PV POWER TECH

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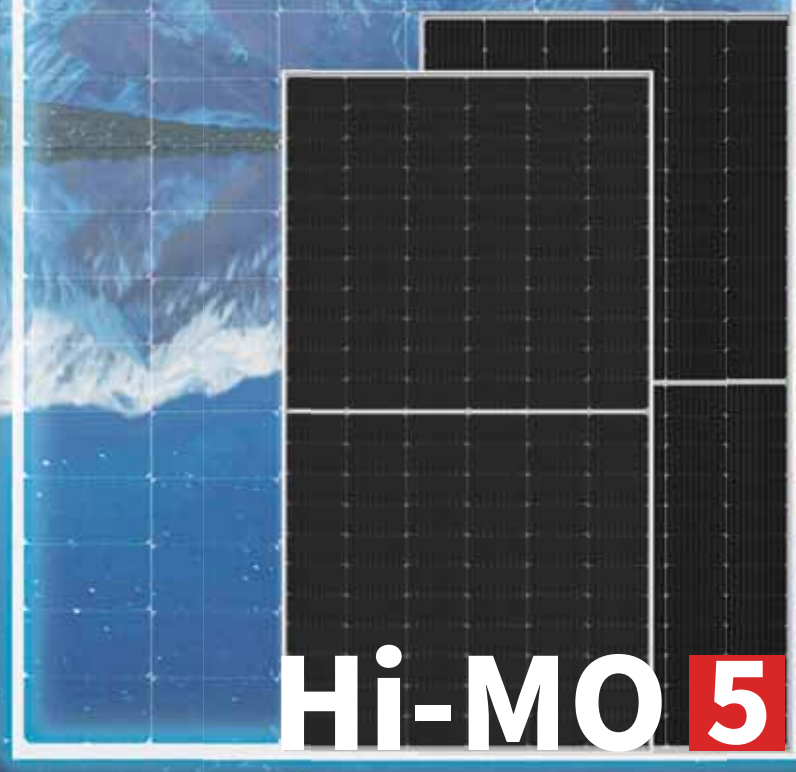

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Introduction

Welcome to volume 27 of PV Tech Power. When we planned this issue of the journal back in February, the signs across Europe for a post-COVID revival remained somewhat promising. While there have undeniably been hiccups along the way, resulting in the postponement of the usual must-attend trade shows until later in the year, there does appear to be light at the end of what has been a particularly dark and arduous tunnel.

And that light is perhaps being felt most by Europe's solar industry. Having experienced the highs of 2011 and 2012 as well as the lows of 2015 – 2017, Europe is now riding the crest of a wave. Last year's installations of 18.2GW are forecasted to soar between now and 2024, with trade body SolarPower Europe's medium and high scenarios projecting 2024 installation figures of 35GW and 45GW respectively. The cover story of this volume of PV Tech Power (p.15) seeks to shine a spotlight on that growth, identifying the key drivers, the markets where it will all happen and the regional differences that make Europe such a diverse and interesting market to operate in.

There are, of course, challenges to overcome, and developers will be unsurprised to hear the most prevalent issue to appear in our research was the grid. While many prospective remedies to grid constraints are emerging, the conclusion that governments must tackle network capacity as a matter of urgency is inescapable. Failure to do so will stymie the growth of solar PV and other renewables, leaving a legacy all the dirtier.

The need for much greater solar proliferation in Europe, and indeed globally, has been drawn into stark focus by a rise in extreme weather events. The damage to human life caused by the Texas winter storm event in February illustrated this all too well and the power sector must heed the lessons from it and other extreme weather events, be they snow, wind, heat or hail. The plant performance section of this volume of PV Tech Power has two features dedicated to weatherisation and performance under extreme weather (p.49, p.53), as solar farm operators learn how best to continue generating under such circumstances.

We also take a look at the rise of special purpose acquisition companies, or SPACs as they've come to be known, as law firm Fieldfisher's Jack Mason-Jebb and Brad Isaac discuss whether the trend could extend as far as the green economy.

Meanwhile, the European theme continues in our Storage & Smart Power section, as Andy Colthorpe discovers that while energy storage definitions and approaches may differ between markets, they have far more in common than not. And if you need a little inspiration, we have the full story behind the Alamitos energy storage project in California, the first in the state to come up against a traditional gas peaker plant and win.

As you'll read throughout PV Tech Power volume 27, solar and energy storage are no longer the future of power markets, but the present. What's happening today – beating all comers on price and application – can be the status quo for years if not decades to come.

Thank you for reading, and we hope you enjoy this issue.

Liam Stoker
Editor in chief
Solar Media

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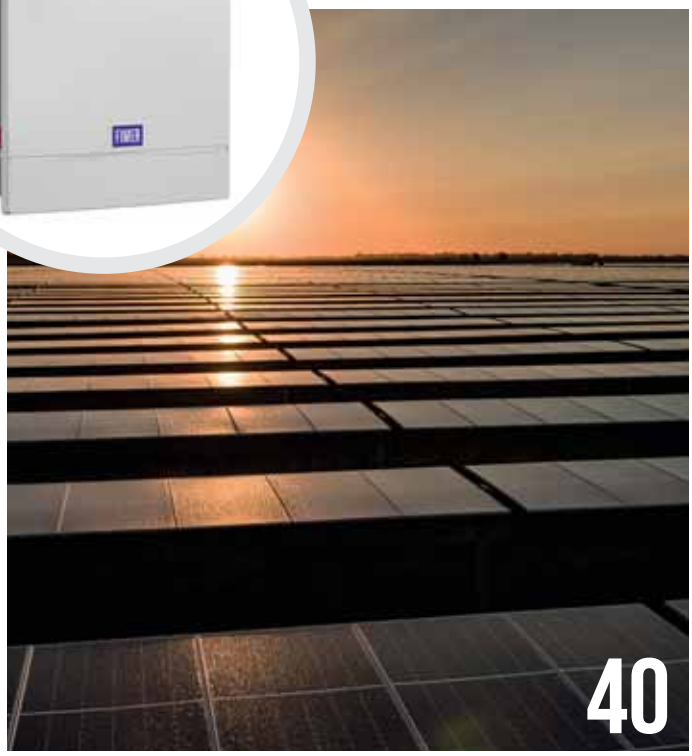

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EUROPE

Policy

European Commission pledges to 're-ignite' domestic manufacturing

The European Commission has included a mission to "re-ignite" Europe's solar manufacturing sector within its refreshed industrial strategy, but industry leaders say it could €7 billion to make it globally competitive. The EC published a revised strategy on 5 May, revealing several commitments to support the recovery from COVID-19, building on an initial strategy published in March 2020. It states that renewables, energy storage, grids and related technologies need more investment, and Europe needs abundant and affordable decarbonisation for the transition to be "genuinely" competitive. Surging demand for solar, it adds, is a "key opportunity" for the bloc. Speaking at May's SolarPower Summit, held by SolarPower Europe, Dr Gunter Erfurt, CEO of module manufacturer Meyer Burger, said the sector needs about €5 - €6 billion of investment to create a 20GW manufacturing base. Christian Westermeier, vice president of marketing and application engineering at polysilicon specialist Wacker said that it could take €7 billion.

Credit: European Union

The European Union has highlighted solar manufacturing as a key sector moving forward.

Green hydrogen

Iberdrola announces latest green hydrogen project with BP and Enagas

Iberdrola has started a string of green hydrogen projects with carbon-intensive industrial groups. The Spanish energy giant said in late April it is planning to build a solar-plus-hydrogen power project at ceramic tile maker Porcelanosa's factory in Villarreal to decarbonise its production process. It announced a second partnership with oil and gas majors bp and Enagas a week later on a feasibility study to develop a large-scale green hydrogen project in Valencia. The latter will comprise of a 20MW electrolyser powered by renewable energy, including a 40MW solar PV system, and could start commercial operations in 2023.

First Solar partners with Norwegian power company on green hydrogen projects

PV manufacturer and Solar Module Super League (SMSL) member First Solar has partnered with a Norwegian hydrogen power company to develop a portfolio of green hydrogen production facilities. As part of the project, First Solar and Norway's Nel Hydrogen Electrolyser AS will work together to develop a power plant control and Supervisory Control and Data Acquisition (SCADA) system. Mark Widmar, First Solar's chief executive, said that the company's expertise in producing CadTel solar technology makes it "well positioned to address the market need for large-scale green hydrogen." The companies said in a statement that the SCADA system is "critical" to optimise solar-plus-hydrogen power projects and generate low-cost electricity as a result.

Auctions

Germany's planned solar auctions expansion 'not sufficient', trade bodies say

Germany's renewables sector has said new plans to more than triple the PV capacity included in next year's auctions "are not sufficient" to support long-term deployment. The government agreed in April to increase 2022 PV tender volumes from 1.9GW to 6GW, while capacity for onshore wind will go up from 2.9GW to 4GW. With the auctions set to take place after Germany's general election in September, industry body BSW said the announcement "must be understood as a mere electoral manoeuvre". While the German Renewable Energy Federation (BEE) welcomed the agreement, president Simone Peter said that "additional tendering volumes for 2022 are not sufficient here."

Over 400MW awarded in French auction as prices jump 4.7%

France's ninth auction for ground-based solar saw 452MWp awarded to developers in late February. The capacity was spread across 69 winners, with the average price proposed coming in at €60.10/MWh (US$72.94), an increase of 4.7% on France's previous auction in October 2020. Winners included a number of Engie projects including three 5MWc and two 10MWc sites as well as several Urbasolar projects. Other winners included EDF, ib vogt GmBH and Neoen among others according to analysis posted by French financial advisor Finergreen. Neoen was the biggest winner, with 73.8MWc contracted for, followed by Engie with 61.4MWc and then Total Quadron with 49.4MWc.

Finance

Spain's Opdenergy postpones IPO amid 'challenging market conditions'

Independent power producer Opdenergy has postponed an initial public offering (IPO) days before its shares were due to start trading on the Spanish stock exchanges. The company said this was due to "challenging market conditions" for renewables companies. Its was expected to start trading on 7 May 2021. Opdenergy said in April it planned to raise €400 million (US$475 million) to support the development of 3.7GW of renewables. It has a pipeline of projects in five European counties and three in the Americas. The cancellation was announced a day after Spanish IPP Ecoener's shares fell by more than 15% on its first day of trading in Spain.

Octopus Energy acquires £3.4bn of assets in bid to become European renewable giant

UK energy supplier Octopus Energy is to take on Octopus Renewable's assets as part of an internal transaction that will see it become one of Europe's largest renewable energy generators. Octopus Renewables currently has a £3.4 billion portfolio of 300 assets across six countries, totalling 2.8GW. This includes 1,290MW of large-scale solar, 29MW of rooftop assets. The supplier will acquire these, and launch a new arm – Octopus Generation – to manage them. Greg Jackson, CEO and founder of Octopus Energy Group said he thinks the acquisition will be a win-win, adding he's "absolutely thrilled to join forces with Octopus Renewables, bringing the supply and the generation side of energy together under one roof."

AMERICAS

DOE launches bid to slash utility-scale solar power prices by 60%

The US Department of Energy has earmarked US$128 million to invest in research and development in a bid to bring the cost of utility-scale solar power down by 60% in 10 years. The initiative, launched by US Energy Secretary Jennifer Granholm, comes as part of an "all out war" on climate change launched by US policymakers. Granholm outlined an ambitious spending package for R&D to boost the US solar manufacturing sector to meet a new target of bringing utility-scale solar power costs down to an average US$0.02 per kWh by 2030, slashing the current US$0.046 per kWh price by more than half.

New entrants

European Energy enters US market with plans for 300MW PV plant in Texas

Danish renewables developer European Energy is expanding its operations into the US market, announcing plans for a 300MW solar project in Texas. The company is buying 1,276 acres of land southwest of Dallas that was previously used for oil and gas extraction. Construction of the plant will begin in the first half of 2022, with completion expected in 2023. The company has also formed a joint venture with Florida-based solar developer Renewable Energy International that will focus on deploying PV several projects on the east coast of the US. The new business will have a 450MW solar pipeline across four states: Maine, Massachusetts, Virginia and South Carolina.

Falling costs

New solar and wind cheaper than 80% of existing coal in the US, report finds

New solar and wind assets in the US are now cheaper to operate than nearly 80% of existing coal-fired generators in the country and could replace the asset class while delivering numerous benefits to consumers, a report has found. The 'Coal Cost Crossover 2.0' report, published by thinktank Energy Innovation, provides an update on the previous version of the report published in 2018, using new datasets to produce new Levelised Cost of Electricity (LCOE) figures for solar, wind and coal. Energy Innovation has determined the LCOE of utility-scale solar in the US is to fall in the region of US$25.80 – US$42.22/MWh, with an average cost of generation of US$33.96/MWh.

Credit: Mario Goebbels/Flickr

Thinktank Energy Innovation is predicting LCOE of utility-scale solar to fall to US$25.80 – US$42.22/MWh as it is now cheaper to operate than 80% of coal.

Meyer Burger to enter US market with Heterojunction solar panels in 2021

Meyer Burger has accelerated plans to target the US high-end residential rooftop market with its heterojunction (HJ) PV modules. Having been buoyed by the Biden presidency's early support for solar as part of plans for the country to reach 100% carbon-free electricity generation by 2035, while also supporting green policies for economic recovery post-pandemic, Meyer Burger said it would enter the US market in 2021, compared to previous plans of market entry sometime in 2022.

Policy

US Treasury to raid fossil fuel subsidies to pay for ITC extensions, other clean programmes

The US Department of the Treasury has revealed how new renewable tax incentives will be paid for by a tax raid on the fossil fuel industry, eliminating subsidies for oil and gas companies. The 'Made in America Tax Plan' report provides more detail and justification for a swathe of tax hikes, cuts and adjustments as Biden bids to recalibrate the US' tax system in the wake of both COVID-19 and Donald Trump's presidency. It documents how proposed hikes in corporate taxes in the US, as well as cuts to swathes of fossil fuel subsidies – to the tune of some US$35 billion over the coming decade – will help incentivise renewable energy in the US.

US solar and wind acceleration 'not enough' to meet Biden's climate targets

The US' fleet of solar and wind generation capacity is set to almost triple over the next decade, but even this is not enough to meet President Biden's ambitious decarbonisation targets. That's according to a report from market analyst BloombergNEF, which claims that the US' renewables market's current growth trajectory "will not be enough" to decarbonise the country's power sector by 2035. This is despite the analyst's prediction that 287GW of solar and 115GW of wind capacity will be added to the US' grid over the next 10 years, with 25GW of solar tipped for "record growth" over the next four years.

Projects

US ''largest' floating solar farm completed in wine country

What's claimed to be the US' largest floating solar farm has been completed in the city of Healdsburg, California. The Healdsburg Floating Solar Project, a 4.78MW array across two wastewater treatment ponds in Sonoma County, is operated by renewables company White Pine. Co-developed by White Pine and floating solar specialist Noria Energy, it claims to be the country's largest installation of its kind to date. The project edges just ahead of the floating solar array to have previously laid claim to the throne; a 4.4MW project completed on a retention pond in New Jersey, which was energised in late 2019.

Powertis breaks ground on two solar parks in Brazil totalling 225MW

Powertis has started construction work on two PV plants in Brazil that each have a capacity of 112.5MWp and are the Spanish developer's first solar projects in the South American country. The Pedranópolis and Araxá plants, located in the states of São Paulo and Minas Gerais respectively, will feature trackers from Powertis's parent company, Soltec, which will also provide assembly and construction services.

MIDDLE EAST & AFRICA

Iraq

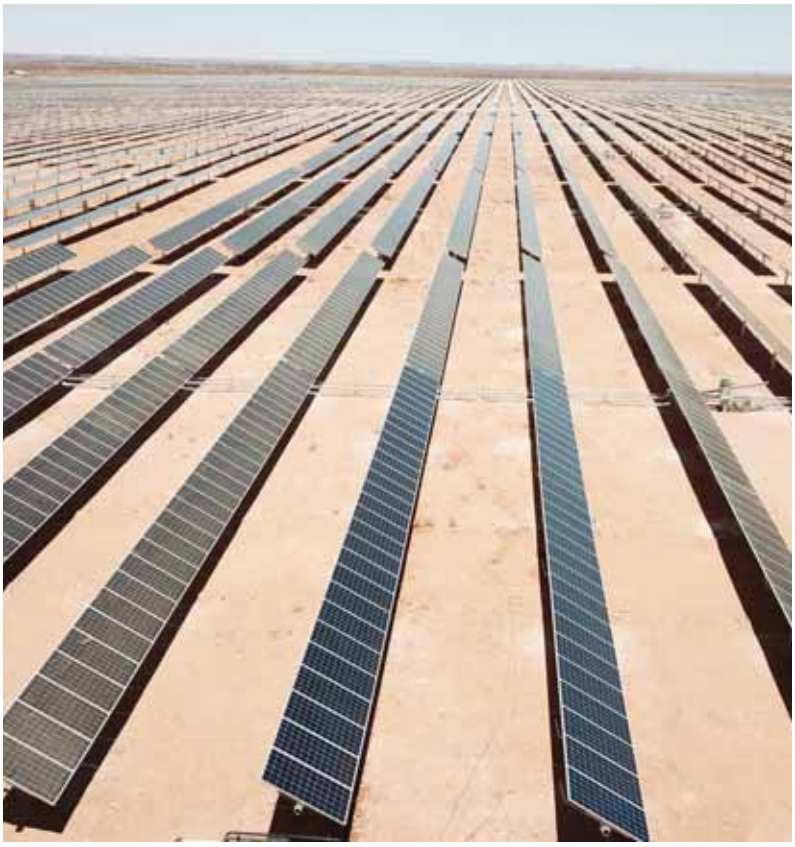
Iraq targets 10GW of installed solar PV by 2030

Iraq is planning to develop seven PV projects with a combined capacity of 700MW and reach 10GW of installed solar by 2030, the country's oil ministry said in a statement. The largest of the proposed installations will have a capacity of 300MW and be located in Kerbala province. It was also revealed that the country is aiming for 20% of its power generation by 2030 to be from solar, in a move to reduce pressure on its hydrocarbon-powered electricity plants. Since the 10GW announcement, the oil ministry signed an agreement with French energy major Total to develop of a host of energy projects in the country, including 1GW of PV.

Tender

South Africa launches request for proposals for 1GW of solar

The South African government has launched its latest procurement round under its Renewable Energy IPP Procurement Programme (REIPPPP), which is to procure 1GW of solar PV. The tender represents Bid Window 5 of the country's REIPPPP, which will allow bids to be submitted by 4 August 2021. Energy minister Gwede Mantashe said the objective is to get winning projects connected to the grid "as soon as possible", given the ongoing energy challenges South Africa is facing. The bidding round is the first stage of a procurement announced last September for 11,813MW of new generation capacity that will come from a range of sources by 2027. As part of that effort, the government will in the next 12 months release four more requests for proposals, which will include 2.6GW of renewables and 513MW of battery storage.



Credit: Scatec.

The 258MW Upington solar power complex in South Africa's Northern Cape province.

C&I solar

Total forms joint venture for C&I solar deployment in Saudi Arabia

Total and industrial conglomerate Zahid Group have established a joint venture (JV) focused on distributed solar generation for Saudi Arabia's commercial and industrial (C&I) sector. Called SAFEER – Saudi French for Energy Efficiency and Renewables, the business will specialise in C&I PV installations on rooftops and carports. Collaborating for the JV are Total Solar Distributed Generation and Altaaqa Alternative Solutions, a utility and subsidiary of Saudi-based Zahid Group. The partners said SAFEER's mission is to bring affordable and reliable solar energy solutions to C&I customers in Saudi Arabia and "lead the way in the development of the ecosystem for distributed generation".

Ethiopia

Masdar and Ethiopia sign agreement to develop 500MW of solar

Abu Dhabi-based renewables company Masdar is continuing its international expansion with new plans to develop 500MW of solar in Ethiopia through a partnership with the country's government. The company signed a memorandum of understanding that is said to include the development, construction, and operation and maintenance of PV plants in the African country. During a meeting with Masdar executives, Ethiopia's finance minister Ahmed Shide stressed the importance of having adequate energy infrastructure to support the country's development and growing population.

M&A

BB Energy targets Africa solar, storage markets with Solarcentury Africa deal

Independent energy trader BB Energy (BBE) has set its sights on Africa's solar and storage market by acquiring Solarcentury's Africa-facing division. The deal will see BBE's Renewables Division gain access to Solarcentury Africa's 2.1GW-strong pipeline of solar and energy storage projects, which the company said were all backed by strong regional and international C&I customers. BBE historically has focused on oil and natural gas trading, but launched a Renewables Division last year which it has looked to grow via M&A activity. Chahid Jarmouni, global head of renewables at BB Energy, described the Solarcentury Africa deal as a "major step" in the company's "energy transition journey".

Angola

Q CELLS supplies modules to portion of 370MW Angolan solar portfolio

Q CELLS has secured a deal to supply its modules to part of a 370MW portfolio of seven solar projects under development in Angola, the first of which is expected to be complete next year. The manufacturer will provide its Q.PEAK L-G4.5 modules to two of the seven plants, including the largest, which will have a capacity of 188MW and be located in the province of Benguela. In total, Q CELLS modules will account for 287MW of the capacity of the new portfolio. The consortium behind the projects is led by Portugal-based engineering, procurement and construction firm MCA Group, which has worked with US renewables company Sun Africa on the development of all seven sites. Hitachi ABB Power Grids is providing electrical infrastructure and, according to MCA, Nextracker will also be a supplier.

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China

China Q1 solar installs top 5.5GW as groundwork is laid for expected rush

China installed 5.56GW of solar in Q1 2021, data from the country's National Renewable Energy Consumption Monitoring and Warning Center has revealed. Data released last week also revealed that at the end of March 2021, China's total installed solar capacity had reached 259GW, an increase of around 24.2% year-on-year following last year's significant ramp-up in installations. The most prolific regions of China for solar installations in the first quarter of 2021 were Shandong (1.28GW), Shaanxi (490MW), Anhui (470MW), Guangdong (430MW) and Jiangsu (400MW).

New Chinese policy proposal plots phase out of national solar subsidies

A draft proposal put forward by China's National Development and Reform Commission could see subsidies for new solar projects phased out, starting in 2021. The draft proposal, 'Notice on Matters Related to the Renewable Power Feed-in Tariff Policy in 2021', if enacted, would mean no further subsidies would be allocated to newly registered centralised solar PV projects or decentralised C&I-scale solar projects approved by China's central government.

Uzbekistan

Phanes Group to develop 200MWac solar project in Uzbekistan

Dubai-based Phanes Group has signed a deal with the government of Uzbekistan to develop a 200MWac PV project in the country. The agreement includes the technical and commercial terms for building, owning and operating the project, including facilities that will connect it to a substation. Phanes has also secured a power purchase agreement (PPA) with National Electric Grid of Uzbekistan for the facility, which will be constructed in the Navoiy region. The solar developer and asset manager said the project will "significantly" increase Uzbekistan's current PV capacity and contribute to the government's plans to reach 5GW of installed solar by 2030.

Malaysia

Masdar to pursue large-scale PV projects in Asia through deal with Petronas

Masdar has signed an agreement with Malaysian state-owned energy firm Petronas to explore the development of large-scale solar projects in Asia and the Middle East. A new memorandum of understanding will see the two companies work together to participate in solar and wind opportunities for utilities as well as commercial and industrial customers, with a primary focus on the Asian market. The partnership will also explore opportunities for the joint production of green hydrogen. Petronas said it is pursuing commercial production of green hydrogen "in the near future".

Credit: Masdar

Masdar has signed an agreement with Petronas to explore the development of large-scale solar projects in Asia and the Middle East.

Fitch upgrades Malaysia's PV forecast thanks to ongoing tender success

Malaysia's installed solar capacity is expected to increase fourfold by 2030, driven by a successful tender policy and improved financing incentives, according to a report from Fitch Solutions. The consultancy has revised its solar forecasts for Malaysia, in part due to increasing investor interest in the market and new project announcements, as it expects capacity to rise from around 996MW as of year-end 2020 to more than 4GW by 2030. This revision is said to stem mainly from the continuation of the country's solar tenders, the most recent of which was the fourth round of its large-scale solar programme, which was launched in 2020 and has seen the government shortlist 30 winning bidders with a combined capacity of 823MW within two categories.

Japan

Canadian Solar partners with Macquarie for Japanese PV push

Canadian Solar has raised JPY22 billion (US$208 million) for its Japan Green Infrastructure Fund (JGIF), which will develop and accumulate solar projects in the Asian country. The company will hold a 67% stake in the fund, while infrastructure investor Macquarie Group will have a 33% interest and act as financial advisor. JGIF is expected to grant first offer rights to the Canadian Solar Infrastructure Fund, a Japanese-listed infrastructure fund holding solar assets managed by Canadian Solar's asset management subsidiary.

India

'Enormous potential' for wind-solar hybrid power in India

India presents an "enormous potential" for the development of solar and wind hybrid power systems, with more than 12.3GW of collocated tenders issued in the country to date. That's according to a report from market analyst JNK Research, which argues that combining both intermittent power systems into one hybrid project would ensure greater reliability and stability in India's electricity grid. In October 2020, JMK Research predicted that India's wind-solar hybrid capacity will reach 11.7GW by 2023.

India approves PLI solar manufacturing scheme

The Indian government has approved production-linked incentives for the country's solar module manufacturing sector to help the country add 10GW of power generation capacity. The government extended a production-linked incentive (PLI) plan to include solar module manufacturing in April 2021, setting out a plan to spend INR45 billion (US$602 million) over five years. Prime Minister Shri Narendra Modi approved the Ministry of New & Renewable Energy's proposal for the PLI scheme, which is hoped will reduce India's dependence on solar technology imports.

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Materials

Solar industry nears 'crisis' amidst material shortages

Solar manufacturing material shortages are nearing a crisis point with the price of polysilicon continuing to rise, JinkoSolar's Dany Qian has said. The price of polysilicon has risen steadily over the course of the last year, prices rising initially due to factory shutdowns as a result of the COVID-19 pandemic but latterly due to a surge in demand. Dany Qian, VP at JinkoSolar, said there was a "perfect storm" of factors impacting supply and demand that companies were struggling to keep up with, adding that the industry was approaching a "crisis" as a result. Qian also noted that the supply constraints are creating a significant imbalance in the pecking order for polysilicon supply. Price increases for raw materials have sent module prices upwards, which in turn caused module sales to contract. Some Tier 2 module manufacturers cut cell orders as a result, only to find themselves at the back of procurement queues when they have subsequently moved to re-order when the market rebounded.

IEA: governments should prepare for 'looming' surge in raw material demand

Governments worldwide must ensure that there are sufficient raw materials available to solar and energy storage developers to safeguard the energy transition. A new report from the International Energy Association (IEA) has warned that there is a "looming mismatch" between global net-zero targets and the availability of critical minerals such as lithium, copper and colbalt that are needed to develop key components and technologies used in power systems. Faith Birol, IEA's executive director, said that governments "must give clear signals" to the renewables sector about how they will "turn their climate pledges into action", and ensure a smooth clean energy transition. "By acting now and acting together, they can significantly reduce the risks of price volatility and supply disruptions," Birol said.

Credit: Trina Solar /

Polysilicon and glass are expected to be in constrained supply.

Polysilicon

Tongwei tops polysilicon ranks as league table set for shake-up in 2022

The solar polysilicon sector is experiencing a changing of the guard, and all four of the top manufacturers will be Chinese next year, research firm Bernreuter Research has predicted. Bernreuter Research has placed Tongwei at the top of its rankings in 2020, ousting German provider Wacker Chemie for the first time. Tongwei's capacity is expected to reach nearly 200,000 MT by the end of this year before rising to 300,000 MT in 2023, continuing a rate of growth which has seen it soar from ninth position in 2016 to the top of Bernreuter's ranking last year. Daqo New Energy has meanwhile assumed the third-place spot from South Korea's OCI, which tumbled down the rankings after shuttering its solar-grade polysilicon operations in South Korea last year.

Daqo New Energy and JA Solar pen long-term high-purity polysilicon supply deal

Daqo New Energy and JA Solar have signed a long-term supply deal for high-purity polysilicon, the latest in a growing line of deals as manufacturers look to lock in polysilicon supply. Under the terms of the agreement, Daqo will supply JA Solar with around 78,200 MT of high-purity mono-grade polysilicon for three-and-a-half years between July 2021 and December 2025. Actual volumes and prices are to be negotiated on a monthly basis according to market conditions, with JA making an advance payment to Daqo.

REC Silicon confident over Moses Lake restart amidst strengthening PV poly demand

European polysilicon provider REC Silicon has pinned hopes on plans to develop an ultra-low carbon solar PV value chain amidst a strengthening polysilicon market, stating it is confident that it will restart production at its Moses Lake facility. Tore Torvund, CEO at REC Silicon, lamented the company's inability to cater for much of the demand for solar PV polysilicon due to trade disputes with China. Instead, REC Silicon is throwing its weight behind initiatives to develop an "ultra-low carbon footprint" PV value chain with other solar manufacturers, as well as the US government. Torvund added that the company intends to restart its Moses Lake facility – shuttered in 2019 – in 2023, with a formal decision expected later this year.

Steel

Array Technologies withdraws 2021 guidance amidst 'unprecedented' rise in materials costs

Array Technologies has withdrawn its guidance for 2021 after experiencing "unprecedented" increases in material and logistics costs which severely impacted earnings in the first quarter. Reporting its Q1 2021 results, Array revealed lower than expected adjusted earnings of US$34.5 million for the reporting period, a 69% drop year-on-year, on the back of headwinds caused by spiralling costs of steel and logistics constraints. Fusaro noted that between the first quarters of 2020 and 2021, spot prices of hot rolled coil steel used in Array's tracker products more than doubled, and have continued to increase since, rising a further 10% since 1 April 2021.

Supply chain

Solar sector 'must remain vigilant' in meeting human rights standards

The PV industry "must remain vigilant" across its supply chain in meeting global human rights standards, trade association SolarPower Europe has said in a new sustainability report. Called 'Solar Sustainability Best Practices Benchmark', the report claims companies' human rights policies and practices "are not yet strong enough" to ensure the transition to a low carbon economy is fast and fair. "At present, there is insufficient evidence to confirm these allegations, however, despite the lack of clarity as to the exposure of the sector, the European solar industry has taken these allegations very seriously," the report reads.

European solar under the spotlight

Europe | Not only will solar be the dominant source of new power generation in Europe by 2025, cementing its position as the third largest market for solar globally, but the continent has placed the asset class at the very heart of its COVID-19 recovery strategy. Liam Stoker, Edith Hancock and Jules Scully explore the drivers for solar in Europe, the key markets and the challenges that remain.

The York Solar Farm, completed by GRIDSERVE in the UK in 2019, was the UK's first commercial deployment of bifacial solar panels with trackers.

In September 2020, when the International Energy Agency (IEA) said that solar PV would become the eminent source of power generation in Europe within the next five years, truthfully the full, lasting impact of the coronavirus pandemic was not yet known. Subsequent second and third waves of the pandemic have altered the economic landscape beyond recognition.

Still, the IEA's forecast underpinned the astonishing growth trajectory of solar PV in its third-largest market globally. That the agency's forecasts would be further upgraded just six months later, cementing solar's position at the top of the tree, is testament to the industry's resiliency, ambition and plethora of use cases. From utility-scale to prosumer rooftops, solar looks set to spread and play a pivotal role in Europe's economic recovery from COVID-19.

Solar's role in Europe's power sector has, in the wake of the pandemic, taken on a whole new importance. It has now been placed at the centre of the continent's economic recovery from the pandemic and identified as a pivotal industry at the heart of the European Union's industrial strategy.

45GW
2024 solar deployments forecasted in SPE's High scenario

Deployment of solar PV in Europe continues to rise, increasing 11% from the 16.2GW installed in 2019 to 18.2GW last year, according to trade body SolarPower Europe (SPE), taking cumulative solar generation capacity to 137.2GW. The IEA meanwhile now expects 23.5GW of solar to be deployed in Europe this year, followed by 25.6GW in 2022. But the IEA's forecasts are historically on the low side. The last-published edition of SPE's EU Market Outlook forecasts for 22.4GW to be installed this year, followed by 27.4GW in 2022 and 30.8GW in 2023. A further 35GW is expected by SPE to be installed in 2024 under its moderate scenario, illustrating the rapid rate of escalation solar deployment is to enjoy.

However that figure jumps significantly to 45GW installed in 2024 within SPE's High scenario, which has underlying assumptions that the industry will be a big beneficiary of Europe's green deal and COVID recovery packages, there remain no import taxes on solar products and, simply put, no other barriers are placed in solar PV's way. A conducive environment is therefore highly integral to solar's continued success

and growth in Europe, but what does that environment look like?

