careful about construction, such as by constructing in dry conditions or using low pressure vehicles, then those impacts can be limited.

Other risks during construction include open trenching and fuels, but these can also be minimised with careful management, Parker says.

"It's a short construction period, and once construction is over there's very little disturbance to wildlife on the solar farm on the whole."

Going above and beyond

It may seem a little doom and gloom, but the potential for improving the biodiversity of solar farms and providing habitats for local wildlife is vast. Establishing wildflower meadows is an easy way of doing this, with such meadows supporting bees and other pollinators. Tussock grassland, meanwhile, is a suitable habitat for around the edge of a solar site as it grows much taller and thicker than wildflowers and provides foraging habitat for fledgling birds and nesting places for bumblebees. Trees and shrubs can be grown, and if a site has naturally wet areas, a pond can be established.

Bird and bat boxes are also an option if suitable, while Armstrong suggests that hedgerows are another great option as they provide habitats and have been linked with carbon storage.

These sorts of measures are not without cost or additional time, of course. Webb gives the example of needing to ensure any planting is done planting season, which can sometimes mean a site is mobilised before the planting takes place.

"That costs us quite a bit to come back to a site and do any necessary planting. But it's important that we do it," she says.

Maintenance is also an important consideration; hedgerows and newly planted trees, for instance, need to be nurtured in the early stages of life. "They need to be watered regularly, they need to be maintained; you need to maintain them and monitor them quite carefully," Webb says. However, once they're more established, they can be mostly left alone.

What comes next

One area that Parker is beginning to look at is decommissioning planning for solar sites, although this is still a little way off in the UK due to the age of its solar fleet. While it's hard to discern what the policy will be for this, based on current policy the obligation is to return solar farms to their original land use. That there will remain a need for renewable energy beyond current asset lifetimes would suggest the majority of sites will continue to have generating technology.

Parker says it's likely that if a site does need to be returned to its original use and there are protected species on site, measures would need to be taken to protect them and ensure their habitats remain.

Kutahya Cherry, managing associate, Foot Anstey, says: "If you've spent significant effort to improve the land from a particular biodiversity perspective or carbon perspective, there shouldn't really be an obligation to reinstate the land back to what it was before, because it would be effectively putting it back into a worse state.

"There's lots of discussions going on about that. I don't think the market has really landed on what will become market standard, or if there will be a market centred on that."

Beyond being a requirement for many solar farms, increasing biodiversity can have other benefits. One challenge often faced by solar developers moving through the planning process is getting the general public on board, with an anti-solar local community having stopped many applications in their tracks.

"Community engagement on all of these developments is absolutely critical," Cherry says, suggesting that that's why developers are moving towards going beyond statutory requirements.

However, Silk adds: "What you'll see particularly with the well-established solar farm developers and the solar investment funds is that it's a standard part of their business values; that business is more than just renewable energy, it's about the wider impact on the environment."

That willingness to put biodiversity and the impact on the environment as a key part of a solar development – or business – is one of the main enabling factors for biodiversity. Regulation of course plays its part, and campaigning from and partnerships with organisations such as BirdLife International certainly contribute.

But as Parker says: "Ultimately, to encourage biodiversity on a solar farm, you need a willing project owner, a sensible biodiversity management plan, a diversity of habitats and consistency in management to enable wildlife to flourish." ■

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SOLAR MEDIA

Terrain-following tracker: Nextracker's revolutionary NX Horizon-XTR is key to unlocking challenging sites

Innovation | Solar project sites with meaningful terrain variance are becoming the norm. Nextracker's latest innovation in single-axis tracking mitigates the cost and schedule risk associated with deploying projects on challenging terrain.

Credit: Nextracker

Nextracker's NX Horizon-XTR poses many substantial benefits to developers.

As ever-larger PV systems increase in frequency and global distribution, "easy" sites for development are fewer and farther between. Gone are the days when developers could target vast expanses of flat land as far as the eye could see. With these once-ubiquitous ideal sites for solar becoming more difficult to find, project developers are increasingly looking to site solar projects on land with undulating terrain.

Developing projects on sites with challenging terrain complicates project economics. Business-as-usual construction approaches require extensive cut-and-fill grading or additional foundation steel, both of which are costly. Moreover, extensive site grading invariably incurs unnecessary risks and unwelcome headaches for developers, EPCs and owners.

As a leader in the global energy transition, Nextracker is committed to eliminating project development barriers and maximising profits for long-term owners, developers, financiers, and other stakeholders. To this end, we worked in partnership with a leading EPC to develop a terrain-following single-axis tracker solution that mitigates risks associated with undulating terrain and improves project-level economics. The result of this multi-year collaboration is NX Horizon-XTR.

About NX Horizon-XTR

Sharing core technologies with NX Horizon, the XTR variant is a step forward for Nextracker's independent-row single-axis tracker product line. A time-tested and field-proven tracker solution, NX Horizon supports more than 50GW of solar generating capacity globally, making it the number one smart tracker in the world.

The capability that makes NX Horizon-XTR unique is that it breaks free of long-standing straight-line tracker row constraints. Every other single-axis tracker product from a major manufacturer requires that the torque tube extend north and south along a single plane. In this paradigm, a laser level represents the ideal of perfection for the tracker torque tube.

This long-standing tracker architecture is well-suited for flat and relatively flat sites. It is considerably less cost-efficient at the system level for sites with challenging terrain. Project developers need more flexible tools at their disposal to open new markets or develop cost-effective sites in highly-saturated mature markets. That tool is NX Horizon-XTR.

Instead of traveling in parallel with a laser, NX Horizon-XTR's torque tube can parallel the arc of the natural landscape. The product design permits some torque tube angle change at each foundation location. Applied cumulatively across a series of foundations, NX Horizon-XTR can effectively follow undulating terrain in a north-south direction.

NX Horizon-XTR's slope-adaptive architecture allows the installer to use a constant pier reveal relative to the natural grade. This trait results in a terrain-following tracker installation. On sites with undulating slopes, this terrain-adaptive approach is considerably more cost-effective than business-as-usual approaches. Viewed holistically at the system level, it reduces costs for owners and developers and eliminates headaches for EPCs.

A constant pile-reveal height is characteristic for Nextracker's terrain-following NX Horizon XTR, which already has a 3GW track record.

Credit: Nextracker

Grading and earthworks benefits

In a competitive market, developers are under constant pressure to squeeze out attractive project returns. These results are difficult to achieve on projects with

Key savings

- Earthworks savings - 1,000 to 3,000 cubic yards/MW savings
- Pier savings - 5,000 to 9,000 lbs/MW savings
- Reseed, top dress, environmental savings - up to 5 acres/MW impact reduction

undulating terrain, which represent a majority of development opportunities globally. On today's terrain-challenged sites, grading costs to cut and fill can make or break a project.

Earthwork costs have both CapEx and OpEx implications. Therefore, any reduction in site grading has a multiplier effect for developers and long-term owners. Viewed through this lens, NX Horizon-XTR is genuinely groundbreaking.

Already deployed across a 3GW portfolio, Nextracker's early EPC partners report that NX Horizon-XTR reduces tracker-related grading on sites with undulating terrain by 30% to 90%. On challenging sites, terrain-following designs significantly reduce first costs relative to straight-line tracker row designs.

In addition to reducing grading costs during project installation, terrain following on undulating slopes also limits opportunities for soil erosion. Extensive cut and fill activities invariably result in degraded surface conditions relative to undisturbed native soils. Over the operational life of an asset, improved soil integrity reduces operations and maintenance costs.

"In my experience, there are some things that you cannot outengineer—and well-established topsoil is one of them," explains Nick de Vries, senior vice president of technology and asset management for Silicon Ranch. "Earthwork is especially painful as it affects solar project economics three times. First, grading a site incurs significant costs. Second, reseeding the exposed dirt is costly. Third, additional costs accrue fixing the inevitable erosion and hydrology issues that result later from a lack of well-vegetated topsoil."

Project risk mitigation

Site grading reductions also mitigate risks associated with a variety of unpredictable project variables—such as environmental review and grading-related change orders and schedule delays—that span the project development timeline.

On the front end of a project, grading reductions limit environmental impacts and the likelihood of community objections, expediting permit review. Permit approval is a critical step for large-scale solar projects, as failure to pass the phase gate represents an existential threat to development.

During construction, grading reductions limit the cost and schedule overrun risk associated with earthwork activities. Earthwork is never a firm-fixed-price contract. Therefore, limiting opportunities for costly change orders is fundamental to delivering a project on budget.

Similarly, limiting cut and fill activities reduces the likelihood of schedule delays. Compared to other trades and scopes, site grading is one of the most challenging in terms of schedule and budget risk. The difficulties are partly due to the sheer magnitude of today's large-scale solar sites and partly to weather risk.

To keep projects running on schedule, it is often crucial that site grading activities occur outside of the rainy season. This timeline is difficult to ensure if permitting takes longer than expected or the extent of the site grading is more widespread than anticipated. At best, it is difficult to grade sites efficiently after a rain; in worst-case scenarios, excessive rain and flooding can halt to all earthwork activities until the ground dries out.

After the commercial operation date, terrain-following benefits accrue to the long-term owner in the form of reduced O&M costs. These project cash flow improvements reflect the fact that terrain following plays a vital role in habitat conservation and intelligent land use.

"For Silicon Ranch, high-quality solar projects and being good stewards of the land go hand in hand," says de Vries. "Conforming to the native ground contours with NX Horizon-XTR just makes sense. It is a smarter, more streamlined way to build solar on challenging terrain."

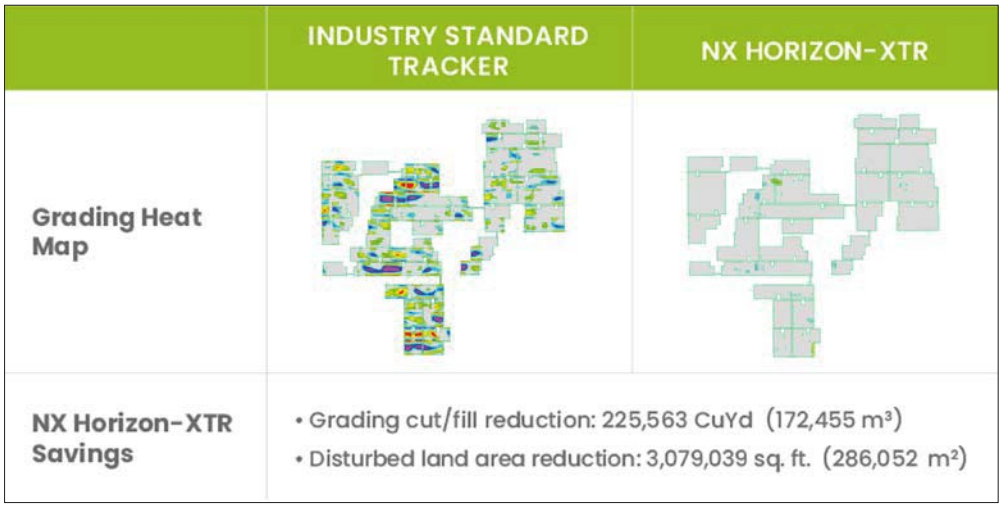
Pier steel savings

Increased pier length is another business-as-usual approach to developing sites with terrain variance. The benefit of this approach is that the incremental cost for additional steel is modest compared to the cut-and-fill expenses associated with extensive site grading. However, this spend-money-to-save-money approach is far from cost efficient in absolute terms.

Given the scale of today's solar farms, buying more steel than is structurally required is a losing proposition, especially in a competitive environment. Though the incremental cost to increase the length of a single pier is not onerous in and of itself, a 100MW solar farm requires approximately 25,000 individual foundation posts. The cumulative cost associated with a universal increase in pier length is non-negligible, especially in a market characterised by inflationary commodity costs.

In the straight-line tracker paradigm, increasing pier length provides project stakeholders with a certain amount of tolerance for spanning low spots in the terrain. Installers can expose this additional steel length above grade, as needed, or bury the excess below ground. Embedding structural steel beyond the minimum-required depth not only wastes money but also increases the subsurface risks associated with pile rejection and removal.

Liberated from these cost inefficiencies, a terrain-following tracker embeds a constant amount of steel and exposes a constant amount of steel. This constant reveal allows for a foundation design that is truly right-sized relative to the site conditions. Engineering projects to these tighter design tolerances can reduce foundation



Credit: Nextracker

NX Horizon-XTR reduces tracker-related grading on sites with undulating terrain by as much as 90%, which mitigates schedule and environmental risks and reduces project CapEx and OpEx.

Credit: Nextracker

NX Horizon-XTR and TrueCapture featured at 250 MW Wright solar power plant, Los Banos, California.

pier length by as much as one meter (three feet) per pile—or 25,000 meters (75,000 feet) of pier steel per 100MW.

Energy optimisation

When implemented correctly, the net cost-benefit of terrain following is highly favourable. Though rolling with the native landscape will result in nonuniform tracker rows, Nextracker's intelligently controlled independent-row tracking system is uniquely suited to capture the total yield of a solar asset. Combining NX Horizon-XTR with Nextracker's TrueCapture software mitigates shade and mismatch losses while maximising energy production and economic performance.

Released by Nextracker in 2017, the TrueCapture system uses advanced sensors, weather forecasting and machine-learning technologies to continuously monitor and refine the control algorithm for each tracker row individually. In addition to increasing yield in diffuse-irradiance conditions, TrueCapture is particularly adept at mitigating shade and tracker terrain loss.

Some mismatch losses are inevitable in very large-scale solar farms. These systems cover thousands of acres, which invariably results in differences in terrain, temperatures, soiling, shade, cloud cover, and so forth. High-granularity tracking hardware coupled with high-speed, high-precision control capabilities mitigates these impacts as they happen, holistically optimising plant-level performance in the process. Best of all, new modelling tools and methodologies can capture the effect of terrain following.

Deployed globally across more than 10GW of installed PV capacity, multiple top-tier independent engineers (IEs) have validated TrueCapture's in-field gains and confirmed its bankability. Nextracker's proprietary TrueSim modelling platform can estimate the yield benefit associated with TrueCapture. The list of IEs that now offer third-party TrueCapture production estimates includes Black & Veatch, DNV, ICF, Leidos, Luminate and RINA.

Making the grade

NX Horizon-XTR is a valuable addition to the industry's collective toolkit. Civil engineers can use terrain following to retain native soils on project sites. Developers can use it to breathe new life into mothballed project sites. Owners can write terrain-following requirements into contracts, ensuring reductions in the long-term cost of ownership.

EPCs can use NX Horizon-XTR to eliminate headaches by working smarter rather than harder. Once installers place piles and brackets within the terrain-following tolerance, the subsequent alignment processes are repeatable, straightforward and well known. The construction sequence for NX Horizon-XTR is consistent with that for our standard NX Horizon solution.

Regardless of where you sit in the value chain, Nextracker has the project engineering team, design tools, technical documentation and field support to quickly get you up to speed with NX Horizon-XTR. Nextracker is not simply selling nuts and bolts and software. We also have in-house subject matter experts who guide clients along the way. While terrain-following tracking is a new discipline for many, our applications engineers have a 2GW-strong track record of proven success with NX Horizon-XTR.

