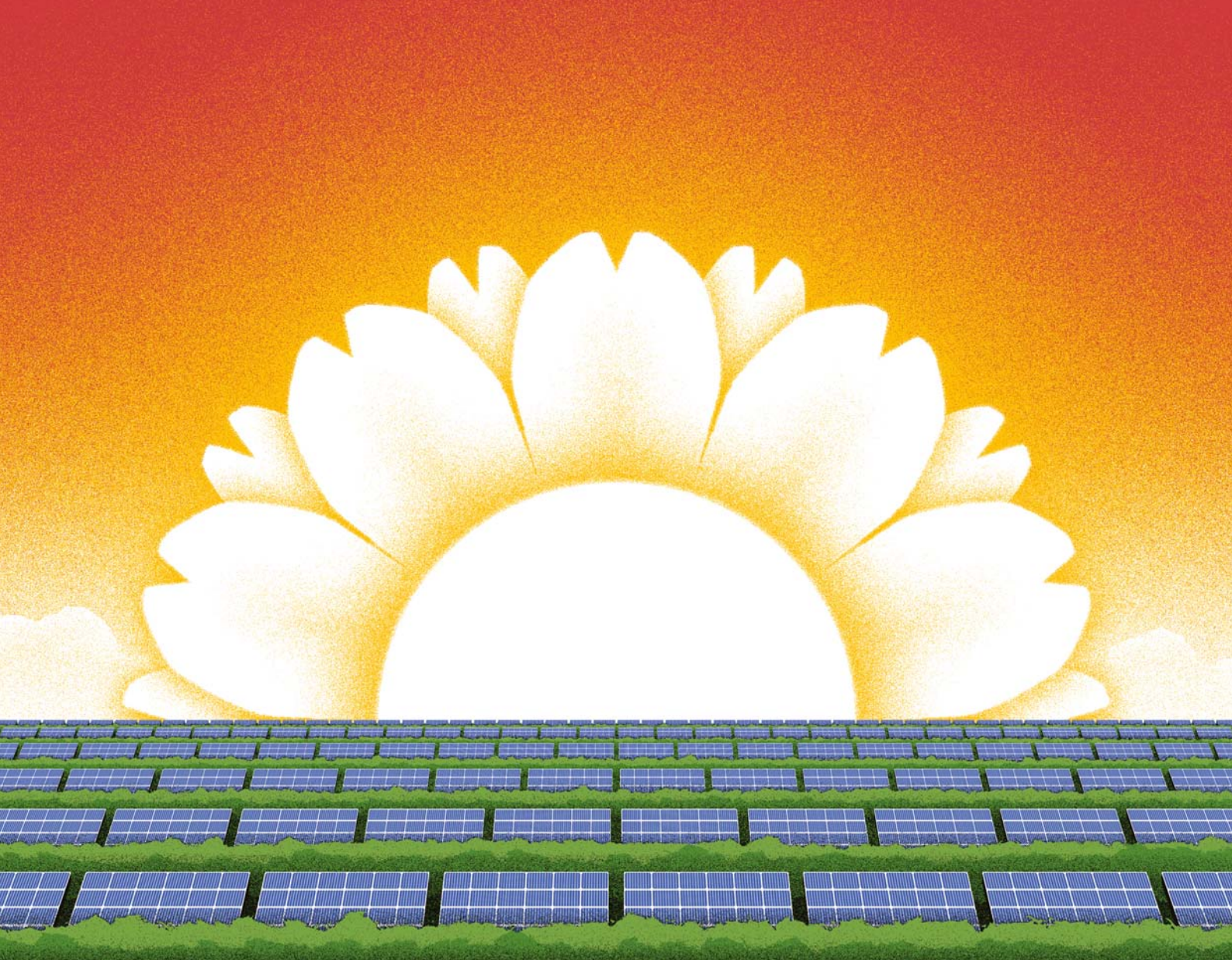


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# Hi-MO 6 Explorer

## Classic, but with Revolutionary Changes


Unique high-efficiency HPBC cell structure sets  
new standard for PV technology



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# Introduction



Welcome to *PV Tech Power 34*, our first issue of 2023. As this edition was being finalised, many in the world marked the one-year anniversary of Russia's invasion of Ukraine.

As well as triggering a global energy crisis, the war "has sparked unprecedented momentum for renewables" as higher fossil fuel prices improve the competitiveness of solar PV and wind, the International Energy Agency said in a recent report. The organisation forecasts that the amount of renewable power added in Europe in the 2022-27 period will be twice as high as in the preceding five years.

Markets across Europe are providing more favourable conditions to boost solar deployment as governments look to gain more energy independence. One such country is Romania (p.32), where a new contracts for difference scheme is due to go live this year, as detailed by Lena Dias Martins in our Market Watch section.

The war in Ukraine has seen Russian forces target power generators and the grid, with 30% of the country's power stations destroyed as of October 2022. Molly Lempriere explores how solar is being rolled out in war zones such as Ukraine to power vital infrastructure (p.36).

With solar deployment being supercharged by the energy crisis and climate change, access to suitable areas for large-scale PV plants will become more difficult, opening up the potential to construct projects on agricultural land.

Our cover feature looks at the challenges of developing and operating agrivoltaic systems (p.16), which could make solar more appealing to communities opposed to standalone installations. We also hear from

experts about opportunities for agrivoltaics in five markets – Germany, the US, France, Australia and Africa – as well as the policies and incentives that are supporting the segment's growth (p.21).

On the policy front, the coming months will see the US Department of Commerce issue its final determination into whether Chinese PV manufacturers have avoided US tariffs by routing some of their operations through Southeast Asia – a decision that could have huge ramifications for both solar's upstream and downstream.

This is in addition to the US's Uyghur Forced Labor Prevention Act, which has caused module shipments to be detained at US borders. Amid supply chain issues as a result of the legislation and the threat of extreme weather events damaging operational solar assets, Rosa van Reyk of GCube Insurance reveals how the industry can reduce losses (p.70).

Other topics explored in this edition include the potential for repowering solar projects (p.64), the challenges of bifacial module performance monitoring (p.62) and how developers are benefitting from new power purchase agreement structures (p.72).

As detailed throughout this issue, PV players are responding to the energy crisis by embracing new opportunities and technologies while leveraging policy support to set up the industry for another year of dramatic growth.

Thanks for reading, and we hope you enjoy the journal.

**Jules Scully**

Section editor  
Solar Media

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### 40-42 MENA aims to become solar-powered green hydrogen hub

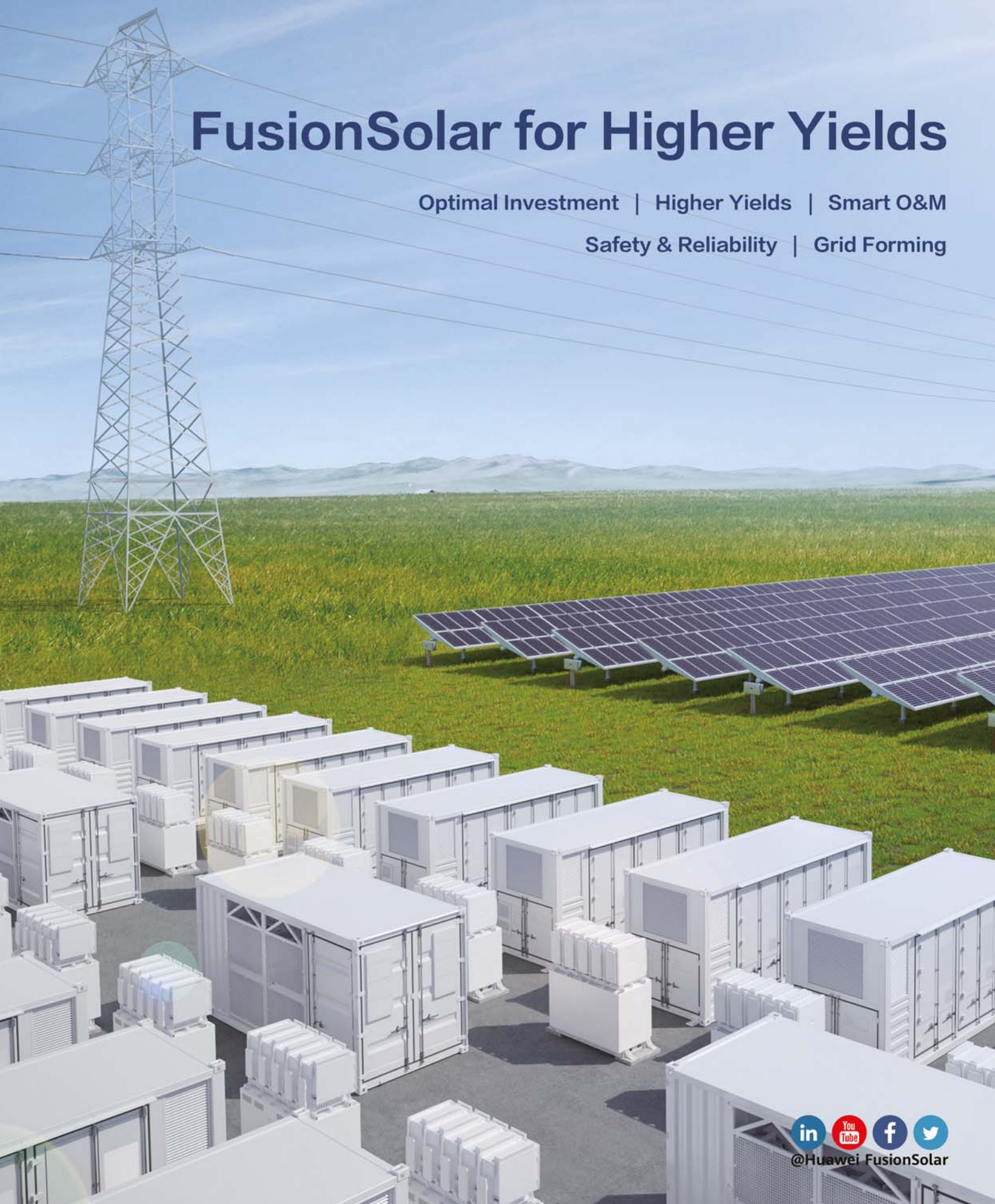
Home to high levels of solar irradiance, countries in the Middle East and North Africa are positioning themselves as major green hydrogen hubs. Jonathan Tourino Jacobo finds out more.



# FusionSolar for Higher Yields

Optimal Investment | Higher Yields | Smart O&M

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# SMART MODULE BY TONGWEI

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## EUROPE

### EU policy

#### 'A good first step': European solar manufacturers welcome Green Deal Industrial Plan but call for more support

The European Commission unveiled the EU's response to the Inflation Reduction Act (IRA) and China's dominance in the solar supply chain with the Green Deal Industrial Plan (GDIP), which will be based on four pillars: a predictable and simplified regulatory environment, faster access to funding, enhancing skills and open trade for resilient supply chains. If the IRA has been welcomed by the US solar industry almost as the saviour to boost a domestic manufacturing industry, in Europe the response to the GDIP seems more lukewarm. Manufacturers from across the value chain have welcomed the initiative, yet are asking for more if the EU expects to compete on a level playing field with the likes of the US and India. The plan will aim to give faster access to funding and investing in renewable manufacturing in Europe, within a level playing field between state members while making it easier to grant necessary aid to fast-track the green transition.

#### European Solar PV Industry Alliance launched, targets 30GW of manufacturing capacity by 2025

The European Commission launched the European Solar PV Industry Alliance in December to promote investment in EU solar manufacturing. Launched alongside industrial actors, research institutes, associations and other relevant parties, the alliance has endorsed the objective of reaching 30GW of European manufacturing capacity by 2025 across the entire value chain.

#### EU provides funding for 600MW transmission line between Italy and Tunisia

A 600MW electricity transmission line between Italy and Tunisia has received €307 million (US\$324 million) in funding as part of the EU's Connecting Europe Facility (CEF) financing programme aimed at developing energy infrastructure across the continent. The transmission line qualifies as one of the EU's Projects of Common Interest, which are projects that "have a significant benefit for at least two EU countries and must increase competitiveness, enhance the EU's energy security and contribute to sustainability", according to the European Commission. The project, to be developed by Italian utility Terna and STEG, the Tunisian grid operator, features a 200km submarine cable, with a maximum depth of 800m, and represents the first time that the CEF has awarded funding to a cross-border infrastructure project developed by an EU member state and a third country.



The transmission line will run for over 200km, between the province of Trapani in Sicily to Tunisia. Image: C-Crete Technologies.

### PPAs

#### European solar PPA prices reach new high of €76.84 in Q4 2022, up 60% year-on-year – LevelTen

High development costs and an unstable regulatory environment increased average solar power purchase agreement (PPA) prices in Europe to a new high of €76.84 (US\$82.4)/MWh in Q4 2022. Prices increased 60% year-over-year, and are up 11.4% from the previous quarter as continued inflation, rising interest rates, supply chain issues and permitting roadblocks add to the tally of headwinds developers are facing, according to PPA services company LevelTen Energy.

### Iberia

#### Spain authorises 25GW of solar PV capacity

Spain's ministry of ecological transition has authorised 132 solar PV projects across the country with a total capacity of 24.8GW. All the projects that received a favourable environmental process – Declaración de Impacto Ambiental – had already received grid access between December 2017 and June 2020, with the deadline for environmental approval due on 25 January 2023. The announcement has led to warnings of engineering, procurement and construction backlogs as the vast amount of projects all look to begin construction.

#### Iberdrola secures environmental approval for Europe's largest solar PV plant with 1.2GW capacity

Spanish utility Iberdrola has received environmental approval for the construction of Europe's largest solar PV plant, in Portugal, with a capacity of 1.2GW. Located near Sines, in the south of the country, the project will be the fifth largest in the world, according to the company, and is expected to be commissioned in 2025.

### Poland

#### Better Energy plans €800 million investment in 1GW of solar PV across Poland and Denmark

Danish developer Better Energy and pension fund Industriens Pension have expanded their partnership with a further investment of €800 million (US\$876 million) in solar parks across Poland, Denmark and Sweden. The investment will add 1GW of solar PV capacity in the northern European countries, with 15 new solar parks expected to come online by the end of 2024. In Poland, the companies have already built five utility-scale solar PV projects with a total capacity of 240MWp.

### Romania

#### European Commission approves Romania's €259 million scheme to support investments in solar PV cells and panels

The European Commission (EC) has approved Romania's €259 million (US\$276 million) scheme to support investments in the production, assembly and recycling of batteries, PV cells and solar panels. Made available partly through the Recovery and Resilience Facility (RRF), the scheme aims to support the country's regional development which will create new skilled workers and bolster the EU's green transition. The scheme will run until 31 December 2024 with direct grants to companies active in the production, assembly and recycling of PV cells and solar panels located in regions that are eligible for the RRF aid.



## AMERICAS

## Policy

**US probe accuses Chinese solar manufacturers of dodging tariffs**

The US Department of Commerce has found that imports of some PV cells and modules produced in four Southeast Asian countries are circumventing antidumping duty and countervailing duty orders on solar cells and modules from China. The preliminary investigation into eight companies concluded that four – BYD Hong Kong (Cambodia), Canadian Solar (Thailand), Trina Solar (Thailand) and Vina Solar (Vietnam) – are circumventing duties, meaning their US imports may be subject to additional duties. While the probe found that four companies – New East Solar, Hanwha Qcells, JinkoSolar and Bovie Solar Technology – have not been dodging tariffs, it said circumvention was occurring in each of Malaysia, Vietnam, Thailand and Cambodia, and therefore made a “country-wide” circumvention finding. In addition, 22 companies were found to be non-compliant and will be subject to the most severe findings under ‘adverse facts available’. Regardless of Commerce’s final decision – currently scheduled for 1 May 2023 – an emergency declaration from President Joe Biden means that duties will not be collected on any solar module and cell imports from the four countries until June 2024.