Policy and pricing

Policy has, obviously, played a critical role in helping establish solar as a force to be reckoned with in Europe. The minimum import price protected the continent's domestic manufacturing scene for years, and subsidies made available by national governments helped the technology deploy and compete until it no longer needed the support. Policy has also contributed significantly to the peaks and troughs European solar has experienced from 2011 until today, with some markets in particular still reeling from policy decisions taken almost a decade ago. Now policy is taking on an entirely different role, levelling the playing field and ensuring that field is clear of any obstacles or hurdles, rather than supporting the technology fiscally.

Critical to Europe's future success will be a raft of policies and targets set by the European Commission, such as the 55% greenhouse gas reduction aim the Commission set in December 2020 to be achieved within the forthcoming decade, an upgrade on the previous aim of a 40% cut in emissions. While that target was criticised for not being ambitious enough, it has laid the groundwork for member states to build on. Further measures that make up the Clean Energy Package 2.0, including the Renewable Energy Directive which, amongst other things, intends to simplify permitting for new renewables projects in the bloc, and stricter carbon pricing signals should nudge the market towards a more renewables future. Equally, the EC's Green Hydrogen Strategy, published amidst the COVID-19 fallout last summer, has established the target of building total hydrogen electrolyser capacity of 40GW within Europe by 2030 – that will require up to 120GW of new renewable capacity to power it, with solar expected to play a leading role.

Heymi Bahar, senior analyst for renewables at the IEA, says that while policy has indeed taken solar PV to new heights, the biggest driver in recent years has been an "incredible" amount of corporate power purchase agreement (PPA) activity in selected markets, particularly Spain. "It has changed the trend in Europe from mostly small scale, distributed PV applications to more large-scale installations," Bahar says. Corporate entities in Spain have flocked to sign PPAs with solar projects blessed with high irradiance able to offer low power prices as a result. While the market slowed somewhat last year, in 2019 Spain deployed around 4.8GW of solar PV, enough to challenge Germany for the crown of Europe's leading solar market that year. Germany looks set to come roaring back courtesy of the lifting of a subsidy cap last year and new, more ambitious targets under the country's EEG law, more on that you can read on page 18.

"Policy is playing an incredible role, because the governments shape these policies based on their ultimate [central European] target," Bahar says, noting the drivers being not just interim targets set for 2030, but the overall net zero ambition which is set for 2050.

Technology driving change

While policy would appear to be doing a lot of the heavy lifting as the key driver for facilitating deployment, the technology is proving itself in different ways. The addition of trackers and bifacial panels is proving successful in more northerly locations than previously thought possible. Frank Niendorf, general manager for Europe at 'Solar Module Super League' member JinkoSolar says that while Europe is perhaps lagging behind other markets in its adoption of bifacial panels to date, bifaciality is widely anticipated to spread into Europe's key markets and be included within most new project designs. Sufficient solar glass capacity – another of the solar PV sector's material constraints of recent months – could prove a stumbling block, but Niendorf is backing Europe's adoption of bifacial panels to continue at pace. "I have no doubt that the bifacial market share will surpass 50% by 2025, at least for the ground-mount project segment," he says. The same goes for large-format modules that utilise wafers of either 182mm or 210mm sizes. While adoption has perhaps been slower than some may have anticipated, most new project designs are taking these size modules into account.

Europe's turnaround from a market that installed in excess of 20GW of new solar in 2011, before collapsing to around 5GW in each of the years from 2014 to 2016, courtesy of a drastic fall in new installations in markets such as Italy, Germany and France, before rebounding once again to a 20GW+ market is garnering attention. "What we are currently experiencing is a very impressive turnaround of the European market which offers fantastic perspective for the coming years. We are very bullish, very confident about Europe in general," Niendorf says.

Europe's solar potential therefore continues to abound, driven by the collective ambition of the European Union's member states – and other nations on the continent – to decarbonise their economies. But as you will read in the forthcoming pages, European solar is a diverse collective. It is multifaceted, from R&D and manufacturing knowhow to financing and deployment nous that is almost unrivalled. Policy levers differ from nation to nation, and each country has its own drivers, niches and histories which make them tick.

The pages ahead provide a deep dive into the key markets driving European solar forward, right the way through from the perennial leaders such as Germany and Spain, to the emerging markets including Poland that are expected to play pivotal roles out to 2024. We also analyse the growing calls for a domestic manufacturing renaissance in Europe and the role in which COVID recovery stimulus packages can – and some may argue should – play in that, while also tackling the hurdles and challenges that remain.

European solar is once again on the rise, and this is the story behind that resurgence.

To discover more about Europe's energy storage sector, turn to page 83.

SolarPower Europe's six recommendations for member states

Boost utility-scale solar and storage
Allocate funds to finance renewable energy tenders, using recovery funds to accelerate permitting procedures.

Roll out solar rooftop and storage
Design solar mandates for all new and existing buildings with suitable rooftops to feature solar installations.

Promote electrification and invest in smart grids
Prioritise investments into the integration of battery energy storage systems and smart vrid projects that unlock flexible and distributed energy resources.

Support the European solar manufacturing sector
Use recovery funds to facilitate the development of new manufacturing projects in Europe to strengthen energy security and independence.

Reconvert former coal and industrial sites with solar
Reconvert former coal and industrial sites into hubs for innovative solar applications such as floating, biodiverse and agricultural solar projects.

Finance training and re-skilling programmes
Support job creation in solar by offering fiscal and administrative incentives for companies growing their workforces and launch large-scale training programmes to upskill employees.

Germany

Germany made swift progress last year in spite of COVID-19 disruption. The country's developers installed 4.8GW of solar PV in 2020, more than any other EU market, with the sector boosted by a tried and tested regulatory scheme as well as attractive feed-in premiums for medium- to large-scale commercial systems, according to SolarPower Europe.

In July, the German Bundestag increased the expansion target for renewable energies in the electricity sector to 65% by 2030 as part of a series of amendments to its Renewable Energy Act (EEG). The country has now targeted adding 98GW of installed solar by 2030, up from the current level of approximately 54GW.

To achieve this, the coalition government agreed to increase the 2022 PV tender volumes from 1.9GW to 6GW. However, the country's solar industry association BSW dismissed the announcement, calling for the industry to see it as "a mere electoral manoeuvre". Carsten Körnig, BSW's chief executive, tells *PV Tech Power* that Germany will need to quadruple its installed solar capacity to 200GW by 2030 if it is to meet the European Union's new climate goals, which includes raising the continent's emissions reduction target to 55% by the end of the decade. Körnig believes the greatest barrier to hitting that 200GW mark will be addressing tender volumes which he says are limiting the sector. "The greatest challenge will be to raise the tender volumes," he says. "The growth of ground-mounted PV plants depends largely on the bid volume in the tender scheme, which limits growth possibilities."

4.8GW
Solar PV installed in Germany in 2020

Although it did increase its renewables target in the course of a coal phase-out, Körnig says one of the amendments to the EEG disadvantaged those plants that use some of the power they produce. An amendment focusing on EEG surcharge, where a charge is added to a consumer or a corporation's bills in proportion to their power consumption, deemed that local solar operators will need to pay a proportionate surcharge for solar self-consumption of more than 10MWh and for solar system output over 20KWp. The surcharge will then be due for every kWh of solar power consumed after 20 years of operation.

Although companies' interest in solar plants is growing, the amendment of the EEG law, which Körnig criticised as a "sun tax" last October, has since worsened the regulatory framework for plants with high levels of self-consumption. BSW said last year that the current plans could lead to a slowdown in new installations, as well as many solar systems being prematurely decommissioned.

Nevertheless, there has still been strong growth across the market over the past 12 months. After lawmakers lifted Germany's 52GW subsidy cap for solar installations, the vast majority of new installed capacity came from systems smaller than 750kWp, which would have been "directly impacted" by the threshold. "Without the removal of the subsidy cap the installation of PV in this market segment would have collapsed," Körnig said. The residential market, he added, has also seen new growth opportunities driven by an uptick in electric vehicle (EV) owners who prefer charging their battery with low carbon energy.

> "The growth of ground-mounted PV plants [in Germany] depends largely on the bid volume in the tender scheme, which limits growth possibilities."

On the monetisation side, although Spain and Italy have historically led European power purchase agreements due to their higher irradiation, Luca Pedretti, the co-founder of software company Pexapark, believes Germany could be "the biggest emerging market" in Europe's unsubsidised solar space, due to the volume of potential corporate offtakers based in the country. Local utility EnBW is in the process of constructing Germany's largest unsubsidised solar plant at a capacity of 187MW, and said last year it has multiple options for marketing the electricity. Körnig says the PPA market will grow in the following years, but it will "only cover a small part of the PV installations needed until 2030."

Domestic manufacturing, on the other hand, will be "very important" to deployment over the coming decade, Körnig says. Swiss company Meyer Burger is so far leading the push in Europe to build out domestic production capabilities. It will open facilities in Bitterfeld-Wolfen and Freiberg, Germany, in late May to begin mass production of its heterojunction (HJ) modules, which will be shipped across Europe and to the US. The manufacturer said in January, after it was awarded €22.5 million in regional German government grants to build HJ PV cell factory there, that it wants to scale up its production capacity to 1.4GW by 2023.

For more on Europe's solar manufacturing prospects, turn to page 28.

Credit: EnBW/Paul Langrock

Germany's largest solar farm, the 187MW Weesow-Willmersdorf project, began exporting to Germany's grid in November 2020.

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Spain

Credit: Solarcentury/Statkraft

Spain's recent solar development has so far been dominated by sizeable projects in excess of 100MW, such as this 300MW project under development on behalf of Encavis.

A new auction mechanism and efforts to tackle grid permitting issues look set to build momentum in Spain's solar sector, which was last year driven by a booming power purchase agreement (PPA) segment and merchant projects.

Thanks to a commissioning deadline for projects awarded in previous auctions, 2019 saw the country top PV deployment rankings among European markets. This was followed by a 45% reduction last year, when around 2.6GW was installed, the majority of which came from PPA-based systems. As well as being Europe's largest solar PPA market in 2021, the country is now home to the world's biggest corporate PPA deal to date, which saw French oil major Total last year acquire a 3.3GW solar pipeline and become the offtaker for 3GW.

10GW
Solar capacity to be supported by Spain's auction mechanism by the end of 2025

In addition to measures to further support the development of PPAs, Spain's government last year passed legislation that aims to speed up licensing approvals for renewables projects and minimise the reselling of permits following a tsunami of applications in 2019.

According to Pablo Otín, CEO of developer Powertis, the legislative package represents an overhaul in the way Spain will tackle the next wave of renewables: "And it was much needed because it has been a while for the government to put everything in place." Otín says that while complications can arise when dealing with Spanish local authorities, which "don't necessarily understand the good of what solar could be for the community or for the country", Spain's federal government is on the whole "doing a great job".

Part of last year's overhaul saw the country introduce a new renewables auction mechanism that is expected to support at least 10GW of PV capacity by the end of 2025. The first of the new auctions took place earlier this year, with solar securing two-thirds of the allocated 3GW capacity, and winners required to complete their projects by March 2023.

Given that winning solar bids were made by 26 companies, 70% of which are Spanish, and average winning prices were €24.47/MWh (US$29.38/MWh), results from the first auction have been welcomed by trade association UNEF. "The good results of the renewables auction guarantee its effectiveness and we hope that they will be maintained over time and that they will be similar to the one recently held, which has been very satisfactory," says José Donoso, director general at UNEF.

The association is calling for future auctions to have 20% of allocated capacity specifically for installations solar smaller than 10MW and is pushing for another to take place for projects with energy storage. According to Donoso, the auctions "are necessary because both PPA and merchant projects are limited when it comes to obtaining financing".

UNEF believes Spain will be able to beat its target of reaching 39.2GW of installed PV by 2030, by which time the country aims to have 74% of electricity generation from renewable sources. The solar industry is also expected be boosted by government plans to grow its green hydrogen sector and reach 4GW of installed electrolysis capacity by the end of the decade. Spanish utilities such as Iberdrola and Naturgy have made notable green hydrogen announcements in recent months, while Endesa is planning 23 green hydrogen projects in the country that will be powered by 2GW of renewables.

Ana Barillas, head of Iberia at consultancy Aurora Energy Research, says that although Spain's hydrogen market is still in its infancy, the sector "is a real upside" for the development of solar in the country. She adds: "When people think about the risk of deploying solar in the Iberian market, the long-term risk of cannibalisation is an important one. And I think anything that can help support prices in the long term, whether that's electric vehicles, whether that's storage or whether that's green hydrogen, will help the sector invest with a bit more certainty and mitigate some of the long-term risks."

Credit: Powertis

All expectations are that Spain will beat its target of 39.2GW of installed solar by 2030.

The Netherlands

The Dutch Cabinet has targeted a 49% reduction in greenhouse gas emissions compared to 1990 levels by 2030, and in correlation to that the Netherlands Environmental Agency expects renewable electricity to grow to 75% of total consumption by 2030.

But the country has struggled to meet targets in the past. The Netherlands' government was ordered by the supreme court to slash emissions by 25% by the end of 2020 last year, after losing its final appeal in a six-year legal case brought by climate group Urgenda Foundation. It has also struggled to catch up with renewables penetration, generating just 7.4% of its energy from renewable sources at the close of 2018, shy of the 14% it was asked to accomplish by 2020 under European legislation.

Nevertheless, trade body Holland Solar sees solar playing "an enormous role" in the country's climate targets, according to policy officer Nold Jaeger. The organisation predicts that the Netherlands will host 58GW of solar capacity by 2030, and more than 200GW by 2050.

As of 2019, the Netherlands hosted 6,754MW of solar power capacity, according to the country's Central Bureau of Statistics. Today, its capacity sits at slightly over 10GW, according to the trade body, with just under 3GW added last year.

Last year, the government awarded more than €2.1 billion in its subsidy scheme, SDE+, to solar projects totalling 3,440MW capacity. The scheme was expanded this year and is now called SDE++, offering a budget of €5 billion to develop renewables projects from next September.

"Depending on how the different policies work out, the coming years will decide what the exact mix between solar and wind energy will be," he says, "but it is very clear that solar will take up a very significant portion of that 75% renewable energy [target] in 2030."

€2.1 billion

funding allocated to solar under the Netherlands's SDE+ subsidy scheme in 2019, supporting 3.4GW of solar PV

While the COVID-19 pandemic did impact the growth of solar power in the commercial and industrial (C&I) space, Jaeger says that residential installations surged last year as consumers "suddenly spent their holiday savings…on solar panels". Around one million homes had installed solar by the end of last year, helping the Netherlands pass the 10GWp capacity barrier, he says.

The question, Jaeger says, is more now about how solar can be integrated into areas beyond electricity, such as heating, cooling, industry, and mobility to help those carbon-intensive areas go green. "In that sense we foresee a bright future for solar in the Netherlands because of the expected increase in demand for green energy from other sectors."

Clearly, to go from roughly 10GW to 58GW in nine years will require deployment to speed up. The Netherlands faces a handful of challenges to get there, namely the limits of its grid infrastructure. An increasingly large part of the country now qualifies as "filled up", according to Jaeger, making it much harder for solar developers to gain connection. "This doesn't mean that the sector will stop growing," he says, but it does have the effect of requiring those working in the energy sector in the Netherlands to "think more creatively about how to solve these issues on a local level." The trade body has negotiated with local grid operators to allow solar power developers to connect their plants at 70% of their maximum capacity, which means more installations can gain grid access overall.

The challenges the market faces today, Jaeger says, are grid infrastructure limits, ensuring local support for projects and establishing "a business case that needs to rely less and less on subsidies." To win over communities, the Holland Solar has launched a code of conduct for ground mounted solar parks in collaboration with several NGOs.

One of the country's strengths is its suitability for floating solar technology. There have been a few examples of partnerships with sand production lakes, which typically allow developers to install solar on their lakes while they offtake the electricity produced, creating a compelling business case.

With land scarce, rooftops have become a key battleground for Holland Solar, which has been lobbying frequently for the government to invest in strengthening support structures in buildings so they can take the weight of panels. Building regulations in the Netherlands have allowed building developers to build constructions that can bear the weight of a good amount of snow or rain, Jaeger says, "but that simply doesn't allow for the constant weight of a solar system." This is especially true of larger flat-roofed commercial buildings, which can become greater platforms for solar installations. "This does require the government to concretely change its policies so that future buildings are all constructed solar proof and that existing buildings can be renovated in such a way that they are able to carry the weight of large solar installations."

Credit: BayWa r.e.

Floating solar projects, like this one in Sekdoorn developed by BayWa r.e., will be essential to the Netherlands' solar growth.

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The emergent markets

POLAND

Driven by successful renewables auctions and a generous net metering scheme for solar projects, Poland has firmly established itself as the market to watch for PV deployment, as the country weans itself off coal generation and aims to derive 23% of its energy from renewable sources by 2030.

Following a 2020 that saw Poland more than double PV deployment year-on-year to 2.2GW, trade association SolarPower Europe labelled the market "Europe's latest shooting star" and "the biggest surprise on the EU's solar map".

The country looks set to smash its target of installing 7.3GW of PV by 2030, and while it was the only EU member state not to commit to carbon neutrality by 2050 when the goal was set in 2019, steps have recently been taken to reduce the share of fossil fuels in power generation.

"I think the Polish government and Polish regulators, they definitely have an appetite for much more solar power," says Przemek Pieta, CEO of R.Power, a Warsaw-based developer and EPC provider that aims to install approximately 200MW of solar in Poland per year as it picks up additional capacity in the country's auctions.

An auction that took place in December for projects up to 1MW is expected to result in the deployment of 700MW of solar, with winning projects eligible for a 15-year guaranteed tariff, and another auction is set to go ahead this June that is projected to award 1GW for small-sized projects and 700MW – 800MW for large-scale plants.

Pieta says "there is a pretty stable outlook", given that the government has announced more auctions for the next couple of years. He hopes the current size of the auctions will be maintained, not increased, in order to prioritise stability and prevent a boom-and-bust cycle of deployment.

Poland's solar sector has also been boosted by a favourable self-consumption scheme for prosumers and a growing micro-installation segment of projects smaller than 50kW that consisted of around 350,000 systems at the end of 2020. As strong micro-installation deployment is expected to continue, there have been calls to update the country's grid to prepare for the increase in the number of prosumers.

Grid issues have also affected utility-scale project developers that are experiencing longer delays securing a connection. Josef Kastner, CEO of European region at ReneSola Power, says the developer has seen grid connection delays reach as much as six months, leading to complications in terms of licencing schedules. "We hope that the utilities grid operator would increase their capability to connect all plants in some kind of reasonable timing," he says.

But while some European markets' solar sectors are held back by limited land availability, this is not an issue for Poland. Kastner makes a comparison between Poland and Germany, which are approximately the same size; while the former has a 2030 PV deployment target of 7.3GW, Germany's is 98GW. "I guess there will be a lot of places in Poland to install solar, so we are very optimistic that this market keeps growing, and we will grow with the market," he says.

Alongside deployment from auctions, where ReneSola has been active, securing 38MW of projects last December and dozens of small-scale solar plants in previous years, Kastner says he now expects a lot more solar parks to be backed by power purchase agreements (PPAs) in the country.

German developer BayWa r.e. earlier this year signed what it claimed was Poland's first solar corporate PPA, with a 64.6MWp solar project set to provide power to a cement manufacturer under a ten-year deal. At the time, BayWa r.e. said the partnership "marks a new era of clean and sustainable corporate energy sourcing" and could serve as a blueprint for more PPAs in the country.

While the nascent PPA segment gains traction, there have been demands for changes in regulations to fully unleash the segment's potential. Ewa Magiera, CEO of the Polish Photovoltaic Association, says it is necessary to alter Polish law so that electricity can be directly sold by renewables installations to end users. She adds that companies in Poland are looking to buy energy from renewables projects to guarantee a stable supply of electricity and to secure predictable energy costs.

With the PPA market on the rise and PV developers continuing to secure capacity through auctions, the growth of Poland's solar sector could also serve to increase energy security in the country. According to Pieta of R.Power, as Poland's service sector has grown in recent decades, changing electricity patterns means there is much more consumption during peak hours and during summer, with more people working in offices and higher demand for air conditioning creating a "huge imbalance" between demand and supply. He adds: "And obviously, solar is cheapest and the easiest way to fix it."

Credit: Renesola Power

A solar project from ReneSola in Poland.

DENMARK

A successful move towards solar projects backed by power purchase agreements (PPAs) is significantly boosting the technology's deployment in Denmark, which at the end of 2020 had 1.7GW of installed PV and has the potential to surpass 10GW by the end the decade if obstacles are removed.

This year is expected to see at least one renewables auction take place in the country, however a price cap is likely to put off solar bidders, according to Eric Anderson, CEO of Denmark-based developer European Energy. "I foresee that the interest in this auction will be low, maybe close to zero," he says.

Instead, developers such as European Energy are focusing on subsidy-free projects and are now awaiting the outcome of a government decision on how it intends to fund much-needed grid upgrades, amid concerns that the renewables sector will be burdened with much of the cost. With a decision yet to be made, there has been a recent drop in solar project connections to the grid.

As electricity consumption in the country is expected to double in the next nine years, some solar companies acknowledge that they should take on some of the upgrade costs and are now pushing for clarification from authorities so completed solar projects can secure a connection.

"The main obstacle right now is the electricity grid," says Peter Bjerregaard, director of regulatory affairs at Better Energy, an independent power producer that earlier this year signed a ten-year solar PPA with Centrica Energy Trading. Bjerregaard describes that deal as a "historic moment" for Denmark's PV sector.

GREECE

Grid issues are also plaguing Greece's PV sector, which will be boosted by government plans to shut the country's last coal plant in 2025, but needs to overcome problems surrounding licensing and land availability to fully unleash its potential.

With a successful auction scheme driving deployment, as much as 1GW of new installations are expected to be installed this year. However, with authorities overwhelmed by requests for grid connection terms, large-scale solar projects could be excluded from participating in future tenders due to the bottleneck.

This is compounded by a growing objection to PV by local authorities and communities because of soaring applications for new plants, according to Takis Sarris, managing director of juwi Hellas, the Greek subsidiary of German EPC juwi. Local authorities "don't give the permissions that are required" to further develop PV projects, he says.

Credit: Juwi Hellas

Construction underway at the 204MW Kozani park, which will be Greece's largest PV project when complete next year.

Sarris adds that these objections are also making it difficult to obtain suitable land at a reasonable price for large-scale projects, with plots for installations in the 20-50MW range "very hard to find".

Juwi Hellas is currently constructing Greece's largest PV project in Western Macedonia, the country's most coal-dependent region. Featuring bifacial modules, the 204MW Kozani plant is due for completion in early 2021 and is backed by a PPA with Hellenic Petroleum Group.

According to Stelios Psomas, a policy advisor at Greek PV association HELAPCO, "it is certain" that the country will reach its 2030 installed PV target of 7.7GW, which is expected to be raised in the coming years as a result of new EU emissions reduction goals.

HUNGARY

Hungary's third renewables auction is set to take place this July, as the country looks to promote PV deployment to reach a target of 90% carbon-free electricity production by the end of the decade.

The tender will have maximum subsidised volume of 300GWh per year and be divided into two baskets for projects in the 300kW-1MW and 1-20MW ranges.

With the country's previous auctions heavily oversubscribed, there were hopes among developers that more capacity would be made available. "What we see here is that this tender regime is not well balanced, the tender volume is very much limited," says Josef Kastner, CEO of European region at ReneSola Power, a developer that entered the Hungarian market three years ago and now sees potential for its solar PPA market.

Additional demands from solar players in the country include an enhancement of cross-border trading and efforts to ease access to the grid, which, according to PV trade association MANAP, is currently "almost impossible". It is hoped the grid access issue will be solved by a new regime on the connection process that expected to be revealed in the coming months.

Photon Energy, a Netherlands-based developer that last year commissioned 23 PV plants in Hungary with a total capacity of 23MWp, is also calling for government support for energy storage systems.

Zoltan Takacs, the company's project development and acquisition manager in Hungary, warns that if rising land prices and the scarcity of grid capacities continue, the country's 2030 goal of reaching 6.5GW of installed solar will be harder to achieve.

Europe's other hot markets

Credit: EDP.

A floating solar pilot project from EDP in Portugal.

PORTUGAL

Although it made headlines for receiving record-low prices in both its solar auctions to date, Portugal's PV sector deployed just 153MW of capacity last year and is now restrained by complex licensing processes and grid connection scarcity.

The country's first solar auction took place in 2019 and resulted in 1,292MW of capacity awarded. This was followed by another last year, which included an energy storage option, allocated 670MW of capacity and saw Spanish renewables company Enerland post the record bid of €11.14/MWh for a 10MW lot, with the low prices reflecting the limited grid access. Winning bidders from both tenders contacted by *PV Tech Power* say they are progressing with project development as planned.

Due to potential land availability issues in the future, Portugal's government is now preparing a third solar auction for "non-conventional surfaces", which will include lots for projects at land beside motorways as well as floating installations on water bodies such as reservoirs.

Alongside the auctions, solar projects can also be submitted via the market, by agreement with the network operator, ensuring part of the financing for the expansion of the electricity network, according to Pedro Amaral Jorge, CEO of Portuguese renewables association APREN. He says the country's clean energy sector faces "two major problems that must be quickly addressed" if it is to achieve its climate goals: licensing and networks.

With the current licensing process requiring promoters to deal with several agencies, APREN is carrying out a project that aims to bring together all the stakeholders that work in renewables licensing to find solutions that can streamline the process.

> "The renewable electricity sector today faces two major problems in Portugal that must be quickly addressed to ensure the achievement of climate goals and objectives: licensing and networks."

A spokesperson from EDP Renewables, which is majority-owned by Portuguese utility EDP, says that despite recent efforts to simplify the process, the company has faced greater difficulty in licensing projects with the introduction of additional intermediate procedures.

EDP Renewables participated in both of Portugal's auctions, securing a contract in 2019 for its 142MW Ribatejo solar project, which is expected to be installed next year. The company will consider its participation in the next one when the rules have been fully defined. The spokesperson says that in order to guarantee the completion of projects, the progress of the development process of plants presented for auction should be more demanding.

With just over 1GW of solar installed as of the end of 2020, the country is already behind its energy and climate plan, which forecasted that 2GW would have been deployed by then. Pedro Amaral Jorge says that while Portugal is among the most promising European markets for solar PV development, extra effort will be required to reach its target of 9GW deployed by 2030.

He says: "This extra effort is partly due to the resolution of problems and barri-

ers that are currently identified in the sector, both with regard to the complexity and length of the licensing process, the unavailability and inadequacy of the electricity grid, and the inappropriate imposition of fees and disproportionate taxes on producers."

FRANCE

France's government has called for 44.5GW of solar to be installed in the country by 2028, but figures from trade body Syndicat des énergies renouvelables (SER) published in February last year warned that the country must double its current installed PV capacity by 2023 to meet future targets. More recently, grid operator RTE has said that that a downturn in economic activity related to the COVID-19 pandemic has created a fall in the deployment of solar, meaning that the country's 2023 targets for deployment appeared "out of reach".

Alexandre Roesch, who became chief executive of SER in 2017, tells *PV Tech Power* that things are starting to move in the right direction. The country said last October it would guarantee tariff support to 341MW of solar projects following the completion of an oversubscribed auction that featured reduced prices compared to previous rounds, and more than 452MWp of solar was awarded at auction this February, with energy prices jumping by 4.7%. Roesch points to France's "clear calendar of tenders" providing opportunities for further deployment, and a move towards a new feed-in-tariff for installations below 500kW capacity to boost the rooftop segment.

However, access to land remains one of a handful of challenges for developers looking to install more solar capacity, with Roesch describing this as a bottleneck for the market to overcome.

One solution currently being considered is combining existing farmland with new solar technology. Solar PV systems could become a "very interesting compliment" to France's agricultural sector as developers seek to add capacity and land is in higher demand, Roech says. SER published a report in December last year, exploring several examples of 'agrisolar' systems. The report takes in case studies from a variety of land uses including greenhouse fruit and vegetable cultivation, vineyards, rooftop installations for farm buildings, fisheries and sheep breeding.

Roesch says that the trade body has "tried to show some good examples of how we can do so on an agricultural land, and we have been inviting different representatives from the agricultural sector." The case studies include innovations such as multi-chapel greenhouses fitted with solar panels in a way to ensure there is "sufficient minimum light" for the crops cultivated.

Another case study demonstrates agricultural shutters for vineyards, that include a raised structure that allows machinery to pass under, and with modules that can be moved to shade crops when necessary and, SER claims, could preserve or even "improve agricultural yield compared to a similar plot". Elsewhere, the trade body is looking into collaborating with army officials to install panels on military land, and is also exploring the growth of the floating solar segment to evade the land issue altogether. "We have French factories, which are very active in this market segment," Roesch says.

ITALY

Although known for being somewhat fragmented, Italy has become a lucrative hotspot for the solar sector. A report from LevelTen Energy published in January this year found that it was the top European market for power purchase agreements (PPAs), accounting for 31.7% of offers from developers. Meanwhile, Italy's solar capacity is projected to increase briskly. Research by Aurora Energy Research expects new unsubsidised solar PV capacity in the country to grow to 5GW by 2025, 12GW by 2030, 32GW by 2035, and 57GW by 2050.

Paolo Rosco Viscontini, the president of Italia Solare, says that this should be "even higher", as the country would need to reach 240GWp overall by 2050 to support its net zero emissions target. If authorisation processes for deploying solar on agricultural land can be solved, he says, "this can absolutely be reached".

At the moment the majority of the country's unsubsidised capacity is based in southern regions as developers have leaned on the region's high irradiation to produce better project economics, and due to the relative ease of sourcing land for utility-scale projects compared to the north. Viscontini says there is something of an untapped potential towards the north, particularly where the unsubsidised market is concerned. The risk in the South, he says, is that prices will be very low, even zero for "many hours per day".

"Now we see entering into the development market more expert investors that are pushing developers to redirect their strategy considering areas where the main driver is not only the irradiance but the expected energy price," he says.

Key players in the market right now include global giants like Lightsource BP, which recently brought its Italian development pipeline to 1.2GW with the purchase of a 78MW project from local developer EGI Sicily. French independent power producer (IPP) Qair is also trying to obtain permits for around 500MW of solar projects in south-eastern Sicily, and like BP's renewables arm, hopes to start construction next year.

For now, one of the country's major barriers to deployment is access to land. Industrial lands, Viscontini says, are still favoured, but constrained by a relatively long (12 month) approval process. The situation for agricultural lands, on the other hand, "is very complicated, both in timing – not less than two years – and in final results [answers are quite often negative]." One of the key actions the trade body has taken recently is to lobby the new Draghi government, which came into office in February, to demonstrate how the bureaucratic simplification and clarification of authorisation processes will increase PV installations. Beside this, Viscontini says improvements must be made to the FER1 Decree, which grants incentives to installing renewable energy sources on industrial lands and rooftops.

TURKEY

Turkey's lawmakers have made continuous efforts over the past three years to remove barriers for solar deployment, but simultaneous attempts to regulate the market have caused growth to slow down. Historic figures from the International Renewable Energy Agency (IRENA) show a surge in installed PV capacity in 2016, rising from 249MW the year before to 833MW. Since then, capacity has soared to 3.4GW in 2017, and then 5.06GW a year later. As of 2020, IRENA reports that Turkey's total renewable energy capacity surpasses 49.3GW, around 6.7GW of which is solar PV.

Özge Özeke, secretary general of the Turkish non-profit think tank solar 3GW, says the slowdown in growth in 2020 was more the result of policy than pandemic-induced delays. In 2017, a set of regulations were put into place which made investments for residential solar power plants harder and more costly, such as

an increase in system usage fees, limits to the maximum capacity that can be built according to consumption, strict limits to the maximum power that can be transferred to the grid instantly, and harsh penalties for those who violate that limit. These, he says, have resulted in a gradual decrease in the total annual installed solar power in Turkey since then. While the industry witnessed substantial capacity growth in 2017 and 2018, the rate of additions has slowed down substantially, with just 660MW added last year. Roughly 250MW was added in the first quarter of 2021, Özeke says.

Nonetheless, solar does keep connecting to the grid. Özeke says this is the result of other beneficial policies, such as a regulation change in May 2019 that gave customers the chance to partake in net-metering. This proved popular with the commercial and industrial sector (C&I) in particular. Another regulation that came into effect this year enables "hybrid investments", so that solar can be added to a power producer's main supply provided its production does not exceed the original source. "An 80MWp solar power plant has already been deployed to a 550MW dam", Özeke says, "and many more are on the way to be added to hydro, wind, thermal, and geothermal power plants."