Site evaluation is one of the many ways that Nextracker works closely with clients. Our standard work process includes a high-level introductory topographic study. While conducting this study, our applications engineers will proactively notify clients when site conditions favor NX Horizon-XTR. This collaboration ensures that project stakeholders are set up for success.

"XTR has allowed us to win more projects by making us more competitive in our project bids," says Donny Gallagher, vice president of engineering at SOLV Energy. "NX Horizon-XTR's ability to follow terrain can reduce earthwork, allowing otherwise infeasible sites to become economically viable solar projects. Less earthwork means lower upfront costs and improved scheduling. At the same time, our projects have less environmental impact. It's a win-win scenario." ■

(L – R) Donny Gallagher, VP Engineering at leading EPC, SOLV Energy with Alex Roedel, Sr. Director of Project Engineering at Nextracker. The two companies partnered to develop the NX Horizon-XTR terrain following solar tracker, a variation of its flagship tracker, NX Horizon.

Module supply to the PV industry in 2022: factors driving changes across manufacturing and supply-chains

Supply chain | Identifying reliable module supply has become a huge challenge in the PV industry over the past couple of years. Moving forward, the industry needs to create a more globally-diversified manufacturing footprint, thereby avoiding any unexpected trade-related barriers that could be enforced. Understanding which module suppliers are going to prevail in this landscape will become of key importance over the next 12-18 months, Finlay Colville explains

Since the start of 2022, the solar PV industry has been kept busy by strong investments in new capacity, record high levels of production through the value chain, and a new round of measures being considered in the US that may affect Chinese module suppliers with capacity in Southeast Asia.

Set against a backdrop of a 200GW-plus end-market in 2022, there are now 50-60 module suppliers seeking to ship as many modules as possible, keep manufacturing costs to a minimum and work out which regional end-markets are the best ones to focus on.

This article takes a fresh look at this select group of 50-60 PV module suppliers that make up 98-99% of all module supply to the industry this year, and are ultimately the ones that are being audited, accounted and inspected the most. Analysis and discussion is presented that explains how much of the module component supply (in particular polysilicon, wafers and cells) is from in-house sources, how many of the module suppliers are serving a global end-market, which companies are least impacted by duties when exporting to the US, and what if anything might change next year.

The key 50-60 PV module suppliers in 2022

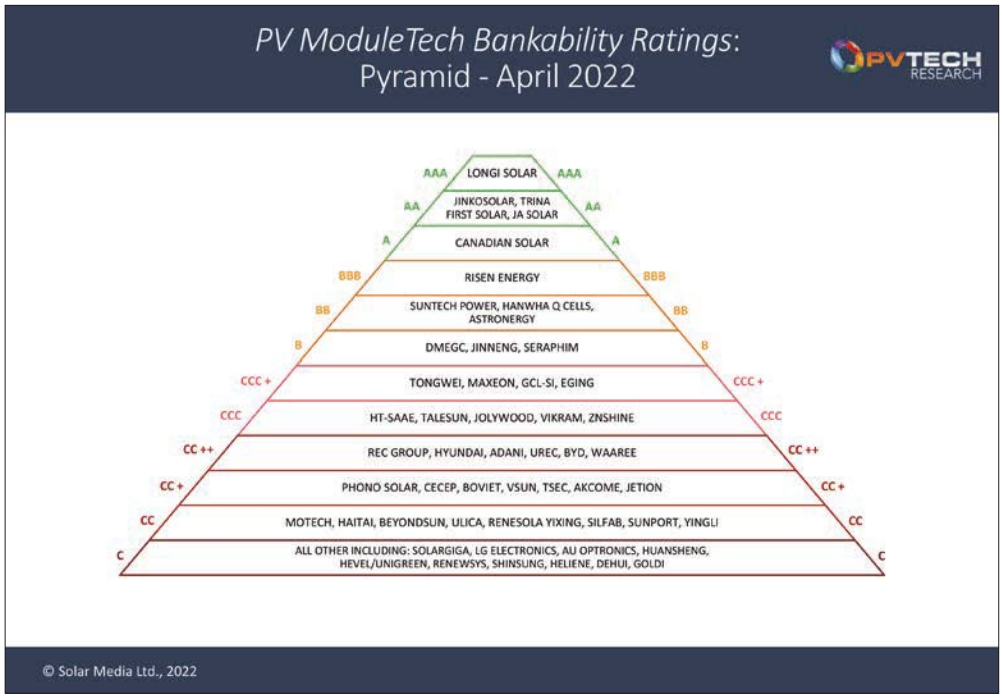
Despite the perennial speculation within the industry that consolidation is imminent, all too often the opposite appears to be happening. However, it is important always to assess the importance of new entrants, in particular those that are established to be domiciled in their country-of-origin; or those set up to be OEM suppliers for named brands, for example. This topic is discussed in more detail later.

As of the start of 2022, there are between 50 and 60 module suppliers that account for at least 98% of global supply. The remaining 2% is spread across a further 50-plus companies. It is perhaps a consequence of a rapidly growing sector - combined with various domestic drivers in place to stimulate final module assembly – that such a large number of entities exist today.

There are many different ways to rank the 100-plus companies claiming to be credible module suppliers. Sometimes, they are ranked on claimed nameplate module capacity levels. Another option (but harder to establish) is to list them all by module supply. Neither one of these really helps module buyers.

Released in 2019, PV Tech's PV ModuleTech Bankability Ratings is now widely recognised within the industry as the first detailed analysis of module suppliers that can rank companies by examining a wide range of manufacturing and financial metrics every quarter. The latest bankability pyramid is shown in Figure 1, identifying the 50-60 PV module suppliers that occupy the various ratings bands from the highest (AAA-Rated) to the lowest (C-Rated).

Each of the 50-60 PV module suppli-



As of the start of 2022, more than 100 companies sell PV modules globally. The top-50 typically account for about 97-98% of global supply and can be ranked by bankability from AAA-Rated to C-Rated.

ers has a different corporate strategy; a different focus on manufacturing components that go into the modules; differentiation in terms of module capacity allocations globally; and differences in shipment volumes around the world. Financial health shows far greater variation than manufacturing differences. The overall combination of manufacturing and financial health metrics ultimately forms the hierarchy shown in Figure 1, as the PV Tech measure of module bankability derived from both manufacturing and financial health benchmarking.

Who makes what in-house?

The Xinjiang issue - and more broadly module component supply-chain auditing - has become a major purchasing decision for US buyers (enforced by tariffs) and a sub-set of global entities that have a strong moral compass and want to show transparency and traceability in terms of module supplier selection.

This has exposed the whole who-makes-what issue within the industry to a level not seen before. Central to this is how many module suppliers, as shown in Figure 1, even make their own cells and wafers, far less have any control over where the polysilicon comes from (the Xinjiang issue).

Less than half of the module suppliers in the top 50-60 make their own solar cells. The rest buy in cells, and assemble these into modules, often serving domestic end-users. In fact, even across the 15-20 module suppliers that make cells themselves, most of these companies operate a flexible supply-chain model, typically buying in large volumes of cells from other companies.

Across the leading A-Grades (AAA, AA and A-Rated), only a small grouping makes a high proportion of their own cells. If like-for-like value-chain production is normalised between silicon-based product and thin-film manufacturing, then First Solar becomes the only module supplier that makes 100% of product in-house, with the exception of glass panels that are bought in as the starting point in the production lines. On the silicon-side, JinkoSolar, JA Solar, Hanwha Q CELLS and LONGi Solar are the most cell-and-module 'friendly', where it can be said that cell production is prioritised to the same level as module production/supply.

Therefore, even before moving to wafer (or further upstream to ingot pulling and polysilicon production), only a small handful of leading module suppliers can lay claim to being in control of cell manufacturing (and the associated wafer supply and cell processing materials).

The list of module suppliers that make wafers (and ingots) and cells is even more diluted. In fact, JinkoSolar, JA Solar and LONGi Solar are the only ones of note today. None of these companies makes their own polysilicon; this all comes from a separate group of (mainly Chinese) producers.

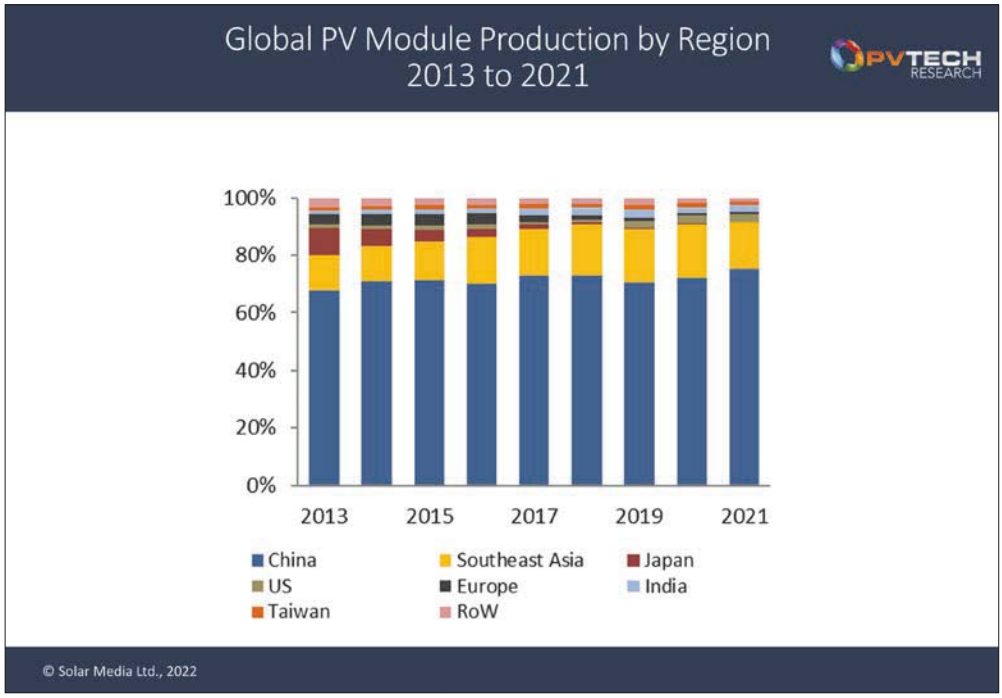
Therefore, before looking at any other benchmarking metric for the leading 50-60 module suppliers, it is clear that they differ hugely in terms of making module components in-house. However, the plot thickens even more when looking at manufacturing footprint; where wafers, cells and modules are made.

Focusing on the module suppliers (and their associated upstream manufacturing stages), almost all wafers are made in China, with the notable exception of LONGi Solar (some Malaysia capacity), JA Solar and JinkoSolar (each with some capacity now in Vietnam). The Southeast Asia capacity for these three companies was located there mainly for the purpose of feeding into cells (and modules) also made in Southeast Asia and shipped to the US market. Figure 2 shows recent trends in PV module production, with increased focus on China and countries across Southeast Asia.

At the time of writing this article (early April 2022), the PV industry is currently having to deal with potential outcomes of a new investigation by the Department of Commerce (DoC) in the US related to possible circumvention of its 2012 anti-dumping (AD) and countervailing duties (CVD) enactment that placed an import tariff on Chinese produced solar cells and modules shipping to the US. If this new case (AntiCirc) is to be upheld by the DoC, it would create another level of scrutiny on the underlying who-makes-what-where debate. Simply put, anyone buying modules now has to be aware of far more manufacturing issues than was ever the case before.

How many module suppliers have a global footprint?

Putting all manufacturing nuances aside, a further issue differentiating the 50-60 module suppliers can be seen when looking at where modules are shipping to. Rather than working out and trying to explain company-specific market-shares in key end-markets (such as Europe or the US), it is more intuitive to review how many of the 50-60 module suppliers have strong overseas (or global) business.



Module production is dominated by assembly facilities in China and Southeast Asia, in particular Vietnam, Malaysia, Thailand, Singapore, and Cambodia. Increased contributions from India, Europe and the U.S. are now needed to provide a more globalised supply-chain offering.

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AGENDA

DAY 1

- **PV module supply in 2022 & factors impacting U.S. module purchasing decisions**
- **State-of-the-art PV module performance today & the outlook for 2023-2025**
- **Who makes what & where, when buying a PV module today in the U.S.?**
- **Module reliability testing for harsh & demanding site locations: how to de-risk panel under-performance & failures in the field**

DAY 2

- **Finding module suppliers with available product in 2022/2023 for U.S. projects: new domestic U.S. suppliers & overseas options including India, Turkey, etc.**
- **Why bankability is crucial to understand when short-listing supply options today**
- **Module pricing for U.S. projects in 2023 & 2024: where is pricing going in the next 2-3 years?**
- **The U.S PV module supplier 'wish-list' for 2023: what's needed to remove uncertainty & risk in buying PV modules in the U.S. next year**

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This turns out to be an excellent filter to apply. Clearly, if certain companies are making all their modules in China and only serving the domestic market, it is questionable how relevant they are to overseas buyers. The same could be said of India, a country still dominated by domestic module suppliers doing business within the country.

Global module purchasing agreements are becoming more widespread in the solar industry today, driven by international corporates, major energy utilities, and diversified investors/funds. This trend is only likely to increase going forward, and almost every module supplier today would love to be on any of the respective short-lists for suppliers within these buyer categories.

Approximately 20 of the top 50-60 module suppliers can be considered as credible global players. Of this grouping, about half a dozen serve each of the key end-market countries/regions routinely. The others tend to be strong domestically, and then have a couple of overseas markets where they focus sales and marketing resources. In fact, if AntiCirc does come to fruition in the US, this very small subset could have even fewer members.

The lack of global module suppliers has come into being largely by default, rather than being a proactive decision on the part of module suppliers. Some companies have just found themselves in a position where domestic manufacturing levels are fully consumed (with decent margins) locally. In this situation, it could be argued that exporting is simply an unnecessary luxury. Conversely, other companies have spent much of the past decade trying to diversify manufacturing footprints, only to come up against unforeseen trade issues (AD/CVD, Section 201, AntiCirc in the US, and similar actions in Europe and India).

At some point in the future, the industry may see companies choosing to make modules (and better still wafers and cells) in different regions globally because they see this tactic as a way of serving local demand only: not simply as a way of avoiding import duties that may prevail at any given time, as has been the case with the US market for more than a decade now. It should be noted that there are no clear signs this is going to happen in the next couple of years. At best, this could be something to aspire to in the 2025-2030 period.

Which suppliers are AD/CVD, Section 201 & AntiCirc risk-free?

Currently, buying modules in the US has the highest barrier-to-entry from a module supplier standpoint. By contrast, the rest of the world is still largely open to modules made in China, and using an entirely Chinese-sourced/produced supply-chain. If this landscape was set in stone - with nothing changing in other regions or within the US - then the problems of US module buying would simply be localised and not of any great interest to companies doing business elsewhere in the world.

> Global module purchasing agreements are becoming more widespread in the solar industry today

Of course, it is highly unlikely things will remain static. More likely, the current issues impacting module supply to the US market will emerge more frequently elsewhere in the world; and since the US is subject to so many of the pressing global trade issues today, it becomes almost an ideal case-study in terms of assessing risk across module supplier short-listing. So, what set of conditions would have to prevail to make a PV module supplier to the US market truly risk-free?