**California to slash solar net metering payments**

NEM 3.0, the latest iteration of California’s rooftop solar net metering scheme, was passed in December by the California Public Utilities Commission (CPUC). Vocal public debate surrounded the legislation before the vote as solar industry workers and representative bodies called for revisions to the proposed decision. The now-ratified net metering legislation purports to incentivise battery storage systems in order to bolster grid security and manage loads in peak summer months. To that end, the proposal offers time-flexible export rates that “have significant differences between peak and off-peak prices to incent battery storage and load shifting from evening hours to overnight or midday hours”, the CPUC said. To account for the theoretical uptick in storage systems, the legislation will cut export rates for power sold back to the grid by around 75%. This has been the main focal point of the criticism of NEM 3.0, with many saying that the legislation will make solar less affordable and cause a drop-off in installations. The new laws are due to come into effect in April 2023.

## Plant performance

**US solar assets ‘not meeting performance expectations’, kWh Analytics says**

US solar assets “are not meeting performance expectations”, according to research from kWh Analytics. The 2022 edition of the insurer’s 2022 annual Solar Generation Index (SGI) compiles learnings from more than 500 operational solar assets in the US, with a total installed capacity in excess of 11GW. The analysis, which reflects on the weather-adjusted performance of solar assets between 2012 and 2021, concludes that asset underperformance persisted in 2021, and over the past decade underperformance has impacted projects independent of their capacity, region and mount type. The research

continues to show newer projects performing worse than projects constructed in the early 2010s relative to their P50 estimates, however the average performance of projects constructed in 2021 had a minor improvement from those in 2020.

## Finance

**Nextracker raises US\$638 million in IPO**

PV tracker solutions provider Nextracker raised US\$638 million in its initial public offering (IPO). The IPO saw 26.6 million of the manufacturer’s class A common stock begin trading on the Nasdaq Global Select Market under the ticker symbol ‘NXT’ on 9 February. Underwriters were granted a 30-day option to purchase up to an additional 3,990,000 shares of common stock. In the six-months leading to 30 September 2022, Nextracker generated more than US\$870 million in revenue and US\$114 million in gross profits.



The Nextracker team, including CEO and founder Dan Shugar (centre), celebrate the company’s IPO in February.

Credit: Nextracker via Twitter.

**Silicon Ranch secures US\$600 million equity raise**

US independent power producer Silicon Ranch has conducted a US\$600 million equity raise, bringing its total funds raised in 2022 to over US\$1 billion. US\$375 million of the new equity raise was closed in December 2022, with the remaining US\$225 million expected in early 2023. The company said that it plans to support engineering, procurement and construction for its project pipeline, as well as maintain its portfolio of over 150 PV projects across the US and accelerate its growth strategy. The initial US\$375 million funding was led by existing Silicon Ranch shareholders including Manulife Investment Management, TD Asset Management and Mountain Group Partners. In January 2022, the company secured US\$775 million to expand its project pipeline and pursue new markets.

## Chile

**Chilean utility Colbún completes 230MW PV project with 32MWh battery storage system**

Utility Colbún has inaugurated a solar-plus-storage project with a 32MWh battery energy storage system in the Atacama region of Chile. The Diego de Almagro project is a 330-hectare site comprising 470,000 solar panels totalling 230MW of power and a 8MW/32MWh BESS allowing for four hours of full power discharge. The overall project totalled US\$150 million of investment of which the BESS was US\$11 million. The project is Colbún’s first operational energy storage unit, the largest solar PV park in the Atacama region and also the “debut of this type of technology” there, the company claims.

## MIDDLE EAST & AFRICA

### Policy

#### New initiative aims to scale up renewable energy manufacturing in Africa

The Africa Renewable Energy Manufacturing Initiative (AREMI) has been launched with the aim of scaling up renewable energy manufacturing capabilities in Africa. Launched by Sustainable Energy for All, the African Climate Foundation, Bloomberg Philanthropies, ClimateWorks Foundation and the Chinese Renewable Energy Industries Association, the initiative aims to unlock up to US\$850 million in investments to advance a renewable energy manufacturing ecosystem across Africa. With the continent home to 60% of the world's best solar resources, Africa has the potential to become a renewable manufacturing hub as it is expected to reach 650GW of solar PV capacity by 2050. A first wave of ten countries – Morocco, South Africa, Egypt, Ghana, Algeria, Tunisia, Nigeria, Namibia, Kenya and Tanzania – have been identified to have medium or high feasibility to localise solar PV or battery storage manufacturing capacities and build the tools and incentives that would increase investment opportunities. The AREMI will focus on capacity building, knowledge transfer, policy dialogues and advocacy, as well as enabling pilot projects that drive low-emission development and carbon neutrality.

### Projects

#### Masdar to develop 3GW of renewables in Angola and Uganda, signs 2GW solar MOU in Zambia

UAE-owned renewables company Masdar is planning to further develop renewable energy projects in Angola and Uganda. As well as signing an agreement with Angola's energy and water ministry to develop renewable energy projects with a total capacity of 2GW in the country, Masdar will also develop greenfield renewable projects in Uganda with a total installed capacity of 1GW. The company also signed a memorandum of understanding and a joint development agreement with Zambia state-owned utility Zesco to develop 2GW of solar PV in the country. The deployment of the projects will be done in several phases, with the first one comprising 500MW of large-scale solar PV.

### Green hydrogen

#### CWP Global signs 10GW renewables and green hydrogen hub agreement in Djibouti

Renewables company CWP Global has signed a memorandum of understanding with the government of Djibouti to develop a 10GW renewable and green hydrogen hub in Djibouti. Strategically located in the Horn of Africa and with strong maritime transport connection to other markets, the Power to X project could potentially place the country as a major exporter of green ammonia in the region, according to Djibouti's ministry of energy and natural resources. The development of solar PV and wind capacity aligns with the country's Vision 2035 to diversify its energy mix and increase its renewables capacity. CWP Global continues its expansion of green hydrogen projects in Africa, with previous green hydrogen hubs powered by solar PV and wind announced in Morocco, Mauritania and Namibia.

#### Voltaia signs MOU for green hydrogen project in Egypt with up to 2.7GW solar and wind

Renewables company Voltaia and Egyptian oil company TAQA Arabia have signed a memorandum of understanding (MOU)

with the government of Egypt to develop, finance and operate a green hydrogen cluster with solar PV and wind power. Located in a greenfield site near Ain Sokhna port in the Suez Canal Economic Zone, the initial phase of the project will produce 15,000 tonnes per year of green hydrogen which will be powered with 100MW of electrolyzers supplied with 283MW of solar and wind power. The project will then be expanded to 150,000 tonnes of green hydrogen with an electrolyser with a capacity of up to 1GW supplied with 2.7GW of renewable power.

### Nigeria

#### Nigeria's solar power output on the rise, innovative financing could boost deployment – IRENA

Solar PV will play a more important role in Nigeria's power supply as it plans to meet the growing needs of all sectors of its economy through renewables. According to a report titled Renewable Energy Roadmap for Nigeria developed by the Energy Commission of Nigeria and the International Renewable Energy Agency, under current and planned policies, the African country's utility-scale solar system can offer 5GW and 25GW by 2030 and 2050, respectively. Meanwhile, its off-grid solar system will provide 13GW by 2030 and 29.5GW by 2050.

### UAE

#### EWEC issues RFPs for development of 1.5GW Abu Dhabi solar PV project

Emirates Water and Electricity Company (EWEC) has issued a request for proposals (RFP) to 19 companies and consortiums to develop a new solar PV project in Abu Dhabi with a power generation capacity of 1.5GW. Located in the Ajban area, the plant is expected to increase Abu Dhabi's solar capacity to about 4GW, complementing the Noor Abu Dhabi and Al Dhafra installations. According to EWEC, the successful developer will own up to 40% of the entity, while the remaining equity will be held indirectly by the Abu Dhabi government. The developer will also enter into a long-term power purchase agreement with EWEC.



The solar PV project is expected to increase Abu Dhabi's solar capacity to about 4GW.

Credit: EWEC





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## ASIA-PACIFIC

### India

#### India to relax ALMM for two years, aims to accelerate installed solar capacity

The Indian government will relax its approved list of models and manufacturers (ALMM) policy for two years, in a move to boost installed solar capacity. In a conference organised by Business Today, Indian power minister, RK Singh said the lifting was due to domestic module capacity not being able to keep pace with the demand for solar PV in the country. The implementation of the ALMM aims to help boost domestic solar manufacturing against China's dominance in the supply value chain of solar PV, and has worked as a "barrier", according to Singh. "I have expanded the bidding so fast that my existing domestic capacity is not able to meet it. I have about 70GW of solar only under implementation, and the manufacturing capacity of 500Wp [modules] and above is just 10GW," said Singh.

#### India to reach 95GW of module manufacturing capacity by 2025 – Mercom

Indian solar module manufacturing capacity is forecast to reach around 95GW – up from 39GW at the end of September 2022 – according to research from analyst and consultancy Mercom India Research. The 'State of Solar PV Manufacturing in India' report also predicted that India's domestic cell manufacturing capacity, which was around 4.7GW as of last September, will reach 32GW by the end of 2024. "Significant" capacity additions of polysilicon, ingots and wafers are also expected by the end of 2024. The projected growth is put down largely to the policies that the Indian government has introduced over the last few years to incentivise a domestic manufacturing base, including the production-linked incentive programme and approved list of models and manufacturers.

#### Indian renewables tenders fall short of government's '450GW by 2030' plans

India needs to issue more renewable energy tenders if it is to meet the government's target of 450GW of installed capacity by 2030, as the changing preferences of distribution companies have seen less uptake and states have been inconsistent in fulfilling purchase obligations. According to a joint report from JMK Research & Analysis and the Institute for Energy Economics and Financial Analysis, 2022 saw 28GW of renewable energy tenders issued in India, falling from 40GW in 2019. Co-author of the report, Vibhuti Garg, said: "To reach the 2030 target, India will need to open renewables tenders for at least 35GW annually."

### China

#### China's solar module exports surge on strong European demand

Solar module export volumes from China between January and October 2022 were up 86% year-on-year amid strong demand in Europe. That's according to a report from the China Photovoltaic Industry Association, which revealed that China's PV manufacturing output of silicon materials, silicon wafers, cells and modules during the nine months increased by more than 42%. Silicon material output was 550,000 tons (a 52.8% increase year-on-year), silicon wafer output was 236GW (+43%), cell output was 209GW (+42.2%) and module output was 191GW (+46.9%). In terms of destinations for Chinese modules, the Netherlands ranked first with 26.8%, followed by Brazil (11.5%) and India (7.3%). Export proportions to Spain, Germany and Poland also increased significantly.

### Vietnam

#### Vietnam to accelerate renewables deployment with US\$15.5 billion deal

The G7 initiative Just Energy Transition Partnership (JETP) has agreed to support Vietnam's green energy transition and mobilise an initial US\$15.5 billion of public and private finance over the next three to five years. The partnership will work towards a series of targets, including the acceleration of renewable energy so that it reaches 47% of Vietnam's electricity generation by 2030, instead of 36% currently planned, as well as reducing the peak coal capacity from the 37GW planned towards 30.2GW. Over the next 12 months, partner countries will work with Vietnam to develop and adopt a JETP Resource Mobilisation Plan that will enable the implementation of the funding.

### Australia

#### Lightsource bp reaches financial close on 515MW of Australian solar

Solar developer Lightsource bp has firmed up AU\$540 million (US\$365 million) in green financing to fund the development of two Australian PV projects in Victoria and New South Wales. The Wellington North and Wunghnu solar projects represent a combined 515MW of capacity. Financing for the projects was secured from ANZ, ING, Mizuho, NORD/LB and Westpac, and has been structured as a green financing loan, with ANZ, ING and Westpac fulfilling acting as joint green loan coordinators. Lightsource bp also entered into a power purchase agreement (PPA) with Australian building manufacturing and supply company Boral, in addition to existing PPAs with Engie, Australian multinational Orica and Mars Australia.

Lightsource bp's Wellington solar farm in New South Wales, Australia.



Credit: Lightsource bp

### Philippines

#### ACEN starts construction of 300MW solar project in the Philippines

Filipino conglomerate Ayala corporation's energy arm ACEN has started constructing a 300MW PV plant in the Philippines. The Palauig 2 Solar farm is located in Palauig, Zambales, an area with one of the country's highest irradiance zones. Palauig 2 Solar is expected to produce over 450GWh of clean energy annually. The cost of the new development, including the construction of the 1,200MW transmission line, is estimated at PHP16 billion (US\$293.1 million). Module manufacturer Seraphim will supply 540 MWp of solar panels while ERS Energy and Global Electric Power Development Corporation were signed on as engineering, procurement and construction contractors.



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## MANUFACTURING

### Company news

#### Qcells investing US\$2.5 billion to establish US ingot, wafer, cell and module supply chain

Qcells plans to establish a fully integrated US solar manufacturing supply chain, aiming to manufacture solar ingots and wafers in the country as well as expand its module supply capacity. Qcells' parent company, Hanwha Solutions, said that it intends to break ground on a 3.3GW of ingot, wafer, cell and module manufacturing plant in Bartow County, Georgia, in Q1 2023 and reach 8.4GW of module production in the state by 2024. The company is planning an expansion to its operations in Dalton, Georgia, to produce an additional 2GW of modules as well as its previously announced 1.4GW module fabrication plant in the state. The announcement constitutes an investment of around US\$2.5 billion, and was heralded by Georgia Senator Jon Ossoff as the "largest" clean energy manufacturing investment in American history.



Credit: Qcells.

Workers at Qcells' 1.7GW module assembly plant in Georgia.

#### LONGi to invest US\$6.7 billion in building new production base in China

Solar manufacturer LONGi Green Energy Technology has announced an RMB45.2 billion (US\$6.7 billion) plan to build a production base in China capable of manufacturing 100GW of solar wafers and 50GW of solar cells each year. In a filing to the Shanghai Stock Exchange, LONGi stated that it had signed a letter of intent with two local governments in the Shaanxi Province. The new base, which will become the world's largest solar manufacturing facility, is expected to begin operations in the third quarter of 2024.

#### JA Solar to build US\$5.9 billion PV industry hub in China

Chinese module manufacturer JA Solar plans to invest RMB40 billion (US\$5.9 billion) to construct a vertically integrated PV industry hub in Inner Mongolia, China. According to a filing published on 19 January, JA Solar signed an agreement with the government of Ordos, one of the twelve major subdivisions of Inner Mongolia, to produce 100,000 tons of photovoltaic raw materials, 20GW of solar wafer capacity, 30GW of cells and a 10GW PV module plant. The filing did not disclose more details of the hub and the construction schedule.

#### CubicPV to set up 10GW silicon solar wafer factory in the US

Solar manufacturer CubicPV is planning to establish a 10GW mono wafer manufacturing facility in the US that it said will be the "first of this scale" in the country. The plant will fill a void in the US PV manufacturing supply chain; the country has no domestic solar ingot, wafer or cell manufacturing capacity, according to research from the Solar Energy Industries Association published last year. The facility is expected to be fully ramped up in 2025. CubicPV also raised US\$26 million in Series B financing that will accelerate its research and development activities specific to tandem module development.

### Efficiency records

#### HZB reaches 32.5% perovskite/silicon tandem cell efficiency, reclaiming world record

Helmholtz-Zentrum Berlin (HZB) has claimed a silicon/perovskite tandem cell efficiency of 32.5%, returning the record of the cell efficiency to the German research centre. The rate was certified by the European Solar Test Installation in Italy, as well as being included in the National Renewable Energy Lab chart of solar cell technologies, maintained in the US. The cell, consisting of a silicon bottom cell and a perovskite top cell, includes an interface modification to reduce charge carrier recombination losses. While the top cell can utilise blue light components, the bottom cell converts the red and near-infrared components of the light spectrum. HZB confirmed that the size of the test cell was 1.014cm<sup>2</sup>.