Finally, falling development and power costs are making solar more attractive. In the country's recent YEKA tenders (Renewable Energy Resource Areas), investors proposed an average price of TRY22/kWh (US$2.67/kWh) of electricity, while in comparison free market electricity producer prices are above TRY30/kWh. "That shows solar has achieved grid-parity in Turkey and even more," Özeke says.

The think tank's mission statement is to get Turkey into a position where 3GW of solar is being deployed each year. Özeke concedes his team are "away from their target" right now. The biggest challenge developers face, he says, is the "reluctance of the government to grant new capacities for solar power". It is announced that each year 1GW of YEKA tenders will be held for solar, but the current tenders have been in place for more than two years. "Therefore, with this speed, it is not very realistic that government can make 1GW of YEKA tenders each year." Solar power-purchase agreements and merchant installations, he says, could bring Turkey back to gigawatt growth. The think tank is working on a report on the subject that the director general hopes may persuade lawmakers.

Credit: NextEnergy Solar Fund

The 50MWp Staughton Solar Farm, owned by NextEnergy Solar Fund, is among the UK's first pure subsidy-free solar assets.

THE UK

Regulators across the world have professed about the need to use subsidies to put emergent technologies on steady glidepaths towards lower costs, avoiding boom and bust cycles which lead to intense periods of activity and deployment followed only by prolonged periods of comparative quiet. While the UK's energy department repeatedly intended to do just that, the way in which the country's Renewables Obligation (RO) scheme, which incentivised the development of utility-scale solar farms in the UK until its closure to new applicants in March 2018, achieved quite the opposite. In its successful years for solar between 2014 and 2017, the RO turned the UK into one of Europe's PV heavyweights, routinely deploying in excess of 2GW each year, and fuelling growth of developers that would become global mainstays, such as Lightsource BP and Solarcentury. But its closure sparked a near complete cessation in build activity and an exodus of market players who left for pastures new.

16.9GW

The UK utility-scale solar pipeline as of April 2021

Now, however, buoyed by grid parity economics, nascent technologies, interest from corporate offtakers and additional revenue streams sparked by co-located energy storage, the UK large-scale solar machine is ready to roar once again.

The most recent update from PV Tech Power publisher Solar Media's in-house market research team indicates that the pipeline of ground-mounted solar sites had reached almost 17GW at the end of April 2021, with around 800 – 900MW of new assets being identified each month as pre-build activity has soared. While the majority of sites – more than 10GW – have been identified as being in the mid-term development stage, indicating they are being slated for buildout from 2023 onwards, around 3.3GW have planning permission. Of that figure, Solar Media Market Research estimates that around 1.8GW is in the mix for buildout this year.

A recent increase in module pricing could prove to be the determining factor for what's built in 2021, however. With little to no government support in terms of subsidy or state-backed power procurement contract – the industry expects little from forthcoming Contracts for Difference rounds, which are expected to be dominated by offshore wind – short-term price fluctuations are significant for fully merchant projects.

However that impact is only expected to be temporary, and Solar Media's head of research Finlay Colville says deployment in 2022 onward could be "potentially explosive", with multi-gigawatt-level project pipelines able to come forward, returning the UK to gigawatt market status.

Manufacturing

Since SolarWorld's collapse in 2018, Europe's solar manufacturing scene has mulled its place in the global value chain. While Europe houses some of the world's leading research institutes, has unquestionably some of the best technology development centres and has a plethora of academic resource at its disposal, it has not been able to compete with the volume and scale of manufacturing on offer in Asia. To date, modules from China account to more than 90% of those sold each year.

But could that be about to change? Efforts to bring about a solar manufacturing renaissance in Europe have gathered pace, spurred on by concerns over supply chain logistics – Frank Niendorf, general manager for Europe at JinkoSolar, notes that the average cost of shipping containers has soared in recent months – the carbon footprint of manufacturing and shipping solar panels halfway across the world and a desire to once again have skin in the game in one of the world's most strategic manufacturing industries.

In Early May, the European Commission published its eagerly anticipated revised industrial strategy, a document updated a year after the onset of the COVID-19 pandemic principally because the crisis had shifted much of the landscape it was originally drawn up on. The strategy concludes that European industry has been "exposed to new vulnerabilities and older dependencies" while also illustrating the "need for more speed in the transition towards a cleaner, more digital, and more resilient economic and industrial model". Its solution has been to identify 14 strategic industries and tailor support for them, one of which is domestic renewables manufacturing.

Walburga Hemetsberger, CEO at SolarPower Europe, lauded the inclusion as a "much-awaited signal to reignite solar manufacturing in Europe and enable the EU to take the lead in the next generation of cutting-edge solar technologies."

Efforts are already afoot, of course. Meyer Burger has recently completed its pivot away from tool and equipment provider to a pure solar cell and is to shortly market a range of heterojunction solar modules in Europe and the US. Its initial volume of 400MW is expected to ramp up to 1.4GW by 2023.

That kind of production volume will not, however, be sufficient to compete with the continent's international counterparts, and is a "drop in the ocean" compared to what's necessary, Meyer Burger CEO Dr Gunter Erfurt says. Speaking at SolarPower Europe's SolarPower Summit in mid-May, those involved in Europe's fledgling manufacturing renaissance noted that it would require up to €7 billion (US$8.5 billion) of investment to hit the kind of scale to be globally competitive – around 20GW. This takes into consideration requirements across the value chain, right the way from polysilicon production, to ingot/wafering, to cell production and module assembly. While Europe's supply of polysilicon could be catered for domestically from existing facilities owned by Wacker Chemie, according to the company's vice president of marketing, sales and application engineering Christian Westermeier, the rest of these critical cogs in the system are lacking in Europe.

Credit: Meyer Burger

Meyer Burger has transformed itself from an equipment supplier to a provider of heterojunction cells and modules, with an initial volume of 400MW

Political support

Financial clout will therefore be essential to the success of Europe's manufacturing renaissance. Financiers will need to be less risk averse, but the business model could also be handed considerable help through political interventions.

Niendorf says that while the idea of localised supply chains is growing in appeal once again, it remains difficult to see Europe competing with Chinese manufacturers in the immediate future. "Just purely looking at the economic viability of the whole value chain of manufacturing cost… [Chinese manufacturers] have completely different economies of scale, compared to what might be possible in Europe," he says. "It will be difficult to reach the manufacturing cost, no matter how much automation of the production process along the value chain you have, it will still be difficult to keep up with the costs that have been achieved in China."

What Europe will continue to lack, Niendorf says, is the "whole industry cluster" that surrounds solar module manufacturing. "It's not just wafers, cells and modules, there are so many more components," he says, stressing the importance of other materials such as glass in the process. "We would need that in Europe as well to make it competitive, because if you have to fly in either solar glass or certain components from other regions in the world, automatically, that drives up the cost."

One potential lever to incentivise the support of a domestic solar manufacturing industry in Europe is the much-mooted addition of carbon footprint requirements on modules. Policy details are being drawn up and are expected to be outlined this summer by the European Commission, but it could prove to be a useful lever in making domestically-manufactured solar products more competitive on price. In a sector as price sensitive as power generation, Europe's solar sector will need all the policy help it can get to compete with China's considerable clout.

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Looking at the drivers and dynamics of utility scale solar in the UK

The UK solar industry is just starting its next phase of growth, in the absence of government subsidies: the so-called 'post-subsidy' period. This comes at a time of great excitement and expectation on renewable energy globally, and in the UK in particular.

While homeowners installing solar panels on rooftops is something everyone is happy to see, the major contribution from solar energy comes from large-scale, ground-mounted solar farms. This is the only way to add GW-levels of new PV capacity quickly, and in a cost-effective manner.

During the days of FiTs and ROCs - between 2010 and 2018 - the UK solar industry showed how agile and efficient it can be, when adding solar farms quickly.

Fast-forward a few years since subsidies were removed by the UK government, and solar costs (for building sites) have come down significantly. Additionally, the power of solar modules is now double what it was a few years ago. Building solar farms now, and with larger declared capacity levels, is now a different proposition altogether, and the timing of the cost/efficiency benefits is coming at the perfect time.

For the past few years, developers in the UK have been working extensively to identify new locations for solar farm additions, and pushing multi-GW of capacity into the planning portals and - in some cases - directly at the government levels across England, Scotland and Wales. In fact, the pipeline of future solar farms is rapidly approaching the 20 GW level, and there appears to be no slowdown in activity here.

During the past couple of years, the first large-scale (50-75 MW) solar farms have been constructed, with zero-subsidies. However, this is just the starting point, and the UK is getting ready for GW-plus of new solar farm additions annually over the next decade.

The new Utility Scale Summit UK event has been put together by the Solar Media Market Research team, to gather all key stakeholders involved in the UK, driving new ground-mounted solar additions to the GW per annum and beyond. The event is set to be a must-attend forum for anyone wanting to know how the UK will move to GW-plus ground-mount additions, and which companies will truly drive this transition.

The 2021 event will runs over two days, 15-16 June 2021, as an online event, with eight sessions and 24 speakers.

Finlay Colville
Head of Research, Solar Media Ltd

Contact us for more information

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The challenges that remain

While the preceding pages have outlined the sheer scale of the opportunity within Europe's solar PV sector across the value chain, a number of common hurdles have emerged and for solar to truly fulfil that potential, the solar and wider energy economies must overcome these.

Grids have, predictably, been identified as a near universal source of ire for the utility-scale solar industry and the one that poses the biggest threat to the technology's dominance of power markets going forward. Decades-old infrastructure is struggling to keep up with an avalanche of modern, sophisticated power generators that disrupt the status quo and, as a result, new grid connections have ground to a slow, if not a complete halt.

Heymi Bahar, senior analyst for renewable energy markets at the International Energy Agency, says that the biggest issue remains that a large amount of renewable energy deployment activity, but grid deployment activity fails to match it. This, Bahar says, has been a "big challenge for Europe". Expanding grids, both at the distribution and transmission level, is considerably costly, and those costs are often borne by grid operators but passed onto consumers via levies on utility bills, additions which are politically contentious.

Furthermore, gaining permits for what can essentially boil down to huge quantities of tall pylons and thick cables can not only be difficult, but can also elicit uproar from local residents. The 'not in my back yard' types – or NIMBYs as they've come to be christened – are not only contesting planning applications for solar sites, but the infrastructure necessary to accommodate them too.

Bahar adds that difficulties in obtaining grid connection agreements has been a prevalent issue for wind and solar assets in northern Germany for some time, while speaking at PV Tech Power publisher Solar Media's Large Scale Solar Europe conference in April 2021, Berto Martins director for electricity markets at utility EDP Portugal, spoke of constraints throughout the Iberian peninsula – a hotbed for solar deployment activity moving forward.

The crux of the matter is that solar, and indeed other renewables, are just moving too fast for the grid to keep up. "The pace of building wind or solar plants is much, much faster than building the grid," Bahar says, a problem that is worse in emerging economies where some project developers have built renewables projects but not been able to connect them. Frank Niendorf, general manager for Europe at JinkoSolar, says that grid infrastructure project lead times are often in the five to 10-year range, creating significant bottlenecks for solar project development.

Furthermore, the problem is not confined to or felt more acutely in either the transmission or distribution grid, but felt equally across the two, with Bahar adding that growth in distributed solar exacerbating the issue even further.

> "The growth of storage solutions… will help lead to, let's say, a more decentralised electricity generation system, and consequently, take some pressure off the shoulders of the grid."

Martins is of the opinion that the first step will be to determine whose job grid expansion is anyway.

Moving beyond 'T' versus 'D'

"The topic here should be how to establish the adequate level of responsibility. Until now, we have – in my opinion – faced arguments over who will be responsible for which grid," Martins said during the LSS Europe event. His view was echoed by Randolph Brazier, director of innovation and electricity systems at the Energy Networks Association, a UK-based trade body representing network operators. "We need to get out of this competition mode of 'T' versus 'D', and networks arguing each other. If we want to meet our net zero targets, we don't have time to waste. We need much deeper collaboration between transmission and distribution, and we very much need to take a whole systems approach. That needs to be driven not just from the networks themselves, but also by the policy and regulation they work under," Brazier said.

The UK's network operators are all run as monopolies and licensed by government-appointed industry regulator Ofgem. Their expenditure is carefully controlled and vetted, with additional license conditions dictating that any action or intervention considered must also be measured against potential consequences further down the network, ensuring a whole systems

Credit: NGET

The UK's National Grid Electricity Transmission is to pilot new power flow technology to unlock grid capacity.

approach is front and centre. Martins added this was being particularly felt in Iberia, where grid connection requests have soared to unmanageable levels. As a result, authorities in Spain and Portugal in particular are understood to be experiencing difficulties assessing the impact on local grids of multiple connection requests. Martins said that while in the past the transmission and distribution grids – both of which can accommodate renewable power connections – have needed to be viewed separately, technology advancements and more modern approaches have enabled them to be viewed together, potentially finding areas of the grid where more renewables could be accommodated.

There have also been recent moves to identify and create additional grid capacity for renewables throughout some of Europe's key markets. In the UK, transmission system operator National Grid Electricity Transmission (NGET) recently revealed a trial it was undertaking of power flow control technology at three substations with the aim of unlocking 1.5GW of grid capacity. Meanwhile, Portuguese grid operator Redes Energéticas Nacionais committed in May 2021 to invest some €900 million (US$1.1 billion) in various grid reinforcements to accommodate new renewables projects. JinkoSolar's Niendorf says the growth of energy storage will also be a gamechanger, driven by cost reductions in the technology that will help the asset class become an alternative to the grid. "The growth of storage solutions… will help lead to, let's say, a more decentralised electricity generation system, and consequently, take some pressure off the shoulders of the grid," he says.

These improvements are, however, perhaps too isolated to truly ease concerns over the grid. Numerous sources spoken to for this piece highlighted the key role legislation passed by the European Commission as part of its coronavirus recovery stimulus can and should play in stimulating grid investments. There are also issues to contend with further up the value chain, ones which are having a very tangible impact on deployment today.

A material world

The solar manufacturing industry has been in recent months by soaring polysilicon prices, continuing a trend first felt towards the end of last year after incidents at a number of facilities in China disrupted global supply. While these incidents have largely been overcome, demand for the material continues to far outstrip, and prices have gone through the roof. As the cost of manufacturing solar modules has increased, purchase prices have had to rise in tandem, threatening project economics across the continent. Project developers spoken to by PV Tech Power remain split, but the general consensus is that some in the sector will be unable to develop at the module price, and projects previously slated for connection in 2021 will be pushed into 2022 when prices are expected to stabilise.

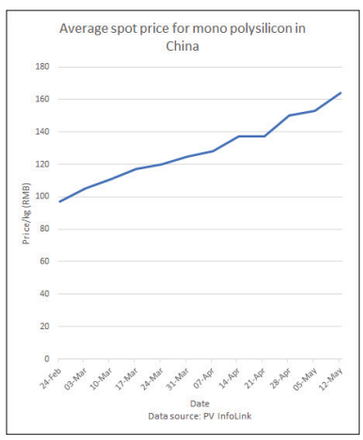
Credit: EDP Renewables

Solar project development in Europe remains subject to component costs, which are rising.

US$25.4

The spot price for mono-grade polysilicon in China in the week commencing 10 May 2021

The IEA's Bahar sees this as a threat particularly pertinent for those participating in Europe's band of renewables auctions. "Those that are deep into the auctions, betting on lower PV prices… if they had tight margins, then they are in a challenging situation to wait or not to wait," he says. Portugal's record-breaking auctions of 2020, which saw prices plummet to low of just €11.14/MWh (US$13.12) spring to mind in particular.



It's not just modules, either. Steel costs have also soared – tracker manufacturer Array Technologies lamented a doubling in steel costs felt between April 2020 and April 2021, and a further 10% hike felt early in this financial year – while semiconductor shortages are leaving inverter suppliers hamstrung.

But, as Bahar says, given the cost trajectory of solar over the last decade, the industry owes far less to component costs than it used to. "Let's remember that of the overall system costs modules are just a portion… there are a lot of other things involved. So the impact [of price increases] to a total PV system is not that big," he adds. Polysilicon prices are also widely expected to peak in July or August this year before normalising into Q2 2022, with huge additions set to come onstream at the start of next year. Any price impact will be in the short- or medium-term, however the prospects for sub-US$0.20c/W modules may perhaps have been revised as a result of the last six months.

Pricing and grid availability may therefore pose threats to solar deployment in the short- or medium-term, but long-term prospects for the technology are significant. The IEA expects north of 20GW of solar to be installed in Europe in each of the forthcoming five years, forecasts matched, if not exceed, by all other analysts. The future is bright for solar in Europe.

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AMLO casts a shadow over Mexico's solar prospects

Mexico | Reforms in energy policy since the election of Andrés Manuel López Obrador have led to increased uncertainty for solar developers in Mexico, with renewables auctions cancelled and changes to power dispatch priorities proposed. Alice Grundy looks at how the market can move forward once again.

Credit: Enel Green Power

The Villanueva solar project in Mexico, developed by Enel Green Power.

Favourable policy, large volumes of available land and a target of sourcing 35% of electricity from renewables by 2024 once made Mexico among the prime markets for solar development in Latin American, standing shoulder to shoulder with other prolific nations in the region like Brazil and Chile.

These factors attracted major international energy firms such as Iberdrola, EDF Renewables and Enel Green Power, with Bruno Riga, head of Enel Green Power Mexico, describing the country's solar and wind potential as "outstanding" due to its geographical location, among others, firmly cementing it as a target for international investors alongside homegrown solar from Mexican firms such as Zuma Energia and IEnova.

But as June gave way to July in 2018, a speedbump emerged in the road, marking the start of what would be a turbulent period not only for solar PV, but for renewables as a whole. A new political maelstrom emerged, garnering wide amounts of support to clinch a landslide victory.

Taking office on 1 December 2018, Andrés Manuel López Obrador, often known by his initials AMLO, promised a "fourth transformation" in Mexico's history in his victory speech, one which would be both peaceful and "radical". This included policies to boost Mexico's economy and increase social growth, as well as to improve the country's education system.

Renewables, however, were rather further down on the agenda, with the left-wing politician bringing with him a decisive shift in energy policy that has led to a two-and-a-half-year stretch of uncertainty ending in – at the time of writing – a battle in the courts.

How the tide turned for renewable policy

Recent years have seen an incredible amount of solar PV installed across the country. From smaller installations to the sprawling masses of panels making up assets such as Enel Green Power's 828MW Villanueva solar park, the message has been clear that developers have been ready and willing to get infrastructure in the ground. This was in part aided by supportive policy coming out of the government of AMLO's predecessor, Enrique Peña Nieto. The previous president enacted wide-sweeping changes to energy regulation that saw state oil firm Pemex's monopoly come to an end and the introduction of auctions for clean energy.

The first of these auctions, the results of which were announced in March 2016, saw seven wind and solar firms win electricity contracts and clean energy certificates (CEL). Results from a second auction were announced in October of the same year, saw 23 firms win contracts and CELs, with renewable projects worth US$4 billion and totalling 2,871MW of new generation capacity supported by the tender. Indeed, at the time of the auction, the average price – US$33.47/MWh – was described as being "among the lowest prices reached at the international level" by the Mexican energy ministry, marking the country as a hotspot for renewables development.

However, following AMLO's election, a series of policy changes that would pause new connections and shunt renewables down the pecking order were enacted.

Firstly, the fourth of such renewable tenders was postponed in the same month AMLO took office, with it then pushed back once again in February 2019 - its supposed new date. At the time, the government gave the rationale that it would have been "irresponsible" to add more capacity when already contracted projects were yet to be built.

Months later, in January of 2020, AMLO confirmed that the government would not be scrapping renewable auctions, although some contracts that state run utility Comisión Federal de Electricidad (CFE) felt it had been "forced" to enter were to be revised, with AMLO taking particular umbrage with the fact "subsidies are being handed out to private [energy] operators".

In April 2019 Manuel Bartlett, CEO of

Credit: Enel Green Power

Enel Green Power's Magdalena II solar project in the country.

CFE, said it was an "aberration being forced to buy power from one's competitors" and being told "we cannot generate our own power".

French renewables developer Neoen's deputy CEO, Romain Desrousseaux, says that privately-owned solar plants in Mexico "are seen as a threat, even if they can ultimately support CFE". Giving the example of a Neoen solar plant in Mexico which is selling electricity at ~US$12.5/MWh and creating green certificates at a price of ~US$6.5/MWh, which is well below grid parity, he says it's Neoen's belief that renewables can be "usefully incorporated into the country, creating jobs, diversifying the mix and enabling better prices".

As it stands, there are no signs that auctions will resume. Marco Nieto-Vázquez, partner at Baker McKenzie Mexico, says that at this time, "we do not see any interest from decision makers to re-establish a new long-term renewable auction".

"We consider that, if the current decision makers in Mexico do not align their nationalistic vision with a cost-efficient approach toward renewable energy principles, any measures taken to support the monopolistic operation in the power sector, will not be economically sustainable," he adds.

This was not the only controversy to hit headlines over the past few years. May 2020 – the height of the COVID-19 pandemic – saw another move, this time from power market operator CENACE, which sought to block nationwide tests for new renewable plants in a bid to underpin system stability. These tests are required to switch on renewable plants, and the blocking of them left 44 solar and wind assets effectively stranded and unable to export the power they produce onto the grid.

One such project was Neoen's 375MWp El Llano solar installation. The asset reached full deployment at the start of 2020 and, pending the pre-operational tests due in July of that year, had already began to pump power into the grid. With the tests on hold, Neoen estimated it would suffer a monthly earnings shortfall of US$2 million.

In June 2020 CFE increased transmission rates for high voltage tariffs – applicable to power generators with legacy permits, so called because they secured contracts with the government prior to the 2013 energy reforms – by 469%, while medium voltage increased 428% and low voltage rates increased by over 800%. This resulted in legal battles between generators with legacy permits that provided low tariffs to incentivise investment in clean energy and the CFE. However, until the Supreme Court makes a final decision, the increases in transmission tariffs have been suspended.

"This uncertainty possibly affects private power generators who may seek to end power purchase agreements (PPAs) that no longer appear advantageous given the policy that placed limits on the number of permits issued for wind and solar projects and banned their construction in some parts of the country," Gavin Rennie, EY global energy emerging markets leader and Latin America North power & utilities leader, says.

This comes alongside other reforms, including changes to power dispatch rules that would prioritise CFE's portfolio of hydroelectric generators, followed by CFE's other sources of power in the country. Only after those sources have been called upon would solar and wind generators owned by third parties be utilised. Despite outcry from the likes of the Global Solar Council, the reforms progressed regardless, passing Congress in February 2021 without alterations and being approved by the Senate in early March.

However, two days after the reforms became law, they were suspended after a court granted provisional injunctions against the law which were sought by a collection of renewables developers. Only a week later, a definitive suspension of the new electricity law was ordered.

This is not the end of the story for this specific law. AMLO has called on the Supreme Court to resolve the matter, although at the time of writing it is unknown when the case will be heard.

Uncertainty, risk and where the market heads next

The journey of energy policy through the courts, spanning many months and

covering a variety of policies, with no end decision yet to be in sight, has created a much more uncertain environment for new solar developments. Desrousseaux says that the different reforms that are under discussion with the courts are creating uncertainty, which he labels as "the main challenge today" for developers.

Certainty can also impact on investor confidence, particularly as the increase in uncertainty can lead to additional risk. As Rennie describes it, while Mexico is a global market for investment in renewables, this investment will "ultimately go elsewhere if returns and certainty are more attractive".

He says that the biggest challenge for investors looking at returns that cover multiple years is to have regulatory and policy certainty. This echoes Nieto-Vázquez's sentiments, who says that any legal change that presumably affects the constitutional rights of private parties to maintain or develop infrastructure projects in a country "could raise doubts and influence an investor's confidence".

Despite this, there is not a simple yes or no answer to whether or not investors' confidence has been dented. Nieto-Vázquez says he has a somewhat optimistic view on investment in the country, which comes from recent experience with Baker McKenzie's clients. Whilst he says that policy changes are affecting "all the large-scale and ongoing generation projects in different ways" and have "stalled or delayed future investments", at a transactional level Baker McKenzie is currently helping its clients with the power purchase process, taking advantage of short-term price opportunities due to the competitiveness in the 'inside the fence' schemes – effectively behind-the-meter projects - as well as the "expected increase in the power demand in certain industries, both in the medium and long term".

It is this behind-the-meter market where Nieto-Vázquez believes opportunities remain. He is not alone in this opinion, with Rennie agreeing opportunities remain in that sector, explaining that given the higher power costs in Mexico, businesses are driven to embrace a self-supply approach and power themselves with cheaper renewable energies. Walmart de México is one of many such companies to have taken this approach, having successfully completed the installation of a solar photovoltaic park that is to generate 20% of the energy consumed by its Aguascalientes store.

"There are still opportunities for insets – creating energy supplies directly for customers on their premises or nearby. These remain very attractive but [are] often smaller," Rennie adds.

Analysis from the IEA in late 2020 examining global solar deployment out to 2025 found that the share of distributed applications in overall PV growth in the country was forecast to increase owing to net metering and net billing policies, while higher unsubsidised residential and commercial retail electricity prices would improve their economic attractiveness.

A solar asset manager operating in Mexico which preferred to remain unnamed says that the commercial and industrial and residential distributed generation markets are where it too sees more opportunity, with the development of utility-scale projects to "remain very challenging over the next few years".

Whilst private PPAs remain the only alternative for utility-scale projects after the cancellation of the auctions, the asset manager says that there are a number of "administrative burdens that are slowing down the implementation of private PPAs through qualified suppliers". It adds that the regulatory uncertainty created by the current administration has changed its appetite in the sector in both the short and medium term.

However, PPAs in Mexico are becoming more popular according to Riga. The ability to provide cheap, efficient power while simultaneously boosting sustainability credentials is standing solar in good stead with commercial offtakers. More and more, Riga says, Mexican companies are realising that using renewables can help them better their relationships with customers and the communities where they operate and build a "better relationship grounded on transparency, sustainability and better business practices".

"As it has happened in other parts of the world, companies are setting ambitious renewable energy targets to reduce emissions and improve their energy costs."

Meanwhile, Enel Green Power's ability to offer not only electricity generation but also risk management and in particular green certificates to companies with a +1MW electricity consumption per year is set to be one of its main growth drivers in the coming years in Mexico.

The IEA's 2020 analysis also found that, with large consumers accounting for over 40% of electricity sales in Mexico, private renewable energy auctions and corporate PPAs are expected to drive annual additions of utility-scale solar PV during 2023-25. Overall, in its accelerated case, it expects an average of 3GW more solar capacity could be online during this time period, although this relies on more regulatory certainty for developers and rapid economic recovery for the distributed segment.

Embracing the multiple opportunities

In its main case, it expects 1.5GW of utility-scale solar to come online over 2021, 200MW of commercial and 100MW of residential. In 2022, it expects 900MW of utility-scale, another 200MW of commercial and a further 100MW of residential.

While forecasts can attempt to put a quantitative figure on the future for solar in Mexico, the question remains as to whether these scenarios will come true and what could be done to enable the market to continue to flourish. In 2020, the country fell further down EY's Renewable Energy Country Attractiveness Index (RECAI) from 25th to 33rd spot, with this being largely as a result of the policy uncertainty. However, that doesn't mean it can't become a more attractive market once again. Rennie says that many countries are creating durable, long-lasting specific policies and regulatory frameworks to encourage renewables, continuing that Mexico has been as high as 6th in the RECAI "due to the scale of opportunity, as well as public auctions to stimulate the market – these are the areas that Mexico needs to work on".

Indeed, it seems the viewpoint of the developers on the ground is that the recent uncertainty is simply a hurdle in the road and not a full blockade. Riga says that both Enel Green Power's partners and nearly every company it has spoken to sees "multiple opportunities to continue driving the adoption of renewable energy, including solar".

This is also similar to the opinion held by Neoen, with Desrousseaux stating the developer remains positive that in the long run, the government will "see the benefits of solar energy and will allow investment to resume".

Indeed, Desrousseaux finished by saying that even with the current political uncertainty, with Mexico having "such strong fundamentals, the very long-term future looks bright". The political uncertainty created by AMLO could prove to be a cautionary tale for the sector, but evidently solar will find a way to deploy regardless of political whims. ■

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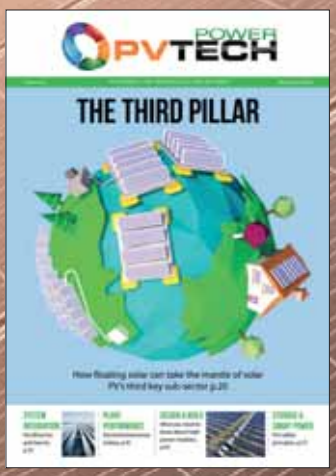

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Product reviews

Inverters — FIMER's PVS-10/33-TL three-phase string inverter offers greater C&I project flexibility

Product outline: FIMER has introduced its new PVS-10/33-TL three-phase string inverter solution that is designed to cater for the increasing demand for flexibility in commercial and industrial sectors.

Problem: Project developers are increasingly demanding PV inverters provide greater reliability, flexibility and faster commissioning for use in a myriad of complex applications such as when bifacial panels are used in rooftop projects.

Solution: The PVS-10/33-TL string inverters are designed to support flexibility in PV plant design, cost-convenient integration within communication and control architectures and openness to new technologies such

as bifacial modules. The range has been designed with higher input current readiness on the 20, 30 and 33 versions. Another major advantage is the inclusion of an integrated zero export system, which delivers savings on BoS and removes the need for expensive additional devices. The fuse-free design removes the need for maintenance and on-site interventions, due to fuse faults.

Applications: Commercial and Industrial PV power plant projects.

Platform: The new PVS-10/12.5/15-TL and PVS-20/30/33-TL string inverter platforms have integrated Wifi/Ethernet for TCP/IP networking allows for cost efficient networking and off the shelf replacements. In retrofit applications, the inverter range offers unique DC side flexibility. The inverters feature current monitoring on each string, which can reach up to 1100 Vdc input voltage, allowing for longer strings as well as the ability to operate across wider temperature ranges. Fast commissioning is made possible with the installer app which enables a quick multi-inverter installation, saving up to 70% commissioning time, according to the company.

Availability: FIMER's new PVS-10/12.5/15-TL and PVS-20/30/33-TL platforms have been launched in Italy, France, Germany, Thailand, India and Australia, followed by a global rollout planned in the first half of the year.

Modules — Talesun's latest mono-PERC module series offers 570/590Wp performance for utility scale projects

Product outline: Talesun Solar has launched a next-generation series of large-area high-efficiency PERC modules for utility-scale PV power plants. Available in both monofacial 'Bistar' and bifacial 'Bipro' formats, using 182mm half-cut cells in 144 and 156 cell configurations.

Problem: The PV industry is rapidly transitioning to larger format modules, with power ratings approaching 600Wp. This is being driven by the need to continue reducing the Levelised Cost of Electricity through lowering the cost of installation and Bill of Material component count, while accelerating the return on investment of utility scale projects. Finding and deploying the correct PERC-based

wafer/cell/module format size and innovations at the cell and module level for a given project and understanding its impact and compatibility with PV inverters and tracker systems, especially with bifacial modules, is required.

Solution: The Bistar and Bipro module series with up to 590Wp performance adopts a number of advanced technologies to reduce the LCOE for utility scale and C&I applications. A key adoption is the gallium-doped M10 (182mm) wafer, which provides better security against Light Induced Degradation with stable, long-term power generation. The mid-sized wafers enable efficient handling due to both the format sizes and weight limitations for rapid installations.

Applications: Utility-scale and C&I PV power plants.

Platform: The Talesun Bistar monofacial modules (3.2mm AR Coating Tempered Front Glass) measure 2,465mm x 1,134mm x 35mm and weigh 31.5kg in the 156 (6 x 26) half-cut monocrystalline cell configuration. This module is available in five versions with power outputs of 570-590W.

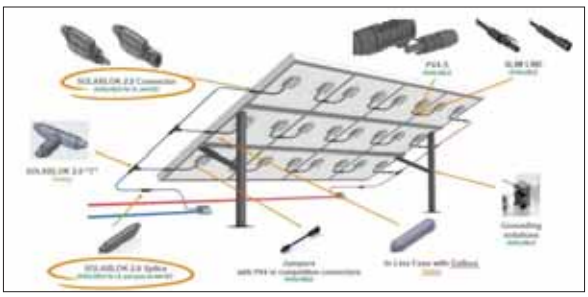
Availability: Volume production from Q1 2021.