- Modules should not contain any polysilicon (or metallurgical-grade silicon) that was produced in Xinjiang; better still, to be truly risk-free, made outside China.
- The ingots and wafers should be made in-house by the company selling the modules, or specified by the cell producer (for the modules) in a way that satisfies the above condition.
- The cells used in the modules should be made in-house by the company selling the modules.
- The modules should be made by the company selling them, and not by a third-party entity (OEM).
- The cells and modules should be produced in countries that remove any import duties arising from conditions set out by AD/CVD, Section 201 or (possible) AntiCirc barriers.
- The module supplier should have sufficient product availability to meet gigawatt-levels of shipments within a three year period (specified to emphasize long-term high-volume supply).
- The module supplier should have a credible track-record in supplying (on-time and with reliable product) to large-scale solar farms in the US, having been through previous rounds of due-diligence and investor acceptance.
- The module supplier (or its parent entity/guarantor) should be financially healthy/stable.
- The module supplier should be considered low-risk in terms of honouring contractual agreements for shipment schedules.

Leading indicators for change

When looking at the scale of the problems buying modules today, there is almost no chance that any meaningful fix will appear in the next 12-18 months. In this context, 2023 could largely be a continuation of the factors prevalent in 2022.

When looking for signs of a changing module supply landscape, the willingness of leading module suppliers to commit to global regions for upstream manufacturing could be important. Until now, efforts in this regard have been defensive in nature; setting up cell/module capacity in Southeast Asia to ship to the US; investing in module assembly lines in the US.

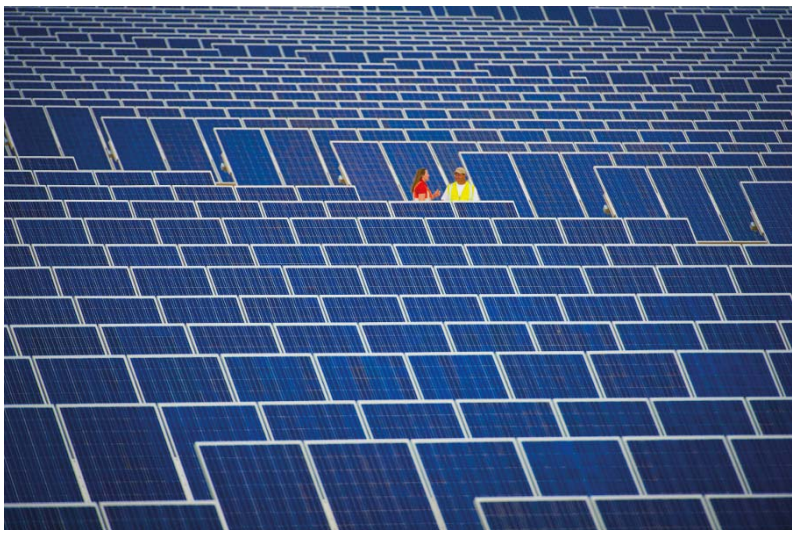
The door would appear to be wide open now for a major silicon-based player to set up gigawatt-level ingot-to-module manufacturing across key regions; India, Europe, North America. This would be a major step in terms of decoupling shipments from tariff-related risks. This could have the scope to see 2024-2025 as the first time that manufacturing becomes truly global in nature, allowing buyers to plan ahead without worrying about unexpected trade wars having a catastrophic impact on module supply in the near- to mid-term. It will be fascinating to see if the sector as a whole unfolds in this way going forward. ■

Author

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

Europe's energy crisis and its impact on PPA and merchant revenue streams

PPAs | In the midst of an energy crisis, both generators and offtakers are considering their next moves. Sean Rai-Roche speaks with analysts and experts across the continent to decipher what is expected to happen to prices and what that means for companies' operations.



Credit: SunEdison.

European nations and power companies have some difficult decisions ahead. The continent's current energy crisis is a product of myriad factors but the way it is dealt with will shape Europe's energy apparatus for years and decades to come.

While some have called for greater fossil fuel extraction in the short term to mitigate the worst impacts of the crisis, others have advocated a massive renewables roll out to help bring prices down. In the here and now, however, asset owners are faced with a dilemma: increase the proportion of their trade on merchant power markets to exploit the high prices or stick to locking in long-term power purchase agreements (PPA) that ensure a more stable, predictable revenue stream?

The key consideration here is where companies and markets think prices will go. Prices are now at their highest point in years – currently spot market prices are averaging around €300/MWh (US$327/MWh), up from around €50/MWh (US$54/MWh) at the end of 2019. Nobody thinks the situation in Europe will be resolved soon, especially in light of Russia's invasion of Ukraine, but market expectations and power prices predictions will be the crucial factor in trading and contract decisions.

PV Tech spoke with analysts from Europe and elsewhere to explore what has been driving Europe's energy crisis and where prices are expected to go. Following this, we examine what power price volatility means for PPA contracts and the upsides of trading on spot markets versus locking in longer-term PPAs. While the final decision will always be based on a company's individual circumstances, operational needs and financing structure, there are definite trends emerging that PV asset owners should be aware of.

Why is Europe's energy market in crisis?

Europe's current energy crisis has been caused by a confluence of factors: natural events, geopolitical actions, poor strategic planning and Russia's invasion of Ukraine. Taken together, these factors have created a perfect storm that has sent prices soaring, rattled governments, reshaped energy policies and hurt consumers in the process.

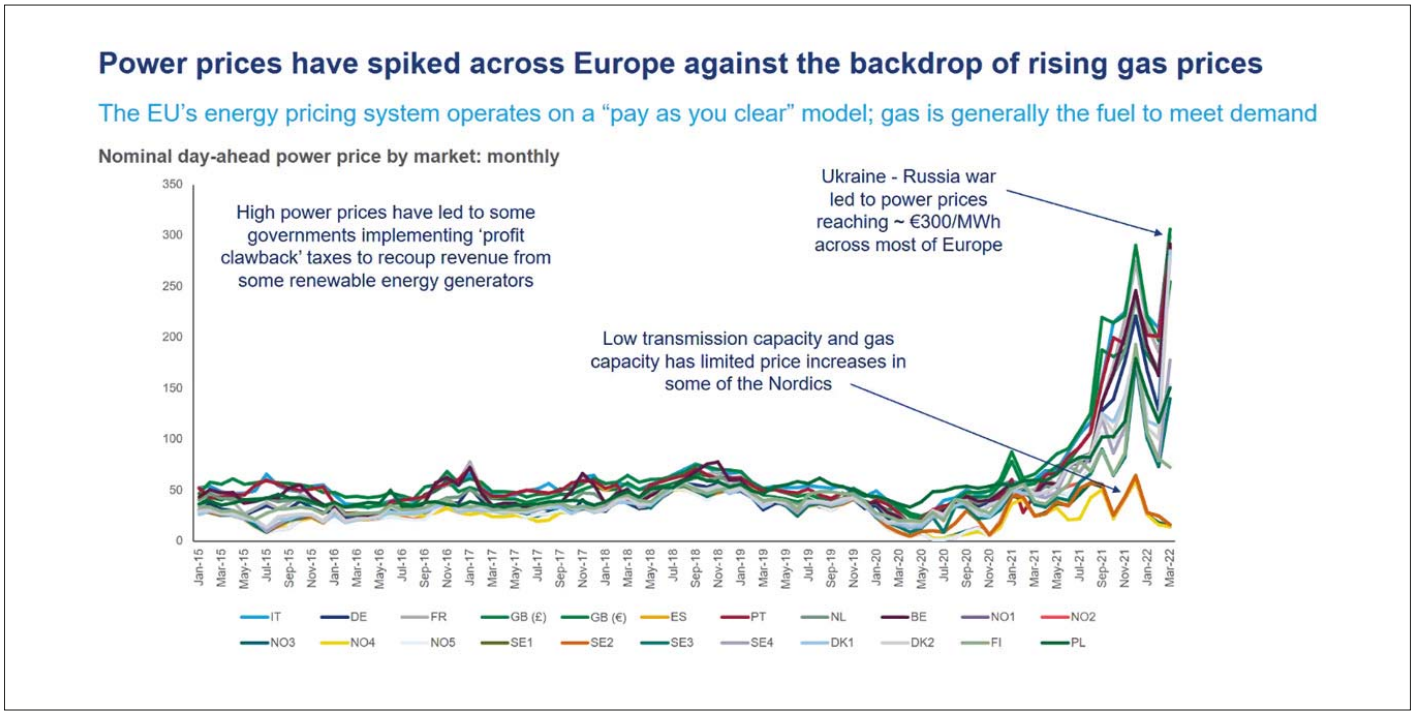
It began last winter, which was particularly cold in both Europe and Asia. These regions compete heavily for liquified natural gas (LNG) and, as economies started to open up following COVID-19 lockdowns, prices started to surge given the increased competition, raising electricity prices in the process. Compounding this was low gas reserves in Europe which further pushed up prices and started supply panics. And, amid a freezing winter and chaos in Texas, the US exported less LNG to Europe and Asia than it normally does, which caused further upward pressure on prices.

Then, on 24 February, Russia invaded Ukraine. Western governments rapidly imposed sanctions on Russia and called for companies to self-sanction their operations in the country. Energy giants BP, Shell, Exxon, Equinor and TotalEnergies have cut ties with Russia or have said they will do so. Germany also declined to approve the Nord Stream 2 gas pipeline from Russia to the EU, sending the holding company into bankruptcy. This has all served to further restrict gas supply and push up prices.

European nations have made attempts to mitigate the impact of the sanctions by looking to alternative sources of natural gas, whether that be expanding the transmission capacity of the Medgaz gas pipeline from Algeria to Spain, Bulgaria connecting its gas network to Romania and Serbia, Poland linking up with Denmark and Bulgaria pushing for greater connection with Greece. Nonetheless, most of these projects won't be completed before the end of the year and are regional, not EU-wide, in nature, meaning febrile and volatile markets are here to stay in the short-term.

Where are power prices headed?

Nobody expects power prices to drop back to normal levels anytime soon and the evolution of power prices this year and next will depend on a few factors such as coal and gas prices, the weather, unplanned nuclear outages, renewable generation and power demand, says Kesavarthiniy Savarimuthu, European power analyst at BloombergNEF (BNEF).



Credit: Wood Mackenzie

And, with European gas reserves still low, do not expect the competition for resources to diminish in any way. "Between gas consumption and restocking of storages, substantial LNG volumes will be required throughout the summer to attain comfortable storage levels until Q4 2022," says Werner Trabesinger, head of quantitative products at renewables advisory firm Pexapark.

"This will put European buyers in direct competition with Asian LNG market participants, in a tighter market from which Russian LNG volumes have been de facto removed," says Trabesinger.

"The European Commission (EC) have been in talks to diversify gas supply source to reduce exposure to Russian gas imports," says Savarimuthu. "Options such as increasing LNG import can come at a premium and have bullish impact on gas and power prices."

"Switching to other fuels like coal can help address gas market tightness. However, the same issue applies here – hard coal has so far come in substantial volumes from Russia, and the search for alternative volumes will be more competitive," says Trabesinger.

According to ING forecasts, future baseload energy prices for European economies such as France, Germany, Belgium and the Netherlands will remain elevated at about €150/MWh (US$163/MWh) for the whole of 2022, dipping in the summer months but rising again to around €175/MWh (US$190/MWh) as we move into winter.

Power prices across Europe have spiked considerably since May 2021.

But the situation is highly volatile and unpredictable. "Wholesale power prices in 2022 have been more volatile than the levels seen over the past decade," says Savarimuthu, adding that uncertainties surrounding gas supply will spur greater power market volatility.

"I think we're in for another very volatile period"

"I think we're in for another very volatile period," agrees Phil Grant, partner in the Global Power Generation unit at energy consultants Baringa, "and it feeds into how people are trading and their forward view of risk."

"As a generator, do you want to now lock in forward prices or are they happy to ride the wave of merchant prices?" ask Grant.

Long term contracts or trading on merchant markets?

The European renewable PPA market is "more competitive than ever" as prices surged 8.1% in Q1 2022 and 27.5% year-over-year, according to LevelTen Energy. Prices, which were expected to level off this year before the Ukraine conflict, have now climbed for a fourth consecutive quarter.

Strong demand for renewable power has created a shortage of project options for offtakers and the P25 index – an aggregation of the lowest 25% of solar offers – for solar offers rose by 4.1% and now sits at €49.92/MWh (US$54.1/MWh), a rise of 20% (€8.32/MWh) year-on-year, noted LevelTen's European Q1 2022 PPA Price Index. "This buyer appetite is quickly creating an imbalance between demand for renewables and supply, as developers struggle to match the pace of demand," the index noted.

"I think we will see the PPA market continue to rise," says Gregor McDonald, head of trading and PPAs at European Energy AS. "But I don't think it will match the wholesale market one-to-one and there are obviously different durations of contracts to consider."

But what does this mean for generators' revenue streams and the proportion of their power they intend to sell via PPAs versus trading on spot markets?

Ultimately, there is no right or wrong answer to this question, says Grant. "This is a decision based on the portfolio of projects an individual developer or independent power producer (IPP) has," he says, adding that it's not a simple binary choice given the complex commercial structures underpinning many projects.

"It's ultimately a risk questions and a shareholder expectation question," says Grant. "You could see identical portfolios or assets making very different decisions simply because of the capital structure that underpins them."