#### Risen Energy reports 'world record' 23.89% HJT module efficiency

PV manufacturer Risen Energy has recorded a 23.89% efficiency rating on its Hyper-ion heterojunction technology (HJT) solar module, which it claims is a new world record for HJT module efficiency. The results were verified by TÜV SÜD, a testing, inspection and certification provider headquartered in Germany. Risen's previous HJT module efficiency record was 23.65%, set in December 2021. The company also said that it achieved a maximum power output of 741.456W. Risen said that the module is capable of maintaining over 90% of its power output over 30 years due to its "extremely stable" temperature coefficient and high bifaciality of up to 85%.

### Polysilicon

#### China's polysilicon imports declined 23% to 88,000MT in 2022 – Bernreuter Research

Chinese imports of polysilicon dropped 23% year-on-year to 88,093MT in 2022, according to polysilicon research firm Bernreuter Research. Imports have nearly halved from their peak in 2017 – when China imported 158,918MT – and are closer to the levels of a decade ago when polysilicon imports reached 82,760MT in 2012. Imports from Japan had the strongest decline in 2022, with a 60% decrease from 15,431MT in 2021 to 6,129MT last year, due to module producer Sharp's supply contract with US-based polysilicon manufacturer Hemlock Semiconductor ending in 2020. According to Bernreuter Research, China's share of global solar-grade polysilicon output increased from 82% in 2021 to 88% last year.



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# PV in pastures new

**Agrivoltaics** | Combining solar plants with agriculture is becoming more prevalent in markets globally, increasing the availability of sites for new PV projects while reducing land-use conflicts. Will Norman details how the industry can take advantage of agrivoltaic opportunities while navigating construction, operation and maintenance challenges.



Credit: Werner Socum/NREL

**Byron Kominek, owner of Jack's Solar Garden, tills the soil at the farm in Longmont, Colorado.**

Farming and solar power compete for two central resources – flat land and sunlight. Agrivoltaics (also known as agriPV, dual-use solar or agrisolar) is the practice of pairing solar PV operations with agriculture in the same location, be it crop cultivation, fruit farming, grazing livestock or providing habitats for pollinators. Panels can be placed alongside or suspended above farming operations, or incorporated vertically into fencing or integrated into greenhouses or shadings for soft fruit.

As well as resource competition, farming and solar seem regularly to inspire cultural and social opposition and debate. Ex-UK prime minister Liz Truss described solar panels as 'paraphernalia' last year as discussion arose about farmland deployments, and the US' largest PV project – the Mammoth solar park in Indiana – received fervent backlash and resistance from a group of residents who opposed the use of farmland for solar plants. One particularly put-out woman bought the office next door to the developers' and pasted the windows with homemade anti-solar posters.

Nevertheless, countries around the world have put money into supporting research and incentivising deployment of agrivoltaics, and solar developers and engineering, procurement and construction (EPC) contractors are increasingly factoring it in as a way to open up more sites and foster more positive relation-

ships with the communities where they operate. Beyond the immediate interests of the PV industry, the dual concerns of two of the most pressing industries for global climate change – renewable energy and sustainable agriculture – converge in an agrivoltaics plant.

## Land use

"This industry is going to be responsible for millions of acres of land over the next 10 years and we have a responsibility to maintain that land, if not improve it for future generations," Matt Beasley, chief commercial officer at US solar PV developer Silicon Ranch, which focuses on regenerative agrivoltaic projects, tells PV Tech Power.

According to a paper published by the US National Renewable Energy Laboratory (NREL), ground-mounted utility-scale solar requires between 3-10 acres per MWdc of generation capacity and will need up to 11 million acres of land in the US alone by 2050. Farmland is often the most desirable and suitable for PV installations, as it's generally flat, predictable and accessible.

Annie Rabi Bernard, an analyst for research and consultancy group Wood Mackenzie, speaks of the importance of dual land use for meeting deployment targets: "For countries like India, China, US, and regions in Europe that are keen on achieving higher electricity produc-

tion through solar energy, deploying solar would be a requirement throughout the country. In these countries specifically, the vast landmass already used as cultivable land could be a market for implementing solar energy harvesting."

According to the World Bank, around 44% of the land in the US is designated agricultural land, whilst Germany has 47% and India 60%. These countries have huge PV deployment targets that will require significant annual capacity expansions and acres upon acres of land. Germany is targeting 215GW of installed PV capacity by 2030, whilst India is aiming for 300GW by that date. The majority of these targets will be met by ground-mount utility-scale projects.

Land is a central resource for the development of PV projects – it's also finite. The scale at which the industry is set to grow over the next two decades will see it needing an ever-bigger portion of the world's habitable land, of which some figures say that 50% is currently taken up by agriculture.

As per Annie Rabi Bernard's analysis, considering the utility of agricultural land proposes a market opportunity and could open up significantly more sites for PV developers. Beasley says that "the biggest challenge for the solar industry in the foreseeable future is land use", and indicated the necessity for a shift in focus, for the industry to consider land efficiency and ease of deployment as a metric of value similar to energy output or capacity.

Jordan Macknick, lead energy-water-land analyst for NREL, echoes the sentiment: "One of the reasons I think developers are excited about the potential of agrivoltaics is that it reduces the barriers to deployment." This applies both in terms of the sheer quantity of land available and the attractiveness for communities of paired systems in comparison with standalone PV.

The potential for deployment on this land raises environmental, social and





Credit: Silicon Ranch.

governance (ESG) concerns, however, both in terms of the moral and ethical imperatives for developers to maintain the integrity of agricultural partners and the land itself and in terms of the long-term advantages of shoring up relationships and longevity within communities.

"One of the subjects not being discussed enough in our industry is the ability for solar companies to maintain a social license to operate," Beasley says. [Agrivoltaics] is a clear way for us to demonstrate to our partners, customers and most importantly our neighbours that we are doing just that."

Though the examples of nimbyism mentioned at the start of this article are of course excessive, solar developers do have a responsibility to the communities and the land where they choose to install projects. This is relatively commonly accepted, but as the global footprint of solar grows the need for partnership and

**Sheep grazing at a solar plant from Silicon Ranch, which pairs regenerative agriculture with PV.**

collaboration between power producers and other industries and communities will grow too.

That sort of collaboration is inherent in the concept of dual land use, where PV deployment and profits can coexist with rural communities and continued farming practices. Macknick says: "There's a clear financial incentive for farmers to adopt solar on their land, but we all need to eat, we all want to have a strong rural economy and rural producers, and people take a lot of pride in farming. So there's this trade-off of these financial values versus cultural and social values."

Not only is it socially necessary for PV developers to work with communities and prioritise both financial and cultural values, it's also advantageous. In instances where pushback from communities threatens to slow projects down, agrivoltaics can provide a balancing factor to aid deployment.

Macknick says that NREL, one of the bodies leading agrivoltaics research in the US through its Department of Energy-funded InSPIRE programme, has seen agrivoltaics being used to make solar projects more appealing where communities have opposed development.

Steven Pleging, business development Netherlands at EPC Belectric, describes similar positive outcomes from its agrivoltaic operations: "Everywhere we or our partners are talking to permitting parties or influencers they see this as a kind of breakthrough in thinking."

**Mutual benefits**

Macro concerns aside, agrivoltaics can provide benefits on a project-by-project basis. In terms of crop production, introducing PV modules to a cultivated area can provide shade and reduce wind exposure. Soft fruits or berries, for example, benefit from partial shading and protection from adverse elements, whilst strong wind can also prove an impediment to grass growth.

The fundamental competition in these sorts of installations is between photovoltaics and photosynthesis. Annie Rabi Bernard of Wood Mackenzie says: "Agricultural lands that cultivate crops that necessitate shading or thrive better/best under indirect sunlight are huge markets for agrivoltaics." On the flip side, crops like wheat or others that require high-intensity, consistent sunlight may prove more difficult for agrivoltaic installations.

She continues: "Land used for fruit production and fruit crops is typically covered by plastics or hail nets, which could now be replaced by solar panels."

**'We have a responsibility to be stewards of the land': Silicon Ranch pairs regenerative agriculture with PV**

Silicon Ranch owns and operates all of its solar PV installations, many of which are paired with either crops or livestock. Its 68MWac Houston Ranch project in the US state of Georgia – part of a larger collaboration between Silicon Ranch and Green Power EMC – is co-located with grazing sheep.

The project is part of the company's Regenerative Energy programme, which focuses on regenerative agriculture on its PV sites to maintain landscapes, ecosystems and agricultural practices and communities.

The company's relationship with agrivoltaics began in 2018. "We were in the early project development phase in South Georgia where our neighbour just so happened to be Will Harris of White Oak Pastures, one of the leading regenerative ranchers in the world," says Matt Beasley, chief commercial officer at Silicon Ranch.

"After our CEO Reagan Farr and I met with Will and his family, we returned to Nashville and thoroughly investigated what it would take to transform the way we manage our lands.

"The entire experience was an epiphany for us, as we all began to realise we have an opportunity to view our land as a biological asset rather than as a liability, and moreover, we have a responsibility to be stewards of the land we occupy."

The company said that from summer 2023 the Houston Ranch project will be home to a flock of 1,200 sheep and host a sheep breeding facility. Silicon Ranch claims to have "the largest flock of sheep owned by a renewable energy company in the US".

Rabi Bernard says that a study testing agrivoltaic installations on grape farms in India showed that revenues had the potential to increase over 15 times with the addition of PV modules to the farming process, whilst yielding a consistent grape crop. The same research indicated that “implementing agrivoltaics across the country in similar farming land could potentially generate 16,000 GWh of electricity”.

There are also benefits that are not specifically economic, in terms of cultivating ecosystems and pollinator habitats, preventing soil or landscape erosion and providing irrigation and shading to desert areas. Citing an NREL project in Arizona – a notoriously harsh and dry climate – Jordan Macknick says that “under the partial shade and the solar panels we got double the yields of our tomatoes using 30% less water. And so you know that’s great, it essentially creates new harvestable land.

“There’s definite aspects of climate resilience here and resilience against extreme weathers and heatwaves and droughts that agrivoltaics can provide.”

Simultaneously, research has shown that thriving plant life underneath solar panels can improve energy efficiency per module. Plants release water vapours into the atmosphere through transpiration, which can then cool the panels from below and regulate their temperature, leading to more stable performance and efficiency.

Regarding grazing livestock, despite seeming as though they create unpredictable hazards, grazing animals can provide operations and maintenance (O&M) benefits for plant operators and farmers. Silicon Ranch senior vice president for technology and asset management Nick de Vries says: “Sheep pose way less of a risk

## Agrivoltaics’ role in food security for local communities

In terms of food security and distributed solar access, agrivoltaics could play a role in local communities.

Food security is defined by the World Bank as “when all people, at all times, have physical and economic access to sufficient safe and nutritious food”. Whilst far broader, far more complicated and systemic factors lie at the root of food insecurity, there are two metrics by which agrivoltaics could provide a valuable solution to these concerns.

Research from the National Renewable Energy Laboratory in the US showed that PV arrays can provide shade and water conservation in desert or arid landscapes, which can be a stimulus to crop growth. It also found that installing a PV array in arid areas of northern India required the same amount of water as was needed to sustain an aloe vera plantation, suggesting the possibility of integrating the two systems.

Agrivoltaics also has the potential to be paired with community solar – a term used to denote small-scale solar installations that serve a local community, often off-grid – to support local communities by reaping the most sustainable value from a given piece of land.

US company Lightstar, for example, develops community agrivoltaic projects that work with local landowners and farmers to generate dual land-use installations, enabling the two economies, systems and resources to co-exist to benefit the community.

of damage to cables than any mower, but they do come with fences, water, which everyone on site has to be aware of.”

Grazing sheep or cattle can also maintain grass height, preventing it from growing and shading the modules, and animals can help with biodiversity and soil quality that may otherwise suffer under a standalone PV installation.

### Project construction considerations

In terms of EPC, “to implement agrivoltaics, it is important to think holistically about the project by first carefully observing the land and being ready to adjust to changing conditions”, says Matt Beasley of Silicon Ranch. Considerations like panel height, spacing, protection from animals or farming equipment, irrigation and fencing are all project-specific and require consideration from an EPC standpoint, and will change depending on the requirements of the specific crop.

However Johannes Linder, head of system design and innovation at Belectric, says that in Germany the company has focused on using tracker systems installed beside crops, rather than the more

eye-catching and expensive raised panels often associated with agrivoltaics. He suggests that standardisation is possible in this configuration.

“The difference in construction of those kinds of power plants is not too big [compared with standard projects],” he says. “You have to involve the farmer in the planning, but overall the story is that it’s a standard technology which can be used and does not drive the prices too high.”

This isn’t always the case with all technologies, however. Speaking about the US market, Jordan Macknick says that NREL has observed some pushback on a cost basis from solar developers regarding large-scale projects paired with crop farming.

“Jack’s Solar Garden, one of our research sites, has panels that are elevated to a much higher height than what you’d normally see for utility-scale solar, something that allows humans and equipment access, that allows for more sunlight, allows us to get higher yields in our crops,” Macknick says.

“But steel is expensive. The solar industry, I think, is not as interested in these larger projects that involve a lot more steel, because it makes them very expensive and less cost competitive.”

As you scale size, so you scale cost when it comes to expensive raw materials like steel. This can cause a problem for utility-scale developers, as greater spacing and accommodation for crops, tractors, irrigation and other sundries often means that, coupled with higher installation and material costs, they see less return on each electron they produce.

### Government support and the future for agrivoltaics

Support schemes for agrivoltaics have emerged across the world. In August 2022, the Italian Ministry of Agricultural, Food



**Introducing solar modules to cultivated areas can provide shade and reduce wind exposure.**



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and Forestry Policies announced a US\$1.5 billion scheme to incentivise agrivoltaic installations across the country. It said that the programme could add 375MW of solar across Italy in crop and livestock deployments through providing direct grants that can cover up to 90% of eligible projects' costs.

Germany introduced a scheme in February 2022 to accelerate deployment of PV on agricultural land through its Renewable Energy Act, opening up agricultural moorland in particular for PV deployment as long as land maintenance and restoration requirements are met. This announcement was lauded by trade associations which saw the new land opportunities as central to the country's ability to achieve its 2030 target of reaching 215GW of installed solar.

In India, the Central Arid Zone Research Institute has been conducting operations on agrivoltaic test locations, though the technology is still in its infancy there and any central collaboration or incentives are yet to take shape, according to research from consultancy Mercom Capital Group.

Of all markets, however, India has a lot of latent potential to develop agrivoltaics, according to Annie Rabi Bernard. "Regions that are highly invested and relying on agriculture (like India and Indian subcontinent, east Asian countries, west and east Africa) are prime markets for agrivoltaics," she says.

"Many of these regions battle with unreliable farming techniques and are in dire need of practices like agrivoltaics which can make agriculture sustainable and reliable. In countries like India which are highly populated, the government is under stress to grow its GDP and proportionately increase its energy supply, which can be tackled with the practice of agrivoltaics."

Turning westwards to the US, NREL has been running its InSPIRE programme (Innovative Solar Practices Integrated with Rural Economies and Ecosystems) since 2015, backed by the Department of Energy to research agrivoltaic deployments across the country.

Jordan Macknick is the lead researcher for the project and says that the US has seen around US\$50 million in research and development funding from the federal government, the majority of which came from the Department of Energy with the rest made up by the Department of Agriculture.

"There's only been one state in the



Grazing animals can provide operations and maintenance benefits for plant operators

Credit: Joe DeNero/NREL

United States that has offered a financial incentive for developing agrivoltaics," he adds, "and that's the state of Massachusetts in their SMART programme."

Looking forward, then, Macknick sees agrivoltaics in the US growing, but with caveats. NREL maps out the different agrivoltaic sites across the US on its website, and the trends seem to be a concentration in the northeast and a large predominance in grazing and pollinator sites over crop production.