Connectors — TE Connectivity's 'SOLARLOK SLK 2.0' DC plug and splice connectors reduce PV power plant installation times

Product outline: TE Connectivity (TE) has launched a new plug and splice connector that is intended to reduce installation steps for PV power plants. The 'SOLARLOK SLK 2.0' DC plug and splice connectors are IEC 62852 (TUV) and UL 6703 approved.

Problem: The demand for solar power continues to grow, and so does the need for more robust systems that deliver increased power and efficiency. When system size grows, complexity does too, as well as costs for installation, operation, and maintenance.

Solution: SOLARLOK SLK 2.0 DC plug and splice connectors connect the PV cable to the solar panel in field installations with extended voltage ratings of 1500V TUV/IEC and UL. The design integrates Insulation Displacement Contact (IDC) technology, removing the need for cable stripping. With fewer installation steps, no special tools required, and reliable product performance, labour and maintenance costs can be reduced. An installation time of 30 seconds is now possible for a mated pair, making the product range 80% faster to install when compared to market standard PV connectors with multi-components and crimp contacts, according to the company.



Applications: PV power plants.

Platform: SLK 2.0 plug connectors incorporate the SOLARLOK 1500V PV4-S interface, to meet the latest solar PV needs, and are available in both male and female versions, enabling them to mate with SOLARLOK PV4-S and PV4-PM DC connectors. They are also range taking, so one connector fits conductors from 2.5 to 6mm^2 (10 to 14 AWG).

Availability: April 2021, onwards.

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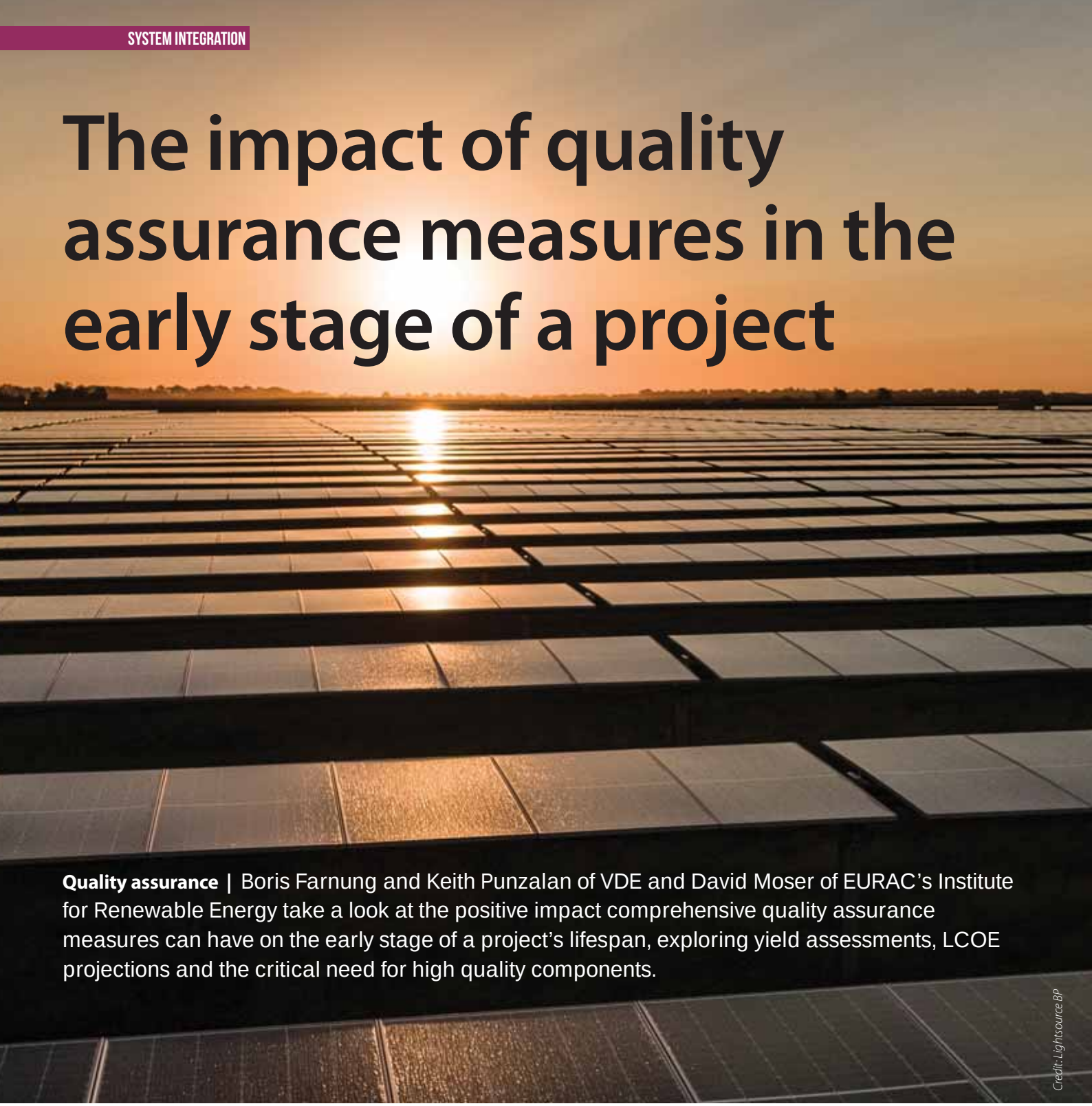
The impact of quality assurance measures in the early stage of a project



Quality assurance | Boris Farnung and Keith Punzalan of VDE and David Moser of EURAC's Institute for Renewable Energy take a look at the positive impact comprehensive quality assurance measures can have on the early stage of a project's lifespan, exploring yield assessments, LCOE projections and the critical need for high quality components.

Credit: Lightsource BP

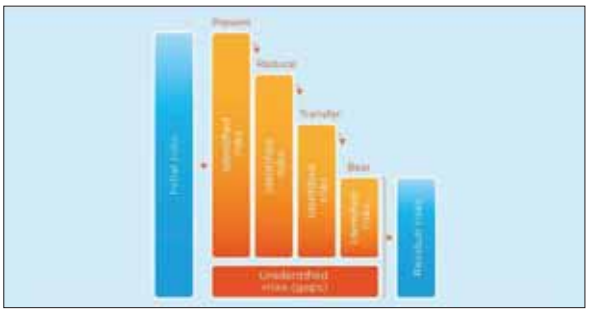
Investments in photovoltaic (PV) projects are a key driver to enabling sustainable growth in the solar PV installations market and thus, an important factor for the energy transition in many countries. To ensure the achievement of the desired rate of return on investment (ROI), it is important to establish a professional risk assessment, which serves to reduce the risks associated with related investments.

The risk assessment is an active quality management process where all stakeholders in the approval process of a PV project attempt to identify potential legal, technical and economic risks through the entire project lifecycle. These risks need to be quantitatively and qualitatively assessed, managed and controlled. Despite a wide overlap in this quality management process, the focus and the assessment criteria will vary depending on the stakeholder.

The different stakeholders must each develop their own individual risk management strategy along the lifecycle of a PV project using a four-step process of risk identification, risk assessment, risk management and risk controlling. Best practice guidelines and concrete tools to better manage technical risks throughout the PV project lifetime are emerging as the experience level in the PV industry continues to rise. The ultimate responsibility of project risks remains with the owner and operator of the PV plant. With the help of a professional risk management plan they can significantly reduce and transfer the initial risks associated with a PV project.

Detailed quality assurance measures can have a dramatic impact on yield assessments and LCOE projections.

With increasing experience gained from more and more projects, a more mature and professional PV industry, and established professional and standardised processes, these residual risks can



Credit: H2020 Solar bankability

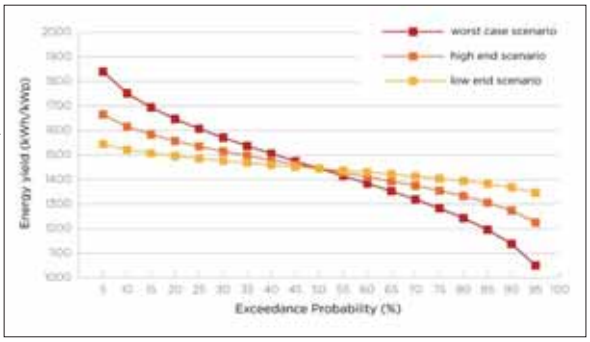
Figure 1: From initial to residual risks.

be low. This is further supported by the positive experiences from many investors that have managed to run successful projects. But when one looks into the details, this may have occurred due to external phenomena such as increased irradiance levels not considered in the early stage of the project.

This article therefore presents updated methodology on key measures as part of the technical risk management during the design and procurement phase of a PV project, that helps to reduce technical risks and increase probability of commercially successful investment.

The yield assessment – frequently underestimated risk in the design phase

Yield assessments (YA) and long-term yield predictions (LTYP) are used by investors in order to take business decisions on long-term investments. Investors know that past performance is no guarantee for future results. Yield assessment is an essential step in a PV project, as it helps to determine whether a system will be funded or not. However, the YA is not only about the utilised software, it is mainly about the user. YAs may not be as reliable as expected, and for example in the IEA PVPS Task 13 Report "Uncertainties in Yield Assessments and PV LCOE" [IEA2020], the authors demonstrated how seven highly skilled specialists did not arrive at the same result, despite having been provided the same detailed inputs.



Credit: H2020 Solar Bankability

Figure 2: Effect of energy yield's uncertainties on the exceedance probability.

Together with cost data (CAPEX, OPEX and discount rate), the output of a YA and LTYP (utilisation rate, performance loss rate and lifetime) provide the financial investors the parameters needed for the calculation of the levelised cost of electricity (LCOE) and to assess the cash flow model of an investment with relative internal rate of return (IRR) and net present value (NPV).

YA and LTYP outputs should be provided with a related exceedance probability. This gives the right tool to stakeholders involved in PV projects to take the best decision in terms of risk-aversion. A reduction in the uncertainty of the energy yield can lead to higher values for a given exceedance probability and hence a stronger business case.

The main challenge in YA and LTYP relates to the trustworthiness of site-specific information. In a global market it is in fact not uncommon to be assigned the task of assessing the yield of a PV plant to be located in areas which are not familiar for the yield assessor, and therefore access to local knowledge is of extreme importance.

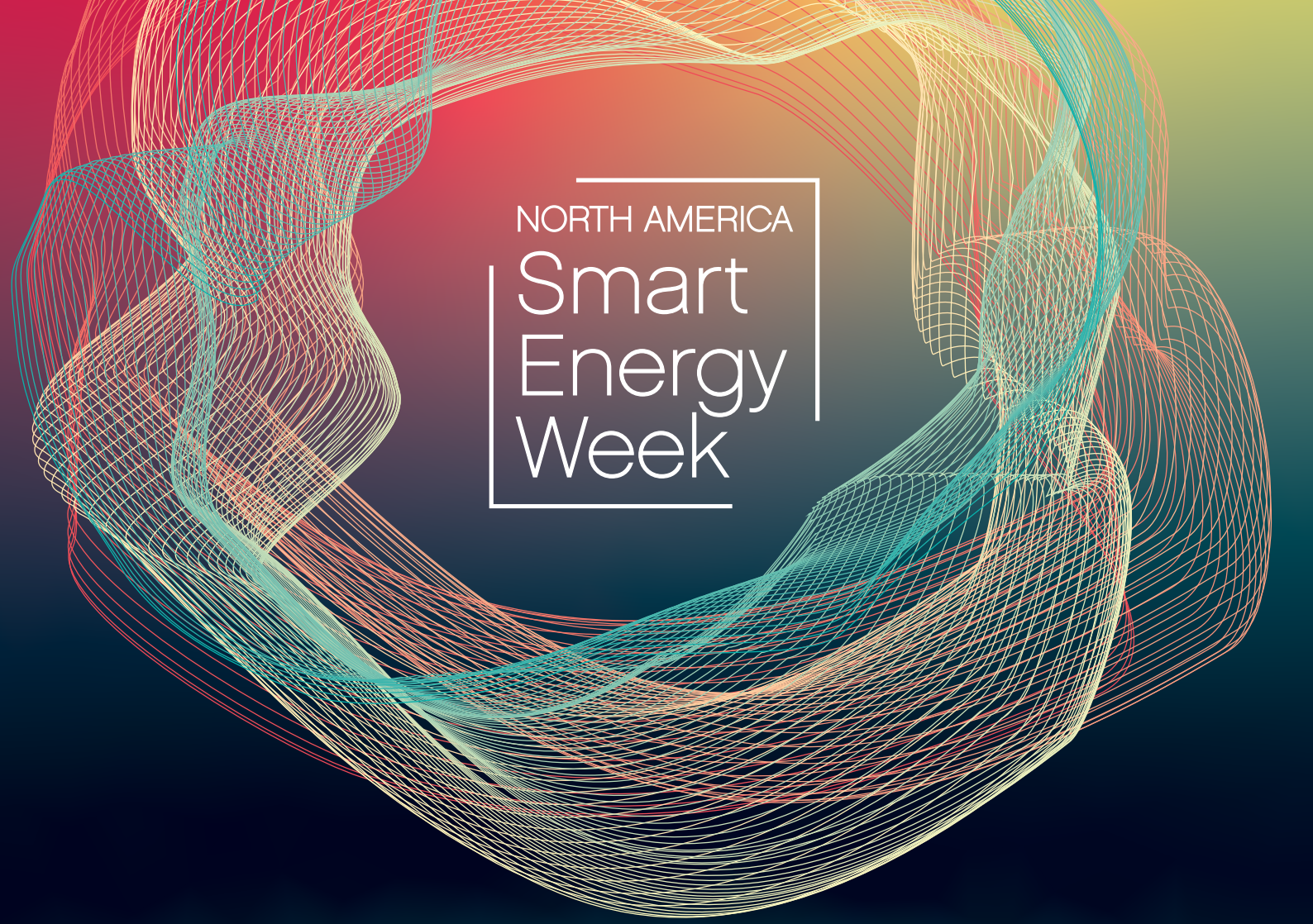
The most important parameter influencing the energy yield assessment is in fact the site-specific insolation. Several aspects need to be considered: reliability of the database, interannual variability, and long-term trends. Availability of validated satellite data or availability of ground measurements is thus an essential first step. To this extent, site adaptation techniques can increase the reliability of the selected site-specific insolation as they combine short periods of measured data with satellite-derived data having a long period of record with not necessarily site-specific characteristics. Upon completion of the measurement campaign, which is typically around six months/one year, different methodologies can be applied to reduce the bias. The bias corrected record of satellite data is then used in this relationship to predict the long-term solar resource at the target site.

Other parameters directly affecting the estimation of the incident radiation are linked to i) the calculation of the irradiation on the module plane and thus the model used for the decomposition and transposition of the global horizontal irradiance to global tilted irradiance, ii) shading losses (near and far), iii) soiling losses and iv) reflection losses. Shading and soiling losses are also site-specific and knowledge on the local conditions can ensure that the losses are properly assessed.

Finally, all the conversion steps from irradiance to electricity must be considered. The power calculation in PV modelling software not only depends on the software's algorithms, it also requires that components (modules, inverters) have been correctly characterised and are available as inputs for the software. While the modeller can input or translate datasheet values as provided by the manufacturer, as of yet, no guarantee is given by most manufacturers as to the accuracy of these key inputs. The uncertainties on (sub)components in the PV power modelling chain are often relatively low through the implementation of peer-reviewed methods. However, modelling risks can occur through errors in module or inverter files, which can negatively affect the yield, and with it, the financial viability of PV plants. Therefore, it is increasingly becoming the common industry standard that PV modules or inverters are subjected to additional characterisation by independent laboratories upon instruction by investors to ensure that the power plant model is bankable. Special care must be taken during this phase in terms of number of modules to be tested and selection procedure in order to obtain a reliable mean value of electrical parameters to be used in power calculation.

To summarise, the main risks related to yield assessments are:

- The choice of database for the horizontal irradiation. Irradiation data derived from satellite images are increasingly used as input for long-term yield estimations and as the basis for reference yield calculations for monitoring and business reporting. Several authors have evaluated the quality of satellite-based irradiance data in the past, typical normalised root mean square errors for satellite-based irradiation reported in literature are situated between 4% to 8% for monthly and 2% to 6% for annual irradiation values.
- Inexperienced yield assessor, or one that is not familiar with a specific location
- Input parameters not validated for a specific location
- Assumed degradation rates higher/



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lower than expected with an impact on the long-term yield assessment
- Specification of components do not correspond to their datasheet and guaranteed values
- Typically, investors require one YA. In some cases, more YAs might be requested if results are unclear. The various YAs can be averaged to assign a purchase value to a given project and this could be a source of error. YAs should contain all information needed to assess their reliability.

Best practices to ensure realistic yield and LCOE calculations over the project lifetime

Investing resources during the design phase is of extreme importance as mitigation measures which prevent future failures in the field and allowed optimal system design are the most effective from the perspective of a cost-benefit analysis. Some measures can be easily applied to reduce risks in YAs and LTYPs:

- Request the satellite data provider for validated data with ground measurements, or apply site adaptation measures
- Gain local knowledge to validate site specific parameters
- Check the trend over different time-periods (e.g. 2011-2020, 2001-2010) to check for long term trends
- Check reliability of provided files, ask manufacturer for qualified data or use independent third-party services for PV component quality assurance
- Make sure that for LTYP module degradation is not the only factor included (use performance loss rates instead of degradation) and that unavailability and reversible failures are also considered
- Design review and construction monitoring serve to detect issues caused by bad PV plant conception and poor PV construction workmanship
- As asset manager, include all the information used in the YA, LTYP and business model inside the same digital platform used for the EPC and O&M phase in order to have a complete overview of the history of the asset.

The direct follow-on consequence from deviations in yield assessments is that LCOE values will also exhibit a variance, on top of the additional modelling assumptions that can be employed for LCOE calculations. Determining P50 and P90 values for LCOE results and highlighting the assumptions/modelling chain will be important. From an industry perspective, it would be beneficial if more "live" post-mortem analyses (i.e. comparison of the LTYP and measured data, at e.g. every 5 years of system life) would be made and published. These can then be used as crucial feedback and inputs for YA modelers, financiers, and insurers.

High quality components – a critical part of achieving planned ROI

Carrying out proper quality assurance in the procurement phase ensures that an appropriate quality level can be achieved, and that the equipment is within the planned specifications. This sounds simple enough in theory, but in reality, there are many cases that indicate otherwise – i.e. where components installed in the field did not meet the desired criteria.

To cite an example: VDE Renewables assessed a PV portfolio in Turkey with a total capacity of 230MWp. The portfolio of systems used eight different PV module types, each of which possessed certification according to international standards. However, underperforming PV modules were detected at the start of PV system operation. The comprehensive quality assurance work carried out by VDE Renewables determined that there were two types of PV modules which were underperforming by around -4%, which was beyond the tolerance limit taking into account measurement uncertainty. These underperforming modules were used in 26% of the whole portfolio. Based on a 4% underperformance rate, the sub-par PV modules lead to annual losses of approximately US$200,000 (or US$2,000,000 over 10 years of operation). Proper quality assurance in the procurement phase would have detected the problem before operation, strengthened the basis for negotiations for the buyer, and saved cost and effort in making the claim to the manufacturer.

However, underperformance of the equipment is by far not the only problem when it comes to procurement. Other risks can arise as well, such as:
- Low quality and reduced reliability due to bad workmanship, pre-damaged materials (e.g. cells with higher tendency of cell breakage) as a result of weak QA processes in the factory
- Uncertified products which can occur if the manufacturer replaces materials in the product bill of materials and does not carry out re-certification and reliability testing
- Fraud due to fake materials or products

In the procurement phase of a PV project, there has always been a strong focus on the quality of the PV modules. The reasons behind this are understandable: modules represent a large share of total costs, are difficult/impossible to repair, and quality assurance results are often easy to interpret and address. The coupling of performance to purchase price, and conversely, low performance to yield loss, are some of the strongest arguments a buyer can use with a supplier. However, problems with other components have also been reported in the field. Inverters are certainly a blind spot when it comes to independent quality assurance during procurement.

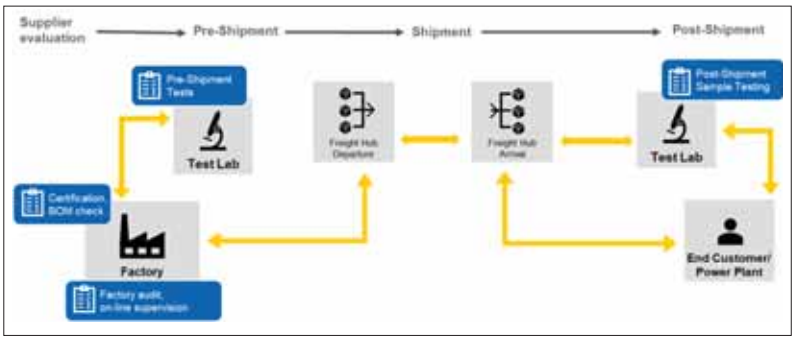
But at the same time the expectations are increasing. In the past, inverters were often operated in a protected and climatically controlled environment, such as in building structures (e.g. central inverters). Nowadays, more and more string inverters with 100 to almost 200kVA are operating unprotected in the field. This of course increases stress on the inverter and thus increases requirements around reliability and weathering resistance. In addition, more variability of operating conditions occurs.

Yield losses mainly result from underperformance in the field compared to the data sheet, but also due to downtime caused by inverter failures. In [NREL2019] it is reported that the majority of failures in PV power plants are caused by the power electronics. Possessing certification according to existing technical standards alone do not ensure that the specifications are fulfilled, and that the modules and inverters will operate in the field without any problems.

How can I make sure my equipment will perform according to plan?

Quality control and risk mitigation for procurement should begin at a very early stage in order to reduce downtime and output losses of the plant. It also helps avoid/reduce the time and effort in making warranty claims or even lawsuits against the manufacturer and replacing defective equipment.

Equipment buyers should specify



Credit: VDE Renewables

Figure 3: Diagram: Steps in the procurement process and the related quality assurance measures.

their quality requirements as well as the quality assurance measures that they plan to implement before they even start approaching manufacturers. Some PV module buyers for example, fail to agree on the terms for taking samples from production to be sent to an independent test lab. It is important to spread out sample selection across the different lines/workshops and production shifts and dates in order to ensure proper representativity during testing.

It is often the goal of manufacturers to limit sample selection to just a few pallets in order to reduce the logistical effort required. Potential arguments with the manufacturer can therefore be avoided if these conditions are agreed upfront with the buyer in their purchase contracts.

Engaging an independent quality assurance partner such as VDE Renewables is a best practice followed by many professional project developers. There are a myriad of quality assurance measures that a buyer can take advantage of, such as the ones listed below

- Review of product certificates and bill-of-materials (BOM) of the selected product – to ensure that the BOM specified by the manufacturer is properly certified
- Pre-production factory audit – to evaluate if the manufacturer's production facility meets industry standard
- On-line production supervision – involves the full or part-time supervision of production of the buyer's products in the factory. This helps verify that the product is being produced according to the contractually agreed BOM, and that quality parameters and processes are being followed properly.
- Pre-shipment inspection – after production, products are typically tested in the factory for quality and performance. The products are then packed and loaded in containers. This shall be witnessed by an independent inspector to ensure all quality parameters are properly executed.
- Independent lab testing – in order to independently verify the test results from the factory, buyers can have their purchased products tested on a sample basis at a third party testing laboratory. Additional tests can be carried out to verify claims made by the manufacturer about their product, for example for PV module resistance against Potential Induced Degradation (PID). These tests can be carried out at the country of manufacture (e.g. China) so that in the case that a batch fails a test and has to be rejected, it can be done so before the products are shipped to their end destination. It can also be additionally performed at the destination country as well as an additional measure.

The above-mentioned quality assurance measures provide buyers with the opportunity to establish "quality gates" during the procurement process. Should the equipment supplier fail at any one of these gates, the buyer can quickly demand for a replacement batch of equipment, which at the same time minimizes the impact on the project timeline thanks to early failure detection.

Buyers can further benefit from the neutral expertise of experience professionals to help define their quality criteria, analyse the results of inspections and tests, and explore corrective actions in case any quality shortcomings are found during the project.

Conclusion

1. Quality assurance in the earliest stages of the project have the highest impact on future performance and thus ROI of the PV plant. It also reduces cost and efforts for remediation down the road.
2. Independent QA also establishes trust with financial stakeholders and insurance providers at an early phase of the project, thus supporting a developer with acquiring financing and insurance thanks to the increased attractiveness of the project.
3. Some of the most critical focus areas for early stage independent quality assurance are the yield assessment and equipment procurement.
4. Streamlined and standardised quality assurance processes, which can be achieved for example by working with experienced independent experts, will reduce complexity, cost and effort.

■

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Beyond PR – New solar PV performance metrics for advanced technologies

Performance Ratios | As it matures, the solar industry is moving beyond the use of Performance Ratios (PR) as the go-to performance metric for operational sites. Christopher West, head of central engineering - solar PV delivery unit at Statkraft, argues the case for PRs to be replaced by alternative, more evolved methods of assessment.

Credit: Soltec.

The introduction of technologies including bifacial and trackers had complicated the production of Performance Ratio figures.

For many years the key performance metric against which Solar PV farms have been judged has been Performance Ratio (PR), essentially a ratio of how much energy a PV plant is expected to produce over a period of time against the amount of irradiance the modules receive. Contracts have been drawn up with clauses guaranteeing PRs of PV plants, and failure of the plants to meet this obligation can trigger heavy financial penalties for the EPC companies who have built them. In some contractual schemes, if PV plants fail to meet a PR by the end of their second year of operation (often called Final Acceptance), it is assumed that the PV plant will underperform by the same amount for the rest of its life. This lifetime might be as high as 25, 30 or even 40 years, and so the penalties to be paid for that shortfall can be very high if a plant is underperforming. It can happen to companies that their simulation assumptions are wrong, or too aggressive, or simply that some unknown environmental factor has upset the result, and the losses for such an error have been, in some cases, quite devastating.

Most companies will therefore be extremely careful with the simulations they produce, and it is very important for them to be able to control the risks and get a handle on environmental variables that might be out of the company's control. For example, the base PR does not take into account the effect of temperature or wind speed on plant performance. Over time, more sophisticated models have evolved; in some markets temperature corrected PRs have been introduced, to compensate for the fact that unseasonably hot years have a negative effect on the plant performance. In parallel, capacity testing methods such as ASTM E2848 have been developed to establish the relationships of the energy production with both temperature and wind speed via multiple regression techniques.

These methods have worked quite well up until the present day; they are by no means perfect, but they are fairly straightforward to understand and to calculate, and are easy to include in a contract. As long as an EPC understands properly the loss factors in the simulation they are undertaking, and include a certain amount of cautious contingency, then for a majority of PV plants it is possible to avoid getting their fingers burned, especially for systems with monofacial modules installed upon fixed mounting structures.

Technology is changing, however, and we are now entering a time when a huge

market shift is happening towards bifacial modules installed on single-axis trackers, potentially combined with battery storage systems. Bifacial modules make use of the sunlight that is reflected from the ground in addition to the top-side irradiance, and this rear-side irradiance is not as homogeneous as the irradiance coming down from the sky, increasing the uncertainty and the risks of calculating PR incorrectly. Battery systems can also add in another layer of complexity, especially when used in situations with a lot of grid curtailment.

Additionally, climate change is causing ever more extreme weather scenarios, with months being consistently labelled the hottest, the wettest or the driest on record. Although temperature corrected PRs can protect against record breaking temperatures, consistently high irradiances can also mean that clipping losses on plants with high DC/AC ratios can be higher, and drier years will increase the soiling losses without rain to clean the panels. These variations are not taken into account in any of the PR or ASTM calculations, and therefore represent an important risk for any company signing up to a performance guarantee.

The changes in technology and shifts towards more sophisticated technologies are therefore driving an interest in alternative or more sophisticated KPIs that can be used to guarantee system performance, ones which are less vulnerable to changes in the real-world variables that are out of the hands of system designers.

The Energy Evaluation Method

The equation for basic PR is essentially just a very basic model of the PV plant, which assumes a linear relationship between irradiance and energy generation, and which doesn't take into account any losses. The introduction of temperature corrections or corrections for wind speed make the models slightly more sophisticated, and help to account for some of the most important variables which are out of the designer's control, but if we want the equation to take into account the variability of other factors, such as clipping, power factor, the variability of cable losses or seasonal variation of soiling losses, we start to find that we are producing a very complex model, essentially similar to those that are used in commercial simulation software packages. This therefore beggers the question: why not simply use the simulation model itself in a contract, instead of using a basic equation?

The IEC standard 61724-3, which has been published since 2016, lays out an 'Energy Evaluation' method, the point of which is to obtain a 'Performance Index' instead of a PR. The index is obtained by keeping the same simulation model which was used to perform the contractual simulation, and then, at the end of the (usually annual) test periods, running the measured meteorological data from the site back into the simulation model, and comparing the predicted energy value against the real energy value. Depending on the sophistication of the simulation model, Performance Indices will be around the order of 100%, instead of PRs that are often 80% or so.

The advantage of this method is that it allows for a much larger number of climatic variables. As well as ironing out variations due to temperature and wind speed, a sophisticated simulation model can take into account losses due to increased clipping and higher ohmic losses in higher irradiance years, varying power factor being set by grid operators, varying albedo of the ground cover and even the soiling factor. As well as being a method that can reduce the exposure to risk from environmental factors the plant designer cannot control, it is also an excellent troubleshooting tool. By comparing the expected vs real curve for any single day, issues of plant performance can be more easily identified.

As the technology being used in PV plants grows more sophisticated, the models being used to simulate them are also evolving to take into account single-axis trackers installed over complex topography, bifacial modules and battery storage, in ways that a simple PR equation simply cannot capture. In the future the Energy Evaluation method may become the only realistic way to really evaluate the performance of such sophisticated projects. However, in order to achieve a wider adoption of this method, the commercially available simulation software packages need to evolve in order to make them more user-friendly to companies wishing to adopt the methodology. Commercial software packages have primarily been designed to make a prediction of yield in the future using historic climate data, and they haven't really fully developed their potential as performance monitoring tools.

The most important issue is that PR uses in-plane measured irradiance as a starting point, while simulation software usually takes the horizontal irradiance as a starting point and transposes it to in-plane irradiance. This makes a lot of sense when you want to make a prediction of energy in the future, but it isn't very helpful when trying to assess plant performance once the plant has been built, where in-plane pyranometers are installed. The transposition step can be quite accurate for a fixed-tilt monofacial system, but for tracker systems using bifacial modules, potentially employing sophisticated AI-based tracking algorithms, the transposition is extremely complicated or even impossible to predict accurately, unless the angle of the trackers at every point in time is also input along with the climate data.

Therefore, in order to use the Energy Evaluation method, it would be helpful if it were possible to directly input the in-plane irradiance values, measured on both the front plane AND the rear plane of the PV modules, directly into the model. Additional features that would be helpful would be the ability to input the angles of trackers and changes to grid conditions (such as changing power factor and export limitation) to at least an hourly resolution, and the ability to simulate the plant at the same resolution as the measured data. Many simulation applications are restricted to 1-hour resolution, but far greater resolutions are available from PV Plant SCADA systems. Although such changes aren't straightforward, such developments to the software tools would be hugely advantageous to the broader PV industry by allowing a broader use of the Energy Evaluation Method in contracts.

Monitoring of bifacial systems

IEC standard 61724-1 is the main standard that sets out the monitoring requirements for PV plants, including numbers and types of sensors required, as well as describing the standard and temperature corrected PRs. The standard is currently under review, with a current forecast publication date for late 2021. Some of the proposed changes are intended to take into account monitoring requirements when using bifacial modules, including additional sensors, and potential formulae for Bifacial PRs.

Bifacial PV systems are complicated, because the ground below the PV modules and spread across a solar farm can vary, both with topography and with changing albedo of ground cover due to

types of soil and vegetation. This means that the irradiance that is reflected onto the rear side of the modules will vary throughout the plant, much more than the relatively homogeneous irradiance that is seen on the top-side of the array. Additionally, the ground cover can change throughout the year, in some countries most significantly because of snow, but also because of changes in the vegetation throughout the seasons.

The inclusion of rear-side irradiance will always introduce a higher level of uncertainty into the yield assessment than when using monofacial modules, and so in order to try and minimise this uncertainty, more sensors are needed to measure the rear-side than the front-side, and these are spread out at different points in the plant, for example both at the ends and middle of rows, in order to try and capture as broad a cross-section of the situation as possible.