If you're owned by an infrastructure or a pension fund or a listed renewable vehicle then taking away risk and locking in three to five year PPA contracts could

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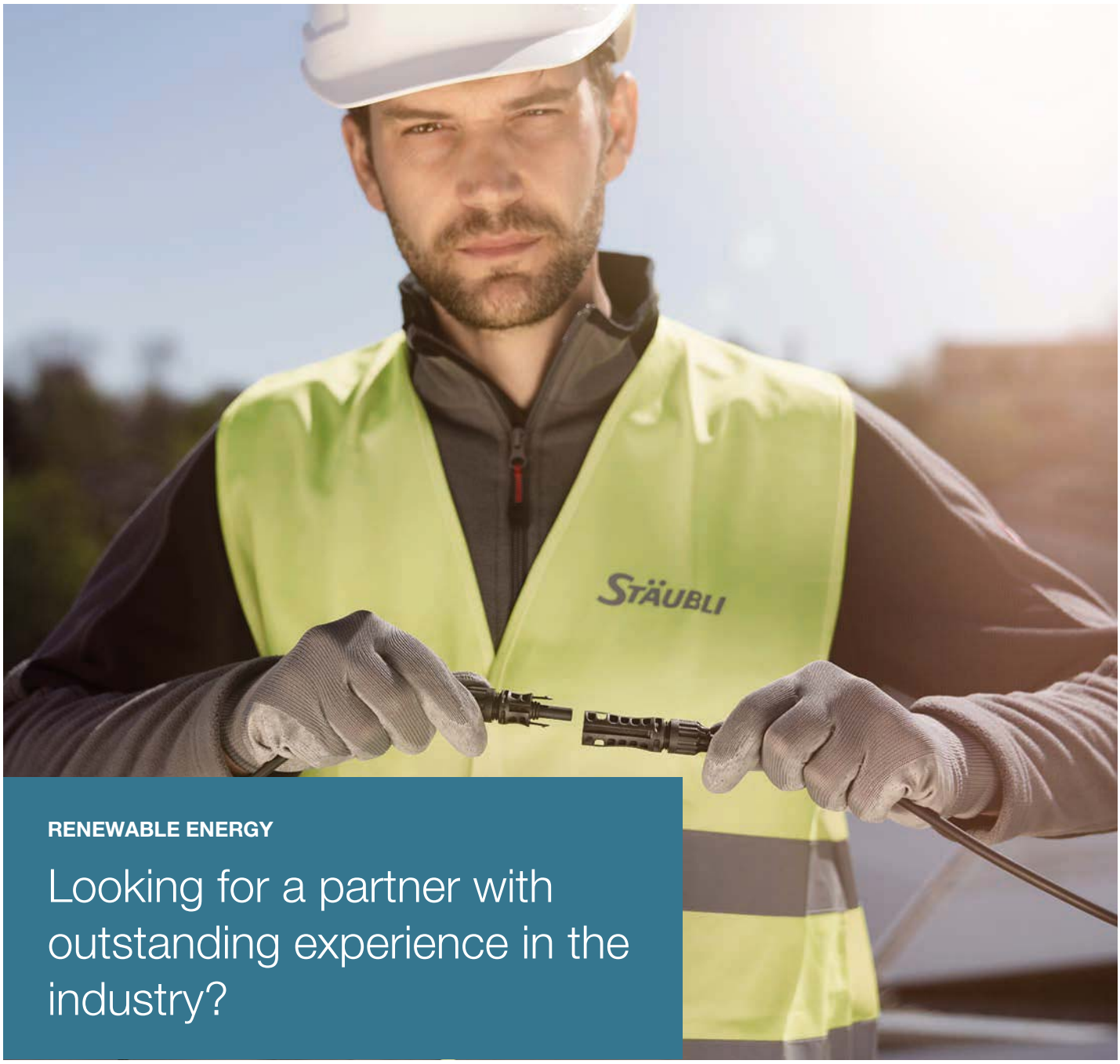

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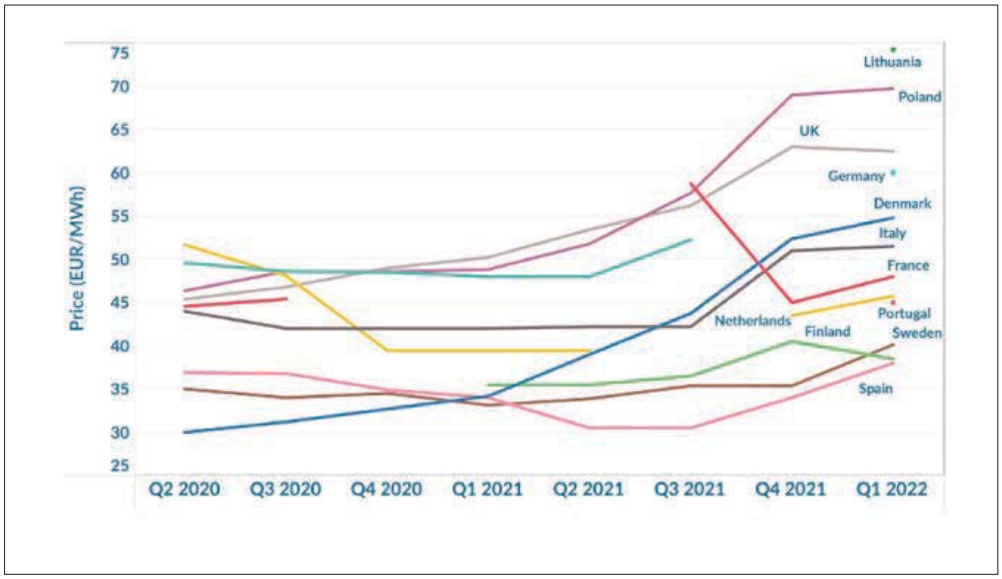

Credit: LevelTen.

Solar P25 price indices by European country.

be prudent, suggests Grant. "They'll be premium contracts and with the way markets are there at the moment there might be less cash value than the merchant alternative but it's also a much less risky world to be in."

According to Pietro Radoia, senior analyst at BNEF, investor appetite for merchant risk is increasing, partly due to an expectations mismatch between sellers and offtakers over long-term PPAs.

For the bigger institutions, large energy companies and established trading houses that have historically enjoyed merchant markets, however, greater asset exposure makes sense given those organisations' ability to effectively monetise their portfolios, agrees Grant.

Meanwhile, Pexapark is seeing increasing challenges for long-term utility PPA deals, with only a fraction of the recent surges of wholesale prices translating into better PPA pricing as offtakers have started to factor extreme risk buffers into their deal pricing," says Trabesinger. "We expect to see that currently extreme price levels at the liquid front end of the curve will translate into more activity on shorter-term PPAs."

"In addition to higher wholesale prices, liquid shorter tenors leave offtakers with less unhedgeable risk, resulting in lower risk buffers and better competition between offtakers," adds Trabesinger.

Portfolio managers are unlikely to go all in on one option or the other, of course, and at any point in time could have a mix of government backed products, an element of fixed price PPAs, floating PPAs and some exposure to merchant markets, says Grant, adding that managers will be considering future price levels and geopolitical events when deciding the balance of trading investments.

When it comes to corporate offtakers, Grant says that it is unlikely that these entities are going to be locking in long-term contracts (which he puts at three to five years) at today's power prices given the expectation that prices will start to fall again next year, with the industry already shifting to shorter PPAs amid a lack of consensus on future pricing.

When it comes to newer projects, "you can earn money earlier through more market-based solutions and hedges then you can on a long-term PPA", notes McDonald.

Wholesale markets have jumped up but PPA pricing has not followed to the same extent, says McDonald. "In the more liquid markets, the PPA simply doesn't look as good as it used to if you can earn as much money in five years on wholesale markets as you could in 10 years through a PPA."

The biggest advantage of being in the wholesale market as opposed to a PPA is the speed with which you can transact, according to McDonald. If you move to standardised baseload products and are able to handle that risk in a portion of your offtake, then you can execute trades in minutes, while PPA closing times are measured in months and that's really holding back the market now, he explains.

On the flip side, "corporate buyers need to understand their goals well, be flexible when contracting, and complete deals with haste to compete in a market that is more competitive than ever," said LevelTen.

Alternatively, other commercial entities, for example supermarkets or data centres, might want to lock into very long term contracts with a generator for 10 to 15 years if it can be arranged at the right price, says Grant. "If they can lock in at £40-50/MWh (US$59-66/MWh) then that may be attractive, but that's going to be a bilateral contract with an individual generator, rather than going to today's market and putting in place a hedging strategy."

No easy answers as the market hopes for stability

Whether you're a generator, offtaker, financier or developer, these are uncharted waters for most of the industry. Prices haven't been this volatile, and market forecasts this uncertain, for quite some time. The decisions made today could well impact businesses for many years to come. Get it right and you could be set to make a killing but get it wrong and you expose yourself to undue risk and tighter profit margins.

The conversations PV Tech has had with energy experts do not produce any easy answers, unfortunately. Investment and revenue decisions should be based on an organisation's appetite for risk as well as the financial structure underpinning it. Some are better equipped to capitalise on the high prices, while others will view a long-term, reliable revenue stream as more advantageous. Both have positives and negatives – there's a lot of money to be made if you are adept at portfolio management, while locking in long-term contracts to ensure a reliable income is nothing to be sniffed at.

The key factor is where market prices are headed. It is almost unthinkable that prices will drop anytime soon and Europe is in store for a difficult year ahead, especially if renewable generation is slow and the winter hard. All of our thoughts are with the people of Ukraine and the awful conflict occurring in Eastern Europe, which looks set to continue for some time to come. How it, and subsequent sanctions, play out remain to be seen but it is highly likely that it will continue to have an inflationary effect on energy prices. Expect volatility, uncertainty and more price pressures moving forward. The situation has already shaken energy markets beyond recognition. The questions is how long will the situation persist and what will be the long-term repercussions of the crisis on pricing and contract structures? We may well be at the inception of a new era of energy management, which could reshape markets for years to come. ■

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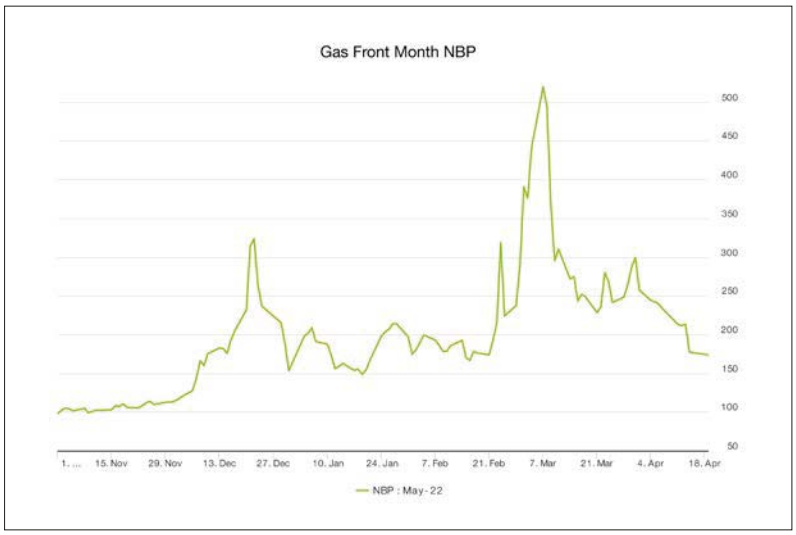
European PPA pricing trends and market fundamentals

PPAs | With Europe's energy crisis showing no sign of abating, Charlie Ward, head of renewables at New Stream Renewables, assesses the contributing factors to price volatility and PPA strategies for renewables moving forward.



Credit: New Stream Renewables.

The gas front month NBP November 2021 – May 2022.

The European energy market has witnessed increased price volatility over the past two years due to many external factors that directly impact the supply and demand balance, resulting in price rises across wholesale energy markets.

These factors range from the global Coronavirus pandemic to the geopolitical stance of politicians and the world's race to net zero and the decarbonisation of supply. Energy security is high on the agenda, and political decisions will severely impact pricing for the foreseeable future. Renewables play a significant role in futureproofing the fuel mix used across Europe. Structuring and fixing PPAs is fundamental to the viability and ultimate success of the project.

The last 18 months of PPA market pricing, driven by strong underlying market fundamentals, pushed gas and carbon pricing higher. The latest and universally publicised move up is on the back of upside gas price risk because of the Russian invasion of Ukraine.

If we take a step back, the medium-term PPA market fundamentals are affected by far-ranging factors. These include carbon price, European generation capacity, gas supply and demand and European gas storage requirements. More recently, Nord Stream 2 and the status of Russian gas flows, considering the widespread sanctions, have been very much in focus. As has alternative supply routes that have focused on LNG cargos in terms of fuel and cross-border power interconnector flows.

In the short term, PPA market fundamentals and price drivers, in our opinion, are:

- European TTF and UK NBP gas contracts moved lower from the highs of earlier in the year.
- Gas contracts are more sensitive to the weather forecast and temperature changes as we move out of the heating season.
- Norwegian summer planned maintenance of their gas fields will become the focus on the supply side.
- Data monitoring on Russian gas flows to Europe through key pipeline routes.
- LNG cargos and European pricing relative to Asian buying levels will be critical.
- New Stream expects price volatility to continue in the short term.

We have seen the market move lower through spring. It's still challenging to call right now, but the price action appears to be to the downside when we don't get a news headline.

Fundamentally we have seen more supply on the gas side with increased Norwegian pipeline flows, and we are attracting more LNG cargo. The data we see on Russian gas flows suggest that they are stable and have shown no real signs of any significant fluctuations. But obviously, anything can happen there. Lower demand is also adding to the weight on the sell-side as we move out of winter.

European Gas

Gas is a key market driver for UK Power and Renewable PPAs. Before the Ukraine crisis, gas was seen as the clean fuel that would help us make the renewable transition. Looking at recent data for the UK combined cycle gas turbine (CCGT) fleet, generation has provided 50% of the required energy for the UK market.

At the start of 2021, Europe had come out of a winter where we saw significant heating demand for fuel, gas storage levels were low, and the global market for LNG cargos was strong as less traditional buyers looked for "greener fuel options". UK NBP gas prices started to move out of historical prices ranges that had seen significant stability over several years. This, in turn, moved up the power prices as the "spark

Carbon pricing in March – April 2022.

Credit: New Stream Renewables.

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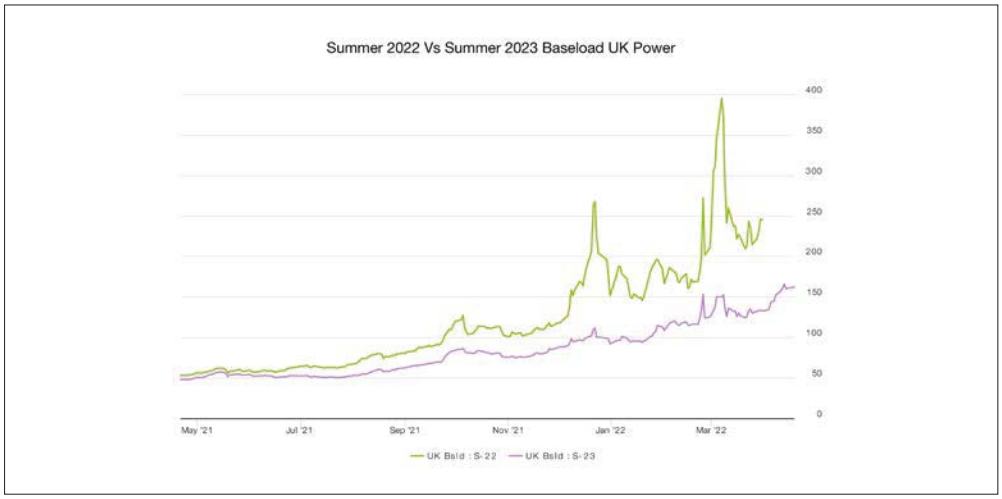

Credit: New Stream Renewables.

Baseload UK power forecasts for summer 2022 versus summer 2023.

spread cost" of buying gas (and carbon) and selling power increased.

The market was looking to Nord Stream 2, a new giant Russian supply pipeline that had been in build for years, to reduce supply pressure. Then everything changed.

Nord Stream 2

The Nord Stream 2 pipeline that runs 1200km from Siberia to Germany will play a crucial role in the coming months. The German government and other European countries have based their future energy strategies on the Nord Stream 2 being open, supplying natural gas. This lack of supply and lower storage levels across the European gas fields will accelerate the need for renewables to contribute to making up the shortfall.

The pipeline owned and operated by a consortium of businesses headed up by the Kremlin-aligned Gazprom was completed in late 2021 but has been put on hold by the German government because of Russian State aggression toward Ukraine. If commissioned, it would have had the capacity to heat more than 25 million German homes with affordable gas due to the capacity being doubled with Nord 2 complementing the existing Nord Stream 1 pipeline that has been in operation for over ten years.

Nord 1 and 2 could deliver 110bn cubic metres of gas to Europe every year, delivering over a quarter of the European Union's gas annually. In 2018, the US and Polish governments warned against the pipeline as they saw it as a threat to European energy security.