Large-scale sites in the US will be grazing sites or "ecosystem services" agrivoltaics, Macknick says, mostly because of the clearer and more researched O&M procedures. The industry better understands the execution and particularities of grazing or pollinator agrivoltaic pairings, but crop projects often have more nuance and can vary depending on the produce in question.

As with land use, Macknick says that the key to unlocking more crop-based agrivoltaics in the future will be communication and collaboration between the PV industry and farmers. "I don't see there being a lot of agrivoltaic development in terms of crop production without a lot more engagement and interaction and partnerships between the solar industry and landowners and farming organisations."

Belectric's Steven Pleging says a similar thing of the Dutch market: "There's still a lot to learn on which crops are actually most beneficial [for agrivoltaics]," whilst production on dairy farms in the Netherlands has proved fruitful for Belectric. The story is not entirely the same across Europe, however,

as Linder says that the company focuses on crop production sites in Germany, and existing projects in Italy and elsewhere often feature crop production.

Macknick says that in the US projects are designed with a view to energy efficiency as the main metric of success, whilst in Europe a more collaborative approach prioritising agricultural benefit has been seen.

When asked if NREL has seen much splitting of revenue generated from the land between solar developers and farmers, Macknick says: "No. It's a great idea, It can make a lot of sense, but it's not something we've seen frequently." This practice could perhaps make crop production more viable on a large scale, as shared value could offset higher costs or lower production in each field as well as shoring up relations and security in the agricultural sector.

The rise of agrivoltaics has been a confluence of the industry's sustainable aspirations and the real market opportunity it presents. From both long-term land use and ESG perspectives, we can expect it to become more and more common. Some resistance or impediments may remain, be they cost or immediate scalability, but as with most technological developments the need for implementation will doubtless see the industry find ways to proceed.

Annie Rabi Bernard says: "Overall, agrivoltaics is largely seen positively as a highly flexible initiative, an innovative compromise to solve land-use conflicts and a welcomed contribution to the green transition."



# Current legal framework for agrivoltaics in Germany

**Agrivoltaics** | Max Trommsdorff of Fraunhofer ISE and Jens Vollprecht, a lawyer at Becker Büttner Held, detail the legal aspects of agrivoltaics deployment in Germany.

Over the last two years, Germany's policy framework has adjusted largely to emerging technologies of using land for both agricultural and solar energy production. A prerequisite of this development is, without doubt, the pre-standard DIN SPEC 91434 which, since April 2021, provides a definition about which criteria agrivoltaic systems must fulfil to assure the primary agricultural use of the land. With this, the standard aims to clearly distinguish between agrivoltaic systems and conventional ground-mounted PV.

According to the DIN SPEC, the agricultural yield after constructing the agrivoltaic system must at least amount to 66% of the reference yield. Land loss after installing the PV system must not exceed 10% of the total project area for category I (overhead systems with a vertical clearance above 2.1 metres) and 15% for category II (interspace systems). Light availability, light homogeneity and water availability must be checked and adapted to the needs of the agricultural products.

## Direct payments

Direct payments of the EU for the cultivation of agricultural land do, in monetary terms, not play a mentionable role in most agrivoltaics projects. Nevertheless, uncertainties as to whether payments can be claimed if an agrivoltaic system is built on an area used for agriculture or not caused a mentionable delay for the development of agrivoltaics in Germany in the past.

Since 2023, § 12(5) of the German CAP Direct Payments Regulation (GAPDZV) considers land used for agrivoltaic installations eligible to receive direct payments if (1) the facility does not exclude the cultivation of the area using usual agricultural methods, machines and equipment and if (2) the facility reduces the agriculturally usable area by a maximum of 15% based on the DIN SPEC. If those conditions are

fulfilled, as a lump sum, 85% of the area is considered eligible.

## Germany's Renewable Energy Act

As the legal cornerstone of the German energy transition, the Renewable Energy Act (EEG) considers agrivoltaic systems since 2023 on a larger scale. Generally, the main advantages that the EEG grants to renewable energy systems are privileged grid connection, privileged purchase of electricity and the regulation of feed-in tariffs. Agrivoltaic systems benefit from privileged grid connection and privileged purchase of electricity as other renewable energy systems do, too. Regarding tenders for feed-in tariffs, eligible agrivoltaic systems do have access to a much larger area compared to standard ground-mounted systems since the latter are generally excluded from agricultural land. Additionally, in the case of overhead systems (category I DIN SPEC), the EEG provides a premium of 1.2 euro cent per kWh in the event of a surcharge in 2023. In the event of a surcharge in subsequent years, the premium is reduced gradually depending on the year of the surcharge.

## Tax alleviations

Until summer 2022, if a photovoltaic system was installed on an agricultural area, landowners faced the risk the area might no longer be assigned to agricultural and forestry property but to the real estate. Consequently, losing the status of agricultural and forestry property also implied the loss of preferential tax treatments combined with agricultural and forestry property e.g. for inheritance and gift taxation. With a decree in the Federal Tax Gazette for agrivoltaic systems of category I and II DIN SPEC, the area maintains its status as agricultural and forestry property with all involved tax benefits.

## Permitting

Regarding building permits, currently, agriv-

oltaics generally belong to the category of ground-mounted photovoltaic systems. Hence, according to the building regulations law, a building permit is required for their construction in most cases. Typically, an agrivoltaic system will be erected on a plot of land located outside urban areas that is not covered by a development plan. In this case, the BauGB differentiates between privileged and other projects. Privileged projects according to § 35(1) BauGB are only prohibited when they conflict with public interests. In contrast, other projects outside urban areas are generally prohibited according to § 35(2) BauGB if they affect public interests. § 35(3) BauGB lists public interests that are to be considered in this regard. If the project is not permissible outside urban areas according to § 35 BauGB, preparing a development plan – possibly with a partial amendment of the zoning map – should be considered. This, however, can be very time consuming. Since January 2023, according to § 35 (1) No. 8 BauGB, ground-mounted photovoltaic systems are privileged in a 200m wide strip on both sides of highways and at least double-track railroad lines. With regard to agrivoltaic systems, a privilege according to § 35 (1) No. 1 or No. 2 BauGB is also conceivable in the case of a service function for agriculture or horticulture. Discussions about generally privileging smaller agrivoltaic systems are ongoing. ■

## Authors

Jens Vollprecht is a lawyer at Becker Büttner Held. As lead counsel on renewable energy projects, he focuses on sustainability, agrivoltaics, moorland and floating photovoltaics as well as hydrogen and electricity storage.



Max Trommsdorff is leading the research group for agrivoltaics at Fraunhofer Institute for Solar Energy Systems ISE, Europe's biggest solar research institute. Since 2014 he has worked on more than 20 agrivoltaics projects.



# The potential of agrivoltaics for the US solar industry, farmers and communities

**Agrivoltaics** | To make agrivoltaics a widely available option for developers in the US, questions about cost, liability and other business, legal and regulatory issues need to be addressed, writes Michele Boyd of the US Department of Energy's Solar Energy Technologies Office.

Large-scale solar energy installations are a relatively new form of development in many rural areas. Solar energy development can create clean energy, jobs and other economic benefits in these communities. At the same time, the conversion of agricultural land, which tends to be flat and sunny, to solar energy development can raise local concerns that delay or derail projects. Agrivoltaics – the co-location of solar energy installations and agriculture beneath or between rows of photovoltaic panels – has the potential to help ease this land-use conflict.

To address climate change, the Biden-Harris administration set a goal to decarbonise the electricity sector by 2035. Solar energy, which currently provides about 4% of US electricity supply, has a key role in this decarbonisation. According to the US Department of Energy's (DOE) Solar Futures Study, solar energy could supply as much as 40% of US electricity by 2035.

This level of solar deployment could require about 5.7 million acres, or 0.3% of the US contiguous land area. While this is a small percentage of US land, it is in addition to other types of infrastructure development that are also leading to the conversion of farmland. Moreover, large-scale solar energy is not going to be evenly distributed across the landscape, because it must be located near transmission lines. Combining agriculture and solar on the same piece of land might be a solution, which is why DOE is funding US\$15 million in research on how agrivoltaics could work for farmers, the solar industry and communities.

Agrivoltaics is still a nascent business model. Based on data collected so far by the National Renewable Energy Laboratory, there are over 2.8GW of agrivoltaic sites in the US, the majority of which involve sheep grazing and/or pollinator habitat. Growing crops under solar panels has been largely confined to research test plots, though this is beginning to change. At least five commercial solar-crop sites

are operating in Colorado, Massachusetts and Maine.

A few states are encouraging the construction of agrivoltaics through incentives or research. Massachusetts has enacted a feed-in tariff adder of US\$0.06/kWh for agrivoltaic projects through its Solar Massachusetts Renewable Target (SMART) programme. New Jersey authorised an agrivoltaics pilot program of up to 200MW on unpreserved farmland and funded a research and development system at the Rutgers New Jersey Agricultural Experiment Station. Colorado has also funded agrivoltaics research.

Agrivoltaics has the potential to help farmers adapt to climate change and diversify their income through land lease payments or other business structures. Research in the drylands of Arizona found that farming under solar panels can decrease evaporation of water from the soil and potentially reduce irrigation requirements. Agrivoltaics can also improve crop yield and crop resistance in extreme weather, such as droughts. Adding farming to existing solar energy sites is being explored as an approach to increase access to land for historically disadvantaged groups, such as Black and immigrant farmers. At the same time, questions remain for farmers about how to do agrivoltaics, including which crops are suitable in a shaded environment.

For the solar industry, agrivoltaics has the potential to facilitate siting of solar installations, improve solar PV panel performance by cooling the panels and lower operations and maintenance costs by limiting the need for mowing. Yet the capital costs of agrivoltaics tend to be higher than traditional solar development due to modified system structures and more complex design and installation. To make agrivoltaics a widely available option for developers, questions about cost, worker safety, liability and other business, legal and regulatory issues will need to be addressed.

For communities, agrivoltaics could help keep farmland in production – and help sustain rural farmland economies. More research is needed, however, to understand whether – and under what conditions – communities are likely to support solar development if it combines both energy and agriculture.

All agrivoltaic stakeholder groups – from developers to farmers to financiers and insurers – will need to understand each other's priorities and establish common goals to realise the potential benefits. Communities will need to see tangible benefits from agrivoltaics.

To help bring agrivoltaics to maturity, DOE's research is examining how agrivoltaics can impact both agriculture and energy production and how agrivoltaics can fit into agricultural communities and economies, including public perceptions. Our projects, like the AgriSolar Clearinghouse, are providing technical assistance and developing resources to lower the barrier of entry for agricultural producers and solar developers. We are collaborating with the US Department of Agriculture on foundational research to help understand the economic value and tradeoffs and ecological impacts of agrivoltaics projects. DOE is also funding the development of new technologies that could facilitate agrivoltaics and help lower the cost premium.

Agrivoltaics is not a panacea for all farmland conservation or solar development needs, but it is a potential tool in the toolbox for meeting our climate goals, supporting farmers by keeping farmland in production and supporting the economies of rural communities. ■

## Author

Michele Boyd manages the strategic analysis and institutional support team at the US Department of Energy Solar Energy Technologies Office, where she focuses on reducing the soft costs of solar energy. She previously worked at a solar company and on issues related to nuclear weapons and nuclear energy.





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# Dedicated tenders boost agrivoltaics in France

**Agrivoltaics** | With France's rooftop and ground-mount solar tenders featuring a sub-family for agrivoltaics, Xavier Daval of France Agrivoltaïsme details routes to market for new projects.



Credit: SunAgri.

Despite being the largest country in Europe, France is fully booked when it comes to PV projects and scarcity of land has led to an exponential rise in the price of compatible land. But the so-called compatibility is a tax-based administrative zoning where 52% of the country is farmland, 39% is natural and only the remaining 9% of artificial land is free from constraints for PV development. It is easy to understand that artificial areas, most of the time, are assigned to a primary function such as hosting a building or road.

For many years solar developers have been eyeing up agricultural land, especially when such terrain is no longer cultivated. But urban development code and energy code impose rather strict conditions for construction on farmland. This is where agrivoltaics comes on board.

Well aware of the risks that poor quality PV projects on farmland would represent for the industry, a small group of entrepreneurs decided to join forces to create France Agrivoltaïsme, a dedicated business association solely focused on the topic. By acting as a lobby and being joined by FNSEA, the leading agricultural union, the association has strongly contributed to providing this new technology with a legal framework.

The new bill for the acceleration of renewables, proposed by the French

government, was too good an opportunity to introduce an official definition of agrivoltaics: agrivoltaic systems contribute directly to the establishment, maintenance or development of agricultural production. Such a system provides at least one of the following services directly to the agricultural parcel: improvement of potential and agronomic impact, adaptation to climate change, protection from hazards and improvement of animal welfare.

A lot of technical solutions are compliant with the above definition. Raised fixed structures can provide shade, vertical systems can improve grass growth, moving panels can cover trees or plants, deflecting rainwater or acting like a cover to displace the frozen point of the ground, dynamic systems can "listen" to plant's needs to control the quantity of light or the evapotranspiration of plants.

Of course such new projects have to be financed, and by nature, lenders are rather averse to novelty or risks. But what is an agrivoltaic system but a standard PV plant with a few extra parameters which are easy to frame? With the support of experienced advisors, the projects are rather straightforward to finance as their constraints are largely balanced by their benefits. To name a few, the most demanding crops are the ones impacted by the highest solar yield and the hybridisation of food and energy

**Grapes being harvested at an agrivoltaics site in France.**

makes high-grade ESG assets.

France's first agrivoltaic projects were developed under the umbrella of innovation, with public tenders providing a format to the technology (prior to a legal definition) and establishing first elements of economics (capex-opex). Today, the pioneers of the topic have already a handful of projects built and connected, providing tangible proofs of concept to the banks. New projects no longer need the innovation tender to exist, and both rooftop and ground-mount tenders are now extended with a dedicated sub-family for agrivoltaic projects.

So what are the best route to market options for agrivoltaics? France is still a very centralised country where the ministries want to maintain some control of the energy sector. Therefore, a lot of projects will privilege the contracts for difference auction schemes. But the energy crisis has triggered the awareness of both business and domestic consumers, and the willingness of participating in energy independence, even at a limited level, is growing. To do so, some people are investigating solutions around own-consumption or starting to discuss corporate power purchase agreements. The optimum solution is still not set as the crisis is blurring all provisions of future prices.

The coming year is also the one where France will be voting on its next energy roadmap (PPE), forecasting targets, per energy sources for the next five and 10 years. We at France Agrivoltaïsme are confident that regardless of the results of the discussions, agrivoltaics, because it provides a positive answer to both food and energy challenges, will take the lion's share of the solar market. ■

## Author

Xavier Daval is the co-founder and administrator of industry association France Agrivoltaïsme, founder and CEO of kiloWattsol and co-chair of the Global Solar Council.





# Solar grazing used to reduce project operating costs in Australia

**Agrivoltaics** | Many companies working in the Australian utility-scale solar sector are exploring opportunities to integrate agricultural production into projects, writes Lucinda Tonge, a senior policy officer at the Clean Energy Council.

Since the mid-2010s, Australia has seen the development of many solar farms, reflecting the sharp fall in the cost of solar PV technology, which is now the lowest-cost form of electricity. As the sector grows, there is increasing interest in exploring and promoting new models for complementary solar energy and agricultural production. This coupling is commonly known as 'agrisolar' or 'agrivoltaics'.

Utility-scale solar (generally considered to be greater than 5MW) typically requires access to relatively flat or gently sloping land in sunny areas within proximity to electricity transmission networks, where biodiversity impacts can be avoided or minimised. This often means that land which has been previously cleared or zoned for agricultural use is well suited to host solar farm developments.