The type of sensors to be deployed will depend upon the methodology used to calculate plant performance, and what the inputs for this performance should be. If using a bifacial PR, or if using the Energy Evaluation method of IEC 61724-3 in a way that skips over the transposition step, then the sensors should be placed to measure the rear-side irradiance in the same plane as the PV modules. However, if the intention is to use the Energy Evaluation Method with the horizontal irradiance as the base input, then albedometers are used to measure the ground albedo instead; the simulation model then performs a transposition based upon the combination of horizontal pyranometers and albedometers to obtain the rear-side irradiance.

It might well be that the measured in-plane rearside irradiance and the derived rear-side irradiance from the albedometers are different, due to the fact the transposition model in the software is not completely accurate. At present, accurately predicting and assessing the performance of bifacial PV plants is difficult, and more work is required by the industry, research institutions and software developers to quantify the uncertainties in the models and introduce improvements to mitigate the risks.

Availability

Solar PV is a relatively peculiar industry in that the entire contractual performance of a plant is boiled down to one number, the PR or Performance Index, which somehow has to account for all potential problems and liabilities in the PV plant, and this number is often written down in a single contract and pinned to a single head who suffers the consequences if the reality does not live up to the modelling. In many other different types of projects, outside of the solar world, the liabilities are spread out amongst several parties instead of one. So, another solution to the problem of quantifying the performance of ever more complex plants in contracts might in fact be to side step the issue altogether, and instead focus the contractual obligations upon the reliability and quality of components and workmanship instead.

Perhaps additional emphasis or attention could be placed on another key KPI of solar PV – availability. Availability is a measure of the fraction of uptime of the main equipment on the plant with respect to the total operating time. For solar PV, it is tackled in IEC TS 63019, where the equipment is defined as being 'available' if it is capable of providing a service, independent of whether it is actually providing that service or not. Availability is typically defined in O&M contracts at a plant or inverter level. However, this level of granularity can be increased to string level monitoring as well if the equipment is available, and the concept of availability can be extended to other equipment as well, such as trackers.

With PR or even Performance Index, the EPC is in some way guaranteeing the simulation model being used, perhaps even more than they are guaranteeing the quality of the PV plant they are building. This focus on PR can actually obscure a lot of problems; although a higher availability will often mean a higher PR, this isn't always the case. In fact, on some PV plants, problems in plant quality can in fact be hidden behind high DC/AC ratios; if clipping is high, it is possible for several strings to be offline during the middle of the day and not affect plant performance at all. These problems can fester, multiply and ultimately become very expensive to repair later on in a PV plant's life. If string level availability is being measured, however, these problems can very quickly be picked up and resolved, and there is more of a motivation for companies to use higher quality cable and easier to maintain installation methods.

So, perhaps there is an argument for the PV industry to mature to the level of other industries, get rid of a 'single number' that tries to embody everything, and instead look at the individual guarantees of manufacturers while relying on availability metrics of inverters, strings, trackers, energy storage systems and communication equipment in order to ensure that the quality of equipment and workmanship is high.

In short, the PV industry is long overdue for an overhaul in the way performance and quality is handled in contracts, and change is becoming more pressing due to ever more complex technologies being used in utility scale PV plants. Perhaps the best contender as a methodology for handling these changes is the Energy Evaluation Method set out in IEC 61724-3, but in order for the industry to be able to implement this methodology, it is important for the developers of simulation software to take note of this standard, and to implement features that make it easier for companies to use measured data from site back in the models that were originally used to forecast future performance.

Bifacial modules introduce a particularly challenging set of factors that increase the uncertainties in modelling, and so it is a particularly pressing challenge for the industry and research bodies to understand and quantify the uncertainties of all the parameters used in simulation models. Perhaps the complexities are so great that we need to look beyond just a single number that defines a PV plant that may be misleading and may even hide quality problems behind it, and instead the industry should be paying more attention to different contractual structures, with more of a focus on KPIs such as the availabilities of the key components in the PV plant: the inverters, the strings and the trackers. Either way, though, as we move into a future of larger plants, greater risks and more advanced technology, it certainly looks like the industry has to move beyond PR. ■

Authors

Christopher West is head of central engineering for the solar PV delivery unit of Statkraft, with over 10 years working in the PV industry, and experience in managing development, construction and post-construction engineering of large scale PV plants. He is an active member and contributor to IEC international standards.

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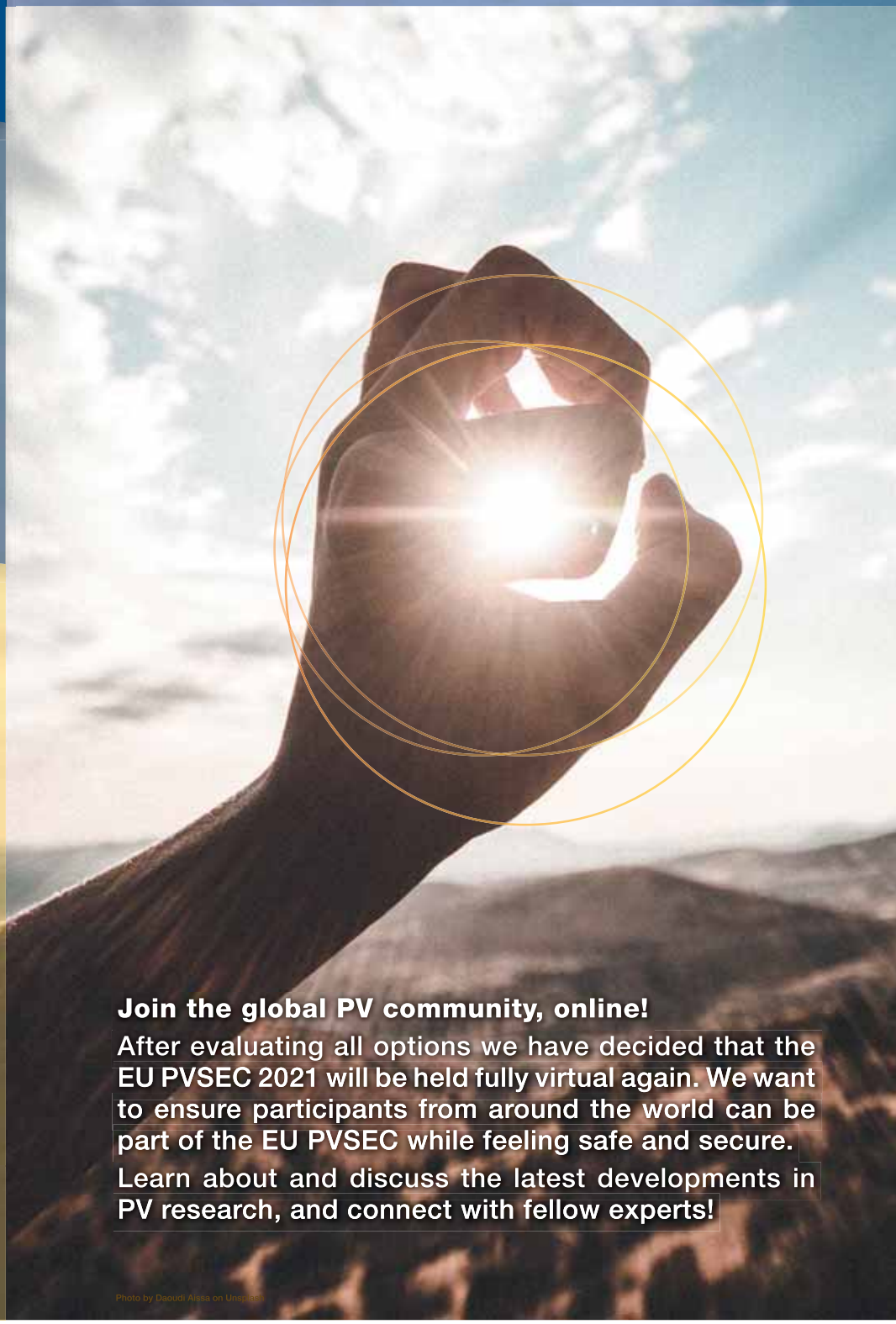

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Through gales and hail: Best preparations for solar under extreme weather

Extreme weather | The cost of insuring operational solar farms has skyrocketed over the course of the year, triggered by carriers rethinking their approaches to natural catastrophes and other extreme weather events. This has placed additional importance on mitigation strategies. Kevin Christy, COO for North America at Lightsource bp, details how the solar developer has adapted its strategy in the field.

Credit: Lightsource bp

Lightsource bp's Johnson Corner Solar farm, located in Kansas.

As I sit down to write this piece for *PV Tech Power* in the Spring of 2021, I'm able to reflect on the truly incredible events of the last twelve months and what they have meant for Lightsource bp and the US solar industry. The COVID-19 global pandemic caused us to reassess how and where we work, and it forced developers, equipment manufacturers, EPCs and asset owners to learn how to meet the needs of their businesses, customers and stakeholders while keeping their employees safe from sickness and harm.

In Spring of 2020, just as the COVID-19 crisis was ramping up globally, Lightsource bp experienced first-hand a new hardening of insurance markets as carriers dramatically rethought their approaches to natural catastrophe ("NatCat") risk to solar farms in the United States. While we haven't had the need to file any claims so far on our operational projects, insurers did get hit heavily in 2019 with claims for flooding and wind damage, fire damage and damage from hail. On our first Operational All Risk ("OAR") renewal, we were seeing for the first time separate sublimits and deductibles for various categories of weather risk, especially from hail, flooding and "named storms"--meaning tropical storms or hurricanes that meet the National Weather Service ("NWS") criteria for being assigned a name from their rotating list each year. The net result of these changes was to move significant risk exposure off the insurers' ledgers back onto project owners. Our insurance broker-consultants declared that the industry was in a "hard market" that might take as long as several years to stabilise, during which we would likely have to navigate new and renewal insurance placements for several gigawatts of solar capacity.

At Lightsource bp, this news had two immediate impacts: first, we doubled down on the level and sophistication of our NatCat screening for our projects, which involved upleveling our GIS capabilities to better understand and convey to insurers the potential NatCat risks to our projects

and what we are doing to mitigate those risks. Second, we conceived and launched a comprehensive program designed to protect our solar farms as much as possible from the damaging effects of large hail stones, with several new and innovative aspects. These two efforts have borne fruit and we're pleased to share lessons learned to date with the industry in the hopes that through collaboration with other developers and asset owners on tools to help us better understand and manage weather-related risks, we can collectively benefit from the old adage that a "rising tide lifts all boats". The more we can as an industry materially reduce the risk of loss, the more favourable terms we will be able to achieve with insurance carriers and the lower losses asset owners will have to absorb.

And those potential losses are already significant: of the 51GW of installed solar capacity across the United States by year end 2020, about 29GW are installed in states that we consider high risk for hail damage (from the Gulf of Mexico north to the Canadian border along with a number of states east of the Mississippi). That results in an estimated US$8.7 billion of module replacement value. Using Wood Mackenzie's recent US Solar Market Insight 2020 report[1] forecasts, that replacement value will double by 2024 to US$17.7 billion and nearly double again by 2030 to almost US$31 billion in replacement value for over 100GW of solar capacity in states at high risk for hail damage. Clearly, real investments in hail damage mitigation by developers, asset owners and equipment suppliers are not only called for but urgently needed.

Lightsource bp's Hail Mitigation Program

Lightsource bp's approach to hail mitigation involves using real-time weather intelligence to protect solar farms from damaging hail; improving our understanding of the hail phenomenon through dedicated sensors, higher-resolution wind data and careful event logging; making smarter procurement decisions; and optimising insurance products and underwriting around a better knowledge of hail risk at a site-specific level, taking into account the actual equipment choices for each project. I'll deal now with each of these workstreams in some detail.

Alerting

Effective mitigation of hail risk has, at a minimum, three elements: single- or dual-axis trackers with the ability to rapidly move from its current operating tilt to a hail mitigation tilt as rapidly as possible; a means of alerting the site operator that a hail storm is imminent, and a means of advising the site operator that the storm has passed and the site can return to normal operations. On the first element, our current tracker partners have released remote operation tools designed to simplify and speed up the entry into hail mitigation mode, along with helpful guides to the appropriate use of the tool. That leaves the need for weather intelligence that can alert site operators of both when to go into hail stow and when to return to normal. From our perspective, that weather intelligence would need to have zero false negatives, meaning 100% of hail storms hitting the site would have been preceded by a targeted warning, and the warning would need to come in time to move the trackers into full protective tilt.

Credit: US National Weather Service

Highlighting the number of severe hail days experienced per year, between 2003 and 2012.

Given these constraints, we quickly ruled out hail sensors as a means of triggering the dispatch of the trackers, for obvious reasons—by the time the hail sensors started registering hail strikes, the site would be at increased risk of damage until the trackers were able to move into full protective tilt—a two-to five-minute window of time out of a typically 15-minute hail storm event. For our program to hit its goal of always being in full mitigation before a potentially damaging hail storm strikes, we needed more advanced warning.

In the United States, we benefit from decades of development in storm monitoring and prediction through the National Weather Service's Storm Prediction Center out of Norman, Oklahoma[2]. The Norman centre produces and updates daily a number of forecasting products, including a Thunderstorm Outlook and a Convective Outlook, with Convective Outlooks for Day 1 (current day), Day 2, Day 3 and Day 4-8. Convective Outlooks can develop into Thunderstorm Outlooks the day of a potential thunderstorm event, and specific areas of the country can be issued Hazardous Weather advisories. As the centre gains confidence about where and when a potentially hail-generating storm may strike, they will issue Severe Thunderstorm Watches, which may develop into Warnings as confidence increases about imminent thunderstorm activity within the region of the Warning.

In an ideal world these Warnings would be sufficient trigger for our needs. However, the NWS targets 0-30 minutes pre-strike for these Warnings which again leaves some risk that the site would not be alerted in time to be in full protective posture before a storm actually struck. In addition, the NWS does not produce for the general public a digitalised version of their web-based Warning products, preferring to partner with commercial weather services to offer more sophisticated products that build on NWS data.

To that end, Lightsource bp has been working with one such weather service provider to develop algorithms that target a minimum 30-minute warning to each of our sites in high hail risk areas. To date, all back end to back end communications and protocols have been fully tested, and the warning algorithm itself will have entered testing by the publication of this piece.

Finally, we intend each warning to further serve as a safety alert to site personnel, as hail that can damage modules may also cause injury to staff—so giving them fair warning to seek cover is a vital part for us of a successful hail mitigation program.

Mitigation

To know what tilt angle and direction is appropriate at each site, we worked with the tracker manufacturers to develop a "rules engine" that takes into account each tracker's maximum tilt angle, preferred direction of tilt (east or west, based on prevailing wind direction), wind speed and direction at the site, and any higher priority stow mode that may be in effect (flood, for example), taking into account manufacturer guidance and warranty terms. That rules engine has been vetted with each manufacturer and will be updated continually as the manufacturers introduce new models and update their operating instructions for each.

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With the instructions as provided by the rules engine, the system can email dispatch orders to a pre-defined list that would include the O&M provider's operations centre, the site supervisor and the Lightsource bp asset management team responsible for the site—defining the start time of the event for data logging and analysis. Future development would take that to full automation, with dispatch commands being sent directly to the tracker controller at the site and notification emails being sent to advise interested parties that a hail stow dispatch command is in place. Similarly, as an All Clear notice comes in from the weather service, the system can return the trackers to normal operating mode automatically, defining the end time of the event.

Recovery

We are developing inspection and monitoring protocols designed to assess the site for damage immediately post-event to quickly identify any damaged modules, and over time using data analytics to detect the presence of propagating microcracks. Post-event assessments will likely include drive-downs looking for physical damage, drone flights looking for module hot spots, and field EL-scans to confirm any microcracking in modules that are showing hot spots in IR scans.

Sensing

While hail sensors aren't appropriate as triggers for hail stow, they can provide higher-resolution data about the volume of each size of hail stone that hits the site. Further, on larger sites, multiple sensors can be deployed to capture spatial differences in the size and volume of hail across the site. We can then pair that hail data with post-event inspection data to better understand how a particular profile of hail storm may result in particular damage patterns and how those damage patterns may change for modules of varying construction.

Insurance optimisation

By all indications the loss models that insurers are using to evaluate and price hail risk to solar farms are blunt instruments compared to loss models developed from the ground up using site- and manufacturer-specific experience data that take into account the hail mitigation capabilities that may be in place. This will be an ongoing effort, partnering with the risk analysis team at our insurance broker-consultants, third party advisors and our insurance providers to continually refine our understanding of this risk. However, even in the near term, merely having a program like the one described in this article can result in some improvement in commercial terms from insurers such as lower deductibles, fewer exclusions, higher hail sublimits and lower premiums if the program can convey enough confidence that the program will meaningfully reduce carriers' risk of loss on the project or portfolio.

Module durability

Finally, a key piece of any long-term hail mitigation solution has to include a better understanding of how various modules perform under hail storm conditions. Current UL pass/fail hail testing protocols don't provide enough data about the relative performance of different modules under different sizes of hail stones striking at angles other than 90 degrees. Ideally, a more "test to fail" protocol would provide enough data to asset owners to actually drive procurement decisions, with potential trade-offs of initial capex against the net present value of losses due to hail over the project's lifetime. Over time, with improved test protocols such as RETC's Hail Durability Test (HDT)[3], module procurement decisions can be much better informed. RETC's HDT protocol pushes well beyond the limitations of existing UL tests and would serve as a more useful comparison across manufacturers and construction methods. Our hope and intent is that before too long, tests like the HDT will predominate and the results will be widely available to asset owners and purchasing decision-makers. Without such data, building better loss estimation models may always be limited by a least common denominator view of module durability.

Our hail mitigation experience to date

As the commercial weather service algorithm and end-to-end automation are in development, we are using the NWS' weather intelligence products to inform us as to project-level risk from developing thunderstorms, usually beginning 1-2 days prior to the anticipated event. When it appears that a mitigation order will likely be issued, we send an informational advisory to our O&M partners at each site with the text and charts from the NWS as context. We clearly mark the email notice as "informational" to avoid any misperception that any particular action is requested.

These informational advisories are then forwarded on to any Lightsource bp construction team that may be building a project within the threatened region so that our site staff and construction partners are aware of approaching severe weather. Even where control functionality may not be available yet at a site, we have developed in conjunction with our tracker partners a set of Standards of Care guidelines for how to lock down trackers into a protective posture against hail prior to a transfer of care, custody and control to our O&M partners, which is when our hail mitigation program as described above would go live for that site.

So far this year, we have issued ten separate hail mitigation orders for our operational projects in Kansas and Texas. Three of those events did result in hail strikes of stones about 1,25" in size or less, with no detectable damage.

The path ahead

At Lightsource bp, we've become advocates of increased industry collaboration to reduce the risk of hail losses to EPC providers during construction, asset owners during operation and of course to our insurance partners throughout. It is in this spirit that we have provided this level of detail into our workstreams, methods and experience to date. In a very real sense, we are all in the same boat together and the scale of the risk warrants more coordination, cooperation and transparency. We believe that with each industry segment working intently to reduce its contributions to the overall risk, losses will reduce and insurer confidence in these efforts will increase. ■

Authors

Kevin Christy, COO, North America, Lightsource bp

Kevin Christy is a veteran renewable energy executive and recognized voice in the industry since 2002. As COO, North America, Kevin manages the operational needs of Lightsource bp's North American fleet. Kevin co-founded the utility-scale PV developer Axio Power in 2007, which successfully sold to SunEdison in 2011. While at SunEdison, Kevin managed the North American utility-scale development portfolio, served as General Manager of North America for SunEdison's Global Services O&M and asset management team, served on the Advanced Solutions energy storage team developing next-generation commercial applications for battery energy storage, and served as the COO of SunEdison's North America Utility team.

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Extreme weather protection: how to 'weatherise' a solar installation

Weatherisation | With extreme weather events becoming increasingly common, Molly Lempriere takes a look at how to ensure a solar installation is prepared to manage wind, hail, heat and anything else nature has in store.

Credit: Nextracker.

Trackers allow panels to move into a defensive stow position ahead of a storm like this in Australia, dramatically reducing the wind load on the panels.

The impact of extreme weather on solar installations has become an increasing concern in recent years. The effects of climate change are being felt more acutely around the world at a time when the economics of solar allow it to be installed across a wider range of locations. With this growth has come a shift from insurers, with more than 80% of claims value originating from weather-related damages, according to insurer Lloyd Warwick International.

Fraser McLachlan, CEO at renewable energy insurance company GCube, says: "Over the last two or three years, there has been an exponentially increasing risk profile when it comes especially to solar and extreme weather."

While traditional insurance perils – earthquakes, hurricanes, and floods in flood zones amongst other events – can be modelled and therefore more easily managed, there are increasing instances of extreme weather that fall outside the normal bounds.

"What we've seen though, over the last 3/4/5 years is more losses in renewables with regards to extreme weather," adds McLachlan. "Things like hail, which is way more unpredictable, heavy rain, tornadoes, small scale wind events, microbursts and things like that, which have caused significant damage to renewables, and in themselves are much harder to mathematically model from an insurance perspective."

With insurance costs rising in response, solar developers and operators are increasingly looking to 'weatherise' their systems in an effort to best protect their sites. But how do you design, develop and manage a solar system to protect it from extreme weather, especially if such instances are so unpredictable in their nature?

Pushing wind testing

Ensuring your solar system can survive extreme weather events begins at the design and testing stage of development. Alex Roedel, senior director of design & engineering at tracker manufacturer Nextracker, says one of the most common mistakes is insufficient wind tunnel testing of solar systems.

This is particularly true with regards large-format solar modules, which are

Proving PV performance in desert climates: A case study from the QEERI Solar Consortium

It's July in Doha and the sun is beating down on the PV test field of the Qatar Environment and Energy Research Institute (QEERI). A string of bifacial modules is being baked to 70°C by more than 1,000W/m² of sunlight. With over 40% albedo, the modules are generating an Amp of current above their STC rating. A sandstorm yesterday covered the modules with dust, which was cleaned this morning by an autonomous robot. Tomorrow morning, humidity will have the modules dripping with dew.

Treatment like this can't be reproduced in a lab, which is why top solar-equipment makers have joined the Solar Consortium in Qatar. The Consortium runs private equipment testing and collaborative research projects at QEERI's Outdoor Test Facility. It's a unique approach. This case study of Hanwha Q CELLS shows how it works.

PRIVATE TESTING PLUS COLLABORATIVE RESEARCH

The Outdoor Test Facility has been running continuously since 2013. When the Solar Consortium launched in 2018, Hanwha Q CELLS was one of the first companies to join. Dr. Max Köntopp, the company's director of Global R&D Test Labs, said that desert testing in Qatar helped the company validate its modules' resistance to light- and heat-related degradation mechanisms, and study the effects of heavy soiling. It is currently testing different strings of six modules each, connected to 2.5kW grid-tied inverters.

The company receives PV electrical and temperature data, which are recorded every minute alongside meteo information. The site's advanced weather station includes a spectroradiometer, soiling and even dew-mass sensors. Once a year the modules are flashed in QEERI's adjacent PV Reliability Lab with an A+A+A+ sun simulator.

In addition to its private PV testing, Hanwha Q CELLS joined the consortium's group project to study module abrasion in real-world conditions. The consortium purchased a commercial PV cleaning robot and abrasion sensors, and member companies provided modules and coupons for long-term field testing. Group projects such as this generate results that would be difficult for one organisation to achieve alone.

HOW TO JOIN

The Solar Consortium is open to companies across the PV industry. Current members include DSM, Hanwha Q CELLS, Kahramaa, Maxeon Solar, Nice Solar Energy, QEERI, Soltec and Total. For more information, please contact qeeri-communication@hbku.edu.qa

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Credit: Nextracker/JinkoSolar/Nextracker/J.

Load testing, such as Nextracker is undertaking in this image, can be key to ensuring a solar system is prepared for extreme wind events.

now being adopted en masse as solar system design principles mature. Larger chord and row lengths in these panels increase wind loads, putting them at greater risk of damage.

According to Roedel, one of the first considerations solar developers must make when looking at weatherisation is wind tunnel testing for all components. Nextracker suggests static wind tunnel testing, wake buffeting-based dynamic analysis, single- or multirow computational fluid dynamics (CFD) analysis and a full three-dimensional multi-row aeroelastic study. This allows companies to ensure their site can withstand not just static wind, but also aeroelastic wind effects that occur due to dynamic wind instances when installed and operational.

Most panels are designed to withstand wind speeds of 140 miles per hour (mph), although the regulations for installations vary from region to region. For example, in most cities in Florida where hurricanes are a concern, solar systems must be able to withstand winds of at least 160mph. Internationally, systems must pass a series of tests set out by the International Electrotechnical Commission (IEC) to ensure that they are weatherised, including IEC 61215 and IEC TS 62782, which include static and dynamic load testing.

While this provides a good basis, Roedel questions whether they go far enough, arguing that the tests aren't comparable to real world events. For example, one test involves placing a bag of sand on a panel for an half an hour to test its ability to withstand load. This is not "indicative of real life" he says, highlighting that strong winds are not a source of constant pressure on a module, but flex throughout a storm. As such, when choosing modules for a project being developed in an area prone to storms, components must be tested beyond those standardised levels.

While this testing is particularly significant for module choice, developers must also consider the benefits of tracking systems when planning a solar site in an area prone to high winds. A tracker would allow modules to be moved into a defensive stow position, based on the site configuration to protect the installation. By defensive stow facing them into the wind, it can dramatically reduce the load placed on the modules in such situations.

Additionally, sometimes it is the smallest components that can make the biggest difference in terms of protecting a solar installation from extreme winds says McLachlan. "We saw in Puerto Rico, for example, the way some of these projects were built, just spending another 20 cents on a different type of bolt to keep the actual panel more securely fixed to the mounting would have saved millions of dollars. But they wanted to save 20 cents a bolt, so they put the cheapest bolts in."

Hail no: the benefits of dynamic systems

Beyond wind, one of the key weather risks for solar projects is hail. Hail testing has been in place in the solar sector since the late 1970s, and features 11 impacts of a one inch diameter ice ball, propelled at solar panels at a terminal velocity of 51.5mph. Nextracker also reserves criticism for the extent of the testing in this field, writing in a recent report that: "industry-standard qualification test requirements are not rigorous enough to characterise perils in hail-prone regions."

300%
How much more kinetic impact energy required to shatter framed PV glass in modules stowed at 60° versus a flat stow position.

Currently, all PV modules pass product certification hail impact tests, but with worsening weather the size and impact of hail is growing. In a test conducted by Nextracker and the Renewable Energy Test Center (RETC), the stow angle and direction of modules and their link to hail resistance was assessed. The study found that 300% more kinetic impact energy is needed to shatter framed PV glass in modules stowed at 60° versus a flat stow position. A report produced by the RETC following the study stated that stowing modules facing into the wind at 60° can significantly increase the survivability of PV panels from 81.6% to 99.4% during a hailstorm.

This again is particularly pertinent when looking at large-format modules, as the larger surface area and thinner glass makes them vulnerable to hail. The same can be said for the use of bifacial panels in areas prone to hail, with thinner glass leaving them more exposed to the impact of the ice.

"Hail, at least in the United States has rocked the industry," adds Roedel. "There was one particular site in Texas that got hit with US$80 million of damage. So while bifacial panels might be great, what's happened is we went from a standard 3.2mm thickness glass on the front side to 2mm on the front side and 2mm on the backside. Combine that with a larger format, what you have now is panels more vulnerable to hail and more vulnerable to impact."

Taking advantage of snow: bifacial panels and the Albedo effect

There are occasions when extreme weather can work in a solar asset's favour, for example using bifacial panels in snowy areas. A study by Sandia National Laboratories entitled *'Snow as a Factor in Photovoltaic Performance and Reliability'* found that in winter months, bifacial-plus-dual-axis tracker units performed 41% better than bifacial-fixed-tilt installations thanks to the rear-side irradiance created by the higher Albedo factor.

This increased generation makes bifacial panels a key consideration for developments in regions more prone to snow, and are already enabling bifacial panels to push out into regions previously thought uneconomical. But there are still concerns developers must take into consideration, not least the impact of snowfall accumulation on the panels – blocking light but also creating a potentially damaging weight. A study conducted by Silfab Solar found bifacial panels were better than monofacial panels at self-shedding major snowfall even at low tilt angles. Those at a 20° tilt angle shed snow faster than monofacial at 40°, lowering snow-related production losses.

As such, when looking at components for solar developments in areas prone to snowfall, bifacial provides notable benefits, especially when paired with the flexibility of dual-axis trackers.

Keeping the air flowing: installations and extreme heat

As solar markets in the Middle East and other arid regions continue to grow, the risk presented by extreme heat increases too. Modules are generally tested to ensure they can continue to operate at or below 70° Celsius for 98% of the time according to Colleen O'Brien, principal engineer at Underwriters Laboratories.

While modules can manage short excursions above this threshold, if it is likely that they will spend more significant amounts of time above it, there are modifications to the testing process and the modules themselves developers should consider.

The need for airflow is a key consideration in this regard given its ability to ensure that systems do not venture above that 98th percentile. Open rack systems generally provide sufficient airflow in utility-scale installations, O'Brien says, but it's more complicated when looking at rooftop or building integrated PV systems where often they are in direct contact with the building with no cooling from the back.

While the current technical specifications allow for testing and modifications up to 90° Celsius, beyond that bespoke testing and modifications will be needed. According to O'Brien, in some regions like the Middle East, a module with an insulated back on a roof could exceed those temperatures and, as a result, would need custom research and development, as well as potentially new materials to be used inside the modules.

In slightly less extreme heats though, O'Brien notes that there are current industry wide recommendations for the encapsulant and backsheets. "In addition, the connectors and junction boxes that are used with PV modules, if they are used at elevated temperatures, should also be tested at higher temperatures in the qualification tests," she says. "And for the PV modules, the testing that they undergo is modified, the hotspot endurance test, UV exposure test, temperature cycling test, and bypass diode tests are all conducted at higher temperatures, if the modules are to be rated for high temperature applications."

Utilising a range of these tests should allow developers to ensure their module choice can withstand the extreme temperatures they are predicting. While as with other extreme forms of weather, having a dynamic installation that takes advantage of trackers systems can additionally help to mitigate some extreme heat. Should temperatures exceed 70° Celsius for longer than 2% of the time however, they can be used to rotate the modules away from the sun.

But this is not an ideal situation to find yourself in. "If you needed to rely on the tracker to move modules away from the sun to prevent high temperatures, you're probably really close to the edge of exceeding the limitations of the products and it would be better to design them for the expected temperatures at that site," says O'Brien. "But I think you could slightly reduce risk by monitoring PV temperatures and rotating them away from the Sun if needed. If temperature started to approach the maximum rated temperature, say 70°C, I think it's possible."

Smartening up O&M

When up and running, operations and maintenance (O&M) works can also help to manage the impacts of extreme weather on solar installations. This can be in small ways, like catching wear before it is exacerbated by weather.

"There's a lot of exposed wiring in PV systems and I have seen wind cause displacement of the wiring over time, it can start to get damaged… and it could lead to arching, which could cause a fire or shock hazard," O'Brien says.

Some of the impact of extreme heat like abrasion and degradation can also be addressed through monitoring and maintenance. If a site's performance is falling, simple field work should be able to determine what the cause is and identify where modules need to be replaced, which can in turn prompt warranty checks, all of which can fall in the scope of works for an O&M provider.

Monitoring has undergone a technological jump in recent years, with Nextracker's Roedel pointing to the impact smart controls have had on O&M. It's possible now for people to manage large portfolios, of two or three gigawatts spread across the world all at once, simply by connecting them all using smart controls.

"You have a control panel that shows you everything on your sites, whether it's wind, hail situations, there's snow, there's flooding, all these different aspects that you can read into using your interface. And so as the owner, you know exactly what's happening on your site," he explains.

"Comparatively, two or three years ago, without the software capability, you'd essentially be in the dark. And you'd have to send someone out physically to [the] site. So if we're connected, and we know that health of every single tracker within our system, every single inverter within our system, that's really going to have such great value to the owner."

The growth in operational software has also allowed companies to increase the weather mitigation abilities of historic sites as well. For example, Nextracker is going back and installing flood sensors on sites which will lead to software updates that can manage the impact of extreme weather events like flooding and hail.

The next big concern?

As the solar sector continues to grow and push out beyond its traditional markets, extreme weather events are going to be a more common concern for many. But with the right testing that can educate the right component choice, and smart software to manage operations once up and running, the durability of solar is winning out.

Each installation will be different, with different concerns and considerations based on the site, but ensuring a level of flexibility in an installation seems to have few downsides and allows for systems to react to events that may not have been considered at development.