The gas market fundamentals, in our opinion, that will impact the energy market in Europe are: -

- Gas storage.
- Global LNG flows, cargos and pricing.
- Heating demand.
- Geopolitical risks and Nord Stream 2 flows.
- European pipeline flows.
- Norwegian supply.

While gas storage sites across Europe show the first signs of replenishment, weather forecasts will still be critical as we move out of the European heating season. There is still some considerable supply risk around Russian flows, although supplies to Europe via key pipeline routes have been relatively stable based on data we review at New Stream. Over the summer months, Norwegian flows around planned maintenance schedules will be critical short-term drivers of spot NBP gas and baseload power contracts.

PPA fixing strategy

It's important to look at where the price action has been for PPAs over the last 12 months.

Much of the high pricing we have seen remains at the front end of the curve, with forward contracts at a significant discount to the near seasons. Volatility is still considerable, and we have seen a mix of strategies from those generators looking for price certainty and some who want to leave floating exposure to market price volatility.

For all renewable energy producers entering into a PPA, we recommend:

- Understand where the market is and what is driving current pricing.
- Use a tender process to create competitive tension and price transparency.
- Consider the PPA structure that best suits their needs.
- Is this a fixed or floating strategy?
- Factor in who you are contracting with. What is their credit status, and how will their back-office processes work for you.
- Break down and analyse the component parts of the PPA:
  - Commodity
  - Embedded Benefits
  - Green Certificate (e.g. REGOs).
- Think about market timing, and don't limit yourself to an auction window.

We still believe that upward price momentum is slowing but are seeing significant volatility at the front end of the curve.

We have been talking to lots of generators over the last few months, discussing a strategy that best suits the asset and risk appetite of the business. We were able to flag the price strength in the market, and many took the opportunity to price-fix PPAs and GPAs on an upside versus downside basis.

In conclusion, recent moves up in PPA pricing have created opportunities for renewable generators but with increased volatility comes increased risk. In the short-term, gas will be the key driver for UK power and PPAs. Getting the correct PPA structure for your project will be more critical than ever, whilst price volatility means that market know-how and price transparency must also be considered.

Due diligence and visibility on who you contract a PPA with will become essential as we navigate what looks to be an extremely challenging global economic environment for at least the next 18 months. It is no good locking in a strong PPA price only for the market to move down and your counterparty to go out of business, so 'blind auctions' will become problematic to manage risk effectively.

Lastly, we should touch on and remember the human cost of higher energy pricing and "fuel poverty". Recent forecasts suggest that as many as four in 10 people in Britain could fall into fuel poverty when the price cap rises again this autumn. We see solar and other renewables as part of the solution to this issue, but it is not a quick fix.s

Author

Charlie Ward

Charlie Ward is head of renewables at New Stream Renewables, a specialist renewable energy market advisor and PPA energy price risk manager. Since 2011 he has been responsible for over 6GW of renewable PPAs, developing the 'best value' process for a route to market power sales to ensure maximum value is achieved for green generators across all technologies and tenors. In terms of solar PPAs, Charlie has worked on some of the largest projects in the UK, structuring short and long-term deals.

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Introduction

Welcome to this latest edition of 'Storage & Smart Power,' brought to you by Energy-Storage.news.

Since Volume 30 only three months ago, we've seen everything from the start by Russia of the horrific war in Ukraine to energy prices continuing to soar in Europe and parts of Asia, to the publication of a stark warning on climate change from the IPCC and even more COVID19 lockdowns in China.

A lot has happened in that short space of time and it's been similarly turbulent in the energy storage industry, although arguably here the downs are balanced out with a little more good news.

There have been numerous large projects announced in Australia, where the business case for energy storage in the National Electricity Market (NEM) is really picking up in response to changes made in the market's design. Several Balkan countries are about to host their first big battery storage projects, California, the UK and Texas continue to see huge amounts of action as leading regions for grid-scale batteries.

In Southeast Asia, the Philippines and Taiwan have seen notable developments that we've been excited to cover on the site. And by all accounts, there will be a lot to see coming from India very soon, in both the upstream and downstream of the industry.

BloombergNEF recently forecast a 30% compound annual growth rate (CAGR) for the global energy storage market to 2030, with more than half of all deployments to be in the US and China. By the end of 2021, we reached 27GW/55GWh of cumulative instalments of battery energy storage worldwide, with 10GW/22GWh during last year alone.

On the minus side, supply chain issues continue to dampen the near-term prospects for project completions, stemming from both a shortage of raw materials reaching demand centres and the shipping and logistics problems that have been characteristic of the latter stages of the pandemic.

One of the industry's biggest recent deals, a 2.15GWh contract awarded by California utility SCE to developer Ameresco was revealed to have been impacted by those logistical problems and it won't be a surprise to hear of more delays at other projects around the world in the short and medium term.

The clean energy industry and its champions and advocates also continue to implore politicians around the world to take notice of the critical role energy storage can play in both the low carbon energy transition and economic recovery. Some are listening, others, not so much.

But we will prevail. We must. The industry is too full of smart people with the right ideas and powerful and innovative technologies.

In this edition, we explore those supply chain issues in detail, with particular regard to the rise in cost of lithium carbonate and why the price of that critical raw material matters so much for the stationary energy storage industry.

I spoke with supply chain experts from Benchmark Mineral Intelligence and Clean Energy Associates, battery and storage system integrators and manufacturers KORE Power and Powin Energy, as well as lithium battery recycling specialist Li-Cycle.

It's been a fascinating series of conversations and really put into context the extent to which, despite enormous growth for the industry in the past few years, we should never take any of it for granted, especially as growth will need to accelerate rapidly to support the global energy transition.

Energy-Storage.news writer Cameron Murray takes a deep dive into the contribution battery storage is making to add stability and flexibility to the grid, as well as asking what we can expect to see as that contribution grows.

Cameron spoke with stakeholders and experts with knowledge of the situation in key regions of the world that are leading the way. California, Texas, Australia, the grids of the UK and Ireland and Western Europe all come under the microscope.

Finally, recent research shows that a big percentage of solar PV projects in development in the US is hybridised through pairing with energy storage. I spoke with four companies active in the solar-plus-storage market to learn what they feel is most important in their strategies and technologies for tackling this exciting and (relatively) new paradigm for the energy sector.

Andy Colthorpe
Solar Media

STORAGE & SMART POWER

'Stop leaving energy storage out of EU energy security plans'

Bill Gates-founded Breakthrough Energy, the European Association for Storage of Energy (EASE), Solar Power Europe and Wind Europe together called on the European Commission to recognise energy storage's crucial role for the security of energy supply. Without rapidly scaling up energy storage technologies, "the EU will be unable to achieve a net-zero power system, risking continued exposure to volatile fossil energy markets", the groups said in a an open letter sent in April. It argued that the EU urgently needs a massive and rapid rollout of energy storage solutions, with most of today's grid balancing done by carbon-emitting resources like gas-fired power plants. There should be energy storage targets set for 2030 as part of the REPowerEU plan, the Commission should also promote the uptake of energy storage technologies and make them integral to the European Commission's implementation of the REPowerEU action plan and in the Electricity Market Design review, the groups said.

LFP to dominate global lithium-ion battery market by 2030

Lithium iron phosphate (LFP) will be the dominant battery chemistry over nickel manganese cobalt (NMC) by 2028, in a global market of demand exceeding 3,000GWh by 2030. That's according to analysis by Wood Mackenzie Power & Renewables, which said the top two manufacturers planning to add the most production capacity during this decade are China's CATL and South Korea's LG. The top 15 producers in 2021 got 200GWh of new production lines running and by the end of last year cumulative manufacturing capacity reached 600GWh. The Asia-Pacific region will continue to lead the market, which globally has announced 5,500GWh of manufacturing capacity to come online by 2030 at 300 facilities.

Terra-Gen brings 560MWh California battery project online

Renewables developer Terra-Gen's 140MW/560MWh Valley Center Battery Storage Project in California is fully online. The four-hour lithium-ion battery energy storage system (BESS) is connected to a nearby San Diego Gas & Electric (SDG&E) substation and has contracted with the investor-owned utility to provide power under a 15-year Resource Adequacy (RA) contract. The procurement by SDG&E was approved by the regulatory California Public Utilities Commission (CPUC) in January 2021 along with Vista Energy Storage, a smaller 10MW project from LS Power. The Valley Center BESS will help prevent power outages, stabilise the grid, lower the cost of meeting peak power demand, increase the value of nearby wind and solar installations and reduce the need for expensive transmission infrastructure investments.

Credit: Sébastien Bertrand.

Energy storage should be made mainstream in the European Commission's planning, the groups say.

Eight-hour Li-ion battery system picked in California long-duration storage procurement

A group representing community energy suppliers in California has made its second long-duration energy storage procurement, with the selected bid once again a lithium-ion battery energy storage system (BESS). Seven of the 10 member organisations in CC Power, a Joint Powers Agency collective of Community Choice Aggregator (CCA) groups, banded together to make the procurements. In late January, it announced that a 69MW/552MWh lithium-ion battery project by developer LS Power had been the first selected for a contract from the group's joint request for proposals (RfP). CC Power's board voted to enter into a contract for Goal Line, a 50MW/400MWh lithium-ion BESS project in development by Onward Energy. The eight-hour discharge duration system will be built in Escondido, California, with an expected online date in 2025 — a year earlier than LS Power's project, called Tumbleweed.

Sumitomo Electric brings 51MWh flow battery online in northern Japan

One of the world's biggest vanadium redox flow battery (VRFB) energy storage systems has come online on the northern Japanese island of Hokkaido. Technology provider Sumitomo Electric said the 17MW/51MWh VRFB system it installed to help integrate local wind energy onto the grid went into operation on 1 April. Hokkaido Electric Power main electric utility and operator of the region's grid introduced rules in 2015 that new renewable energy must be paired with energy storage.This has lead to various battery storage projects including the first installations in Japan for Tesla's Megapack BESS solution and a recently-completed solar-plus-storage project supplied by Sungrow. For Sumitomo Electric, the project follows up an even bigger VRFB project in Hokkaido, a 15MW/60MWh system commissioned in 2015.

Fluence's next Australia megabattery project to demonstrate advanced grid-forming technology

A 50MW/50MWh grid-scale battery energy storage system (BESS) will be used to demonstrate the ability of smart inverter technologies to support the stability of the power grid in Australia. Broken Hill in New South Wales is a site with a strong history in the mining industry. More recently, it's become host to solar and wind power generation.However, the area has only a weak connection to the grid network. The large-scale lithium-ion BESS will be equipped with grid-forming inverters which will improve system strength and allow for the greater integration of renewables. Major Australian utility company AGL is developing and will own the project, part of an 850MW BESS rollout it currently has underway. Global energy storage system integrator and services company Fluence will provide the BESS.

Centrica's 60MWh battery project will help integrate Scottish offshore wind

Centrica Business Solutions has acquired a 30MW fully consented battery energy storage project in Scotland, UK, which will help manage North Sea offshore wind farms. The two-hour duration (60MWh) battery storage plant in Dyce, near Aberdeen, was developed by Cragside Energy Limited and backed by Omni Partners LLP. It obtained planning consent in November 2021, and currently has a go-live date of mid-2024. As the offshore wind sector continues to grow in the UK, there is an increasing need to manage network constraints. National Grid paid £244 million (US$321.7 million) to UK wind farm operators to curtail generation in 2021.

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What role is large-scale battery storage playing on the grid today?

Grids | With a handful of leading regions deploying grid-scale storage at a faster rate than ever, what sort of impact are these additions having so far on the problems they are intended to solve? Cameron Murray investigates.

Energy storage had a bumper 2021, with 2,419MW deployed in California, some 830MW in Texas and around 450MW in the UK and Australia. In the four markets combined, 2021 accounted for more than half of cumulative deployments to-date. In California and Australia, more than 80-90% of deployments to-date happened last year.

But what role are grid-connected utility-scale projects playing in helping the grid maintain stability and power supply? How is that role evolving and what challenges does the future hold as we get towards the multi-GW levels of deployment forecast over the coming decade? PV Tech Power speaks with grid operators, market intelligence firms and system integrators across these markets to find out.

A "breakout year" for storage

"Last year was a breakout year for the sector, to prove that on a utility-scale basis, battery storage is a viable, resilient and dependable source of energy," Thomas Cornell, senior VP Energy Storage Solutions at Mitsubishi Power Americas tells PV Tech Power.

"But the market was mainly restricted to a handful of states in the US. Now we're seeing it much broader than that - if you look at the transmission queues in all regions of the US they're getting saturated with battery energy storage projects. We're going to deploy 2x what we did last year and we think the market will also be 2x what it was last year."

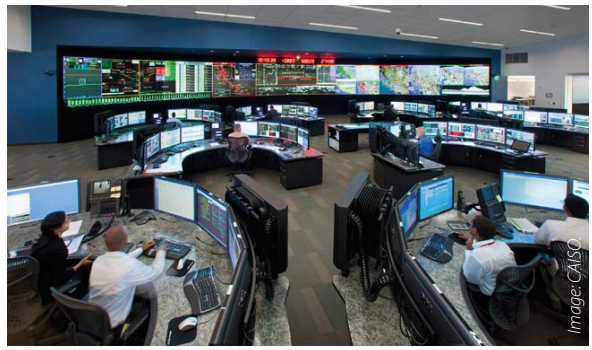
Image: CAISO

CAISO's Folsom Control Center.

At the time of writing, around 7,500MW of grid-connected battery storage has been deployed in the most advanced markets in the US and Europe, detailed in the table below.

Most interviewees agreed that despite these high deployments storage is still mainly being used for its power, for frequency regulation services, and not for its energy.

"Right now storage is mainly being a backup system. There's hope it will start to do more load shifting of renewables but with the amount out there, it's limited," says Haresh Kamath, of the Electric Power Research Institute (EPRI), recently labelled the 'cool uncle' of the sector by the moderator of a panel at Berkeley Lab's virtual National Energy Storage Summit in March.

Shifting renewables-produced energy from periods of higher production to high-demand periods is the big long-term benefit of storage, but the ability to do this profitably is at a relatively early stage. And even where load shifting is happening, it's not necessarily shifting renewables.

CAISO

As by far the most mature market on deployment, the California ISO (CAISO) grid is the ideal place to start, with over 2,700MW of grid-connected storage on the system. Storage has taken off in response to a number of CPUC directives obliging utilities and other load-serving entities to procure new flexible capacity.

The state is also the exception to the trend outlined in the introduction about storage's limited load shifting activities.

Gabe Murtaugh, storage sector manager for CAISO tells PV Tech Power that energy storage is now regularly shifting as much as 6,000MW of energy from low-price periods in the middle parts of the day to high-price periods later in the day. This goes a long way to helping dampen the so-called 'duck curve' in demand for power throughout the day in California.

With a grid frequency regulation service market of just 500MW and a typical duration of four-hours for grid-connected storage - driven by CAISO's Resource Adequacy requirement - storage's earlier move into load shifting than other markets should not come as a surprise.