The cumulative risk caused by large-scale solar development to Australian agricultural land and productivity is very low. For example, the Australian Energy Market Operator estimates that New South Wales (NSW) will need approximately 20,000MW of large-scale solar generation to replace coal-fired power stations by 2050. This would require approximately 40,000 hectares of land or only 0.06% of rural land in NSW. Even in the highly unlikely scenario that all of NSW's solar generation was located on important agricultural land (which covers 13.8% of the state) only 0.4% of this important agricultural land would be required.<sup>1</sup>

Regardless, many companies working in the Australian utility-scale solar sector have committed to minimising the impacts on highly productive agricultural land (see the Clean Energy Council's Best Practice Charter for Renewable Energy Developments) and exploring opportunities to integrate continued agricultural production into projects.

With the deployment of large utility-scale solar farms commencing in Australia from around 2015, the local experience

of agrivoltaics practices is still developing and currently dominated by the practice of sheep grazing on solar farms. The first Australian solar farm to implement agrivoltaics practice was the Royalla Solar Farm, which began grazing sheep in 2015. Since then, there have been over a dozen solar farms that have introduced grazing, and it has proved to be an effective partnership for both solar farm proponents and graziers.

'Solar grazing', as it is known, is the most prevalent form of complementary land use for utility-scale solar farms due to the compatibility with ground-mounted solar PV panels.

In Australia, we've seen solar panels and solar farm fences improve the sheep's welfare by providing protection from the elements and predators. While these results are generally anecdotal in Australia, one recent Australian study found that the reduced windspeeds recorded within a solar farm could reduce the wind-chill index for newborn lambs. For winter 2022, this had the potential to reduce twin merino lamb average mortality rate from 20% in open paddock to 12% within the panel field. Furthermore, preliminary results from a wool analysis of the sheep at the Parkes Solar Farm indicated that the quality was high, even during drought conditions.<sup>2</sup>

Ground-mounted solar PV panels are also compatible with biodiversity and bees, as well as some types of horticulture. According to the National Renewable Energy Laboratory in the US, the partial shade conditions of solar installations can create favourable conditions for plants grown under or around the panels, including creating cooler conditions during the day and warmer conditions at night, and increased soil moisture levels.<sup>3</sup> In an Australian context, research has been conducted at Enel Green's Cohuna Solar Farm by Agriculture Victoria to understand pasture growing conditions under the panels.

Besides ground-mounted solar PV, other forms of agrivoltaics include:

- Elevated PV panels where the panels are raised on stilts or reinforced structures from 2.5-5 metres high to allow for crops and trees to be grown underneath
- PV greenhouses and rooftops, including innovations such as semi-transparent panels
- Floating PV systems which are compatible with aquaculture

At present, these forms of agrivoltaics are typically deployed at a much smaller (i.e. non-utility) scale. This is largely due to the necessity for taller and more complex structures, as well as the larger area of land required and increased equipment costs. One example of a trial using elevated panels in Australia is the Tatura Smart Farm in Victoria, which has grown pears under several long panel arrays.<sup>4</sup>

An agrivoltaics approach may not be suited to all solar farms, but optional support will help more industry players adopt these practices where possible. This not only provides potential co-benefits for both solar and agriculture, but also helps to bring the community along the renewable energy journey that is happening in their local areas. ■

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## Author

Lucinda is a Senior policy officer at the Clean Energy Council, assisting with policy and advocacy for the large-scale storage, solar, wind and renewable hydrogen sectors. Lucinda led the research and development of the Clean Energy Council's Australian Guide to Agrisolar for Large-Scale Solar.



# Investment incentives and knowledge sharing key for agrivoltaics in Africa

**Agrivoltaics** | With appropriate policy support and investment incentives, agrivoltaics could play a crucial role in Africa's green energy transition, writes Dr Richard Randle-Boggis of the University of Sheffield.

**A**grivoltaics have generated promising results for energy security and food production in Europe, the US and Asia. Yet, the greatest benefits are likely to be found in locations with abundant solar radiation, an urgent need for decentralised energy systems and where water scarcity threatens food systems. Agrivoltaics could therefore play a crucial role in green energy transitions across much of Africa. These conditions here present an unparalleled opportunity for agrivoltaics to deliver sustainable economic benefits.

Electricity demand across Africa is predicted to triple between 2015-2030, yet more than half of the population of Africa still do not have access to electricity. Addressing electrification needs poses several challenges, including a lack of coordinated regulation and financial investment from governments. Given the expansive grid-connection challenges, decentralised solutions are the only option to bring power to unconnected communities in the short term. Previously, PV prices were prohibitively expensive for most people and businesses across Africa, leaving much of the rural population in the dark, but rapidly decreasing costs have resulted in substantial growth in solar developments. The International Energy Agency reports that 71% of investment to achieve universal electricity access around the world by 2030 needs to be spent on off-grid and mini-grid infrastructure, and 95% of that directed at sub-Saharan Africa.

The solar energy sector already employs over 100,000 people in sub-Saharan Africa, and emerging markets require innovative business strategies. There are three broad business models currently used to operate mini-grids: utility owned, community owned, and privately owned, each with various advantages and disadvantages. The model that has achieved the greatest success has been the anchor-business-customer (ABC) model, which supplies power to three different groups of targeted customers: 1) an anchor client,

who is ensuring a steady revenue for the developer; 2) small village businesses or institutions with a greater load demand than regular households; and 3) rural household customers. Both the community model and the ABC model could be applied to agrivoltaics, as such systems offer several improvements in community livelihoods.

Mini-grid systems that offer financial benefits beyond those associated solely with electricity access will increase economic benefits and the likelihood of securing finance to cover initial costs. Agrivoltaics do just this, adding an income source via the sale of crops. The sale of higher-value crops in marginalised zones further improves livelihood gains, while the mitigation of environmental challenges reduces risks to farmers' incomes. Agrivoltaics will also generate new, skilled employment opportunities for agrivoltaic construction, operation and maintenance, especially in rural locations currently lacking modern infrastructure.

Various financial instruments have been used to promote investment in the energy sector. Government bodies have the mandate to pool resources from various sources, such as government funds, investors and development partners, towards renewable energy projects. These government bodies also offer tools to attract investments from the private sector, including partial risk guarantees during the early phase of projects and credit enhancement instruments directed at reducing the risks faced by commercial lenders and other financial institutions. This financial mobilisation for renewable energy initiatives could be used to support agrivoltaic development. However, there are currently no mandates spanning co-use of land for energy and agriculture, so new supporting policy briefs need to be produced.

Knowledge exchange and co-design are essential to appropriately designing and implementing agrivoltaics in Africa. The first key driver in implementing agrivoltaics successfully is capacity building. It is

important that the end-users, ranging from multinational agribusinesses to smallholder farmers, have access to information on how agrivoltaic systems work, how they are competitive with alternative solutions and what benefits they can bring. Cross-sectoral dissemination and engagement strategies are also key to realising the benefits of agrivoltaics, which span both the energy and agricultural sectors.

The private sector plays a key role in sustainability innovation, and policymakers should explore ways to improve interactions between the private sector and governments' climate-smart agriculture programmes. To support investment, it will be necessary to demonstrate the economic competitiveness of agrivoltaic systems compared to conventional ground-mounted PV systems, which are slightly cheaper due to the smaller mounting structures. Metrics such as land equivalent ratio and levelised cost of energy can be used to compare the values of agrivoltaics with alternatives, informing policy reform to support dual use of land for energy and agriculture. To overcome initial implementation barriers, governments could provide incentives to farmers that co-use their land for food and energy production, such as by subsidising development costs. Government- and NGO-backed training and knowledge exchange programmes will also support the expansion of agrivoltaics effectively. With appropriate policy support, investment incentives and knowledge sharing, agrivoltaics could play a vital role in the rapidly growing PV sector and the green energy transition across Africa. ■

## Author

Dr Richard Randle-Boggis is a research associate at the University of Sheffield. His research bridges different sectors and disciplines to tackle complex global challenges such as energy and food insecurity. The overarching question guiding much of his research is: how can we achieve even greater socio-economic and environmental benefits from solar energy initiatives, in addition to low-carbon electricity? His current research focus is on agrivoltaics in East Africa.





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# Is the sun still rising in Japan?

**Japan** | While solar has been the backbone of Japan's renewable energy push, deployment has been stalling in recent years. Chris Wilkinson of Rystad Energy details the benefits of the country's feed-in premium scheme, the potential for corporate PPAs and the importance of battery storage.

Solar energy in Japan will undoubtedly take a prominent role in helping the country address its three most pressing energy concerns: energy security, energy supply and a net-zero carbon society. However, meeting their targets of 36-38% of electricity generated from renewable sources by 2030 will not be as easy as simply building more solar and wind farms. There are a multitude of challenges and issues Japan must first overcome in order for the land of the rising sun to achieve these.

While the world saw a record amount of new solar PV capacity installed in 2022, mainly coming from a large uptick in new projects in countries like China and India, Japan saw flat growth continuing with a trend which started in 2019. Since then, Japan has been installing approximately 1GW of utility-scale solar PV each year, which looks to drop to 0.86GW in 2023. Which begs the question, is Japan's rising sun still a promising market to enter?

## Current market situation and major players

A look at players in the market shows a steady increase of foreign investment,

namely from Thailand, India and Spain; foreign companies now account for almost 40% of the market share in new annual solar PV capacity additions, an increase from only 12% in 2015. This suggests that companies such as Vena Energy, BayWa r.e. and Sonnedix certainly believe in the prospectivity of Japan's solar market going forward. However, when comparing with Japan's peers in Asia, the rate of penetration from foreign players into the solar PV market remains fairly low. With Japan's offshore wind industry still in its infancy and with over-burdened grids surrounding ideal onshore wind locations, investment into the solar market from players both home and abroad seems indispensable if Japan hopes to achieve its carbon-neutral targets.

If we look within the utility solar PV market (approximately >1MW) in Japan (Figure 1), currently Pacifico Energy has the most meaningful capacity (operating and under construction) with just over 1GW to come online by the end of this year. Other players such as Sonnedix and Kyudenko Corporation also have reported projects under development due to come online in the coming years.

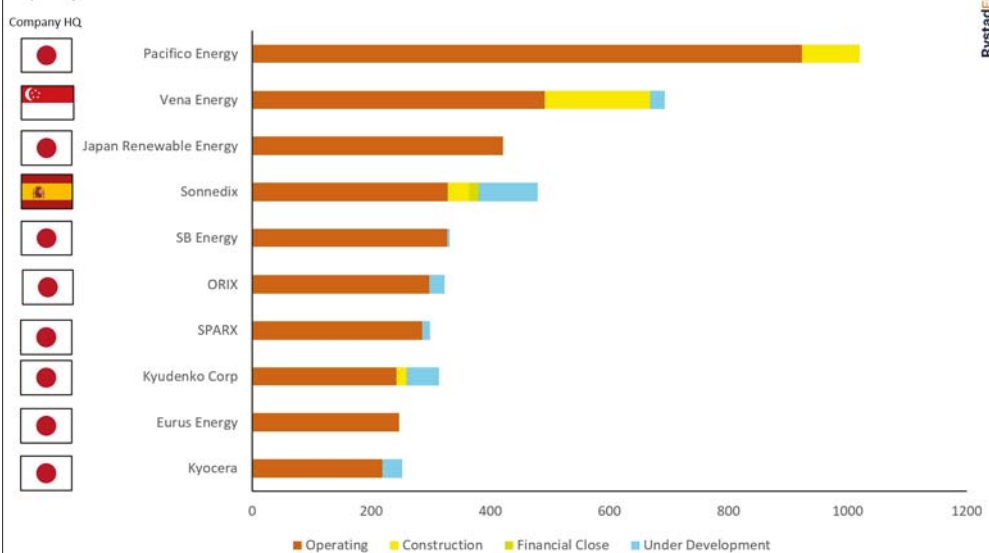
Over the last few years one noticeable change has been the progression from smaller capacity projects to larger scale projects (>50MW). 98% of the new utility-scale solar projects to come online in 2017 were below 50MW in size, compared to 2022, 49%, and 2023, 29%, which sees fewer but larger projects. These projects tend to have the economy of scale and are more appealing in terms of garnering investment and power purchase agreements.

A typical entry point for foreign players into new markets is via joint ventures or through mergers and acquisitions. Globally, 2022 saw 340GW of solar energy capacity trade hands, however only 1GW of this occurred in Japan. Despite multiple foreign players having invested into inorganic growth in Japan over the last decade, the amount of capacity per deal tends to be on the lower end of the scale, suggesting foreign investors still prefer to acquire equity in assets with Japanese developers to learn the market, rather than outright company acquisitions. Additionally, the foreign companies that do tend to buy into the Japanese solar market are well-established renewable generators abroad and there seems to be a distinct lack of large-scale investment from traditional oil and gas exploration and production companies as they try to divest their portfolios to include green energy, as has been the case in Australia and the US.

## Feed-in tariffs and feed-in premiums

Solar energy has been the backbone of Japan's renewable push especially since the feed-in tariff (FIT) scheme was introduced in 2012. This stimulated investment into renewable generation technologies, as intended, and kicked off the journey towards a greener power mix. However, end users took the brunt of payment for the scheme and so the government has decreased the subsidy prices year on year, although they still remain some of the highest in the world. The nature of

**Figure 1: Top 10 solar energy developers in Japan**  
Capacity MWac

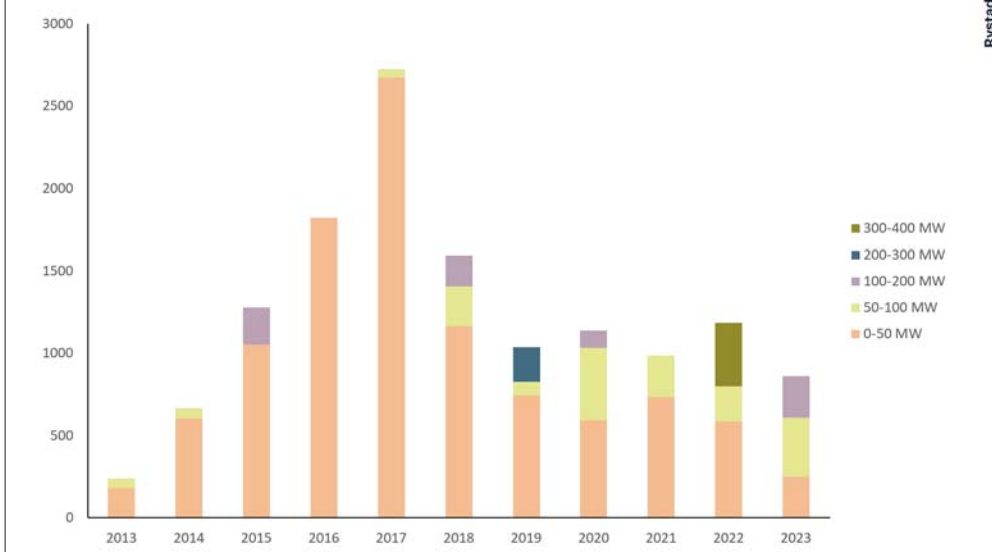




**Figure 2: Capacity size of solar projects**

Capacity MWac

Source: Rystad Energy RenewableCube



the FiT allowed generators to receive a stable flow of revenue regardless of power market prices, however it meant they were un-linked from electricity demand.

To incentivise companies to generate more during peak hours and less during off peak, the government has now switched to a feed-in premium (FiP) scheme for >50kW capacity projects. The FiP scheme will tie generators to market prices and hence should encourage them to generate electricity during peak demand times when the price is high, however it does also expose companies to price volatility and imbalance risks. The Japanese government hopes the FiP scheme will encourage development of new solar farms to capitalise on high market prices in the short term and bridge the gap from the FiT phase to a standalone market where developers no longer need to rely on subsidies in the long term.

However, thus far, the FiP scheme has yet to meet the government's expectation. There have been two auction rounds since the introduction of the FiP and both have been undersubscribed, woefully so in the latest round. As seen in Figure 3, the subscriber rate of the FiP auction rounds have seen similarly low winning bids as compared to the early FiT rounds from 2017 to 2020.