But stormier clouds could be on the horizon, especially as weather events become more severe and more common. The Texas winter storm in February 2021 was illustrative of wider trends given that a similar event happened a decade ago, and lessons were not learned in time. That these events are happening with greater regularity is of concern. "We weren't talking about the dynamics of trackers in 2015. We weren't talking about hail in 2018. What are we going to be talking about in 2025? What are we going to be talking about in 2030? That's a big thing, and that's what really scares insurers who have forced this conversation," says Roedel.

"That's why I'm just so big on the software aspect, because there could be a risk that happened next year that we don't even know about today." ■

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The yin and yang of Agri-PV: Bringing together the best of both worlds

Agrophotovoltaics | Stephan Schindele, head of product management Agri-PV at BayWa r.e. Solar Projects, explores the mutual benefits of 'Agri-PV' to both solar farm operators and farmers alike, and reveals what is needed to take the sub-sector forward.

Credit: BayWa r.e.

Agri-photovoltaics (Agri-PV), where PV modules are used to optimise agricultural processes, is turning a lot of heads in the renewable energy and farming community. While in the past it was a question of either food or solar energy production on farmland, Agri-PV can combine both.

This bold application unlocks dual use of cropland by integrating PV modules above the crops, enhancing climate resilience and allowing sustainable food and energy production on one single piece of land.

Today, we're looking at how technology is adapting to accommodate fruit grown beneath the panel. What lessons can we learn from these early projects pushing production boundaries and how are they helping farmers face up to the climate challenge?

The story so far

To date BayWa r.e. has undertaken several pilot Agri-PV projects across the Netherlands and Germany, which have been helping to deepen the industry's expertise. These projects focused on wheat, potato, celery, blueberries, red currants, raspberries, strawberries, and blackberries. Currently, BayWa r.e. is also installing an Agri-PV research facility at an apple orchard.

One of BayWa r.e.'s first commercial Agri-PV sites in Babberich, the Netherlands.

Two of these projects, located in Babberich and Wadenoijen in the Netherlands, have now moved on from being 'pilots' and are fully fledged commercial projects in their own right. The raspberry growing Babberich site is counted among the biggest and most sophisticated in Europe.

The pilot project in Heggelbach,

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Credit: BayWa r.e.

Germany, uses bifacial PV modules - utilising the albedo effect to increase solar power yields. While this project was a success, BayWa r.e. found it made more sense to elevate the PV modules to a higher level and substitute existing farming protection systems on cash crops. This approach can be seen on the latest 'fruitvoltaic' project in Wadenoijen; this project uses 4,500 PV modules to cover 4,500 red currant plants and was installed in March 2021.

Using monocrystalline panels constructed specially for the projects, engineers were able to balance protecting berries from the elements with giving them enough light to grow. Standard PV modules obviously aren't fit for this task, as light needs to reach the plants.

These monocrystalline modules are specially constructed to let light pass through while still absorbing energy, with different levels of transparency tested to find out what would suit each fruit variety. This optimisation process in photon management between photosynthesis and photo-electric effect is the yin and yang of Agri-PV.

Meanwhile, below the panels, the crops' environment has been fine tuned. The pilot projects grew berries, fruits requiring notoriously precise growing conditions to come out big, sweet, and juicy. Extremes of either temperature can negatively impact the quality of the fruit, so control is crucial.

Crops grown underneath the panels at BayWa r.e.'s sites include different forms of berries.

Early signs show exceptional promise. On hot days, conditions beneath the panels are around two to five degrees cooler than traditional growing methods. That brings significant benefits; less heat stress and evaporation from the soil reduces water demand.

At night, heat gets retained even better than under the plastic coverings farmers currently used to protect berries from the cold. Humidity is another factor, and the environment beneath the panels keeps it more consistent 24 hours per day.

The elements are famously fickle. Those plastic coverings often fall prey to high winds, leaving berries unprotected and prone to damage, while crops risk going to waste. Too much water retained on the leaves allows fungus to grow, damaging crop yields. The thicker, more robust PV panels used in these Agri-PV trials provided excellent protection.

All this seems like a hugely promising head start. In the time since these pilots were declared successes, BayWa r.e. has been able to reflect on what a wider rollout of these sites would look like in practice.

Constructing the ideal growing environment

Adapting a fruit farm to capture solar power takes a very specific approach to constructing both the panels and the containers for the berries to grow. Materials can't impact soil fertility and support pillars are laid out so as not to obstruct planting and harvesting.

For those growing containers, the pilot projects highlighted how much raw potential there is to integrate different subsystems which can make farmers' lives easier.

As mentioned, too much water isn't favourable for the sensitive berries. So, incorporating rainwater harvesting, rain gutters and water storage subsystems adds extra protection. Water is captured, treated with fertiliser and plant protection products, then recycled once it has been used to grow crops.

As well as being efficient, this could ease tensions between farmers and the water sector. With water in finite supply, suppliers do not appreciate being given large quantities of treated water from farmers and being told to make it potable again. Using and recycling rainwater cuts down that pressure.

A good harvest can also present its

own challenges. Branches laden with fat, juicy berries can bend and crack under the weight of their own success. Traditionally, these branches would be supported with wires whenever farmers noticed them drooping. The subsystems underneath the Agri-PV panels incorporate these supports as standard. Farmers spend less time looking over their shoulders, micromanaging plants branch by branch.

Of course, we humans aren't the only ones partial to these sweet berries. Insects have been the farmer's natural nemesis for thousands of years; protecting plants means using chemicals or encasing them entirely in foil. This new environment incorporates far more effective and efficient insect protection into the mounting system.

Improved water usage, less micromanagement, and increased protection are the three standout lessons learned from the success of the pilots. The ability to tweak fine details of growing conditions also adds huge benefits.

The benefits of digital farming

Early frost warning systems interact well with environmental controls. In turn, these controls can detect when the plants are too shaded from the sun and activate LED lighting at key points throughout the day.

The interplay between these systems gives farmers minute control over the environment. The parameters of that environment can be identified as part of the farm's water cycle. Humidity, temperature, solar radiation, soil temperature, even leaf wetness can be measured and controlled.

Algorithms work out the consequences of changes to the environment and make suggestions to farmers via a web portal and app. The entire system can then connect to weather satellites which provide the macro 'big picture' of each individual farm's context. BayWa r.e. is using the products and services of NEXT Farming and thereby leveraging synergies and competence from its own parent company, BayWa AG.

Agri-PV farming has the potential to create a large amount of data which can be used to refine future projects and control growing environments down to the fine details. But farmers have to buy into these projects and see value for themselves and their customers if they're going to change centuries of tradition. What effects do such advanced growing conditions have on the daily lives of those working with them?

The effect of Agri-PV on traditional agriculture

When you think of farming, you envision long days in the fields manually tending to every inch of land by hand. There's a certain romance to that idea; the notion of a farmer so in tune with his crops that he can spot and correct potential issues merely by looking at them. As with all romances though, the reality is a little grittier.

Commercial pressure on farmers in northern Europe means any help is very much appreciated. Even if we isolate the benefits we just mentioned; environment control and access to better weather forecasting, that alone carries enormous potential to assist farmers. Communicating a wider sense of value to farmers is crucial, as some farmers may be sceptical regarding the cost saving potential. Understandably, they fear both the losses in their agricultural production and higher costs of maintaining the PV installation.

But on the other hand, farmers will have lower operational and investment costs, as well as far less waste and improved quality of the fruit. Agri-PV diversifies a farmer's income with multiple viable revenue streams and, of course, the land is performing two vital jobs instead of just one, helping farmers in addition to decarbonise their farming activities.

For a project to be viable, a contribution margin analysis needs to show positive financial returns on the agricultural products. It's not a case of solar power propping up the crops, or vice versa. Both need to turn a profit.

The pilot projects grew berries; blueberries, strawberries and the like. Current Agri-PV technology lends itself well to crops with shorter lead wetness phases. As it matures, we'll start to get a clearer picture which might educate crop selection.

Further pilot projects on other crops in the Netherlands and Germany are set to expand our ideas of what's possible. Initial projects placed solar panels at a height of five metres, enough for harvesters to pass through. However, the perfect height for projects is still something that the pilots are trying to ascertain.

The fact that Agri-PV is such a young application of an established technology means now is the time to work closely with farmers to see what does and doesn't work in practice. It's important to note that farmer satisfaction was a key metric for the pilot projects.

Without the thumbs-up from those using the technology every day, none of the pilot sites could be considered a success. The fact that farmers approved so strongly of new Agri-PV methods suggests strong potential for wider uptake. However, for that to happen, we need to be having honest conversations with the farming sector about the benefits and challenges of adopting Agri-PV.

The real cost of Agri-PV technology

The nature of the elevated, transparent panels used specifically for these projects means that, on the surface, upfront costs will always be higher than ground-mounted PV modules. Cost drivers include specialist construction and installation of transparent modules and the lower power yield per area.

In Europe, the levelised cost of electricity for berry cultivation sits at around eight cents. For tree-grown fruits like apples, you might expect around nine or ten cents. Compare that to a cost of five to seven cents for ground-mounted units.

Reasons for this are fairly clear. Constructing special PV modules which actually generate less solar power then standard ones might seem like a tough sell at first. But in context, that thinking is like comparing apples to pears.

For one thing, those costs are likely to come down as the technology becomes more widely accepted and perfected. Ground-mounted PV modules have been iterated and improved over a 20-year period, Agri-PV has been in development for maybe two years. Given that the difference in levelised cost is a matter of a few cents, that's actually very promising for Agri-PV.

It's also short sighted to compare it only to ground-mounted PV units. Building-mounted PV has been in development for a similar amount of time, decades, and still

Developing quality control standards in Agri-PV

BayWa r.e. has been involved in developing standardisations for Agri-PV since 2019. The aim of this work is to set out quality standards for Agri-PV systems and to ultimately reduce the technical risk for all project participants, with a particular focus on the farmer. This work has helped to support the recent launch of the German Agri-PV standard - DIN SPEC 91434 which was recently published in April 2021. The standard, which was initially developed by the Fraunhofer Institute for Solar Energy Systems ISE and the University of Hohenheim, sets out the requirements and quality standards needed to define an Agri-PV project. The standard looks at the main agricultural uses for Agri-PV as well as elements such as the standards for planning, operation, ongoing monitoring, and documentation.

Credit: BayWa r.e.

Mounts of different heights have been assessed to accommodate different crops.

comes with a levelised cost of between seven and 11 cents. That's potentially even higher than the much younger Agri-PV. When compared to rooftop PV modules, the cost is roughly equal.

For the farmer, any agricultural subsidies they are currently receiving from the government remain in place. The majority of the farm will remain untouched and they simply add the benefit of the solar PV infrastructure. This is combined with lower investment, operating, and cultivation costs. Less plant production products, fewer plastic coverings and wooden supports which need to be regularly changed. It's been estimated that introducing Agri-PV could give farmers savings of €4.0 - 6.5 per hectare per year, as well as improving the fruit's quality.

That's the crux of the matter. The conversation needs to focus on this new technology as a holistic thing that fits into a wider reality. Because that reality involves all sectors of society pulling together for the greater good.

The bigger picture

Climate change presents a challenge with far-reaching consequences beyond simple profit and loss. Not just in developing countries, but also in the EU, we're already seeing serious degradation of formerly arable land. As land starts to become scarcer, the nexus of food, energy, and water demands options like Agri-PV.

Extreme weather is set to become more common, requiring greater crop protection. Excess solar radiation calls for new farming solutions. Water needs to be preserved and handled more efficiently. Densely populated areas require solutions to ease the competition for land. These hurdles can be overcome by a wider adoption of Agri-PV, but political leadership is needed to bring all the players in line and bridge the gap between different elements.

One example sums up the situation perfectly; customers in supermarkets are being encouraged to use less plastic. In some cases, plastic packaging has been banned from stores altogether. Meanwhile, on the farms producing the fruits sold in those supermarkets, farmers are still employing single-use plastic on an industrial scale. Plastic sheets used to protect crops are damaged by high winds and replaced every few months. Solutions like Agri-PV bridge the gap between legislation, production, and the reality of what consumers want.

All this can be done quickly and at scale. In Germany alone, the amount of land used for compatible crops is around 1% but that's still over 70,000 hectares. Having all that land performing two tasks at once completely changes the equation of how we approach sustainability.

As the technology matures and becomes viable with more and more crops, those environmental pull factors will grow exponentially. Agri-PV isn't the only solution to the climate challenges facing the world, but it's one potential option with enormous levels of synergy. It lets farming interact with other sectors more productively and plug into the solutions employed by those sectors to answer their own climate questions.

Right now, Agri-PV shows huge potential, both in terms of the technology being used and the spaces in which it can be applied. Engineers can tackle interesting technical challenges, helping develop a young technology with huge room for growth. Investors can bet on proven solutions with clear applications, politicians can demonstrate that they have the answers to big challenges.

But central to all that are the farmers whose land will form the backbone of this new approach to clean energy and agriculture. Anyone with a technical, commercial, or political interest in Agri-PV needs to spend serious time listening to those who make their living from the land.

Engaging with the agricultural sector, BayWa r.e. is building a compelling case, which is no surprise. Born from agritech giants, BayWa AG, farming is in their DNA. With the early success of its pilot projects, it prepared a body of data which offsets cost against value, demonstrating how much sheer scope these methods have to grow.

Ultimately, addressing climate change isn't an exercise in navel-gazing. The time is now to get this evidence in front of the right people so they can act on it. Agri-PV is only one piece of the climate puzzle, but working together with other innovators in other sectors, it could prove invaluable. The sooner those connections are made, the better.

Authors

Stephan Schindele, head of product management Agri-PV, BayWa r.e. Solar Projects
An internship in a solar association in 2009 was the starting point of his professional career in the field of renewable energies. During his studies Stephan Schindele worked several times for the United Nations Framework Convention on Climate Change (UNFCCC). After completing his MBA program at the California State University East Bay (2011) he was employed as a PhD candidate and project manager at the Fraunhofer Institute for Solar Energy Systems ISE. There he built up the new business field of agri-photovoltaics, wrote numerous publications on the topic of Agri-PV and received several awards for his work (2012-2020). Between 2015 and 2020 he taught energy policy at Reutlingen University. In 2020 Stephan Schindele joined the BayWa r.e. Solar Projects family as Head of Agri-PV. He supports the global Agri-PV market development and successfully leverages the synergies of the agricultural and energy industry.

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Corporate PPAs | The broader decarbonisation agenda is driving interest from businesses in procuring renewable power, and now a whole host of solutions and market structures are coming forward to accommodate them. Edith Hancock explores the maturation of corporate power purchase agreements.

As the cost of renewable energy falls, a growing cohort of corporations have seen power purchase agreements (PPAs) as an effective way to keep costs down while working towards their climate targets. Not even last year's unprecedented power demand fluctuations due to COVID-19 could put an unmendable dent in the market's growth. Bloomberg-NEF found in January that corporations bought 18% more clean energy last year compared with 2019. Pexapark, a software company that provides data on renewables PPAs, believes more than 10GW of clean power capacity could be contracted in Europe under PPAs this year, up from 8.9GW in 2020 that was driven by a "frenzy" of activity in Spain.

When the coronavirus pandemic reached Europe in early 2020, power pricing was thrown into uncertainty, bringing new PPA deals to a standstill. Some 23 power purchase agreements (PPAs) were signed between January and February 2020, for a total of 2.8 GW, according to the European PPA Market Outlook report from Pexapark. Then, the market came to a near complete standstill from March. Over the next three months, just 14 PPAs were signed in Europe for a total 664MW as industrial demand for energy slowed and companies halted planned investments.

But for all the warnings that were signalled at the start of last year, renewables companies have said that the consequences of COVID-19 restrictions and the power demand fluctuation that came with them won't be as long-lived as previously feared. Indeed, although it shows high volatility throughout last year, Pexapark's European Price Index shows that the average PPA price on the continent has risen from €35.64/MWh (US$43.07) in April 2020, to €42.14MWh at the time of writing. At the end of last year, the software company's European Outlook Report estimated that Spain saw the lowest solar-linked pricings at €35.63/MWh, followed by Germany, with prices averaging €41.61/MWh. Those contracted in France and Italy were around €1/MWh higher.

Credit AB InBev / BayWa r.e.

Budweiser brewer AB InBev is one of a number of large companies to have gone down the solar PPA route to decarbonise business operations in recent years.

Beating the pause

Drew Barrett, head of energy markets at Octopus Renewables, says there was a "slight pause" on corporate PPA processes at the start of the pandemic. "Procurement managers were either distracted dealing with the volatility witnessed in near-term prices or waiting for some degree of longer-term certainty to emerge."

But following that initial pause, the energy group saw a rebound in buying appetite, the consequence being that prices for longer-dated PPAs "have remained relatively stable throughout, as buyers and sellers alike have tried to look beyond the pandemic". "As a result, prices have remained driven by the long-run marginal cost of the assets," he says.

This is reflected in Pexapark's figures in the second half of 2020. 33 new deals were signed between July and the end of the year, with 3.1GW of capacity under contract, and 1.1GW of renewable power PPAs was procured in December alone. Solar energy accounted for almost half (46%) of all capacity in Europe that was contracted under such agreements.

Andrea Grotzke, head of energy solutions at BayWa r.e, agrees that "not that much" has changed when it comes to pricing structures for PPAs, again, due to the typically long contract life.

"Of course the corporates take into consideration," she says, but on the other hand, long-term price expecta-

tions must be taken into account "in order to calculate the business case from the corporate perspective, and discuss saving potential."

"If you look at the long-term price structures in corporate PPAs compared to a price development on a forecasting basis, obviously, that still is a quite an interesting business case for the corporates."

Barrett says that shorter-dated contracts saw "greater volatility" as a result of trends in the forward markets at the start of 2020, but added that, prices have now significantly recovered. "As an example, the Summer 21 baseload contract traded in the low £30s in late March 2020, rising to the mid £50s a year later," he says.

However, as Pexapark's co-founder Luca Pedretti notes in his company's European Market Outlook report, price volatility is still present in the continent's PPA market. "Price volatility is here to stay," he says, adding that pricing pressure across European markets will remain high. To manage the challenges imposed by the subsidy-free renewables market, he says, industry players have now started to invest more in building energy risk management capabilities.

More renewables, more structures

Speaking to our sister publication PV Tech during the Solar Finance & Investment Europe event held by our publisher Solar Media in February 2021, Pedretti said that financial contracts between offtakers and power producers have become more nuanced to account for risk on either side. "Certainly, those structures have become more structured," he said.

The new, more sophisticated structures include baseload pricing, further options, and in some cases, shorter contracts. Lee Moscovitch, partner at UK-based asset manager Greencoat Capital, told panellists at the same event that the UK market in particular is starting to see prospective offtakers asking for shorter PPA lengths with more sophisticated pricing structures to mitigate the risk associated with price volatility in the energy market.

"What we're starting to see more creeping in is either shorter term PPAs with fixed price, people asking you to price [a] month ahead, or baseload pricing, looking at shaping cost ahead and who takes that risk," he said, adding

Credit: BayWa r.e.

HeidelbergCement has entered into a 10-year PPA for power generated at the Witnica solar park in Poland (pictured)

there has also been work in "pricing in floors and discounts to market".

This change in structure comes as a result of projected decreases in PPA prices over the coming years as solar energy gets cheaper, and as more corporations come into the fold. What was once a space dominated by utilities and tech giants has now started to include other household names, but smaller businesses with different electricity needs will also require slightly different financial models.

"I definitely believe this is going to take off," says BayWa r.e.'s Andrea Grotzke, adding: "but I think there are a couple of challenges here". Large corporates, she says, have facilities all over the world with large power demands and are far more likely to have "done their homework" with respect to how and where they find it.

But there are also a lot of smaller companies with high energy demands, she says. "So it's still interesting for them to enter into these kind of decision making processes… However, they have to prepare, and then they have to really also take an entire team on board in order to make that happen."

Identifying a developer partner to work with, and finding the best approach, is crucial for entities with less room for manoeuvre. For a power generator to be comfortable with an offtaker, they have to perform a certain level of due diligence to "confirm that they expect that counterparty to be trading at that point in time", says Ricardo Piñeiro, head of UK Solar at investor Foresight Group. "That's why it's so important to work with a blue chip entity that ticks a lot of boxes. It makes the process extremely simple compared to an SME," he adds.

But James Armstrong, founder and managing partner of investment group Bluefield Solar Income Fund, believes the corporate market, particularly where direct-wire installations are concerned, is "very underexploited", and "should be a very big area of growth in the future".

At Octopus, one of the key trends Barrett has noticed is "a wave of US companies with European operations looking to decarbonise their energy demand via virtual PPAs," but this is also happening beyond Europe. Facebook, for example, signed a novel agreement with developer Sunseap, establishing a virtual PPA for a 5MWp floating solar installation in Singapore. All renewable energy credits from the project will be transferred to the social media giant, while power from the project will be used to support Facebook's operations in the city-state.

Proxy generation PPAs, which unlike other kinds of contracts don't settle on energy metered generation but instead use an hourly index that specifies the energy a solar project would have produced based on being operated under best practice standards, is also an option. Earlier this year, Lightsource BP and Allianz Global signed a proxy generation PPA for a 152MW solar project near Dallas, Texas, which is due to come online later this year. Lightsource BP has also recently secured a virtual PPA agreement with US aerospace and defence firm L3Harris Technologies for 100MW of capacity at the developer's Elm Branch solar project, also in Texas. Over in Europe, Budweiser maker AB InBev inked a 10-year virtual power purchase agreement (VPPA) with BayWa r.e. last year to fully transition its European business to renewable energy, supporting the development two solar plants in Spain in the process. BayWa r.e.'s Grotzke says that virtual arrangements

are better suited to companies that have less load in one country, but instead have several facilities across a region which need renewable power.

"It's a hell of a financial product… it's not a physical delivery of power anymore… if a company is ready to do that, and to just buy the financial derivative, and thereby neutralise its CO2 footprint, then this is also an instrument which is interesting," she says.

Virtual PPAs, Barrett says, have remained popular among US corporates for two reasons. "Firstly, existing supply agreements can be left untouched and therefore avoid some contractual complexity. Secondly, virtual PPAs enable corporates to procure significant volumes through one transaction which can be attractive where operations are spread across disparate jurisdictions." With pricing and structures evidently maturing and changing rapidly, the future of PPAs is emerging as an exciting space for solar to feature.

The future of PPAs

As well as baseloading structures and offering virtual PPAs to offtakers with distributed business operations, working with different companies in new markets has also led to changes in how power producers navigate the subsidy-free solar landscape.

BayWa r.e. kicked off 2021 by securing what it claims is Poland's first PPA with construction materials company HeidelbergCement. At 10 years, it is on the slightly shorter end of contracts prevalent in the market today. While a PPA may have typically run for between 15 and 20 years, a steady flow of shorter contracts has emerged in recent years. PV developer Solaria signed a 10-year deal with Shell Energy Europe at the start of the year for six solar plants in Spain with a combined capacity of 300MW, shortly after Danish renewables group Better Energy secured a seven-year PPA with pharmaceutical company Lundbeck.

Earlier this year Anna Chmielewska, associate director of the European Bank for Reconstruction and Development, joined a panel of industry players to discuss Poland's emerging solar market at Solar Finance & Investment Europe, and told the audience that the sector "cannot hope for 15 years corporate PPAs" in such an emerging market.

Others involved in the execution of PPAs noted that shorter contracts could be more appealing to the increasingly wide variety of corporations. Fernando de Juan Astray, head of origination, structured and long-term products for Axpo Iberia, said at the event that there is something of an "oversupply" of power for potential offtakers, nothing this was occuring "particularly in hot countries... That's where we have seen structures tend to be shorter term, perhaps five years instead of 10, 12, 15 which they were before."

Asked how the solar industry could bring more SMEs into the fold, Bluefield's Armstrong says they will be "looking to try and lock (themselves) into a contract for the shortest duration possible", which makes contracts, particularly direct-wire agreements, more complicated.

UK utility Thames Water, for example, has worked with Bluefield to install dozens of solar arrays across its network. Armstrong says it's easier in some ways for a utility like Thames Water to enter into a long-term PPA because how their site ownership is structured. "They have long-term leases or ownership of their land and they know that their infrastructure is going to be there for longer than the certifiers. But if you're an SME, and you have maybe a five-year lease on the building, you're not going to be able to enter into something which is longer. Therein lies the tension," he says.

"There's still the question of how many years will it take to get to the pre-pandemic levels. I don't think anybody has the answer at this point in time unfortunately."

Armstrong says that although shorter power agreements are not ideal for all developers, PPA providers will need to be more flexible in how they can cater for a customer's needs, and shorter agreements can be one such route to pursue. Pedretti, however, believes it may be a while before PPAs become significantly shorter. "According to our data, it's still a marginal aspect. I think that's something for the next two, three, four years, as this is developing. The standard way is still this long-term PPA approach," he says.

Barrett meanwhile is of the opinion that a "blended approach" of long-term price certainty with flexible shorter-term contracts is "likely to provide the best risk-adjusted returns", particularly when a portfolio is spread across multiple jurisdictions or there are different technological demands. "Across Octopus Renewables we take advantage of the feedback loop between our Investment team identifying new opportunities, who then engage with the Energy Markets Team to define an investment strategy, alongside a PPA and hedging strategy," Barrett says.

The possibility of opening up far more flexible approaches to PPAs could be exciting to budding SMEs looking for sustainable investment, but Grotzke warns that this is a difficult avenue to pursue when additionality is still a priority in the renewables market. "For new projects, it's still the case that the developers seek long-term structures," she says, and if the corporate buyer, like so many that are aiming for strict net-zero targets, need additionality to reach them, "then it's going to be difficult".

"However, there are also companies that don't have that strict target on origination." She refers to examples of subsidised wind farms in Germany which have been commissioned under 20-year tariffs. "Now the first wind projects will run out of the tariff, and there are opportunities to procure power from those projects because they are written off if they don't engage in repowering. It could be a match between those projects and between the corporates who don't have the strict targets on additionality."

At Foresight group, Ricardo Piñeiro concludes that there have been few fundamental changes in how offtakers agree energy contracts, but the rise of the corporate PPA has led to the market becoming more liquid and has opened up the possibility for things like financial hedges, baseloading structures and simply providing a wider range of options to an equally widening customer base. However, with much of Europe still struggling with waxing and waning lockdowns, he warns that there is still much uncertainty over the power pricing and investment.

"It seems that it's stabilising", he says, adding that there has been a marked improvement compared to the second quarter of last year. "But there's still an element of uncertainty. There's still the question of how many years will it take to get to the pre-pandemic levels. I don't think anybody has the answer at this point in time unfortunately." ■

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Fuelling the boom: Are SPACs in the energy sector here to stay?

SPACs | As special purpose acquisition companies, or SPACs, prove a popular route to public markets for private energy businesses in the US, Fieldfisher's Jack Mason-Jebb and Brad Isaac consider whether the trend has enough momentum to take it across the Atlantic.

Credit: bfishadow/Flickr

The US markets have seen the majority of SPAC listings, but could they spread across the Atlantic?

The surge in popularity for using special purpose acquisition companies (SPACs) to launch privately-held companies into publicly-listed entities was a trend that defined US capital market activity in 2020 – and one that accelerated further in the first four months of this year.

While they have been most prevalent in the US tech sector, SPACs have also been enthusiastically embraced by the energy industry, specifically for renewable power, clean tech, hydrogen, energy storage, electric vehicle charging and battery technologies.

Although there is nothing in particular about SPACs that lend them to energy company floats, a cluster of clean energy companies that went public via SPAC acquisitions in the US in 2019 saw dramatic increases in their valuations over their first 18 months of trading.

This has tempted more capital to the sector over the past year, with investors hoping to identify the next runaway success story at a time when politicians and investors are motivated to tackle climate change through "energy transition" solutions.

Conventional energy companies in the oil and gas sector have also seen an uplift from the SPAC boom, but to a much lesser extent than their clean energy counterparts.

What are SPACs?

SPACs, in their current form, have been around since at least the early 1990s. Often referred to as "blank-cheque" companies, they are empty cash shells with no business operation, created with the sole purpose of holding investors' cash and listing on a stock exchange, with the objective of acquiring a company or asset.

SPACs are formed by a sponsor, or group of sponsors, consisting of a management team who will seek a private business to purchase using their pool of invested cash. Private companies that are acquired by/merged with SPACs become publicly-listed and the SPAC relinquishes its acquisition vehicle status (known as "de-SPACing").

If the acquired company trades well and its share price increases, investors receive a return on their investment.

Although SPACs do not usually have a specific target in mind at the time of listing, the sponsors typically have industry-specific knowledge and will target businesses in these industries. As part of the acquisition, the SPAC's sponsors will often join the acquired business' management, and may serve on the board of the public company. Investors in SPACs do not know what company the SPAC will ultimately acquire, but trust their capital to sponsors to select a target.

Once listed, SPACs typically have two years in which to acquire a private business, or they must return the money to their investors.

To date, the vast majority of SPACs have been born from the US' burgeoning tech sector and the inclination of seasoned Silicon Valley executives, inspired by examples of entrepreneurial success in taking companies public, to use their experience to pursue new ventures.

Some of this experience and appetite has spilled over into renewable energy and related technologies, seeking to ride the wave of interest in low/zero-carbon power and circular economy solutions.

Why have SPACs become so popular?

The attractiveness of SPACs in the US has been boosted by a combination of factors.

Near record-low interest rates have prompted investors to look to equities for returns and made it cheaper to raise debt for new M&A deals. Meanwhile, fiscal stimulus measures from central

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banks have flooded markets with cash. Such circumstances often prompt private companies to make a dash for public markets to take advantage of the available capital.

SPACs can offer a quicker and cheaper route to the public markets than a traditional initial public offering (IPO) and consequently appeal to early-stage businesses with growth potential in need of fresh liquidity. The start-up culture that emerged from the 2008/9 financial crisis has created a huge choice of potential targets for acquirers, and these are beginning to be snapped up rapidly. In the US, data from various SPAC trackers suggests that the amount of time between SPAC IPOs and closing acquisitions has shortened in tandem with rocketing valuations.

"Data from various SPAC trackers suggests that the amount of time between SPAC IPOs and closing acquisitions has shortened in tandem with rocketing valuations."

What are the main benefits of SPACs?

One of the principal 'benefits' of SPACs from the perspective of gaining access to public markets is that they do not have to comply with the tougher listing rules that apply to traditional floats. Floating a company on a major stock exchange is typically a lengthy process that requires a business, with the help of financial and legal advisers, to draw up a detailed prospectus or admission document designed to give potential investors as much information as possible about its operations.

For energy companies, especially those with novel technologies and/or complicated business models, this can be a particularly long and complicated part of the listing procedure.

While this rigorous practice is designed to prevent companies from providing insufficient or misleading information that could harm the interests of investors, company management teams may regard IPO requirements as overly onerous and expensive when weighed against the benefits of a listing.

Another draw of SPACs versus IPOs is that company founders get to keep or redeploy a greater share of the IPO rewards, rather than paying significant shares of the listing proceeds to banks. Investment banks working in parallel with companies undertaking an IPO can expect to receive between 5% and 10% of the proceeds through underwriting fees alone, and legal and accounting costs incurred through due diligence further eat into companies' finances. By opting for a less expensive route to market via a SPAC, companies can choose to channel the money they save into, for example, marketing or research and development for future growth.

For smaller companies seeking to access the public equity markets, where underwriting the fundraising is much less common, listing via a SPAC de-risks the potential for the fundraising to fail. The company and the SPAC can also agree a valuation for the business upfront, rather than have it determined (or "priced") through the IPO marketing process.

A SPAC listing, particularly merging with an entity with the proceeds of a previous funding round, is therefore an attractive prospect to early stage pre-revenue companies. Reversing into a cash shell or investing company has for instance been a popular way for exploration and appraisal companies in the natural resources sector to come to market.

A less significant but nevertheless noteworthy feature of SPACs is that, for now at least, their acquisitions tend to attract less media attention than IPOs. IPOs often receive close media scrutiny, from the publication of the intention to float right through to first day of dealings, which can be desirable and useful but can also be negative and/or unhelpful, particularly if the business looking to float is a complicated energy business whose proposition or target market is difficult to sell to the press. By contrast, SPACs can make acquisitions and bring companies to market relatively quickly and quietly.

What are the chief concerns about SPACs?

The meteoric rise of SPACs in the US over the past year has refocused attention on their role in the market and generated some debate about whether the SPAC operating model requires reform. Unlike IPOs, where a company's business proposition and valuation is scrutinised through investor presentations and verification of the admission document by legal and financial advisers (and the press) before it floats, such detailed examination is largely absent in SPAC mergers.