Grid	Grid-connected battery storage today	As of	Source	2021 deployments (MW)	Source
CAISO	2700	March 2022	CAISO	2419	CAISO
ERCOT	1300-1800	March 2022	ERCOT	832	ACPA Q4/2021 report
National Grid (UK)	1700	March 2022	Solar Media UK Battery Storage Project Database Report	450	Solar Media UK Battery Storage Project Database Report
Australia	580	March 2022	Ben Cerini, Cornwall Insight	450	Estimate based on Sunwiz report and ESN analysis

Image: FlexGen.

FlexGen 100MW/110MWh BESS project in Texas.

But, Murtaugh adds, this load shifting is mostly shifting low-price but high-polluting gas resources: "There are some periods of overproduction of renewables and storage is certainly absorbing some of that energy but there will be some transition years before storage is charging primarily from renewable resources."

CAISO recently revealed the role of storage during the Oregon Bootleg wildfire in July 2021, when it dispatched around 1,000MW to help keep the lights on after three transmission lines connecting the regions were disabled.

"We now regularly see five-minute intervals where essentially all storage is dispatched for energy on the grid, nearly 3,000MW, and that will increase over the summer as more storage interconnects to the system," he adds. With a peak demand on the CAISO grid of 28,971MW in March that means storage is regularly contributing at least 10% of load at various intervals.

CAISO is anticipating about 4,000MW of storage to be online by this coming summer which will further help to mitigate the wildfire risk to grid stability. During Bootleg, only around 1,500MW was connected.

ERCOT

Texas is by far the leading US state when it comes to renewable energy deployments with 45,077MW, mostly wind. That is twice the amount deployed in California, which is second with 22,929MW (end-2021, figures from the American Clean Power Association).

This creates a huge opportunity to capitalise on a volatile energy market and help smooth out imbalances in the grid, and colocation with wind promises to be a big driver of the storage market in the coming years.

Storage's main revenue driver historically has been in frequency response, specifically Responsive Reserve Service (RRS) and Firm Frequency Response (FFR), says Jason Abiecunas, SVP Business Development at Texas and California-focused system integrator FlexGen.

However, the proportion between grid balancing and frequency response services and energy trading is now closer to 50:50, says Alex O'Cinneide, CEO of UK-based energy storage investor Gore Street Capital which recently acquired several storage assets in Texas.

Based on figures released by grid operator ERCOT at the end of 2021, there is likely to be somewhere between 1,300-1,800MW of grid-connected storage in Texas at the time of writing.

However, there is no sign that the FFR and RRS markets will saturate any time soon so these will remain the main driver of energy storage in the state, says Abiecunas.

"But there's money being made in arbitrage as well. Alongside price spikes around congestion points, there's times when you see negative pricing from a lot of the wind, especially in West Texas," he says. "The explosive growth in renewables will continue to drive this volatility going forward."

> "Wholesale and merchant revenues have really started to kick off for storage. Back in Q1 and Q2 (2021) you'd have been looking at less than 5% of your revenues coming from those sources but then into Q3 and Q4 that's going up to 10%, even 20%."

Although over a year has passed since the devastating winter storm of February 2021 which took hundreds of lives, it is still talked about as the seminal moment for demonstrating the potential of energy storage on the Texas grid.

Abiecunas: "Everybody saw the enormous value that energy storage was able to deliver during this time of crisis. They saw that it was a resource that provided localised stability, that could be relied upon to provide a variety of services when the grid needed it and could adapt what it was doing to meet the needs of the moment."

He says around 100MWh of FlexGen-delivered energy storage across multiple plants were operating during that time and the assets performed at over 99% availability. Another extreme winter storm raged across the US in February this year but the system held together well. "The grid held together, the storage assets worked and the headline was 'all systems normal'," he adds.

UK/Ireland

Some 446MW of battery energy storage was deployed in the UK in 2021, bringing the total grid-connected power to 1,700MW at the time of writing (figures from Solar Media's UK Battery Storage Project Database Report). Storage is mainly discussed with regards to its load shifting capability as the grid decarbonises but today it mainly provides frequency response services.

"Most of the batteries most of the time are being used for their power capacity, rather than their energy capacity. They are on standby in case something happens - so the actual utilisation of the batteries in terms of how much energy they charge and discharge in services like Dynamic Containment (DC) is really very low," says Robyn Lucas, chief analytics officer at market intelligence firm Modo Energy.

Frequency response services total a little over 1,000MW and are largely designed for and thus dominated by energy storage. They are DC, FFR and enhanced frequency response (EFR) which accounted for well over 90% of battery storage's revenues in 2021 according to Modo. But a shift started towards the end of the year.

"Wholesale and merchant revenues have really started to kick off for storage. Back in Q1 and Q2 you'd have been looking at less than 5% of your revenues coming from those sources but then into Q3 and Q4 that's going up to 10%, even 20%," says Alex Done, head of research at Modo.

"There's now a hell of a lot of opportunities in the wholesale market because of how volatile prices have been."

O'Cinneide says the optimal revenue mix in the UK is still 80-85% grid balancing, 10% capacity and 5-10% energy trading.

DC, FFR and EFR are all services which

target different parts of the frequency spectrum. EFR will be retired over 2022 and two new services, Dynamic Moderation (DM) and Dynamic Regulation (DR) have been introduced, but these will be relatively small in size.

Utilisation of storage measured in MWh discharge may be low but frequency response services are essential to the smooth operation of the grid. Lucas says that the most recent big event where their power was needed was on March 22, 2022.

Some 1,100MW of storage was contracted to respond to grid frequency and quickly restore the balance between supply and demand. At 15:27, a trip on the system caused the grid frequency to crash to 49.67Hz. Assuming the 1,100MW of batteries responded as per their contracts, a max response of 650MW of power was produced by storage to help restore frequency to 50Hz, which took 10 minutes, she says.

A total 45MWh of energy from storage was discharged to the system across Great Britain during the 10-minute period (split between batteries doing DC low, FFR and EFR).

Another notable example which made headlines last year was when the new IFA2 interconnector with France tripped on January 29, one month after going live. 900MW dropped off the system but DC "took the sting out" of the loss according to a National Grid ESO operational manager. The result was that the frequency drop caused by the trip was only 0.25hz, which would normally indicate around 300MW of drop-off.

One of the batteries involved in the response is operated by Arenko, whose CTO Roger Hollies told PV-tech sister site Current± at the time that DC had "changed the shape of the grid."

Energy storage is also becoming a notable player in Capacity Market auctions launched by National Grid. In the most recent auction for 2025/26, 1,094MW of batteries won out in a tender totalling 27,632MW, or 2.5% of that amount.

Although storage's role in the Balancing Mechanism is small for now, it's a hugely important area for National Grid to balance its network in a short-term way. Trading in the wholesale markets helps dampen price volatility so it's good from a system point of view.

Ireland has seen much lower levels of deployment but there are still notable examples of battery storage. Two battery storage systems totalling 37MW stepped in when the frequency of Ireland's electricity grid dropped below normal operating range in May 2021. It was the longest under-frequency event seen in the country in years as the grid went out of bounds of 49.9Hz – 50.1Hz for more than 14 minutes, but the batteries stepped in within 180 milliseconds.

Western Europe

Western Europe is a bit behind the UK, California, Texas and Australia when it comes to storage deployment. France has around 300MW of grid-connected storage, Germany around 600MW and Netherlands and Belgium are below 100MW each, says Jean-Paul Harreman, director of market intelligence firm EnAppSys. Though, he adds, there are big pipelines in each including 500MW in France alone.

Most of this is providing Frequency Containment Reserve (FCR), a frequency response service requiring activation within 30 seconds of a drop. The auction has seen higher availability payments in the last year due to shorter delivery periods and an increase in gas and carbon prices. Shorter delivery periods for frequency response services are also pushing more conventional assets out of the market in favour of storage.

But, due to the small scale of storage in West Europe there are no examples to-date of it playing a key role in maintaining grid stability. "It will take three to five years for storage to start having an impact," he says.

However, the next one to two years should see storage increase both liquidity on intraday markets after the SIDC (Single Intraday Coupling) gate closure and the potential to install renewables in congested grids like Spain and the Netherlands.

Harreman: "In the longer term, storage has the potential to reduce market volatility, starting with the tail-ends of the distribution. As a certain price spread between charging and discharging is required to break even, storage will try to capture the most extreme prices at both ends of the distribution."

He says the FCR market may be the first to get saturated but that storage can qualify for a variety of markets and asset operators will be able to pick their market, be it FCR, automatic Frequency Restoration Reserve (aFFR) or energy-only markets.

"There is a clear long-term floor revenue, based on intermittency of renewables and the run hours of conventional generation and the price differences that result from that volatility," he concludes.

Australia

Australia's grid operator AEMO wants more storage to be connected and

At the time of writing, around 7,500MW of grid-connected battery storage has been deployed in the most advanced markets in the US and Europe.

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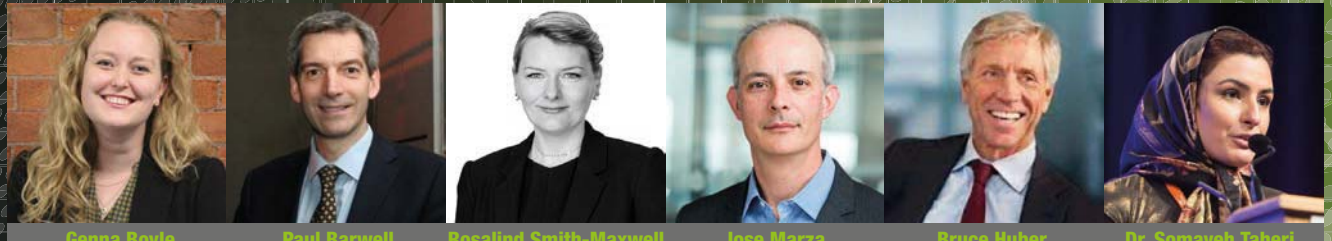

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The Minety energy storage facility in Wiltshire, UK.

participating in the ancillary services market. But it's a thin market, totalling around 800-820MW including 600MW of frequency control ancillary services (FCAS), and so the more storage is deployed the more prices are cannibalised.

That is according to Ben Cerini, managing consultant at Cornwall Insight Australia who says there is around 580MW of grid-scale storage connected today and around 15GW expected by 2030 (another 30GW will be distributed energy resources including rooftop solar). Storage today has a market share of around 25% in the FCAS services.

Today, 80-90% of grid-scale energy storage's revenues in Australia come from FCAS services with only the remaining 10-20% coming from energy trading, he says. The economic viability of a purely merchant model is not proven yet, but the opportunity is growing so this could change in future.

"The spreads between the middle of the day and the evening peak will continue to increase in future, especially as lots more rooftop solar comes onto the system," he says.

Cerini says that one of the biggest events in which storage played a key role in maintaining grid stability actually came a while ago.

"So there have been a few trips but one of the better examples is when South Australia was forced into an islanded state two years ago, isolated from the rest of the grid. Most of the storage in the country at that point had been deployed in South Australia, and that was all called upon to provide those services over the 17-day period to keep the grid stable."

He says the cost to the South Australia grid to provide those frequency support services was "astronomical": the money spent on FCAS services over the 17 days was equivalent to 12-18 months of FCAS revenue across the entire National Electricity Market.

Future challenges and market design

Alongside all the various challenges for energy storage developers and owners around maximising revenues, grid and distribution network operators face their own problems with growing amounts of energy storage.

Murtaugh admits there are challenges involved in bringing a new asset online in the quantities we are seeing for storage but doesn't go into the specifics. He does say that it makes planning for resource adequacy, the program to ensure CAISO has adequate generating resources to meet demand, much more complicated.

"Energy storage flips the premise of resource adequacy on its head because you are no longer simply thinking about generating capacity during a given hour. You also must ensure that there is enough energy to charge the storage resources and ensure there is enough energy from those resources to provide full generating capability across all 24 hours of a stressed day. Developing longer duration storage technologies will help with this," Murtaugh says.

> "We now regularly see five-minute intervals where essentially all storage is dispatched for energy on the grid, nearly 3,000MW, and that will increase over the summer as more storage interconnects to the system."

Round-trip efficiency also has to be taken into account and further complicates the storage requirements CAISO sets. Lithium-ion's 85-95% is good but other technologies, especially long duration, may have lower figures which would change the storage capacity equation.

Haresh Kamath, EPRI, highlights another issue that independent system operators (ISOs) in the US will face as storage grows.

"There will come a point when the ISOs will have to understand how much storage is available at any given time in terms of duration. That will be a challenge to the ISOs once storage is a large enough asset to really make a difference," he explains.

Discussing the UK's national grid, Modo's Robyn Lucas echoes this point: "As storage grows, there will be a big challenge for the distribution networks in getting the data they need to manage their network - things like storage availability, power and energy capacity.

"Distribution networks don't really have any visibility on the batteries that are connected to the system on a real time basis at the moment. And that's going to be a big problem as we go to more local services."

A hot topic in the sector everywhere is how storage is recognised and integrated into the grid and tweaking market rules to fairly reflect its unique characteristics. CAISO is looking at changing market rules to allow storage operators to specify prices which are based on a battery's state of charge, Murtaugh says.

"No other market has anything like this in place today and the storage community is really excited to see this change implemented," he adds.

Asked about system challenges further down the line in the Australian market, Ben Cerini highlights resistance to integrating it from operators of transmission and distribution networks.

Conclusion

So it's clear that despite the massive amounts of deployments we saw in 2021, energy storage is still some way away from doing the renewable load shifting that everyone hopes it one day will.

But as the examples covered show, its role as a backup power source through frequency response is still hugely important to the functioning of grids. The instant responses we've seen to frequency drops, be it technical faults or extreme weather events, provide wonderful, tangible examples of what storage can do.

And there is a clear move to more wholesale trading over time which should start to encompass renewable load shifting, even if it is currently at a relatively early stage. Paired with more renewables coming online, we will increasingly see how storage can make a dent in our electricity system's carbon emissions in the coming years. ■

When solar meets storage

Colocation | Solar and energy storage were described by Elon Musk as going together "like peanut butter and jelly". Andy Colthorpe meets some of the players creating this winning combination in the US.

Image: Recurrent Energy.

Slate solar-plus-storage in California, which includes over 560MWh of battery alongside 300MW of PV.

First, some quick stats: out of 10GW of battery storage additions planned for deployment in US utility service areas over the next two years —around 60% — is paired with solar, according to figures from the US Energy Information Administration (EIA) released in March.

Solar-plus-storage is becoming a massive part of the renewable energy market in the US. In Vol.28 of this journal, Lawrence Berkeley National Laboratory (Berkeley Lab) researcher Will Gorman noted that as of the end of 2020, there was about a gigawatt of solar-plus-storage in operation at 70 sites.

Then, utility interconnection queues, Berkeley Lab found 160GW of solar PV being developed that was paired with batteries. Of course, not all of this will be built by a long shot and certainly given the challenges of securing interconnection some of it may not be built for several years, but clearly a lot will.

If you haven't read Gorman's article, we'd urge you to go back and do so. Among the fascinating insights is the assertion that hybrid resources — pairing energy storage with solar or wind (or both) — isn't always the best solution versus standalone.

The high value of a grid interconnection point that the renewable and batteries can use, as well as the federal investment tax credit (ITC) incentive which applies to solar-plus-storage but not to standalone storage, are strong drivers for the phenomenal growth in interest in hybridisation.