This may seem like a bad omen for the solar industry going forward, however another emerging trend may be partly responsible. As of 2021, developers are no longer required to sell their generated electricity to a utility company, rather they are able to directly tie a contract with a consumer via a corporate power purchase

agreement (CPPA). With solar energy's affordability having vastly improved over the last decade, and with the added bonus that developers can still receive a FiP, these agreements have led to CPPAs rapidly taking off in Japan.

These reforms indicate the government's willingness to change to reach its net zero targets. Many Asian countries have made similar reforms over the last few years but Japan has taken to them the strongest. Retail companies, such as Aeon and Lawson, have contracted the most green energy in Japan, as they look to act on their own net zero commitments and as developers look to seek a steady supply of revenue. We believe that the introduc-

tion of CPPAs will boost solar, and wind, development as Japanese companies seek to follow their peers in markets such as the US and Australia which are dominated by rapid development underpinned by CPPAs.

## BESS

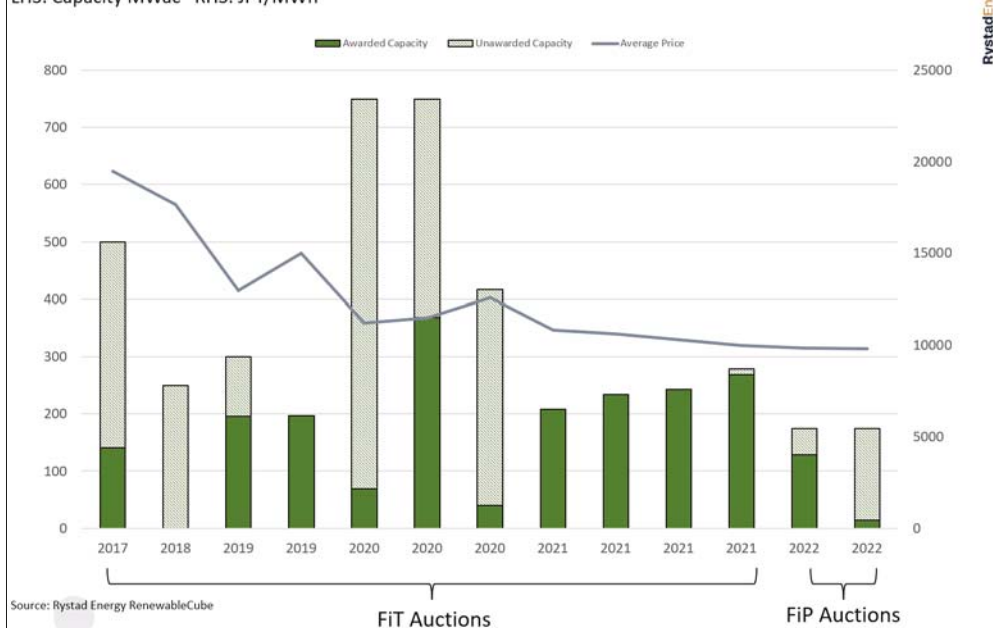
The FiP scheme is all well and good in encouraging companies to generate electricity during peak hours, but when the sun tends to shine during the off-peak hours, then this poses a problem. This is where battery energy storage systems (BESS) come in; a standalone battery connected to a solar farm could minimise imbalance costs for the developer.

The BESS industry is still nascent in Japan, however the government has understood its necessity in supporting a grid powered by intermittent renewable sources. As such, it recently tweaked legislation to allow standalone BESS business to connect to the power grid and subsequently announced a JPY 13 billion (US\$95.4 million) budget to fund subsidies to help battery development where a standalone 1-10MW battery would be entitled to receive up to one-third of the total construction cost and >10MW batteries would receive a subsidy of up to half of the construction costs. However, the budget allocated to the initial round was quickly expended with no subsequent rounds announced as of yet.

One of the main benefits of this subsidy is that it can be used alongside the new FiP scheme; this would allow developers the flexibility to generate electricity during

**Figure 3: Japan solar auctions**

LHS: Capacity MWac RHS: JPY/MWh

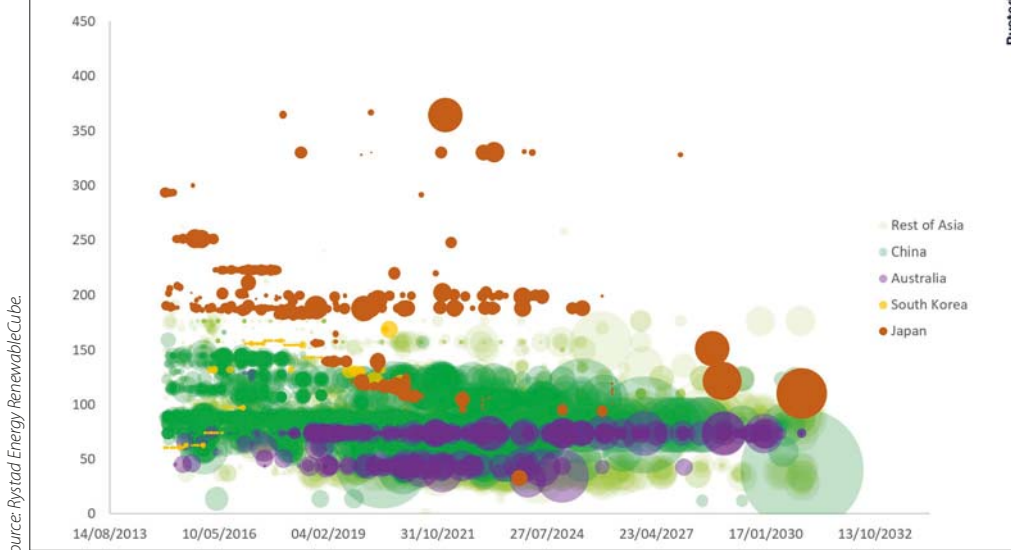


Source: Rystad Energy RenewableCube

Source: Rystad Energy RenewableCube

**Figure 4: Solar PPA prices across Asia**

Y-axis: Offtake price USD/MWh X-axis: Start-up date Bubble: Capacity MWac



Source: Rystad Energy RenewableCube

high-demand hours but also be profitable while doing so. However, for the BESS industry to really develop and cultivate more flexibility of generation on the grid, more subsidies will need to be announced to incentivise the growth of BESS in Japan. There are signs of progression as currently there are already a few announced projects which plan to utilise BESS such as Orix and Kansai Electric Power Co.'s 40MW battery in Wakayama and Mitsubishi and Kyushu Electric Power Company's joint development plan to develop grid-scale batteries across Kyushu.

### Supply chain

Even with all new policies, subsidies and technologies, an industry still won't bloom without a robust and affordable supply chain. The good news is that in the international market, the cost of solar panels will likely come down after a few years of inflated prices. This is mainly due to China, where 95% of supply comes from, drastically increasing its polysilicon production capacity to surpass that of global demand. This can be seen reflected in global solar PPA prices which are forecasted to drop over the coming few years. Japan is no different in that solar panel manufacturers source the majority of their ingots and wafers from China and hence lower manufacturing costs of solar modules will likely lead to more projects being developed.

Despite this, there are still supply chain issues at home. Governmental incentives have promoted rapid development of renewable energy, however the grid's capacity hasn't been able to keep up. In

January this year the Okinawa Electric Power Company announced it would have to apply curtailment measures due to high solar radiation levels and low energy demand. Other regions, such as Kyushu, Tohoku, Shikoku, Chugoku and Tokyo and especially Hokkaido also face similar curtailment. In Kyushu, where renewable energy accounts for roughly 50% of the energy supply, solar energy is the third in line energy source to be curtailed during power crunches, after thermal and biomass. Here the average curtailment rate is increasing, up from 3.8% in 2021 to 4.4% in 2022, however some companies are looking to capitalise on this excess supply via the development of grid-scale batteries on the island.

To make matters worse, Japan's electricity grid is split into two frequencies. The north of Japan operates at 50 hertz while the southwest operates at 60 hertz and hence when energy demand peaks, especially when exacerbated by natural disasters, only a limited amount of electricity can be supplied to different regions via the inter-grid connectivity points. However, Japan's Agency for Natural Resources and Energy (ANRE) has outlined plans for major investment into transmission line infrastructure and the electrical grid which should minimise some of these constraints, such as the Hokkaido-Tokyo transmission line.

Furthermore, connecting to the grid still proves troublesome and costly. Not only is it difficult to get the rights to agricultural land to build solar farms in the first place, consent for grid connection is needed before applying for development approval.

ANRE has also started accepting non-firm connection and local connection types to alleviate some of the developers' stress here.

### Costs and investments

Another concern investors looking to enter Japan may have is cost. Japanese quality is renowned around the world, but with high quality comes a premium. Compared to other countries, labour and construction costs are notoriously high and this affects overheads. In general, PPA prices are decreasing globally; however, when compared with Figure 4, it is clear to see that PPA prices in Japan are still higher than other countries in Asia. As projects increase in size they will benefit from the economy of scale and such a trend can be seen within Japan, however despite this the total cost of developing solar assets is higher than Japan's peers.

This is also reflected in the levelised cost of electricity in Japan. Compared with other key countries, Japan's average cost to generate solar energy is still much higher. This must be taken into consideration with the relatively high power market prices, which could still induce a healthy profit.

### Final thoughts

As a country with some of the most densely populated cities in the world and a firm commitment on supplying electricity from renewable sources, the solar industry in Japan has large potential. To fulfil this potential and in order to significantly reduce its current reliance on foreign fossil fuel imports, a fully developed BESS industry will be necessary to provide developers the flexibility they require to avoid curtailment, earn revenue and further promote development of not only solar but all renewables.

This, in conjunction with FIP subsidies and CPPAs, should support the development of more large-scale solar farms, thus also attracting investment from international players. The sun in the east looks to rise, but just how high will depend on further government intervention. ■

### Author

Chris Wilkinson has been working at Rystad Energy for four years where he covers the Northeast Asia renewable market, excluding China. He studied geophysics at the University of Southampton and later worked at oil and gas companies before deciding to focus on green energy.





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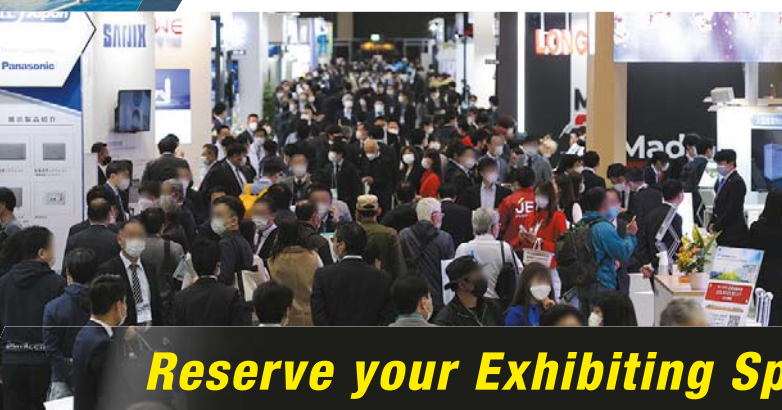
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# Developers drawn to emerging solar hotspot Romania ahead of new CfD scheme

**Romania** | With grid availability, plenty of land and a new contracts for difference scheme that is set to go live this year, Romania is proving an increasingly attractive market for solar developers. Lena Dias Martins finds out more.



Credit: Econergy.

Romania is becoming an increasingly prominent entity in the EU solar market, as the country ramps up its efforts to attain its government's goal of developing 7GW of renewable capacity – 3.7GW of which will be solar – by 2030.

According to International Renewable Energy Agency's *Renewable Energy Statistics 2022*, Romania's total renewable energy capacity at the close of 2021 was 11,138MW – 1,398MW of which was solar.

Having successfully met its previous target of 24% of the country's energy consumption being provided by renewables in 2020, the *National Integrated Plan for Energy and Climate Change 2021–2030* reported that reaching 7GW of renewable capacity would mean raising this figure to 30.7%.

Market research company, Mordor Intelligence, predicted that achieving this target will see the Romanian solar market register a compound annual growth rate of over 9% between 2022 and 2027.

Romania has accelerated its transition away from carbon and its receptiveness to renewables, alongside geographical benefits, have drawn a number of solar

developers to the country.

Evaluating the benefits of developing solar in Romania, Simonas Sileikis, head of solar business at Green Genius – which has a 10MW portfolio at late development stages in Romania – tells PV Tech Power:

"The size of the country and size of the market are really attractive. The market in Romania is not so crowded as it is right now in Spain or Italy. So we do see this as good timing for development in this country."

"Then, the stability of the country itself. It's a European Union country and we see it being secure and stable. From this perspective, it's a functioning market and the availability of resources such as the land and the grid capacity, which we also see still available in the country, means that we are absolutely focusing right now on development in Romania."

The attractive prospect Romania presents for solar development is becoming increasingly conspicuous to developers, however, as the utility-scale PV market grows, challenges begin to emerge which could threaten to impede the development of solar.

**Romania offers a number of benefits in both grid capacity and connectivity.**

The Romanian government has maintained strong support for the growth of its renewable industry, as demonstrated by emerging policies to incentivise the growth of solar. One example is the reintroduction of power purchase agreements (PPAs) following their ban from Energy Law no. 123/2012.

The ban was initially eased in 2020 when new renewable generators were allowed to apply for PPAs, before being completely lifted in 2022.

## Power purchase agreements

A PPA is a long-term electricity supply agreement between a power producer and electricity trader or consumer. The bilateral agreement allows both parties to negotiate the long-term price of energy, which offers developers some revenue security.

Despite its intentions, the maturity of the PPA market may not yet be on target.

In conversation with *PV Tech Power*, Eyal Podhorzer, CEO at Econergy, which has eight solar projects in Romania at varying development stages, says: "The price that we'd be able to secure for a PPA is very much discounted from what the market consultants [for Econergy's Romania projects] believe the price could be in the next 10 years."

This, Podhorzer believes, is the main obstacle for investors in the Romania solar market, stating that: "At the moment Romania is a market only for investors who are willing to take the merchant risk."

Discussing what could inhibit the growth of Romania's solar market, Panos Kefalas, senior associate for South Eastern European markets at consultancy Aurora Energy Research, says: "We often hear that it's still hard to get financing for a PPA-based project from a Romanian bank,



they are not as comfortable doing this as they are in other markets. This makes it hard to find bankable PPA offtakers."

These financial teething points led renewable energy provider, Rezolv Energy, to look outside of Romania for its route to market.

Discussing the ongoing planning process for Rezolv's 1,044MW PV project in Romania (which the company claims will be the largest solar farm in Europe once online) Shane Woodroffe, CFO at Rezolv Energy, tells *PV Tech Power*: "The problem that we have with countries like Romania is finding credit-worthy offtakers that our lenders will accept."

"We're having to look extensively outside Romania for high-credit-quality corporate PPAs that will support the financing and which are acceptable to us and our lenders."

Although PPAs may not have overtaken the merchant market as the predominant route to market for solar in Romania, the Romanian government is working to offer alternatives for renewable developers.

Podhorzer adds: "The Romanian government is very supportive in terms of facilitating the process in order to allow for the quicker realisation of solar projects."

### Contracts for difference

Another example of the Romanian governmental support for solar – and perhaps the policy gaining the most industry interest – is the implementation of a new contracts for difference (CfD) scheme, which is set to go live this year.

A CfD is a private law contract awarded through a private auction, which allows renewable generators to bid for a guaranteed revenue scheme for the duration of the contract. Once the contract is agreed, the counterparty will pay the difference between the agreed fixed strike price and a generator's revenue. By offering investment security CfDs are used to encourage investments in renewables.

The scheme is being carried out with the support of the European Bank for Reconstruction and Development (EBRD).

Senior banker at the EBRD, Ahmad El Mokadem, explains that as well as providing funding, the bank appointed a legal firm with experience creating CfDs to help the Romanian government through the design and structuring process.