This lack of regulatory scrutiny and thorough due diligence is one of the principal concerns about the potential hazardousness of SPACs as investment vehicles. Protection of retail investors is a key concern for institutional investors and financial market regulators, and SPACs are considered particularly risky because investors usually decide to invest in the SPAC based on little more than the sponsors' reputation and a hope that they will choose a successful target.

In the UK, when a SPAC buys a company, the transaction is classed as a reverse takeover and the SPAC's shares are suspended and trading cannot resume until a deal prospectus is published, for which there is no deadline, meaning investors' money can be locked up for years.

The lack of transparency around sponsor compensation and incentives for insiders has also generated concern, as has the sustainability of valuations being given to pre-revenue companies by the acquisition frenzy. The popularity of SPACs with largely unsophisticated retail investors (in some cases thanks to celebrity promotion of certain SPACs) has prompted unease among regulators about consumer protection. In September 2020, the US Securities and Exchange Commission (SEC) indicated that it plans to enhance disclosure and transparency requirements for SPACs, following regulatory concerns over recent fundraisings.

So far this year, the SEC has issued various further statements covering a range of SPAC-related issues, including commentary on celebrity endorsements, what it considers to be misunderstandings about liability risks involved in de-SPAC transactions and possible accounting and financial reporting changes for SPACs.

Are we likely to see more SPACs in the UK?

While UK capital markets activity and IPOs have been buoyant since the middle of last year, SPAC mania has so far not infiltrated the London markets. The main reason for this is the UK listing

"SPACs are considered particularly risky because investors usually decide to invest in the SPAC based on little more than the sponsors' reputation and a hope that they will choose a successful target."

regime is not designed to cater for SPACs. The "reverse takeover" classification of SPAC acquisitions and corresponding suspension of shares has resulted in the paralysis of a number of UK SPACs, and effectively halted any momentum behind this trend.

Another deterrent for listing SPACs in London is that, to join the Primary Segment of the London Stock Exchange (which is a requirement for companies to be included in the FTSE indices, and therefore eligible to be purchased by index tracker funds), companies must fulfil various criteria. This includes a financial trading history, which, given they are cash shells, renders SPACs ineligible.

A Treasury-backed review published in March 2021 recommended, among other modifications, that the UK listing regime be amended to make the London markets more attractive for SPACs by removing the suspension of their shares after an acquisition of a target company. The report highlighted fears that London's burdensome IPO requirements are harming the competitiveness of its capital markets in the face of competition from other exchanges – which in the case of SPACs includes New York and, more recently, Amsterdam.

The report's findings are merely recommendations and will require further regulatory consultation, as well as primary legislative changes to become law. Nevertheless, the UK's Financial Conduct Authority welcomed the report's proposals and has indicated that some changes could be made before the end of 2021.

For energy companies thinking about a SPAC listing in London, it remains to be seen whether these structures will find favour with oil and gas and related conventional energy businesses that have historically dominated the energy segments of the London markets, or whether new doors will open for renewable energy companies that have so far made relatively little impact on UK exchanges.

What is the European perspective on SPACs?

London is not alone in its cautious approach to SPACs. Europe's conservative capital markets have also been largely sceptical of these vehicles and to date European regulators have resisted emulating the US' enthusiasm for SPACs – although there are signs that this is beginning to change.

As of April 2021, France's Euronext Exchange had only seen two SPAC listings. However, the Autorité des marchés financiers (AMF), the French financial markets authority, issued a statement in April clarifying that the professional segment of Paris' regulated market "is a suitable listing place for SPACs, which, in their initial phase, mainly target such qualified investors".

AMF also noted that it had "observed a significant increase in the number of SPACs preparing their listings on the Paris stock exchange since the beginning of 2021" and stressed that the French legal framework and regulatory requirements are equipped to "welcome" SPAC listing in Paris, while providing appropriate investor protection.

Italian regulators have also indicated their interest in seeing more domestic SPAC listings, although the effectiveness of such financial vehicles is undermined by the difficulties in finding appropriate targets and Italy's complicated process for approving business combinations.

In Germany, the Frankfurt Stock Exchange has seen a modest number of SPAC listings over the past decade and is now facing calls to encourage more to join its markets, encouraged by comparisons between the Frankfurt Exchange's SPAC structure and the structure used for such companies on the New York Stock Exchange.

The Netherlands is most hotly tipped to emerge as the European capital for the SPAC craze. Like Frankfurt, Amsterdam's stock market (the Euronext Amsterdam) bears comparison with the NYSE in its treatment of SPACs. Unlike most other European jurisdictions, Dutch law does not have rules that apply only to SPACs, and allows further flexibility to entities formed as a BV (a private limited company). Investors in Amsterdam-listed SPACs can exercise redemption rights at ease, and also remove their money in the SPAC if they do not like the proposed target chosen for the merger.

Euronext Amsterdam also has earned a reputation as a European home for many international and technology-focused companies and may be a more natural venue than London for renewable energy and clean-tech related growth companies.

Are SPACs in the energy sector here to stay?

The future of the SPAC boom depends to a large extent on how the trend develops in the US. If the US' SPAC bull market, which is already starting to appear saturated, turns bearish, it seems unlikely that, even with potential capital markets reforms in London and across Europe, a rush of SPAC reverse takeovers will flood Europe's stock markets.

If SPACs are destined to remain a modest feature of European capital markets, such structures can still offer a useful way for small and growing energy companies to achieve a public listing as an alternative to an IPO.

In the current climate, energy companies with a technology aspect to their business or a focus on renewable energy may be best placed to take advantage on the SPAC boom. ■

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Introduction

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

If someone had told us we'd be into the second year of the COVID-19 pandemic this time last year, perhaps they wouldn't have been believed, but here we are. Some semblance of normality returns to some parts of the world, others are in the grip of a fresh wave of horror. Our thoughts are with those still affected, wherever you may be.

The pandemic has had all sorts of unintended economic, social and environmental consequences: last year for a few months it was considered a silver lining that a reduction in industrial and transport activity meant a reduction in air pollution and greenhouse gas emissions. This year it seems unlikely any of those gains will be sustainable unless the mood of the moment can be captured and turned into solid clean energy growth.

What we can't afford to do, is try and reapply business as usual paradigms to the economic recovery. There is plenty of ingenuity and know-how in the energy storage industry that can contribute to a 'Build Back Better' agenda which has been coined as a catchphrase across the political spectrum from right to left, from West to East.

Beginning with the West, in this issue, we take a close look at a project which marked the first time energy storage competed directly with natural gas in a US utility's all-source procurement Request for Proposals — and won. We spoke to AES Corporation's Mark Miller and Fluence's Ray Hohenstein about Alamitos, a 100MW / 400MWh battery storage project which provides locational peaking capacity to the grid in California. Within that piece we also hear from Lillian Patterson, an expert at Australia's Clean Energy Council trade group why some of those same lessons can be applied elsewhere.

To enable energy storage to flourish, it needs to be an asset that the financial community knows it can invest in with a reasonable expectation of healthy returns. We've got perspectives from two experts in the industry, one based in Europe, the other in the US, to help us through both the pros and cons of the energy storage investment landscape as it is today.

Renewable and clean energy financier Laurent Segalen tells us that lithium-ion batteries are now a fully bankable technology, but the business models for using them in the electricity network are complex and require careful thought and the picture is greatly varied across Europe. Specialist lawyer Adam Walters from Stoel Rives LLP meanwhile tells us that the procurement of battery storage systems and equipment in the US is chaotic and difficult to negotiate, leaving many smaller players at risk of falling by the wayside. In both papers, the main takeaway seems to be that the technology is ready, the challenge is there to be tackled, but now the hard work lies with the industry to put it all in the right place.

Last but not least, I was privileged to sit in on a roundtable-style discussion with representatives of four leading trade associations in European Union territories: Germany, Poland, Ireland and Spain. We learned about the differences and similarities in each country as well as how it all fits together in the bigger European picture. Some of the things we heard will definitely surprise you and I'd like to thank Valeska Gottke from Germany's energy storage association BVES for her help in organising that unique opportunity. I hope you enjoy it and learn from it as much as I was able to.

Andy Colthorpe
Solar Media

Thermal energy storage startup EnergyNest secures US$130 million investment

An investment worth €110 million (US$131.5 million) has been agreed by 'thermal battery' manufacturer EnergyNest which would make infrastructure equity investor Infracapital its biggest shareholder.

Norway-headquartered EnergyNest makes its own branded ThermalBattery product which essentially stores heat in a patented form of concrete, which it has dubbed Heatcrete. A heat transfer fluid (HTF) at high temperatures passes through steel pipes cast into the 'battery', in technology that the company claims enables storage of energy at very low CapEx cost, using low-cost materials in a simple design. EnergyNest has previously said the Heatcrete materials can last 30 to 50 years of use without degradation.

Infracapital's investment will be used by the thermal energy storage company towards delivering financed turnkey energy storage solutions in a range of international regions, targeting the difficult to abate reduction of carbon emissions in industrial processes that use heat.

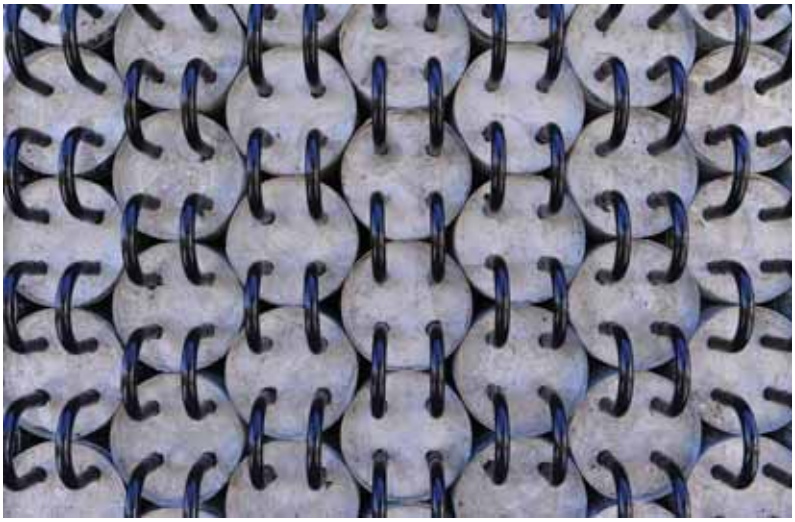


Image: EnergyNest

Inside EnergyNest's patented 'Heatcrete' which stores thermal energy.

China's largest solar-plus-flow battery will be accompanied by 'gigafactory'

Large-scale Vanadium redox flow battery (VRFB) technology looks set to be deployed at a 100MW solar energy power plant in China, two years after a smaller-scale demonstration project was commissioned in the region.

Canada-headquartered vertically-integrated technology provider VRB Energy said that the solar PV power station will be integrated with a 100MW / 500MWh (five-hour duration) battery that the company is developing in Xiangyang, in China's Hubei Province.

A framework agreement has been signed by VRB Energy with the municipal government of Xiangyang, local project partner Hubei Pingfan New Energy and Xiangyang High-Tech State-Owned Capital Investment and Operation Group (GXGT).

US Secretary of Energy: 'Flow batteries are good for grid storage'

US Secretary of Energy Jennifer Granholm said that flow batteries are "good for grid storage" as her Department of Energy (DoE) announced funding to support domestic manufacturing for the energy storage technology.

The US Department of Energy is setting up a competitive award process for flow battery system research and development (R&D) projects with up to US$20 million available. Award negotiations are expected to take place between October and December this year.

"Flow batteries keep the energy flowin' more reliably …that's why they're good for grid storage and that's why we're investing $$ in them! Cleaner, more efficient energy for all," Granholm tweeted.

Stem Inc becomes 'first publicly-traded smart energy storage company' in US

Stem Inc's shares begin trading on the New York Stock Exchange on 29 April 2021, after the company completed its business combination with special purpose acquisition company (SPAC) Star Peak Energy Transition Corp.

Stem Inc, a pioneer in deploying battery storage systems in combination with smart software that enables commercial and industrial electricity users to lower electricity bills from reducing their draw of power from the grid at peak times, while also enrolling the batteries in various grid, energy and capacity services programmes to earn revenues, announced its intent to merge with the SPAC last December. At the time, the two companies said the deal could be worth as much as US$608 million in total.

Fluence and Northvolt to co-develop grid-scale battery storage technology

Energy storage technology provider Fluence and battery gigafactory startup Northvolt will collaborate to develop "next-generation battery technology for grid-scale storage applications".

The partnership will see the pair develop Northvolt battery hardware as well as battery management systems (BMS) optimised for Fluence's energy storage solutions. The intention is to lower the cost of ownership of ESS solutions and offer systems tailor-made for Fluence's customers, using digital intelligence integrated into the full battery lifecycle.

as part of the agreement Fluence will also buy batteries produced by Northvolt, which aims to produce 150GWh of cells annually by 2030. The deal could help Fluence from avoiding a potential pitfall for its rivals in the stationary energy storage system (ESS) industry, namely that electric vehicle (EV) manufacturers are being prioritised as customers by battery cell manufacturers.

Introducing storage ITC a 'once in a lifetime opportunity to protect earth'

A politically bipartisan effort to introduce investment tax credit (ITC) incentives to support and accelerate the deployment of energy storage in the US could be a "once in a generation opportunity" to protect the future of the earth.

The Energy Storage Tax Incentive and Deployment Act would open up the ITC benefit to be applied to standalone energy storage systems. At present, the tax relief can only be applied for energy storage if batteries or other storage technology are paired with solar PV and installed at the same time.

Moves to push for an ITC have been ongoing since at least 2016. In March this year, politicians from across the aisle in Congress put forward their bid to introduce it once more.

"The Energy Storage Tax Incentive and Deployment Act would encourage the use of energy storage technologies, helping us reach our climate goals and create a more resilient and sustainable future," Congressman Mike Doyle said.

Why battery storage procurement is still a chaotic, challenging endeavour in the US

Credit: Wikimedia user High Chapparal Sweden.

Procurement | Battery storage deployments, both with and without solar, have been in a new growth phase that has smashed quarterly records consistently while costs have continued to fall. Nonetheless, the maturity of the industry is not always reflected in the information available to financial decision-makers, writes Adam Walters from Stoel Rives LLP.

Seasoned renewable energy lawyer Adam Walters from Stoel Rives argues that procurement in the battery storage space is currently like a sort of Wild West. Here, Walters describes some of the finance risks that face this maturing industry around procurement issues.

Ensuring supply chain robustness, ensuring customers understand the warranties and performance claims they are getting from manufacturers as well as navigating the patchwork nature of market opportunities are among the significant challenges he sees in the market today, particularly in the US.

I got into utility-scale solar back in 2008, when it was just kicking off in the US. And then I moved on to Asia and kicked it off in Australia a few years after that. What you saw with PV, of course, is how rapidly it came down the cost curve for CapEx and ultimately became commoditised. You had the big shake up in around 2011 in solar PV, with the Chinese coming in with incentives for their manufacturing industry and essentially blowing out of the water, the European and American manufacturers.

There were very few survivors of that. We're not seeing that in battery storage, but what we are seeing is the rapid decline down the cost curve that is very similar to solar. It hasn't been quite as exponential as solar has so far, for battery storage. It certainly came down like that, and then it's somewhat flattened out over the last two or three years. Perhaps that's because you don't have the same glut of supply as was seen in PV in 2011, 2012.

The other big difference is where the players started out. You really saw in batteries, the Koreans, Samsung SDI and LG Chem, being the early leaders along with Panasonic to a lesser extent. So Asia was already a leader for batteries. Once we started to see the stationary storage industry take off, the Chinese didn't catch up quite as quickly.

There's been some standardisation across the industry in areas like round trip efficiency but battery procurement is in many ways still like the Wild West: chaotic.

Tesla's kind of a whole different animal altogether in being an auto manufacturer that designs its own cells and jumped into that space along with Panasonic. In the last two years, you're starting to see the Chinese manufacturers really start to take over, but I just don't expect to see that kind of dominance that we saw with PV.

We are going to see a more balanced market where you have different players in different parts of the world, with Europeans and North Americans still

being competitive. And part of that is the technology is different. I don't think battery systems are going to get commoditised as easily as solar panels.

A lot of it is in the energy management system, or the battery controller, where you're talking about firmware, operating battery systems and optimising for market conditions, PPA, temperature, climatic conditions, and all of that. It's a more complex bit of technology than solar PV was, so I think we're not going to see prices crash as quickly and we're also not going to see one country completely dominate.

Batteries for life, or for the lifetime of the batteries

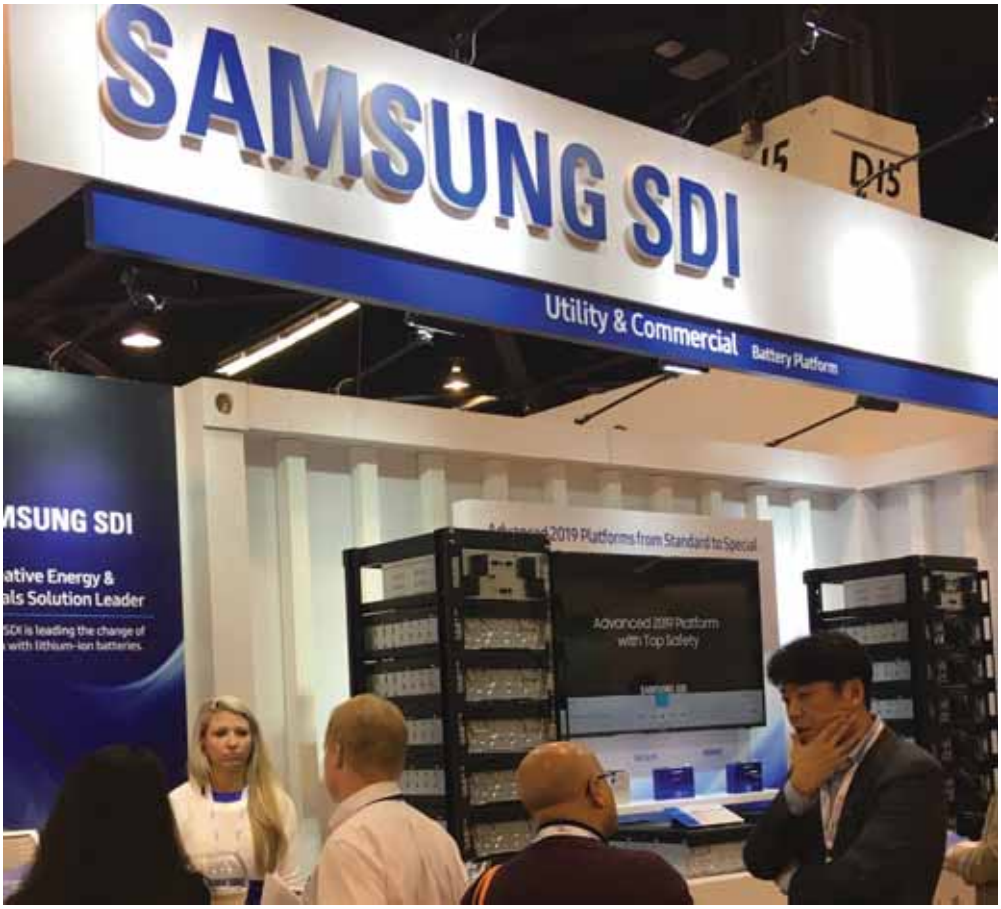
You have something that does something very simple. It stores energy, it sits idle, and then it discharges energy, that's all it does, just those three things. But it's how, and when, those three things occur that determine the value of the battery system. The other real key thing and key difference between this and PV is that availability is a critical part of the value of a battery system.

Whereas with solar PV, once you've got the PV system commissioned and operating, it's going to sit out there and just generate electricity more or less for 20 years, and up to 35 years. Of course, you have to change out the inverters and other components eventually, but it's just going to keep doing that.

Whereas a battery system, you have more complexity in the hardware and the use case and how the battery is used is going to determine the life of the battery and when components need to be replaced. So availability is just a much more critical part of the ownership and operation of a battery than it is a solar system where you might have availability guarantees, but it's not a high risk, it's not something you worry terribly about and it's also not something that you're going to get heavily 'dinged' on in your PPA. Because those are mostly energy-only contracts.

There's a difficulty in financing standalone energy storage projects right now in a lot of markets, because you may not have a long-term off-take contract, or a 20-year power purchase agreement, for instance.

In some countries, or markets, you might have a robust enough ancillary services market where you can model it based upon capacity that's online and maybe get financiers comfortable with the revenues that you're going to be able to generate from that, in addition to revenues from energy arbitrage. But unless you can find somebody that's going to give you a long-term capacity contract for standalone storage, right now that's the real difficulty — how do you finance it?



Credit: Andy Colthorpe / Solar Media.

South Korea's Samsung SDI and LG Chem were the early leaders of the industry.

A lot of our clients are independent power producers (IPPs), and they're doing solar-plus-storage. There you have an easier case, because for the most part they're choosing DC-coupled battery systems and so really what they're just doing is maximising the energy uptake from the combined system. So you don't have the financing issues as much.

There's a lot of financeability issues with the product offerings, though. What I emphasise for my clients who are looking to procure battery systems or energy storage systems, is that you're not focusing on the engineering, procurement, construction (EPC) partner nearly as much.

You're focusing much more on the technology, on the long-term service contracts, the availability guarantees, the energy retention guarantees that you're getting from the battery integrator or OEM. You have to make sure that you're going to have somebody standing behind that battery system, in the long-term for the lifespan of the battery, which in most cases is going to be 15 years without battery augmentation. You have to emphasise those warranties and guarantees, and long-term service contracts.

Augmenting: the reality

My main point when I'm advising clients, is to think through these issues upfront and when you're initially putting out your RFP to tender to determine exactly what you want, and what you think your financing parties are going to require.

Augmentation is another big point. You usually have a standard availability guarantee that's long-term and then an optional battery augmentation contract, which is really CapEx. What financiers are used to seeing is basically, 'Well, this is a power plant that's going to operate for X number of years at X power capacity'. They're less used to this idea, that you're going to have a bunch of CapEx already in year six or year seven, or the energy capacity is substantially degraded by that point.

So there's different ways to do it. You can do it as an upfront CapEx contract, I've seen some suppliers do it that way. Or you do it through the long-term service agreement (LTSA) as part of that contract, and then that's built into the annual maintenance fee.

A lot of it just depends on who the end user is, and what their preference is. Do

they want to try to finance 100% of the CapEx of an augmented battery upfront? Or do they want to try to do it as OpEx over the course of 20 years? Or do they want to just take a punt on it and decide to just take the standard OEM energy retention guarantee and see what the revenue situation and use case of the battery looks like and five years down the road decide whether to engage someone to augment the battery. You're going to pay more to do it that way down the road in some cases, because the original system hasn't been designed for that, but we're seeing different ways, and all of those ways can be successful.

It's like the Wild West out there

The battery storage procurement space is still a kind of Wild West and I don't see it becoming any less chaotic just yet. However there are some things that are starting to coalesce, in terms of standard offerings. Round trip efficiency is a good example.

The Korean manufacturers initially came out with fully integrated offerings, which really had more to do with the way that the construction industry in Korea works and how it's regulated than anything else. You have to have a different company for every aspect of the value chain under their labour and construction laws, and so you don't have full turnkey types of contracts, like you typically do in the West.

These big conglomerates, they have their electrical contractor affiliates, they also have their construction affiliate, their high voltage affiliate and their battery manufacturing facilities affiliate, so they can actually cover everything. They do it through multiple contracts, that all flow upward to the parent company.

The Koreans really started the trend with round trip efficiency. Back three to five years ago, nobody else offered round trip efficiency guarantees at all. Then we started seeing those kinds of requests from utilities. This was coming from your Samsungs and LG Chems, because they were fully wrapping, providing 10-year warranties and full wraps where you just can't get that from an EPC contractor, for instance, in North America or Europe.

Nowadays, it's pretty rare to see a battery contract that doesn't have round trip efficiency guarantees that run usually the same duration as the energy retention warranty. So they're going to warrant round trip efficiency over 10 years or, typically sometimes 15 years, just like they warrant energy retention. So we're seeing that whereas, just maybe three years ago, you didn't. So there are some kinds of things that are starting to become more standardised.

OEM technology risk remains

What concerns me as chaotic really relates to the OEM technology risk. Outside of a couple of exceptions, most of the battery cell manufacturing capacity is in China, and you have these Chinese manufacturers, and you have really no idea — at least I don't as a lawyer — how bankable these are.

Where are their materials coming from? Those kinds of questions. And their warranties are kind of all over the place. The way they tend to do their warranties is to leave lots and lots of blanks and so if you're just looking at a form warranty, unlike a Western company, which is going to say, "Here's our standard warranty, and here's our extended warranty, and these are the offerings," — they leave all this stuff blank, and it's open for negotiation.

You have to trust the battery integrator to make sure that the battery integrator negotiates the kind of warranties with the OEM that you expect and that you want. We see a lot of battery integrators that are pretty squirrelly about that stuff, they're not telling the developers or their purchasers: "This is exactly what you're getting from the OEM and the warranty that we're going to assign to you".

Or they're not even trying to assign that warranty to the owners, and the smaller projects. Whereas with large utility-scale, you're going to demand a full wrap and for a number of years, and then you're going to demand assignment of that OEM warranty and you're going to approve that warranty upfront.

This is where I'm seeing a lot of craziness in a market where some developers are signing up battery integrators, and they're thinking, "Oh, it's a small battery and I care more about my solar plant, it's only a few million dollars of CapEx or whatever".

The agreements are just really sloppy when they get to me and I look at them. They don't have the kind of performance testing that you would normally see from the top tiers. They've signed up a battery integrator without even knowing really what the OEM warranties are that they're getting.

Stand by your plan

Battery integrators have to stand behind the technology that they're procuring for the battery system for that period of time in order to get the deal. One thing that alarms me a little bit with battery systems is a trend in procurement strategy that I think started with the big utilities.

Rather than procuring through turnkey contracts, they don't want a bunch of margin stacking, driving up their project costs. So they started to procure the major equipment themselves. It started with inverters, probably 10 years ago. You had developers say, "Okay, we're just going to start procuring our own inverters," and then moved on to other things, trackers, racking, solar PV modules, all of that kind of stuff.

With batteries, they just kind of extended that straightaway, without adding a period of time where they said, "We want to see turnkey contracts. We're going to continue with our standard procurement methods".

And there is definitely some concern in the market about procuring battery capacity for their larger battery storage projects in the next three years. There are legitimate reasons to do that beyond avoidance of margin stacking, but the result of that is, you've got a bunch of split contracts and you're increasing your interface risk, and you're increasing all kinds of other risks in the construction and procurement stage of the project.

In some markets, the project finance is still very, very conservative and would not allow what we see in the US. When you have a new technology, like battery systems, I think there's going to be a lot of projects that run into availability issues if you have something going wrong with the different components in battery systems.

You're going to have situations where you've got nobody standing behind that and it might take months to procure the spare parts that you need. You're left as an owner dealing with two or three different parties, and they're all finger-pointing.

As a lawyer, that's my biggest concern: how do you mitigate all of those risks? ■

Authors

Adam Walters is a transactional, commercial and project lawyer specialising in offering legal counsel to clients across a range of industries including wind, solar PV, telecoms, manufacturing, water and of course, energy storage. Having spent 10 years as an in-house lawyer for solar and storage industry heavyweights First Solar, Tesla and SolarCity, he now practises in the energy development group at independent law firm Stoel Rives.

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Batteries as an infrastructure asset class: A new paradigm

Investment | Battery storage is flexible, remarkable — and investable — but you need to know what you're doing and know where the market opportunities and limits lie. Renewable and clean energy financier Laurent Segalen from Megawatt-X explains some of the things he's seen as batteries have become an infrastructure asset in their own right.

Credit: Flickr/James Case

Energy storage is like a digital Swiss Army Knife for the grid.

As we witness the relentless growth of renewables, operators and investors are wondering how to mitigate the increased intermittency of power generation. We are seeing more and more instances of negative prices, and also an increased volatility in daily power prices, especially in the zones with high renewable penetration and thin grids.

These zones include Australia, the US West Coast, and the EU periphery (Spain, Scandinavia, UK). Going forward, the burden of dealing with intermittency will fall back, either directly or indirectly, in the hands of investors. This is not great news for infrastructure investors who allocated equity and debt into the renewable industry for its fixed income revenue profile.

Once long term capital-intensive solutions (such as interconnectors and pumped hydro) have been exhausted, it is clearly the time for batteries to become a key infrastructure component of the balancing mechanisms.

How then can batteries become a proper infrastructure play?

From an investment point of view, going long on flexibility when the market is shorting it, is the perfect move. The technological trends are also heading in the right direction, as the cost for stationary storage is falling precipitously, in the wake of the billions of USD investments in EV batteries. Within a few years, leading experts such as Benchmark Minerals and BNEF expect another 50% fall in the costs of battery cells.

The question of bankability: From tech to revenue model

From a financial point of view, li-ion batteries are now a fully bankable technology. World-class providers like Fluence and Tesla are delivering new products with up to 20,000 cycles and above 90% round-trip efficiencies. And lithium ferro phosphate (LFP), with its lower cost and reduced fire risk, seems now the chemistry of choice for stationary storage.

Now that the technology aspect has been sorted, how can the revenue model of stationary storage become bankable? Contrary to wind and solar, batteries don't typically benefit from long-term secured revenues, such as power purchase agreements (PPAs).

Instead, investors in storage need to deal with several types of revenues (arbitrage, grid services, reserve) which are difficult to model. Even more important, capturing those new revenues relies on implementing ever-improving software that maximise the monetisation of the numerous market opportunities but can be often seen as "black boxes" by investors.

The software race is on. Against Tesla's Autobidder, you see Fluence acquiring AMS to provide an integrated hardware + software solution. Those new software are incomparably more suited to optimise battery assets than human traders. For instance in Australia, the new market design has created five-minute bidding windows: the best human trader will post 15-20 trades a day, whereas the software will be able to bid 288 times (12 bids per hour x 24h).

A tale of two countries: Germany and the UK

Germany has the most liquid and competitive power market in the EU. It is also at the centre of the European Grid. 800 distribution system operators (DSOs) are daily managing the flexibility of the system. The arbitrage cases are widely publicised but overall not sufficient to sustain a "buy low-sell high" business case. The balancing market is dominated by coal plants which remain cheaper than batteries. And for network services, a German DSO will directly invest in batteries. So there are limited short-term opportunities for infrastructure investors.

The UK presents a radically different picture, with less access to the ultra-liquid Central European Grid, much less pumped hydro capacity than in Germany and fewer interconnectors. Hence, there are many more opportunities for batteries and the strong UK investment community has started to invest in them.

Namely, the UK harbours two pioneering funds, Gresham House Energy Storage Fund and Gore Street Energy Storage Fund which are 100% dedicated to batteries. Infracapital, with the support of M&G is also very ambitious in its plans for storage and e-mobility solutions provider Zenobe. We also have leading traders, such as Hartree, Goldman Sachs and soon Mercuria and Trafigura that are joining the fray. And of course the "master disruptor" Tesla is also present; Tesla obtained this year a UK electricity trading license and signed an agreement with Octopus to connect all its Powerwall into a gigantic virtual power plant (VPP), while Shell's sonnen is doing the same.

So how do you build a revenue stack for battery storage in the UK? First, it is better to partner with a digital platform that can provide you access to the various arbitrage, balancing and flexibility markets: routes to market providers like Flexitricy, Habitat Energy, Kiwi Power and others are delivering such very innovative services.

Second, a growing list of asset optimisers with solid balance sheets like Shell's Limejump are offering PPAs with long term price floors to battery asset owners in return for a share of the upside; this is catalysing the interest of debt lenders.

The digital Swiss Army Knife

A few years ago, a battery revenue model in the UK was a boring set of "ancillary services", mostly frequency response in the form of long-term Enhanced Frequency Response (EFR) or shorter-term Firm Frequency Response (FFR).

As those legacy services are now close to saturation, we are entering into a more "revenue agile" phase. Namely, the UK's electricity system operator National Grid ESO has signalled a clear intent to move to shorter term, more liquid markets for system services reflective of real time system needs. And it is the new generation of software that allows this transformation.

With a battery in the right place and at the right time, an investor can simultaneously:

- provide newer, more precise frequency services such as Dynamic Containment for National Grid ESO
- deliver Voltage Control for a local DSO overnight
- trade in the power exchanges day ahead
- switch out position to play in the grid's Balancing Mechanism instead because just before gate closure there's an energy shortfall due to the wind dropping off sooner than forecast.

No way back

New market infrastructure designs are now allowing a deeper penetration of batteries to cope with the growing market share of renewables. In Europe, Project TERRE, which stands for Trans European Replacement Reserve Exchange, will increase the digitisation of short term power markets.