But of course, in many cases solar-plus-storage does work very well indeed — among Elon Musk's many pronouncements was a then-famous 2016 quote that the pairing is like "peanut butter and jelly".

We spoke with four companies that are putting that metaphorical sandwich together in the field. Broadly speaking, they are active in two scales of solar-plus-storage: very large utility-scale power plants and smaller distributed generation projects.

Lucas Moller is head of energy storage at Recurrent Energy, the US-based developer subsidiary of Canadian Solar. Recurrent develops large-scale plants, including Slate in California: 300MW PV with 140.25MW/561MWh of BESS, which the company sold to Goldman Sachs and came online in March.

Jamal Burki is president and Joonki Song VP of marketing and supply chain management at IHI Terrasun Solutions. The full lifecycle services provider for solar-plus-storage is a subsidiary of Japanese conglomerate IHI, currently working on the US$1.2 billion Gemini project in Nevada for developer Primergy.

Mark Frigo is VP for energy storage at Nexamp. Known as a leader in US community solar, based on the East Coast, the company is developing a wave of solar-plus-storage projects at a more distributed level in key markets like Massachusetts.

Mary Cauwels is VP of product marketing at smart energy storage technology and services provider Stem Inc. From a background delivering behind-the-meter batteries — and solar — for commercial and industrial (C&I) customers, Stem Inc is now also in energy storage procurement, integration and operations for distributed level solar-plus-storage, both in front of and behind-the-meter.

Recurrent Energy - Lucas Moller

"Solar-plus-storage for us to date in terms of executed projects is all California, is the case for most of the market. But, fundamentally, we look at all solar projects in our portfolio as potentially solar-plus-storage. That's just our perspective on how we do project development and plan for future market demands — not today's demands," Lucas Moller says.

While it seems like solar-plus-storage has sprung up in California almost overnight, in fact it was developers like Recurrent taking that perspective early on which has made it so. Moller refers to Slate, the "star project of sorts".

Slate was conceived as a solar-plus-storage project from 2015 when interconnection plans were drafted up. Even further back, interconnection requests for solar projects filed by the developer in 2014 included storage.

That "first flag planted" highlighted that the areas large solar projects were being developed in would have enough variable solar generation to need storage to shift energy into later hours sooner rather than later. While the economics didn't pencil out for solar-plus-storage then, Recurrent knew they would before long.

Image: IHI Terrasun Solutions.

An IHI Terrasun solar-plus-storage project.

"We look at all solar projects as solar-plus-storage projects. As it pertains to California, and [more broadly] the Desert Southwest US, there's no such thing as a solar-only project anymore. There is pretty much a fundamental need to add storage to every project to make it economically viable."

In other words, the value of solar-plus-storage is directly associated with the degree of solar penetration.

"The reference, of course, is the duck curve, which is fundamentally driving value in energy shifting. That is creating necessity for storage, but further than that, it's saying any marginal solar that comes online needs to effectively ameliorate the very low or sometimes negative value of midday energy. So, we don't want to create a new power plant that is primarily going to be stranded out there injecting low value power in the middle of the day if it's a standalone PV asset.

For the buyers in these markets, whether it's a regulated market like Arizona or an open market in California, the value of that midday energy is so low in every marginal megawatt of renewable power that when you buy a new plant, you want it to be associated with the ability to shift and not be exposed to that low value in the middle of the day."

IHI Terrasun - Jamal Burki and Joonki Song

"Four years back, if you did a 50MWh project, you would do a big press release and hold an event. With Gemini, a 1.4GWh, DC-coupled, solar-plus-storage, solar-only charging project, it's really a milestone project that we're working with Primergy on," Jamal Burki says.

IHI Terrasun is also involved with some of the smaller, distributed generation projects — including a recently completed project in New England ISO territory for Nexamp — and while these are worthy of celebration in their own way, solar-plus-storage on the sheer scale of Gemini, which charges from 690Mwac/966MWdc of PV, shows "how the industry has really come together," Burki says.

The four-hour duration BESS at Gemini will provide solar time shifting, taking cleanly generated power into the evening peak. Joonki Song says Gemini and projects like it show that the combination of solar and storage creates dispatchable power plants.

They may not be 24/7 power plants, but they combine the two technologies to "provide consistent power from when the sun rises and capture energy when the solar generation is higher than the inverter limit and then smooth out in the afternoon".

Conversely, another large-scale project IHI Terrasun is working on, Leeward in California (72MW of PV with 36MW/144MWh BESS), is AC-coupled.

"It's really more of a peak shaving and interconnect firming application and the customer is also planning to use that for voltage regulation," Burki says.

The differences in applications drive the decision to AC-couple or DC-couple: solar-plus-storage projects intended to provide a lot of ancillary services and grid stability will be AC-coupled, while DC-coupling is better suited for doing a lot of solar shifting.

Meanwhile, in terms of technology and system design solar-plus-storage is broadly speaking more complex than standalone energy storage.

"If you have standalone energy storage, the controls are relatively simplistic. You have a signal coming in for charging the batteries from the grid, and a signal coming in for discharging it, so the controls piece is relatively straightforward," Jamal Burki says.

Standalone storage's two main use cases are to provide either short-term peak reduction or ancillary services, or both. As alluded to by Joonki Song, solar-plus-storage plays more of a power plant role, but of course, the batteries there can also provide other applications.

While standalone and solar-plus share some complexities around making sure batteries are healthy, state-of-charge management is in place and so on, for DC-coupled projects in particular, there is also a "lot of technology that needs to go in" to ensure solar PV otherwise clipped during times when generation goes above that inverter limit is captured efficiently.

The market continues to evolve and Burki says "tremendous improvement" is being seen in the technologies, in batteries, but perhaps even more so in inverters. All of the Tier 1 inverter companies are already providing AC-coupled and growing numbers are adding DC-coupling too.

Over the last three years, IHI Terrasun has doubled down on developing solar-plus-storage controls and monitoring for DC-coupled systems and partnered with two inverter companies to bring solutions to market.

Where previously a solar-plus-storage project was more like two separate systems operating side by side, integrated controls create "green power plants": "so you can start to think in those terms — a dispatchable renewable solar power plant," Burki says.

"We see that trend continuing and growing."

Nexamp - Mark Frigo

"If you're in solar, you have to be in energy storage. They go together, like Yin and Yang," Mark Frigo says.

Nexamp has been around since 2007 and started ramping up its energy storage efforts two or three years ago, to the point where it now has 140MW of distributed solar-plus-storage or standalone storage in construction or in operations, largely in the northeastern US.

When asked if there may be a 'one size fits all' solution for US solar-plus-storage, the answer is "an emphatic no," because depending on which state your projects are in and what opportunities they will target, the batteries can be solving different problems, Frigo says.

For instance, two Nexamp projects recently brought online in Massachusetts and paired with Nexamp community solar PV installations have four distinct revenues associated with them.

"One, they're part of a state programme called Solar Massachusetts Renewable Target (SMART). Two, they're part of [another] state programme called Clean Peak. Three, they are a capacity resource and they are also a frequency regulation resource for the independent system operator, ISO New England."

Elsewhere in New York, another project

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Image: Stem Inc.

"This is what our planet needs," Mary Cauwels says.

is being developed for a utility as a non-wires alternative to building out transmission and distribution infrastructure. It's still paired with solar, but the energy storage's main use case is to mitigate a substation overload in the utility's service territory.

As Frigo describes it, there are only a handful of US states that have put in place incentives and programmes to move forward the progress of clean energy development and associated energy storage, Massachusetts, New York and California being prime examples.

Outside of those leading regions, in the US market, there are generally two major drivers for solar-plus-storage. One is the ITC, which can lower the capex cost of the equipment by up to 30%.

Storage is eligible for the ITC if colocated with solar generation and charged at least 75% to 100% of the time from that PV annually. The closer to 100% you get, the closer to that full ITC capex reduction you get.

"The reason for that is simple. The ITC is meant for renewable generation and if instead of charging from the solar, you charge from the grid, you have no idea of where that power is coming from," Frigo says.

The other option is in creating what Nexamp calls "a shaped product", adjusting the shape of the solar generation curve to meet demand when most valuable, typically in the early evenings and at other peak demand times. By adding storage, instead of giving a customer a take-as-is type of power purchase agreement (PPA), generation is provided at different times based on the customer need.

Frigo argues that the ITC should be extended to standalone storage, for instances where pairing with solar doesn't necessarily make sense. However he also acknowledges that with batteries as a relatively new phenomenon on the grid, these things take time to move through regulatory and political steps. That includes solar-plus-storage as much as it does standalone.

Stem Inc - Mary Cauwels

Focusing on Massachusetts, which targets net zero emissions by 2050, Stem Inc's Mary Cauwels explains how the state uses the SMART programme in service of that goal.

SMART pays a per kilowatt-hour rate for all solar production for a 20-year term. Recently the administration of Governor Charlie Baker doubled its target to 3.2GW. It incentivises the addition of battery storage with state-provided funds, paid by the utility to the project owner.

Massachusetts' Clean Peak Energy Standard meanwhile incentivises clean energy tech that supplies electricity or reduces grid demand during seasonal peak demand periods, as established by the state's Department of Energy Resources (DOER).

For Stem Inc, as a California headquartered tech company, it was a question of building on its experience of delivering solar-plus-storage in its home market for behind-the-meter commercial and industrial (C&I) customers and adapting those offerings for a market which is characterised by more complex — but rewarding — use cases.

That meant configuring the company's Athena artificial intelligence-driven software platform and bidding algorithms to tackle applications that earn those four distinct revenue streams that Nexamp's Mark Frigo referred to.

"We're optimising charging the battery from the solar and then dispatching the solar, dispatching the batteries' stored energy to the market, as appropriate, into the different value streams: for the wholesale market in ancillary services and forward capacity markets at the right time, so we can capture the full value of the solar," Cauwels says.

Cauwels offers a simple revenue breakout of a solar-plus-storage system operating in Massachusetts.

"We're seeing about 34% of the revenues coming from the energy market. About 27% coming from forward capacity markets, 15% coming from real time reserves, 12% coming from clean peaks, and about 12% coming from frequency regulation. There's a really interesting kind of spread across all these different value streams that solar-plus-storage is able to participate in."

In the near term, Stem Inc sees a bright future opening up in Connecticut, where regulators want 580MW of a 1,000MW energy storage deployment target by 2030 coming from aggregated behind-the-meter systems. Hawaii will continue to be a hotbed of solar-plus-storage as it has for years, pushed on in particular by Hawaiian Electric's Battery Bonus incentive programme which just got extended.

All of this pushes in the right direction. Cauwels says it is important to recognise how far the clean energy movement has come with just solar alone in the past, and how much more will be done now energy storage has hit the mainstream.

In the last five to 10 years, without energy storage a lot of excess solar energy was generated and wasted, meaning fossil fuels were used to meet peak demand. With energy storage, more clean energy can be absorbed, injected into the grid and add more flexibility as more and more renewable energy is integrated into the networks.

"This really helps shift loads better, absorb more low cost clean energy, during optimal times and really discharge energy, when more expensive greenhouse gas emitting conventional resources would have otherwise been used," Cauwels says.

"This is what our planet needs. This is the purpose of what wind and solar are all about and storage is one of the answers to bringing that intermittent resource into play more responsibly." ■

Overcoming the great disconnect in the battery storage supply chain

Supply chain | The rising demand for lithium-ion batteries far outstrips the available supply, even as investments into materials extraction and manufacturing ramp up like never before. But what does the situation really look like and when will it ease up? Andy Colthorpe investigates.

It's no secret there's a tightness constricting the energy storage supply chain. A few weeks ago, on E*nergy-Storage.news*, we heard from a specialist on procurement, lawyer Adam Walters at Stoel Rives, that lithium carbonate price rises in particular are at "crisis point".

Rising demand for batteries, largely coming from the electric vehicle (EV) sector, means raw materials prices continue to be volatile. Cell supplier contracts are moving to shorter and shorter term pricing. With terms changing over periods as short as a week, it becomes more difficult to get them signed off.

Fluence noted in its Q1 2022 financial results that while the company's US$1.6 billion backlog of energy storage orders has been hedged with fixed price contracts, future contracting will be based on raw material indexed pricing to minimise exposure to fluctuations. The system integrator is not alone in this.

"Historically, it was possible to do off-take agreements at fixed price, that's no longer the case. Certainly now, all new agreements use index referenced pricing. You're not going to be effectively getting a stable price. Fixed price contracts, very common up until this year in lithium, don't really exist anymore," says Caspar Rawles, chief data officer at lithium battery supply chain information provider Benchmark Mineral Intelligence.

The demand situation has been exacerbated by the COVID-19 pandemic, which has thrown logistical headaches into the mix for over two years. Fluence CEO Manuel Perez Dubuc said at the end of 2021 that supply chain issues caused by logistics largely represent a "bump in the road" for the clean energy transition, likely to normalise by the end of this year.

The two-level problem comprises logistical problems arising as a knock-on effect of the pandemic — made worse by China's lockdowns — alongside the ongoing demand-driven undercurrent of raw material prices soaring.

Image: Fluence.

Like many others in the industry, Fluence has moved away from fixed price contracts in recent months.

Factor in that the thirst for economic recovery is leading politicians, particularly in Europe, to place that within a 'green recovery' agenda. That's undoubtedly a positive thing, says Rawles, but puts more strain on already-constrained supply.

Russia's invasion of Ukraine is also bringing energy security issues to the fore, alerting Europe to its dependency on Russian gas, driving higher sales and awareness of battery storage and EVs as well as exerting pressure on nickel prices.

"It's an unprecedented time in the energy storage industry. Customers have had the expectation set over the last five to 10 years that batteries will always be on a declining cost scale," Danny Lu, executive VP at US energy storage system manufacturer Powin Energy says.

The last few months show that the industry can never get too comfortable, Lu says, and Powin has had to be "ready and dynamic enough" to help customer projects remain viable. This has meant leveraging relationships and leveraging the vendor pool to provide "the most competitive solutions".

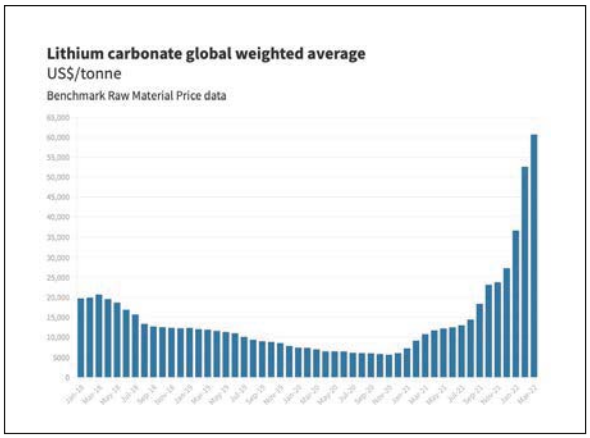
Joseph Johnson, market and data analyst with solar and storage market intelligence group Clean Energy Associates (CEA), says dramatic increases in pricing not just for lithium, but also cobalt, nickel and other materials affects the stationary storage market "very much".

But — and it's important to note this — many EV manufacturers are also switching to lithium iron phosphate (LFP) chemistries instead of nickel manganese cobalt (NCM) or nickel cobalt aluminium (NCA) to reduce their exposure to cobalt and nickel price rises.