El Mokadem confirms that Romania's CfD scheme will be similar to a traditional CfD, with some alterations to tailor it to the Romanian market.

In November 2022, the CfD was presented at a market funding event in Bucharest where El Mokadem notes there was "huge interest" in the scheme.

The additional route to market means that Romania will have a similar development process to Poland, however the youth of the market makes it less saturated than its Polish counterpart, which can speed up the development process for renewables – a highly attractive prospect for investors.

PV developers in Romania agree that the CfD scheme will have a positive impact on the growth of the Romanian solar market.

"The problem that we have with countries like Romania is finding credit-worthy offtakers that our lenders will accept"

"It will attract more investors," says Podhorzer, "because I think the main barrier to entry at the moment for major investors is the fact that they need to go to the merchant market."

As the PPA prices are still relatively low, Podhorzer believes that implementing a government-backed CfD scheme will attract much bigger investors.

Commenting on the forecasted benefits of the CfD scheme in Romania, Jörg Menyesch, managing partner at developer CCE Holding – which currently has project rights in Romania totalling 680MW – says: "If it provides us with higher stability in our business plans, then it's a good thing."

Looking ahead to the CfDs implementation, El Mokadem explains that, although not yet finalised, its key parameters are in place and expectations are for the scheme to go live in the second half of this year.

Once implemented, El Mokadem expects the scheme to be a "very powerful and relevant" tool for developers to enter the Romanian solar market.

### Agriculture versus energy

Agriculture contributes a higher share of GDP in Romania than in any other country in the EU, according to the Global Economy's data from 2021. Therefore, concern from the Ministry of Agriculture and Rural Development over how much land is used to accommodate solar farms can significantly impact the development of Romania's solar industry.

Policy will be a key driver in addressing

the food production versus energy security debate.

The Romanian government recently passed a new law to simplify the application process for renewable energy projects built on less than 50 hectares of agricultural land by removing the need for a Zonal Urban Plan (PUZ).

A PUZ ensures that a project's development plan correlates with the provisions of its area's General Urban Plan. The PUZ can only be initiated if an urban planning certificate has already been obtained. Removing this requirement ought to significantly speed up a project's development.

According to the World Bank's 2021 collection of development indicators, 59.1% of Romania's land is agricultural. The sheer size of agricultural land means that Romania could become an exporter of food as well as power – offering a welcome compromise between energy and agriculture.

Johannes Srajer, managing director for CCE Romania, a business arm of CCE Holding, states: "I think that the combination of producing energy and producing agriculture products in this agrivoltaic field can make a real benefit. The land could potentially be used more productively than before, because farmers could not only produce food, but also energy."

Addressing the mounting pressures on all farmers due to climate change, Srajer's colleague Menyesch notes that the combination of agriculture and PV could be "part of a solution for farmers to be more profitable, more resilient against tougher times". He adds: "We don't see photovoltaics as a threat for agriculture, the opposite is the case."

Similar considerations are expressed by Woodroffe: "There are certain activities we can consider using the land [of a PV project] for because we don't use all the land for the PV infrastructure. And there is an optimum design of the land where you can potentially get vehicles down between the rows and panels and still use it for certain agricultural activities where the land is not needed for PV."

Econergy's Podhorzer suggests another potential solution: "In my opinion the compromise that Romania will find – which you see in every other market including the UK – is that the agricultural land is graded into different types."

In the UK the development process for solar built on agricultural land of classifications 3b, 4, and 5 is significantly shorter as it avoids the use of the most versatile cropland.

Despite the ongoing debate around agriculture and energy security in Romania, the industry appears optimistic that a compromise will be found.

### Grid capacity

Grid connection is one of the most significant – and often more problematic – aspects of building a PV project. On this front, Romania offers a number of benefits in both grid capacity and connectivity.

Romania's integrated transmission grid is connected to all five of its neighbouring countries. This integrated system is a much more attractive prospect than an isolated market.

An additional benefit to Romania's relatively new market is its grid availability, especially in comparison to similar markets, such as Poland, that are struggling with capacity.

"The Romanian grid is not as congested as its neighbouring countries," says Kefalas.

"Sometimes grid connection can be a limitation but that doesn't seem to be the case yet in Romania. And that's because Romania's grid was oversized in the past, it had a larger size and demand than it has now, so there is some more space to start with.

"Maybe this will be a problem in five years or so. But for the time being, it seems that it is easier for generators to connect to the Romanian grid."

Kefalas alludes to a consideration that is currently looming over Romania – as the Romanian solar market grows, so will the need for both grid availability and flexibility.

Grid capacity was a prominent consideration for the Romanian solar panel at the Solar Finance and Investment (SFIE) 2023 event, hosted by *PV Tech Power* publisher Solar Media in February.

Anastasios Christakis, managing director at Claritas Investments and one of the Romania panellists at SFIE, said: "My personal view is that if all these projects that are being developed at the moment in Romania come to fruition, Romania in three or four years' time will be where western Europe is in terms of grid constraints. So Romania will have to think how they can alleviate this problem."

Grid constraints are widely recognised as having a huge impact on the wider renewable transition.

El Mokadem, for example, calls grid capacity "the most important constraint that is not only facing Romania, but facing every country trying to deploy renewables".

An operational PV plant from Econergy in Romania.



Credit: Econergy

Woodroffe makes the same observation, stating that he believes grid connectivity to be "a European-wide problem and probably worldwide". He adds: "It's one of the biggest challenges for renewable energy and, indeed, PV. So the issue is, you've got grid infrastructure that was originally designed around very large centralised generating units. And now we're moving to a very decentralised system, renewables projects spread all around the place.

"You need to take all this new electricity generation and to move it to where it's consumed. So I do see it as one of the biggest challenges for Europe: adapting, strengthening, building new lines, reinforcing the whole grid network."

Developers in Romania appear widely in agreement that the Romanian government, as well as the country's transmission system operators (TSOs), are both cooperative and proactive in their approach to grid connectivity.

Another member of the SFIE Romania panel, Jim Campion, CEO at Rezolv, said: "Interactions are fairly open. I think that Romania has improved massively since the first wave, so that's definitely a positive."

Referring to one of Romania's largest TSOs, Menyesch says: "We see that Transelectrica, for example, is making an effort to increase the quality of the grid.

"Though it may not be very fast, there are real efforts to do so and we can see that Romania is really willing to move to a liberal energy market."

El Mokadem reports the same willingness from TSOs in Romania, agreeing that, in terms of grid upgrades, "transmission system operators are setting the right plans and allocating the right budget".

Funding for these upgrades has already been received from the Modernisation

Fund – an EU programme to support 10 member states modernise their energy systems.

During the fund's second year of operations, Romania received €1.39 billion (US\$1.48 billion), which will support the modernisation of its energy networks and contribute to grid upgrades.

This investment will help to both increase and upgrade Romania's grid, which, according to Transelectrica, has a current total cross-border capacity of 34GW; thus, facilitating the continued growth of the Romanian solar market.

Romania's solar market has developed significantly since 2020 and with the CfD scheme estimated to go live later this year it is set to continue its upward trajectory. Consequently, many developers are beginning to consider Romania as a pillar market.

As it grows, Romania's energy market will need to remain reactive and flexible. For example, with increased energy produced by renewables, energy storage will be key to avoiding cannibalisation. Panos warns that as of yet there is still "no framework for energy storage at all" in Romania.

However, the Romanian government's proactive support of the solar market so far presents a positive outlook for the future of solar in Romania.

"This is a year that is very important for solar in Romania. We see a lot of appetite for solar and a lot of people moving ahead with projects," says El Mokadem.

"So it is really important that this continues, and we are involved heavily with a number of projects in different approval stages and I hope, before the end of this year, we'll be able to announce a number of audits that we signed in Romania to help with the deployment of more solar." ■



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# How solar can bring light to war zones

**War zones** | Cheap and quick to deploy, solar PV can provide a vital source of power to areas impacted by war, supporting critical infrastructure and helping to keep day-to-day life running. Molly Lempriere details how the technology is helping communities in Ukraine and other war zones.



Credit: DTEK

Energy infrastructure is often a primary target within war, throwing people into darkness and limiting a vast number of services and technologies. This has increasingly led companies and countries to look to technologies like solar, which can bring light to countries gripped by war.

As a technology it is cheap, fast to deploy and once running doesn't rely on regular fuel input, as well as being capable of being rolled out in a vast number of sizes and locations.

"Solar systems can provide a reliable energy source during emergencies such as power outages caused by natural disasters or conflicts. But more importantly, they can be used for a long-term energy supply," says Bartosz Majewski, CEO at PV distributor Menlo Electric.

"The essential advantage of solar systems during the targeted attacks on energy infrastructure in a centralised energy system is their decentralised nature. Solar systems, especially hybrid

or off-grid ones, provide a stable energy supply that can operate independently of the primary grid and are more resilient against missile attacks. The most telling example for me was how household solar stations saved the lives of residents of surrounded Mariupol, allowing them to cook food. I wish it would not be an exception, and more people could survive because they had access to electricity."

Already we've seen solar's use in areas including Syria, Yemen and – over the past year – Ukraine, as nations work to provide energy security in incredibly challenging conditions.

## Solar in war zones around the world

The potential of solar to provide power to areas gripped by war is fairly well established. For example, amid the continued fighting in Yemen, a number of charities and companies have rolled out solar to support people as the crisis in the country enters its ninth year.

## DTEK's Tryfonivka solar plant in the Kherson region was damaged during the Russian occupation

In March 2015, Yemen's largest power plant in Marib, which was responsible for powering most of the country, went offline. The high power prices of private generators and frequent fuel shortages meant this closure threw the majority of the country into darkness, according to the World Bank.

But following on from this, there has been a significant growth in the number of firms importing and selling cheap solar systems, with many small electronics retailers offering them.

For those who still found the cost prohibitive, projects such as the World Bank's Yemen Emergency Electricity Access Project have helped fill the void. Between 2018 and 2022, it installed pico solar systems at 91,715 households in rural and peri-urban areas, and installed a total of 6.45MWp of solar across 517 critical facilities, along with wider work to bring solar power to women impacted by the war and develop the skills and supply chains needed to keep growing the sector.

Today more than half of all Yemenis use solar power as their main source of lighting, according to the World Bank.

Elsewhere, solar has been used during the war in Syria, where initiatives like the Union of Medical Care and Relief Organizations' (UOSSM) 'Syria Solar' has been providing the technology to hospitals, to support their function even in challenging conditions.

Commenting back in 2019, Dr Anas Al Kassem, board member at UOSSM International and war surgeon, said: "In the past three months, 34 medical facilities have been bombed in north-western Syria. After eight years of conflict, the electrical grid in many parts of Syria has become dysfunctional leading many health facilities to depend on diesel generators for electricity. Frequent shortages of fuel and gouging fuel prices jeopardise patient lives."



The group launched a second solar power system in north-western Syria on 22 July 2019. The 90kWp solar PV system was made up of 300 panels, 12 inverters, 216 batteries and an advanced data control system.

Not only do these systems support the continued operation of crucial infrastructure, they save approximately 60,000 litres of diesel fuel per year. This represents 40-45% of the annual energy cost for the hospital, allowing that money to be redirected to providing medical care.

### Rebuilding solar in liberated areas of Ukraine

When war broke out in Ukraine following the Russian invasion on 24 February 2022, energy infrastructure quickly became a key concern, both in the country and beyond. Artillery and rocket strikes have targeted generators, the grid network and the wider energy sector, with 30% of Ukraine's power stations destroyed as of October 2022.

One glimmer of hope however was the Tryfonivska solar plant in the Kherson region, where activities resumed in November following liberation from Russian forces. The 10MW solar site's

*"Today more than half of all Yemenis use solar power as their main source of lighting, according to the World Bank"*

owner and operator DTEK has since worked amid the challenges of war to energise the site, allowing it to once again contribute to the energy mix in the country.

The site holds a particular place of importance for the company, says DTEK Renewables CEO Oleksandr Selyshchev, meaning its liberating provided a particular morale boost to the company and the local region. "We construct much larger PV stations, but as our first child [Tryfonivska is] especially important for us, and we were very glad when we understood that the station was deoccupied in early October."

In November, the company got permission to return to the site following assessments by the military confirming that it had been largely demined. There is a deficit of sappers and other demining

**The portable connectivity container is quick to install, allowing it to provide immediate support to medical facilities**



Credit: Dmytro Balda.

specialists currently, delaying the return.

Once DTEK was back on site, it could begin to assess the damage. About 40% of panels and 30% of inverters were damaged, destroyed or stolen, says Selyshchev, but the biggest blow was that the local substation was destroyed completely.

"A key task for us now is to help our regional distribution company Khersonoblenergo to install new transformers. Unfortunately, some of Khersonoblenergo has suffered a lot. They have a lack of employees, a lack of liquidity. Actually, we use our labour force from our sister company, DTEK Grids [to help them]. They are helping them to restore wires, and now we are discussing several alternatives for how to renew usage of medium- or high-voltage grid, as soon as possible."

Having returned to the site, and constructed the workers' village needed to allow additional staff, DTEK began rebuilding. This included assessing each panel and inverter, removing the broken ones and reconfiguring the site to run using the ones that remained.

While this is a somewhat unusual task for solar developers, according to Selyshchev this is one the team took in its stride, benefitting from a new mindset that is driving the Ukrainian people more broadly.

"It's not like typical life. The war changed mindset. So we are struggling even more to achieve our goals," he says.

As such, the operational team – which would usually be responsible to controlling electricity flows – took up a range of tasks, from reassembling inverters to cleaning out the administrative building after the Russians.

"I really think that our employees are heroes, the people who accept the risks, as the territory is still not completely demined – of course, we mark with special strings, mark safe roads and restrict dangerous areas. But all of us understands that, as I said, it's not like completely safe atmosphere, and they really are heroes," says Selyshchev.

Whilst work is being undertaken to

restore the substation, the Tryfonivska solar plant has been connected to a low-voltage line, allowing it to feed 2MW into the system.

"Of course, we understand it's not huge, but it's really important, at least for local villages, small cities, because the original grid suffered a lot. And in any case, it's really useful to support the grid system in the region with our even small capacity," says Selyshchev.

When possible, DTEK plans to bring the site back up to its previous capacity, but will face challenges around sourcing panels and inverters similar enough to fit into the system.

### Modular systems and rooftop aid

Along with the large-scale solar sites in Ukraine helping to provide vital clean energy, there are a number of smaller-scale projects popping up to roll out generation at speed.

Lithuania-based solar module company SoliTek has been donating solar panels to Ukraine as part of humanitarian projects, which are being used to build mobile power generation stations. These are being used by Ukrainian soldiers to charge reconnaissance drones as well as by medics in mobile medical stations.

As well as being suited to modular solutions, solar has the additional benefits of being easy to transport, small and compact, as well as not emitting any noise and not requiring fuel as a consumable.

Similar solutions are being offered through other collaborative partnerships such as Computer Aid International, Community Organised Relief Effort, Simplyhealth and Geeks without Frontiers, for example, who are rolling out solutions like the portable connectivity container on the ground in Ukraine.

These are solar-powered converted shipping containers, the first of which was installed at the Volyn Medical Institute in Lutsk, Ukraine, in December, where it is helping to support training for medical students.

Elsewhere, companies are working to deploy fixed solar installations at pace

	School	Hospital
Solar modules	20-40kWdc	30-50kWdc
Hybrid three-phase inverters	10-30kW	20-35kW
Battery storage	20-50kWh	60-96kWh

as well. For example, Menlo Electric is working in cooperation with the Ukrainian foundation Energy Act For Ukraine (EA4U) to roll out ten installations with a total output of 300kW at schools and hospitals.

"The project aims to reduce the number of hours when the facilities are operating without electricity and enable schools and hospitals to use stored electricity during power outages, while reducing their dependence on the grid and the energy bills respectively," says Yuliana Onishchuk, founder of the EA4U.