It is therefore my opinion that infrastructure managers who don't invest in batteries in the next two years will be marginalised as renewable energy investors by mid-decade; they simply won't be in a position to catch up.

I am not saying it's going to be simple for early movers; lots of things to learn, mistakes to be made, new value chains to be created. But this is not a leap of faith, it is simply common sense. ■

Author

Laurent Segalen is a franco-british banker specialised in Renewable Energy transactions. He is the founder of Megawatt-X, the London-based platform for investing in Wind and Solar assets, which he currently heads. Megawatt-X has listed more than 14GW of Wind and Solar transactions over the past 8 years. His career spans over 25 years, from Director at PWC, Fund Manager at Natixis/Mirova to Managing Director Clean Commodities at Nomura. Along with fellow financier Gerard Reid of Alexa Capital, Laurent is a co-host of the podcast Redefining Energy, launched in 2018.

More in common: Europe's energy storage associations' unified stance

Europe | What do Ireland, Germany, Poland and Spain all have in common? Well, like the other members of the European Union they all have a requirement to decarbonise and a desire for sustainable economic growth. Andy Colthorpe speaks with energy storage associations from those four countries to hear about their unique situations as well as the opportunities and challenges they share.

The European Union brings together 27 different member states with shared goals across everything from promoting peace, security and justice to promoting scientific and technological progress and establishing an economic and monetary union.

Where energy markets and policies sit within this loose unification of nations is a complex issue, one that also spans the distance from social issues (climate change and environmental justice) to economic (job creation and security of supply) and more.

The macro trend is the same as it is worldwide: renewable energy is on the rise and energy storage is a key to unlocking the decarbonisation and economic growth potential of the energy transition. Representatives of energy storage associations from Ireland, Germany, Spain and Poland gathered together to discuss the status and role(s) of energy storage in their respective countries, in Europe and in the wider world.

While Energy Storage Europe, the annual conference and trade fair held in Düsseldorf, Germany, could not take place in person due to coronavirus, German trade association BVES' policy and markets expert Valeska Gottke helped us put together this multi-lateral online gathering from which the responses below were gathered.

Ireland - Paddy Phelan, president, Irish Energy Storage Association

Paddy Phelan was appointed earlier this year as president to the Ireland Energy Storage Association, taking over from Peter Duffy, who founded the group just over two years ago. Phelan says that Duffy and colleagues Eugene Coughlin and Frank Burke, coming from backgrounds working at Irish transmission and distribution groups and the regulator, put a "very strong concept together".

"Energy storage is regarded as relatively new" in Ireland, Phelan says. The first projects to be handed contracts through the DS3 grid services scheme set up by high voltage grid operator EirGrid to help meet Ireland's 2020 goal of sourcing 40% of its electricity came online earlier in 2021. The transmission system operator (TSO) modelled pathways to achieving net zero by 2050 and as a result a policy target of 70% renewable electricity by 2030 has been set.


Credit: Statkraft

Ireland's first grid-scale battery storage project, supplying grid services under the DS3 regime, was inaugurated at the beginning of this year.

Ireland has now surpassed the 40% target. Renewable energy development is gathering pace: the first large-scale solar facilities broke ground in this calendar year, while "significant" offshore wind development is expected over the next decade, Phelan says. Alongside this, the first national community auctions for renewable contracts were completed in 2020, handing contracts to four solar and three wind projects. The three 'Ds' of the energy transition: decentralisation, decarbonisation and digitalisation are now being developed at a system modelling level, but outside of a number of test centres, there is not yet "too much in practise," Phelan says.

The DS3 market gave the energy storage market a strong start, but the fixed tariff regime for 14 different network ancillary services is due to expire in Q2 2023 and the future is uncertain. IESA has been lobbying and it looks as though DS3 will last at least a year longer. The 12 month extension "wasn't as much as we'd hoped for," Paddy Phelan says, but it still "gives investors a good opportunity, or new companies to come into the market from outside".

To achieve 70% renewable electricity by 2030, non-synchronous generation would have to be at about 90%, leaving only 10% for conventional heavy generators which historically have provided grid stability. At present there is about 65% non-synchronous generation and so the requirement for very fast-acting response that energy storage can provide, is increasing.

There's also a strong scope for distributed and community energy storage; Ireland has many villages of less than 1,000 people, rural towns with populations up to 15,000 and five major cities of 30,000 to 1.1 million people.

"Offering demand level control at a community level is of real interest. There are some sandboxes in place, there are some considerations around peer-to-peer trading. And the European directive is due to be adopted and transposed into Irish legislation by the first of July this year, which is really interesting. These local energy networks will all need storage and smart controls as part of their proposals," Phelan adds.

One of the challenges — created partly by neighbouring Britain's decision to leave the EU — is that under EU market design rules each member state must be interconnected to two others. The grid in Ireland is shared with Northern Ireland, which is now in an "unusual position" straddling Europe and Britain. Going forwards, interconnections are planned with Spain and France via the Celtic Interconnector project, along with an interconnector with Wales on the UK's western coast.

The energy potential for Ireland from onshore and offshore wind is "phenomenal," Phelan says. In order to make Ireland a "smart island," short-term energy storage will be required. That's where the market and support, financing and funding is

at the moment. However, long-duration energy storage will become "very valuable in the context of interconnection to be able to supply green electricity to our European counterparts from renewable resources," the IESA president says.

Another clear challenge today is that retrofitting energy storage with existing wind resources is tricky from a standpoint of regulatory treatment. Co-location might be more common among new-build projects, but IESA is still seeking answers to the retrofit question. Phelan says his association seeks cooperation with European stakeholders that could participate in helping to provide some solutions for the regulators.

"A lot of the wind infrastructure that's been built out over the last 20 years is in quite isolated areas, but there are significant barriers to co-locating with hybrid battery storage," Phelan says.

"If you modify your connection to incorporate a battery, you trigger some unintended consequences. There's simple little things, like: because priority dispatch is now no longer on new projects, it was part of the old regime. If you integrate a new battery system and modify your connection, you lose priority dispatch. Secondly, it triggers a requirement to completely modify your controller mechanism to comply with the new grid code, whereas your wind farm could be 10 or 12 years old, and is controlled on the basis of the grid code at that time."

Germany - Valeska Gottke, senior expert for communications and markets at Bundersvand Energiespeicher (BVES)

In Germany, which was of course a global early adopter of solar PV, it seemed about five years ago that battery storage would similarly also become an integral and fast-growing component of the energy system.

Yet while residential energy storage sales to environment and independence-conscious households has accelerated to more than 300,000 such systems now installed and commercial and industrial (C&I) sales continue despite a slowdown during coronavirus, the utility-scale segment's opportunities largely became saturated after an initial first wave. Regulatory barriers also prevent the unlocking of the full value of energy storage, inhibiting the delivery of multiple applications and "double charging" operators of assets for using the grid (levying fees when drawing power from the grid and again when injecting into it).

"Germany does not consider energy storage as a key element of the Energiewende (Germany's 'energy transition')," relying largely instead on moves to extend grid infrastructure, Valeska Gottke at German storage association BVES says.

In contrast, the European Union, particularly its Clean Energy Package for All Europeans, recognises the central role energy storage plays in "new climate-friendly and secure energy systems". The EU also has a strong geopolitical interest in diversification of its energy supply within and beyond the Union, while the European internal market promotes peaceful ties within Europe, including cross-border energy interconnection. EU law isn't applicable directly on member states, but instead member states' national laws are adapted to meet EU requirements.

However, Gottke says that many people are concerned that Germany's legal mechanisms for implementing energy policy are somewhat divergent with the EU's Market Design Directive and Renewable Energy Directive frameworks for promoting renewables and regulating energy networks. For instance, rather than adopting a regulatory definition of energy storage set out by the EU Clean Energy Package, the German government has created its own definition of energy storage.

The EU defines energy storage as the deferral of the final use of electricity to a moment later than when it was generation, or the conversion of electrical energy into another form of energy which can be stored. By contrast, the German definition, translated into English, describes energy storage as facilities that consume electrical energy for the purpose of electrical, chemical, mechanical or physical, intermediate storage and generated as an electrical

Credit: Tesvolt.

Battery pack production line for energy storage systems in Germany. Despite the regulatory difficulties, there is high confidence in the German industry's competencies and tech, Valeska Gottke says.

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energy or used again in another form of energy.

"So in a way [according to the German definition], storage is not storage," Gottke says. The German definition of storage as a consumer and generator means that assets will continue to be charged twice for "consuming" power from the grid and charged again for "generating" for grid use.

"For the federal government, it is so important to make energy storage fit into the current system we have, which is still designed according to the old energy system and doesn't give [consideration] for flexibility options like energy storage."

The EU CEP also emphasises the importance of prosumers, generating and using their own renewable energy and making renewable energy available to third parties. Similarly, community energy facilities are an integral part of the CEP, which Germany of course had a hand in designing. Yet the German EEG and EnWG laws which are currently in the process of being passed do not do anything to strengthen the hand of either set of resources.

It is "not consistent with EU requirements" from the Market Design Directive that in Germany, prosumers are not able to provide several services at the same time with one energy storage facility, for example. There are additional levies for self-supply of energy too.

Since late 2017, BVES surveys of its member organisations has shown consistently that the industry considers regulatory conditions to be the main burden on the energy storage market preventing it from developing "more positively," Gottke says. There remains a lot of work to be done on this side, urgently so, she says, because deadlines for Market Design Directive implementation passed last December and Renewable Energy Directive deadlines are this June.

Despite the regulatory difficulties, Gottke says the German energy storage industry is still "very strong internationally, especially within Europe, with a strong reputation for system competence and ability to provide customised solutions in very complex conditions". Within the country however, the front-of-the-meter market, initially accelerated by access to frequency control opportunities is largely saturated. Behind-the-meter storage applications in residential and C&I are "growing very strongly", but as BVES has previously argued, energy storage needs to be recognised as an integral part of the Energiewende, along with grid infrastructure build-out and other options.

Credit: Edison Energia.

Poland's rooftop solar and community energy sectors can be a strong engine for decarbonisation and development of the energy storage industry.

"The overall main trend, the most important one, is that the Energiewende is still important and very popular in Germany. It enjoys a lot of support from society and installing an energy storage-plus-renewable system, at home, or at your office, is a way of doing your own Energiewende. It's still developing well, but there could be more force [at the top level] in my opinion and I think a lot of Germans see that, so they just do their own Energiwende."

Spain - Luis Marquina, president, AEPIBAL

By contrast, at the moment, "Spain is the place to be," says Luis Marquina of Spanish energy storage association AEPIBAL. While only three years old, 20 of its 60 member organisations from across the whole value chain have joined the group within the four months leading up to this interview, he says.

Spain's renewable energy industry has enjoyed a huge renaissance in the past couple of years and now from a policy standpoint targets more than 50GW of renewable energy capacity by 2030 including 30GW of solar PV and 20GW of wind. Nuclear and coal plants will shut down and Marquina describes energy storage as the "unique solution" to mitigate the risks to security, quality and quantity of electricity supply.

Marquina says the renewable strategy and target is "absolutely achievable," with about 4GW of solar capacity deployed annually in the last two years. The challenge comes with the way that electricity prices and revenues will likely change with the addition of massive solar capacity in the middle of the day. This of course opens the door to energy storage if there's a big discrepancy between peak and off-peak pricing, while the system will also require grid services that batteries and other storage can deliver to provide stability to the grid.

With this in mind, the country has set a 20GW target for energy storage deployment by 2030, 9GW of which should be coming from electrochemical batteries. There was also a recent renewable energy auction which included an energy storage option so that developers could provide "manageable" electricity capacity to the grid. While the incentives proposed by the government were not enough to provoke an "explosion" of energy storage through the auction, the hosting of the auction in itself caught the attention of the wider energy sector and served to raise the profile of energy storage, the AEPIBAL president says.

"These are exciting and historic times," according to Marquina, with great, industrial-scale deployment of new technologies just beginning. He says he sees great potential in Spain for technologies including second life batteries, redox flow battery storage, hybrid renewables-plus-storage and energy management and power control systems.

But while Spain may be enjoying — if you'll pardon the expression — this moment of sunshine on its industry, Marquinos says, the challenges it faces are shared across many countries and the energy transition is an effort that should be undertaken collectively.

"We have to be more coordinated in Europe, because we are living all the same experiences. Ireland is at the same point we are. The difference between Ireland and where we are is very small. We have a lot in common and a lot of information to share, we can serve business opportunities."

The UK might be outside the EU now, but given the UK's rapid development of a thriving energy storage market, Marquinos still believes there's a lot of knowledge sharing that can happen with the former member state too.

EU membership will nonetheless have a bearing on the support the industry in Spain directly benefits from: the Recovery and Resilience Funds will provide more than EU750 billion to be invested by 2026, 70% of that sum before 2023, Marquina says. More than a third of those sums will go to climate transition causes and loans and subsidies into the energy sector for technology innovation, including transmission and distribution grid digitisation.

Poland - Barbara Adamska, president, PSME

When people think of Poland's energy sector, they usually think of coal. However although around 70% of electricity production still comes from the fossil fuel, renewables now provide around 18% of electricity production and Poland was Europe's fourth largest solar PV market in 2020. Coal plants are also scheduled for phase out by 2049.

With policy in the country adapting to climate risk, partly driven by its European Union commitments, the "dynamic deployment of renewable energy sources" is the main driver for energy storage, Barbara Adamska, president of the Polish energy storage association PSME, confirms. The country is targeting at least 32% of domestic net electricity consumption to come from renewables by 2030.

"The photovoltaics sector in Poland is growing rapidly. The development of the photovoltaics market in Poland is actually a matter of the last few years. At the end of 2015, the installed capacity in PV was only about 70MW. At the end of 2020, it amounted to around 4GW — an increase of some 5000%. In the same period, the number of prosumers went up from 4,000 at the end of 2015 to over 450,000 at the end of 2020. An increase of 11,000% over 5 years," Adamska says.

At the same time, Poland's energy supply security is "jeopardised by the deteriorating technical conditions" of its power infrastructure, with the majority of transformers and transmission lines built in the 1970s and 1980s, making the development of energy storage a necessity, according to Adamska and PSME.

After several years of discussion, the first few "experimental investments" into energy storage have begun in Poland, but as with other territories, the lack of regulatory framework has been a burden for the industry. However, this year looks set to be transformative for the Polish energy storage sector: the Polish parliament adopted an amendment to its Energy Law in April which Adamska believes will "enable the dynamic development of the energy storage market".

These changes include the elimination of the "double charging" of fees for import and export to the grid, the removal of licensing requirements for systems under 10MW rated power, exemption from the obligation for a specific energy storage tariff and allowing distribution and transmission networks to invest in energy storage as eligible costs for recovery through rate structures.

Poland has moved faster than the UK or Germany to adopt a set of regulatory definitions of "grid energy storage" and "grid energy storage facilities". The PSME president says this will solve "interpretation problems stemming from inconsistencies in these definitions across different legal acts".

Allowing network organisations to classify investment in energy storage assets as eligible costs for running their transmission and distribution grids more efficiently and as a substitute for grid expansion has led the transmission operator PGE to announce that it will deploy at least 800MW of energy storage by 2030. This includes a 205MW / 820MWh system in Zarnowiec, northern Poland, which will be the largest of PGE's planned systems — so far.

Microgeneration has benefited from the implementations of programmes such as the "My Electricity" incentive scheme, to which around EU250 million was committed to support prosumer rooftop PV installations. The programme is expected to restart in July 2021 and Adamska says it is expected to be extended to include subsidies for energy storage systems. She believes support for home energy storage is crucial to continuing the rapid and so far successful development of small-scale renewables.

Meanwhile, community energy generation is a "hot topic" in Poland too, with the government's Ministry of Climate and Environment supporting the concept of local energy clusters. A policy formalised since 2016, different stakeholders can form these community clusters to meet local energy demand with local energy supply, covering up to five municipalities or one district. Adamska believes these clusters could be a game changer for Poland's energy transition, with over 100 already established and 66 receiving approval to proceed as pilots. As many as 300 could be in operation by 2030 and the "local range" concept is of course favourable to energy storage and distributed energy resources of various types as well as renewable energy. Furthermore, the policy is firmly in line with EU directives.

As with all of the other trade association representatives spoken to for this article, Poland's energy storage association president believes international cooperation and communication is vital for the future.

"For the development of the energy storage market in Poland, it is extremely important to exchange experiences with industry representatives from other countries and to stay in contact with foreign universities and research institutes," Adamska says.

"I wholeheartedly appreciate the Energy Storage Europe fair, along with the conferences accompanying the event. Every year since 2015, the Polish delegation, which I chair, has participated. The delegation includes representatives of ministries responsible for energy, Polish universities and research institutes and entrepreneurs from the energy storage industry. Establishing contacts and exchanging experiences with representatives of the regulator, representatives of the world of science and entrepreneurs from other countries are extremely valuable. Hopefully in 2022 we will have the opportunity to meet again face-to-face in Düsseldorf at Energy Storage Europe."

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Battery storage as peaking capacity: How Alamitos changed the game for California

California | Commissioned at the start of this year, the Alamitos Battery Energy Storage System in California is a landmark project for the industry in having competed against natural gas to provide peaking capacity for the grid. Andy Colthorpe finds out the project's backstory from Fluence's Ray Hohenstein and AES' Mark Miller.

Credit: AES Corporation.

When it was first proposed in 2014, at 100MW / 400MWh, Alamitos Battery Energy Storage System was the world's biggest contracted battery project. By the time it came online as scheduled on 1 January 2021 — after a construction period which began in 2019 — it could no longer take that crown, although it is certainly still one of the biggest around.

However, Alamitos was and remains historic for another, arguably even more significant reason. It represents the first time that battery storage has directly come up against natural gas in a competitive solicitation process and won. California investor-owned utility (IOU) Southern California Edison (SCE) picked out the plan designed by power producer AES Corporation as a means of providing essential local capacity following the shutdown of the San Ofre nuclear power plant (see timeline, p.92).

The utility put out an all-source procurement to find 2,200MW of capacity to replace San Ofre's in its energy mix and from a minimum expectation that about 50MW of that would come from battery storage, SCE actually made 235MW of awards. Alongside 135MW of behind-the-meter energy storage, AES Corporation's front-of-meter Alamitos project won out.

Alamitos BESS in Long Beach, California is part of AES' Southland platform.

The big caveat perhaps is that Alamitos' battery storage will be flanked by two new natural gas plants. These are combined cycle gas turbine (CCGT) plants which provide baseload capacity. As such they are the more efficient and less emissions-intensive cousins of open cycle gas turbines which are commonly used as peaker plants. The CCGTs AES is building at the sites however have a lower

emissions profile again and are also 70% less water-intensive than legacy CCGTs and frankly, at this stage, it's a difficult truth that rapidly deploying energy capacity cost-effectively to meet the shortfall created by San Ofre's demise would be extremely challenging without these plants.

Nonetheless, the arrival of Alamitos Battery Energy Storage System (BESS), reduces the need for gas peaker plants in the Greater Los Angeles area: as you probably already know, gas peaker plants may have been the cheapest option to deploy when most of them were built in the 1960s and 1970s, but are expensive to run and typically only go into action very infrequently.

Many peaker plants have a capacity factor of 15% or below. When they are called into action, they are also extremely polluting and due to their need to match peak demand are often in or close to heavily populated areas. Put simply, the BESS at Alamitos will charge at off-peak times and at times of high solar generation and then discharge for up to four hours to meet local energy demand on the grid at peak times.

Back in 2014, after several years of developing and building battery storage projects around the world of about 5MW to 10MW each, AES Corporation wanted to propose, alongside the two CCGT plants, a showcase of large-scale battery storage as "very capable and competitive technology against open cycle gas," Mark Miller, AES' market business leader for California, says.

"When you look back on it, that's almost seven years ago. It's an extraordinary decision, not only by AES to table that and show the confidence in our technology, but even more so to think about what Southern California Edison did in awarding that 100MW, four-hour duration product as a direct competitor to natural gas. We showed that four-hour duration, on a cost basis, was directly competitive with natural gas, so hats off to SCE to actually take that bold step and give us a 20-year power purchase agreement (PPA). From that perspective, it was a very unique opportunity and kind of showed the merits of not only our confidence in technology, but also the ability to deliver."

From a bold decision and a step-change in the understanding of what emissions-free battery technology can do, now that the system has gone into operation, this year will be pivotal in proving the value of batteries to the grid. The California Independent System Operator (CAISO), has said that it expects the amount of battery storage on its transmission network to leap from 250MW last year to about 2,000MW by August 2021 and the majority of that new capacity will be four hour batteries.

Four hours is considered to be the sweet spot for mitigating peak demand on a daily basis as solar ramps down in the late afternoon and evening from about 4pm or 5pm to 8pm or 9pm in California, while four hours is also the sweet spot for lithium-ion batteries to provide that capacity, before the technology starts to become more expensive than other resources like CCGTs (at present). With California having faced a difficult balancing act to meet peak load during last summer's August heatwave, this summer season will be the real test, Mark Miller says.

"That [battery] asset has a lot of flexible technology, from grid support [applications], like frequency support or spinning reserve, but primarily why it was contracted is peaking capacity, and to cover that net peak during the most critical part during the summer season," he says.

"This year is going to be a very interesting period of time, because we'll now have a 100MW, four-hour duration battery in the system operating moving into the peak summer season. We're anxious to see it perform — which we've got a high level of confidence that it will — and SCE by that point will be very, very capable of understanding how they plan to utilise it through that peak period of the summer."

AES believes the project and the way it won out through a competitive solicitation process planted a seed for future deployments, not least of all because SCE

Credit: AES Corporation.

Inside the halls of battery racks at the 100MW / 400MWh 'battery peaker plant'.

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Alamitos: A timeline

1968:
Unit 1 at San Onofre Nuclear Generating Station (SONGS) goes into action and remains so until 1992.

JUNE 2013:
Southern California Edison (SCE) announces decision to permanently retire Units 2 and 3 at San Onofre Nuclear Generating Station. The two units were safely shut down in January 2012: unit 2 after a planned routine outage, Unit 3 due to a leaking tube in a steam generator installed in 2010.

"Looking ahead, we think that our decision to retire the units will eliminate uncertainty and facilitate orderly planning for California's energy future," SCE president Ron Litzinger says.

SEPTEMBER 2014:
SCE unveils the Tehachapi Energy Storage Project, part-funded by the US federal Department of Energy (DoE) at Monolith, a substation in the utility's service area close to the Tehachapi Wind Resource Area, supporting the rapid expansion of renewables. At 8MW / 32MWh, using LG Chem batteries, it was a rare four-hour duration utility-scale battery and at the time, the largest battery energy storage system in North America.

"This installation will allow us to take a serious look at the technological capabilities of energy storage on the electric grid. It will also help us to gain a better understanding of the value and benefit of battery energy storage," Dr Imre Gyuk, programme manager for energy storage at the DoE explains at the time.

NOVEMBER 2014:
Meeting local reliability needs as part of that "orderly planning", Southern California Edison awards 2,221MW of contracts — around 10% of the utility's peak load usage — following an all-source procurement for capacity requirements. SCE receives more than 1,800 final offers and selects 69 including energy efficiency, demand response and solar as well as marking the first time the utility has contracted with energy storage projects through a competitive solicitation.

A minimum of 50MW of energy storage is expected to be procured — in the end SCE contracts for 261MW, including a 20-year power purchase agreement (PPA) for AES' 100MW / 400MWh Alamitos project.

The outcome is a "monumental decision" that "demonstrates that energy storage can be competitive with other preferred resources on both performance and value, and that it's now an integral part of the utility planning tool kit in California," says Janice Lin, executive director of the California Energy Storage Alliance.

DECEMBER 2015:
AES signs 1GWh supply agreement with battery manufacturer LG Chem; a deal worth around US$300m according to one analyst at the time. AES' existing pipeline of projects is estimated by the analyst to be about 100MWh.

JULY 2017:
AES closes US$2 billion financing for the Southland Repowering Project, which involves retiring 2,075MW, 1,392MW and 474MW of gas at its Alamitos, Redondo Beach and Huntington Beach facilities respectively, to be replaced by the Alamitos battery system and 1,284MW of combined cycle gas generation.

Also that month, AES and Siemens launch energy storage technology provider and system integrator Fluence. The joint venture is initially a vendor for both AES' Advancion energy storage which up until then had been deployed across 200MW of projects worldwide as well as Siemens' Siestorage products. Later, Fluence launches its own range of branded systems, bringing out its sixth generation in 2020.

JUNE 2019:
Fluence breaks ground on the Alamitos project, setting an expected date for it to be operational at the beginning of January 2021, a year earlier than original plans.

"Alamitos energy storage will stand as the first of a new generation of energy storage procured as stand-alone alternatives to new gas plants. It represents a whole new way to think about capacity and reliability. Its size, flexibility and long duration stand as a benchmark, and showcase energy storage as a mainstream option for peaking power and grid support," explains Fluence chief operating officer John Zahurancik.

1 JANUARY 2021:
Alamitos battery storage project goes online.

itself has made other contract awards for battery storage as a peaking asset since Alamitos, Miller says. Indeed, as of December 2020, SCE said it had procured and contracted for around 2,050MW of energy storage capacity.

Making it look like a conventional asset

Battery storage might be the wave of the future, happening today, but when Alamitos was a twinkle in AES Corporation's eye, the company realised that from a contracting standpoint, it would have to look as much as possible like an asset that a utility could be comfortable with, says Ray Hohenstein, director of business innovation at storage technology provider Fluence.

"One of the big elements of AES' approach was to try to make energy storage, from a contracting standpoint, look and feel as similar as possible to a natural gas plant. To minimise the change from a contracting structure standpoint and from an operations standpoint. The contract is a tolling agreement. That's the typical model you see with fossil fuel plants — and that was deliberate," Hohenstein says.

"It's this idea that basically a utility contracts for the asset's capacity and then they're in charge of bringing in the fuel, which is in this case electricity. A deliberate and smart choice was made to utilise precedent from how gas plants are contracted. Obviously, it worked out and made it a lot easier to make the case economically, contractually and legally for it."

Fluence is of course part-owned by AES Corporation and was the evolution of AES Energy Storage, while also combining the energy storage business of Siemens, its other majority owner. Alamitos was one of the first big projects under the Fluence brand as the company officially launched as its own entity in late 2017.

It sounds daunting to have gone from 10MW projects or smaller, often with much shorter durations than four hours, to a 100MW / 400MWh undertaking, but Hohenstein says this is made simple by the versatility of lithium-ion technology.

"In 2014, we were several generations earlier in our energy storage technology. It was definitely a calculated decision that everything from the density of the system and the layout to how we interact with the grid, these are all concepts that had been tested and proven in the field, but at much smaller scales and it was a bit of a leap to scale it up," he says.

"But, one of the best parts about lithium-ion based energy storage of the type that Fluence builds, is that it is highly modular. It's essentially blocks that are able to be repeated, all linked together with advanced controls, and digital intelligence to oversee the dispatch of the entire system efficiently, but the system can scale up quite easily from a few megawatts to 100MW — without sort of dramatically changing the underlying architecture. In that sense, it actually wasn't nearly as big of a leap, as you know, the scale might seem from the outside."

'No longer economically rational to build gas peakers in Australia'

There's still a disconnect between what's achievable and what is actually being achieved, in the drive to decarbonise.

Credit: Edify Energy.

Large-scale battery storage at Gannwarra solar farm in Victoria, Australia.

During 2020, renewable energy generation in Australia amounted to about 27.7% of the national total, with wind about a third of that, but more than 3GW of small-scale solar was installed in the year and about half as much large-scale solar capacity.

Yet, despite that boom, and despite strong recognition of the potential of renewable energy by several state governments, the national federal government has been criticised for its seeming inability to form a coherent set of long-term decarbonisation goals. Indeed, the mantra during the more recent months of the COVID-19 pandemic, as other countries consider a 'green recovery,' Australia's government line is instead commitment to "a gas-fired recovery".

That commitment is a dangerous one says Lillian Patterson of the Clean Energy Council, a national trade association which recently published a study showing that battery storage can be more effective and 30% cheaper on a levelised cost of energy (LCOE) basis than new-build gas peaking plants.

"Our federal government has committed to a gas-fired recovery. They have been reticent to commit to a climate change and energy policy. This is one of the things that has been really lacking in Australia for a long time: we don't have a long-term climate change policy that considers energy policy as well."

The Australian Energy Market Operator (AMEO), which manages electricity and gas markets to oversee the reliable and affordable transmission of energy, has modelled that the National Electricity Market (NEM), covering the southern and eastern parts of the country will need between 26GW and 50GW of large-scale renewable energy and between 6GW and 19GW of new dispatchable resources by 2040.

The lower end of those figures is what it will take to largely retire coal power generation, but Patterson says the AEMO's Integrated System Plan 2020 doesn't see a role for gas to fill the gap over the next 20 years, it could be filled by a range of different types and scales of energy storage.

When it comes to peakers, the Clean Energy Council's own analysis finds it's no longer economically rational — or necessary — to build gas power plants for peaking capacity when batteries can be "the new clean peaker".

Peaking plants are generally needed in the NEM after 6pm each night for an average of three to four hours as solar systems ramp down and demand hits its peak. Gas peakers are able to ramp up in about 15 minutes; on the other hand, batteries can respond accurately and near-instantaneously to signals from the grid.

"[The paper is] really highlighting that batteries, that storage is offering the services that gas is doing, but it's a cleaner option to do that. It's not [just] the cleaner option, it's also a cheaper option as well," Patterson says.

The Clean Energy Council wanted to "put in a different perspective into the conversation" about the government's gas-fired recovery strategy. And while the study does find that, modelling a 250MW / 1,000MWh 'battery peaker' for the New South Wales region, it's considerably cheaper than gas, what could become even more important is a) the future value of battery storage and b) the economic and policy risk of developing new gas facilities.

"We didn't factor in anything to do with a carbon price, because we don't have a carbon price in Australia, but there is a carbon risk associated with gas as well. That could be a carbon price or similar [policy] within Australia. That would obviously increase the LCOE for gas. We're also seeing the 'carbon border taxes' that are being considered in places like Europe. That's something else that needs to be considered in this as well.

If we produce anything and we want to send it overseas, they're going to recognise that we don't have a carbon price and so therefore, the cost of that could be more expensive."

So the cost differential would be even more significant if carbon taxes were incorporated into analysis. The national Clean Energy Regulator is currently considering the role of a 'carbon exchange,' effectively an exchange trading market for offsets. The other side of the coin is that the additional revenues a battery storage plant could accrue will also alter that differential further.

There is already a frequency control ancillary services (FCAS) market which large-scale batteries and virtual power plants (VPPs) have already benefited from. In April chief rule maker, the Australian Energy Market Commission (AEMC) said it will be introducing a fast frequency response market within a couple of years that will value response times of less than six seconds: an opportunity lithium-ion batteries will be perfectly suited to take part in, where many other resources will not.

The introduction of shorter, five-minute settlement windows in the wholesale market, expected to begin this October, will also change the game. Knowing all of this, who would even want to invest in new gas peaker plants?

"Coal and gas generation have been an important part of our energy mix but we are transitioning, and in moving forward, we need diversity. We need renewables, we need solar and wind, we need energy storage — we need different types of storage. We need shorter duration battery power, we need virtual power plants (VPPs), we need longer duration pumped hydro and we need transmission because as everyone knows the sun doesn't always shine and the wind doesn't always blow." ■

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Solar's materials and supply chain crisis

Balance of system component testing: what you need to know

Taking floating solar to deeper waters

EXPO SOLAR
www.exposolar.org

GREEN NEW DEAL EXPO
www.greennewdealexpo.com

ESS EXPO
www.essexpo.co.kr

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SOLAR + ESS + GREEN NEW DEAL EXPO 2021

June 16(Wed.)-18(Fri.) 2021
KINTEX, SEOUL KOREA

EXPO SOLAR

- Since 2009, only exhibition specialized in photovoltaic energy in Korea
- Co-sponsored by local governments and associations to share the latest PV trends
- Related parallel exhibitions: Energy Storage System (ESS) and Green New Deal Expos
- Supporting global marketing and PR activities for participating brands and technologies
- Held at KINTEX, Korea's largest exhibition center within an hour drive from Seoul and Incheon International Airport
- Exhibiting Items: solar cells/panels (PV modules), inverter, components, monitoring solution, power system, production technologies, plant, repowering, BIPV

GREEN NEW DEAL EXPO

Exhibiting Items: New Renewable Energy, Green New Deal Convergence Industry, Smart Energy Platform, Hydrogen·Electric Vehicle Market, Low Carbon Dispersive Energy, Smart Green Industrial Complex

ESS EXPO

Exhibiting Items: Energy Storage System / Technology / Components & Devices, Control Engineering for Optimal Energy Consumption

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