The supply chain has "struggled to keep up and that's resulted in rapidly accelerating prices," Caspar Rawles says.

"The rise in the price of lithium is particularly important for ESS because the majority of people are using LFP, or aiming to use LFP cells, which are essentially a bit of a proxy for the lithium price — the biggest component of the cathode cost by a long way."

"The challenge that we've seen since late 2020, after the first wave of the pandemic, is that [rising] demand for battery minerals. It's all battery minerals, but lithium is the one that's having the



The rapid rise in cost of lithium carbonate. Based on data provided courtesy of Benchmark Mineral Intelligence.

biggest challenge," Rawles says.

Both Benchmark and CEA have noted about a 500% increase since early 2021 in the cost of battery grade lithium carbonate from China, which translates to prices going up ten-fold in dollar values, from about US$8 per kilogram to more like US$80.

As the graph below illustrates, courtesy of Benchmark's data, the lithium carbonate price has been rising and rising. There have been price fluctuations before, notably between 2016 and 2018, but prices "didn't get anywhere near as high as they are now," around US$20,000 to US$25,000 per tonne. They are about four times that amount today.

In that earlier timeframe, excitement around EVs drove that short-term price increase, but was a short-lived rally that perhaps jumped the gun a little bit, Rawles says. From 2018 to the end of 2020, there were essentially three years of falling prices, which meant hardly anyone was investing in new supply.

"Despite companies like Benchmark saying 'this is coming, we can see the numbers and we know what's going to be needed, and we know how long it takes to bring this new supply online,' there was a lack of supply chain investment. It was already on the horizon that we were pretty much there with lithium, the market was going to get very tight. Then the pandemic hit. Following the pandemic, it has amplified demand."

Catalysts included renewed EV subsidies from China and European governments, but at the same time the supply side of the market for Europe and the US still remained largely uninvested into.

A situation some saw coming

Lindsay Gorrill, CEO of US-based cell and systems manufacturer KORE Power, was previously head of a company selling feedstock for lithium battery electrolyte. From working in the supply chain for 20 years, Gorrill says he understood that creating upstream and downstream capabilities in the US would be the only way to solve the problems that he too saw coming.

KORE Power has 2GWh of manufacturing in China, which it is expanding to 6GWh in 2023 as well as developing a 12GWh plant in Arizona, US, on which it plans to break ground later this year. Helping solve those long-term supply chain issues was what drove the CEO to found the company in the first place, he says.

"That whole process was in my head even six years ago. I was saying, 'If we don't start bringing supply all the way through upstream to downstream to the United States or near the United States, there'll be a problem,' because before anybody was even talking about supply chain problems, there was already a shortage in late 2019."

"It was already coming before the pandemic — the pandemic just basically magnified it 30 times over!"

KORE Power makes both LFP and NMC cells, making a conscious effort to supply to the underserved ESS market as well as EVs. That makes the company a rare example in the US — and in the wider world — where the EV segment's far greater current and projected demand accounts for the vast, vast majority of planned capacity additions.

Pricing dynamics are changing the conventional wisdom of NMC for EVs, LFP for ESS, Gorrill says.

"It's funny — if you roll back three years, NMC was by far the dominant chemistry. LFP was still coming along. LFP is a good technology but doesn't have as much [energy] density as NMC," he says.

For an outdoor ESS, or for large footprint transportation applications like buses, that doesn't matter so much and the rising cost of cobalt drove customers towards LFP, even for EVs.

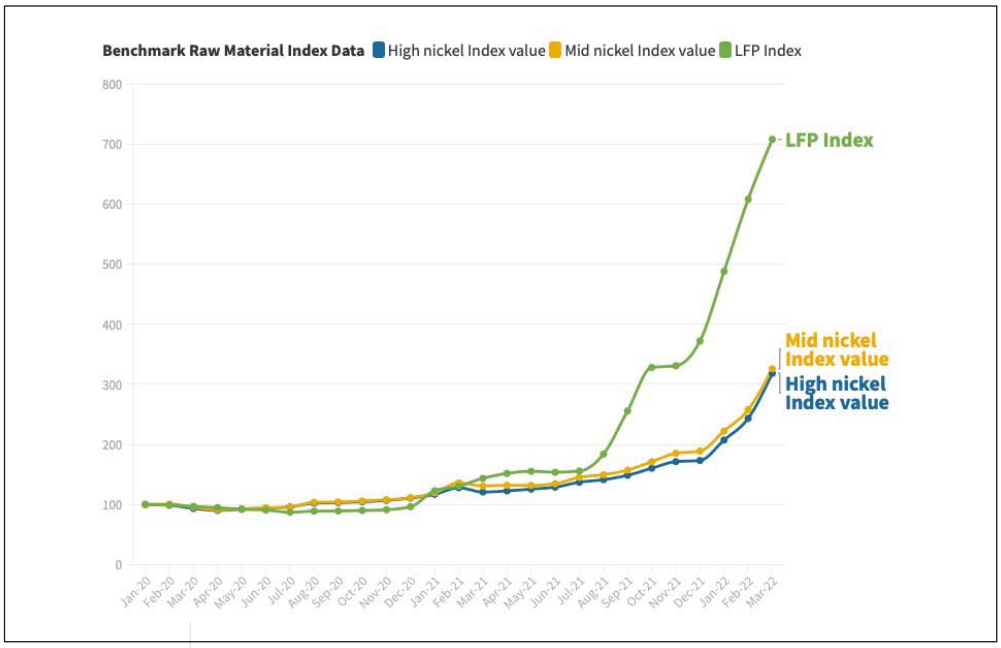
Over the next few years, cost may remain the biggest determinant of cell chemistry choice and the chart below shows just how much that differential has driven up the cost of LFP. One customer in Europe KORE Power has been speaking with was looking to switch over to LFP, but is now going back to NMC.

Great raw material disconnect

Supply chain investments are now starting to happen, but the market dynamic is still characterised by what Benchmark Mineral Intelligence has dubbed "the great raw material disconnect" — while new battery factories can be built in timeframes of short as two years in some cases, new material extraction facilities take much, much longer.

As expansion takes place, the market will eventually reach some kind of balance in the latter part of this decade, but the wave of electrification, from transport to heating to the grid and beyond, is on an unprecedented scale.

"This isn't a demand cycle that's going to last a couple of years. We're looking at CAGR rates of over 20% for more



LFP has been the most affected among commonly used battery chemistries. Based on data provided courtesy of Benchmark Mineral Intelligence.

than the next decade for lithium. You're essentially asking the market to add a world class operation to the market every year for more than 10 years. That is a big challenge," Caspar Rawles says.

"The market will balance itself out in the coming years, but there's a long tail of investment needed to keep up with forecasted demand growth."

CEA's Joseph Johnson also refers to a "huge disconnect" even between planned manufacturing capacity additions and projected stationary storage installation figures, somewhere between 2x and 4x — albeit mining and refining is the "real limiter that determines how many cells can get produced".

That upstream capacity is starting to come online, but where a battery factory can be built in perhaps two to three years, a new mining operation can take much, much longer, anything from five years at best to decades in extreme cases.

With investments having begun at scale from 2019, that points to 2024 being the earliest the supply chain will start to ease. It'll take at least another couple of years for the material extraction side to really catch up to demand.

CEA believes logistics issues will likely ease over a two-year window, viewing the end of 2023-beginning of 2024 timeframe as when availability of containers, additional vessels and sea lanes to carry freight will improve. Port congestion and backlogs will start to be resolved and worked through.

Can we Build Back Better?

The battery industry might look very different in the second half of this decade, as today's efforts to correct those mismatches in supply and demand take hold. Joseph Johnson notes that cell manufacturers are pushing to have more upstream control.

Established players like LG and startups like Northvolt alike are moving towards partnerships and investments for long-term materials supply. Upstream involvement can give cell manufacturers more control over their technology roadmaps, better visibility into refining and cathode production.

Policy has a role too of course — the US has identified that its lack of a domestic value chain is a critical weakness, not just in energy policy but in national competitiveness and security.

KORE Power's Lindsay Gorrill, invited onto a US Department of Energy task force on supply chain issues, says that in the past there hadn't been a realistic attempt to plan for future demand. The government needs to support upstream — and downstream businesses — to get the permits and financing they need, he says. Permitting in particular, can take a "very long time," as things stand, Benchmark Minerals' Caspar Rawles says.

While demand for ESS, or EVs, hasn't been hugely negatively impacted by the supply chain situation, it has led to delays for many ESS projects. As pointed out by Stoel Rives' Adam Walters, we are likely to see many more projects get delayed.

However, Rawles says that a number of ESS providers which have moved into a cost pass-through structure in their contracts are finding it a tough financial hit to bear, eroding "all of the margin". If those companies move into the supply chain, they once again find themselves in competition with the much bigger electric vehicle sector.

All our interviewees say the situation will ease and that actions being taken today can make for a more robust industry and value chain tomorrow. But it will take time, it will take investment, it will take hard work.

The next chapter

It also represents an opportunity to create a huge industry, a global source of new jobs and of course the very engine of the transition to sustainable energy. How we do that is really important too. The European Union is phasing in regulations over carbon footprint labelling and recycled content in batteries over the next few years.

Lindsay Gorrill says that building from the ground up has given KORE Power the chance to design its 1.5 million square foot Arizona gigafactory to be net zero — with nothing but solar panels on the roof paired with the company's own battery storage systems.

"We're going to create enough energy with solar and our own storage to run the plant and create extra energy for the grid. So we're looking at this whole thing holistically, how we run the plant and run it effectively and properly."

Recycling will also be a valuable and potentially cleaner source of raw materials. Kunal Phalpher, chief commercial officer at North American battery recycling company Li-Cycle says that more recyclable materials coming on stream throughout this decade can lower battery production costs and improve sustainability.

"Sustainability-wise, the big differences are water production and greenhouse gas (GHG) emissions per tonne of materials produced. On the economic side, because we produce lithium, nickel, cobalt, all in the battery grade in one facility — our feedstocks very different than what you'll find in the ground — the cost is distributed amongst those three raw materials so you can really get towards the bottom of the cost curve on all those materials."

We'll look at some of the ways that the mismatch — or disconnect — can be solved in the next edition of Storage & Smart Power; from upstream investments into recycling and sustainable mining to downstream procurement strategies. ■

Credit: Tesvolt.

German manufacturer Tesvolt said demand for its battery storage has risen nearly 200% year-on-year, likely in response to rising electricity prices and Europe's energy security concerns.

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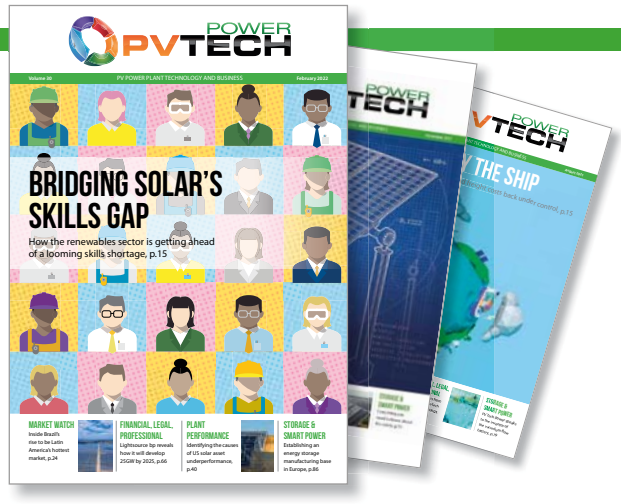

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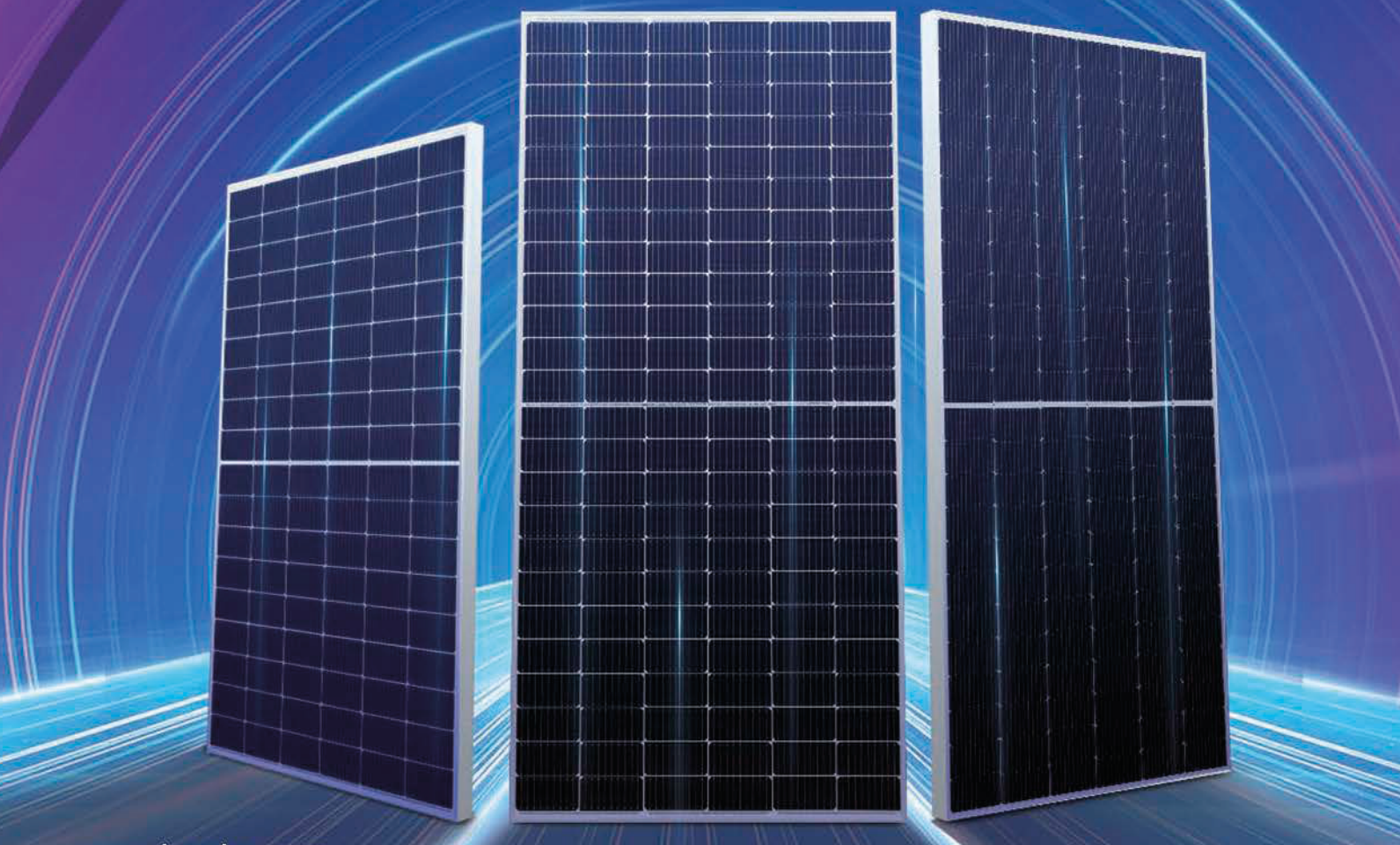

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