"Hospitals are experiencing serious problems with electricity supply, or worse, not having it at all. This makes it hard to provide medical assistance and, in some situations, impossible to save lives. The foundation's goal is to equip 50 hospitals and 100 schools with solar stations within the next five years."

EA4U then conducts a multi-stage selection process to choose the most appropriate sites for is 100RESforSchools and 50RESforHospitals programmes. One of the key considerations is proximity to the front line and Russian and Belarus borders, with sites having to sit beyond 60km from such.

The schools and hospitals need to be operational, with this including schools that are offline or using mixed forms of attendance meaning that they are equipped with an underground bomb shelter under Ukrainian legislation. Additionally, the roof cannot be made of slate, given how brittle it is, creating additional risk during the installation process.

Hospitals have been chosen that have surgery rooms, intensive care units, and maternity wards, as these are medical departments that most critically require a stable electricity supply. This is also a driving factor in the inclusion of a battery energy storage asset alongside the solar at these sites.

"While choosing energy storage, its capacity plays an important role, especially for hospitals, where uninterrupted power supply is essential for critical equipment such as life support systems, ventilators and surgical instruments. The capacity of hospital storage batteries is

usually at least twice that of a solar power plant to cover the energy demand of the required critical equipment at the surgery rooms/intensive care units/maternity wards for an extended period, usually several hours," says Menlo Electric CEO Majewski.

"When deciding on the capacity of the solar system for a school, we take into account the consumption of the bomb shelter (wired by default to our solar system), several classes chosen by the school (usually IT classrooms that need electricity for computers) and street lighting (for ensuring the security of pupils going home after classes when there is no daylight)."

The typical configuration of projects is shown in the table above.

Installing solar during wartime brings numerous additional challenges, alongside the clear benefits it offers.

"The security-related risks of constructing a rooftop solar power plant in Ukraine have never been higher than after 24.02.2022, and so is the need for decentralised energy sources. The latter is why we proceeded doing our projects, as decentralised renewable generation and energy storage facilities can secure essential critical and social infrastructure operations during the war. So, lives continue to be saved and kids keep studying no matter what," says Yuliana Onishchuk, founder of the EA4U.

"The lack of skilled workers may become more pressing from the middle-to long-term perspective. Before the full-scale invasion, the Ukrainian energy sector employed significantly more men, especially in STEM jobs. Currently, many men are conscripted into the Armed Forces of Ukraine, and as long as the war continues, many more may be called to fight. It potentially can increase the deficit of skilled engineers, mounting specialists and electricians who work with renewables."

However, the biggest challenge is securing a sufficient and constant flow of donations, according to Onishchuk. The EA4U is targeting installations on 100 and 50 schools and hospitals, respectively, by 2028.

## Reducing overreliance on fossil fuels in the long term

It is clear that solar can provide a vital source of power to those impacted by war, helping to keep day-to-day life running and supporting vital infrastructure. Additionally, as a fundamentally independent generation source, it provides greater security for countries moving forward, ensuring they are less reliant on large petro-states such as Russia.

Interest in solar since the Russian invasion of Ukraine has surged not just in Ukraine but across Europe, as nations look to develop additional resiliency.

"With renewables demonstrably cheaper, safer and more resilient than overreliance on imported fossil fuels, the clear lesson is that energy security and net zero can, and must, go together," said Bernice Lee of thinktank Chatham House on the anniversary of the invasion.

"The response to the conflict has also demonstrated that where there is a will, there are many ways to cleaner futures, as seen by the rallying of the Europeans around efficiency. A year on from the invasion, the shift towards cleaner technologies is only accelerating, with the landmark US Inflation Reduction Act spurring the EU to enter into a race to develop the clean technologies of the future."

**In 2022, the first school (Irpın Academic Lyceum "Mriya") was equipped with a solar power plant and an energy storage system with a total capacity of 20kW as part of EA4U's work.**



Credit: Menlo.



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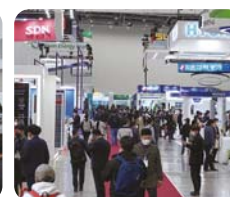
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# MENA aims to become solar-powered green hydrogen hub

**Green hydrogen** | Scores of new green hydrogen projects have been announced in the Middle East and North Africa in recent months, as countries look to take advantage of high levels of irradiation and available space to deploy renewables. Jonathan Tourino Jacobo explores the challenges and opportunities for the region's burgeoning green hydrogen sector.

**H**ome to some of the highest levels of solar irradiance, some countries in the Middle East and North Africa (MENA) are positioning themselves as major green hydrogen hubs globally and compete with the likes of Australia, Chile or Europe.

Even though green hydrogen is still a nascent technology with only a few pilot projects operational around the world – of which one is in Dubai – a few key countries are trying to get ahead of the game and have announced a plethora of projects at a gigawatt-scale in the past twelve months.

## Key players in the region

When looking into the MENA region, most of the production of green hydrogen and green ammonia is aimed to be exported, says Ignacio Carreras, project development manager at renewables developer AMEA Power.

The region is already an exporter of ammonia for which it will be able to leverage the existing infrastructure, according to Claude Mourey, director of hydrogen and new energies in EMEA at research firm Wood Mackenzie, adding: "Currently, to export hydrogen there are two key demand centres: Asia and Europe. And there is no pipeline coming that can be used to actually bring this hydrogen to Asia and Europe."

This puts the MENA region in an advantageous position to create a green hydrogen hub with the intention of producing green ammonia which will then be exported by ships to key demand markets.

For AMEA Power, the countries it is focusing on are those that have a combination of natural resources and regulatory frameworks where green hydrogen can be the most competitive, says Carreras.



Credit: DEWA.

**A pilot green hydrogen project from Dubai Electricity and Water Authority and energy Siemens Energy in Dubai.**

In terms of natural resources, solar alone will not be enough due to the constant need for a power supply for the production of green hydrogen, despite its abundance in the region. Thus a balance between solar – which is more competitive – and wind is required.

Land availability is another aspect that will help the MENA region attract more projects, as at the moment many of the countries have plenty of land available for the development of renewable energy resources. This allows for projects of gigawatt-scale to be developed in the region and achieve a better economy of scale and competitiveness in terms of price production.

On the other hand, political stability and a regulatory framework that supports these projects are a must to be competitive in the international market, according to Carreras. "In order to be competitive, you need to achieve certain

economies of scale," he says. "These economies of scale means that you need to make very large projects. And that's why you're seeing this massive scale of projects of minimum 1GW."

Among the key players for the production of solar-powered green hydrogen projects, four countries – Egypt, Morocco, Saudi Arabia and Oman – are placing themselves ahead in the competition, according to Carreras. "These are probably the top four. Then there are other countries which are well positioned but will need some other combinations, like Tunisia or even the UAE."

Saudi Arabia, the UAE and coastal and southern areas of Oman have good solar potential, says Mourey.

Egypt – which has a good combination of solar and wind resources that couple well together as wind picks up at night, according to Carreras – has been drastically increasing its interest



in green hydrogen projects, and further demonstrated it when it hosted COP27 in 2022. "COP27 has been really helping in fast-tracking several project initiatives," says Mourey.

During COP27, Egypt put green hydrogen as a key technology for the decarbonisation of its electricity resources and signed a plethora of green hydrogen projects. With no less than eight framework agreements – including deals with AMEA Power, Fortescue, Globeleq, Masdar and TotalEnergies – these would position the country to be a key global player in the exportation of green hydrogen and green ammonia. This is not counting the more than 20 memorandums of understanding Egypt signed for green hydrogen projects in the region.

Rather than creating an oversaturation of the market and cannibalisation between the companies, Carreras sees it as a positive: "This is something that is actually helpful for everyone." Carreras adds that given these projects will need a common infrastructure to be developed – such as transmission lines and adapting ports and storage facilities – this will help the companies be more competitive and attract more investors with the creation of a hub.

For example, an AMEA Power project in Egypt aims to produce 100,000 tonnes of green ammonia annually, which would be 1% of what Europe expects to import by 2030. "We could have 100 projects like ours, and this is only for Europe," says Carreras.

Furthermore, many of these projects involved a key public body that showcases Egypt's interest to export the production of its green hydrogen or green ammonia with the General Authority for Suez Canal Economic Zone as many of the projects will be located in the vicinity of the Suez Canal.

Almost a third of the global container traffic passes through the canal, representing 12% of global trade, according to the International Chamber of Shipping.

Another key partner to help with the supply of Europe's target of 10 million tonnes of renewable hydrogen by 2030 is Morocco. Its proximity with Europe and an existing gas pipeline that passes through the North African country and connects with some European countries could give Morocco an edge in terms of exporting its green hydrogen production without the necessity to transform it into

ammonia, says Carreras. He adds: "Having this pipeline will help Morocco to be in a better position and in theory be faster than other countries."

Meanwhile, Oman's approach to attracting renewable energy and green hydrogen development is slightly different from its neighbours in the region, with the country forming a strategic partnership last year with oil giant bp to map out the best locations in terms of renewable resource potential. "It gives you an understanding of where are the best spots and once you really know where they are you have a competitive advantage for your hydrogen production," says Mourey. It will also allow developers to save time in the assessment of the potential for a solar or wind plant and could save up an entire year in the project's development, adds Mourey.

And if the Abu Dhabi Sustainability Week in January 2023 can give any indication of what to expect from the UAE at COP28, but also other countries in the MENA region, green hydrogen is poised to have an important role in the event. Mourey expects the country is preparing to display all the different initiatives that are under development.

#### Importance of working with public bodies

One thing that all these countries have in common is how public entities have

been involved in partnering with developers to build green hydrogen projects, especially at a gigawatt scale. Those are no longer an exception in the region, and thus getting the backing of government bodies remains important, especially for the projects that will primarily produce green hydrogen or green ammonia for exportation.

No matter the size of the project, having the government's backing is absolutely necessary, says Manuel Kuehn, senior hydrogen executive at Siemens Energy.

For Carreras, working without the local authorities on large-scale green hydrogen projects would be impossible and lead to nowhere. Many parts of the project will involve working with the country's authorities, be it on securing permits or coordinating the development of infrastructure. Carreras says: "In Egypt, we are talking about an infrastructure that will be located in the Suez Canal in Al Sokhna to produce hydrogen and ammonia. But the upstream, the renewable assets, are far away. More than 100 kilometres away. That's where the winds and solar assets will be."

#### Regulatory challenges for export projects

Partnering with public bodies can also help work around one of the main challenges when developing a solar-

### Learnings from MENA's first operational green hydrogen project

One of the first green hydrogen projects to be operational around the world, and the first in the Middle East, is a plant co-developed by UAE utility Dubai Electricity and Water Authority (DEWA) and energy development company Siemens Energy. The pilot project is currently operating in Dubai. Having the support of local authorities and the fact the project was tied with the Expo 2020 Dubai helped accelerate the project becoming operational.

"It's important to find alliances that can really make things happen. In that particular case, the combination of having the local utility DEWA involved and also with Expo 2020, a relatively powerful organisation with a deadline, it helps get things off the ground," says Manuel Kuehn, senior hydrogen executive at Siemens Energy.

The pilot project helped Siemens Energy better understand how the green hydrogen plant, which is connected to a solar field, operates. And one of the first findings is that despite the location of the plant in a region with high irradiance, the output does not end up being the same, day after day, and always ends up with an anomaly (either due to a flock of birds, dust or clouds), according to Kuehn. He says: "One very interesting thing is that you would assume in a location like Dubai, where the sun always shines, that the output of your solar field is a bell curve every day, as boring as it could be."

This is the reason why many of the gigawatt-scale projects announced will have a mix of both solar and wind, in order to lower as much as possible the intermittency of each, since even in regions where there is high irradiance there will end up being fluctuations which need to be diminished as much as possible in a green hydrogen plant.

"This shows us that even in a solar-to-electrolyser setup and also the planned and unplanned intermittency plays a bigger role than anticipated," says Kuehn. Being able to see how the pilot project plant behaves while running on solar helped Siemens Energy gather crucial information for the construction of utility-scale green hydrogen plants and be better prepared for the intermittency of power it gets from solar PV.

Meanwhile, the choice of the electrolyser – be it alkaline, polymer electrolyte membrane or solid oxide electrolysis cell – will not be a factor differentiator, according to Kuehn, even despite the differences of flexibility each brings when powered up with solar energy. "There will be room for all the technologies at least in the next decade."



Credit: DEWA.

powered green hydrogen project in the MENA region: making sure to have the local authorities' interest aligned with the project's developers and have a common interest. "You need to keep in mind that these projects most likely will be focused on export. It could be a situation where the country gets very little [of the production]," says Carreras.

Aside from the creation of local jobs, these projects might end up getting the best locations for solar and wind performance and a transmission line to connect to the grid to have the optimal assets to power the green hydrogen plant. This is one reason why some of the projects in Egypt have local authorities or sponsors as investors in the projects, with some cost sharing in terms of infrastructure, according to Carreras.

Most importantly, one of the challenges to take into account when developing a green hydrogen plant in the region is to do with the fact that it will mostly be used for its exportation to other markets around the globe. This means that developers will need to factor not only the regulation in the country that has produced the green hydrogen, but also in the country it will be sent to, as these

could in the future differ significantly. "I am exposed to the regulatory environment of the country I'm exporting to and exposed to the regulatory environment of the country where I installed my equipment," says Kuehn.

The EU, one of the main markets that will be sourcing its green hydrogen from the MENA region, established two acts in

**Most green hydrogen produced in the MENA region is expected to be exported.**

*"COP27 has been really helping in fast-tracking several project initiatives"*

February 2023 to help define renewable hydrogen production in the bloc, not just for domestic producers but also third countries looking to export into the EU.

The rules will be implemented in a transition phase, and setting stricter rules in order to prove the hydrogen was produced using renewable electricity. Other countries will follow suit, but at the moment there is no certainty that a common standard will be set worldwide

or across several markets, forcing developers to work through different regulations – which could change with time – to be able to dispatch their production to as many buyers as possible.

One option could be for a project to oversize its solar and wind capacity in order to feed the grid later, with the hydrogen plant being powered when renewables are not able to dispatch any electricity, for which they will need to be certified green, says Mourey, adding: "This kind of arrangement is going to be very geography dependent and it would be policy driven. Some regions will say 'yes, we accept it' and others might say 'no, we don't accept it'."

For Mourey, in the short term, the tendency would be to accept it in order to help kickstart the hydrogen economy, but regulations will be an important issue for developers as they could change over time and a project might no longer fulfil the requirements needed to consider the hydrogen or ammonia that they made is in fact green and made only with renewables. ■



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# Product reviews

## Inverters Solis introduces new Sixth Generation three-phase hybrid inverter

**Product Outline:** Ginlong Technologies' Solis inverter brand is launching its new Sixth Generation hybrid inverter, featuring three-phase connectivity and flexibility to choose from a wide range of compatible battery brands.

**Problem:** Energy prices and the European Union's REPowerEU strategy are both key reasons to consider storage alongside solar PV. Storing solar energy produced ensures that system owners are maximising their return on investment and achieving true cost savings on energy bills.

**Solution:** Simple commissioning via in-built Bluetooth ensures quicker installation time, with integrated connectivity eliminating the need for additional equipment or

accessories to link the system to SolisCloud. The wide range of battery brands compatible with the hybrid inverter is also a significant advantage.

**Applications:** Three-phase applications for homeowners and small businesses.

**Platform:**

- Connect up to 10 units for up to 100kW Solar PV systems
- 1:6 DC:AC ratio for more PV capacity
- Up to 16A input current to support connection with high-power modules
- Supports unbalanced loads on the grid and backup ports



- Less than 10 millisecond switching time for seamless energy supply

**Availability:** Throughout Europe by end of 2022.

## Modules Yingli eyes residential, commercial PV sectors with YLM 3.0 Pro module

**Product outline:** Yingli Solar's new YLM 3.0 Pro 415W module is ideal for both residential installations and commercial projects where larger, more cumbersome modules are difficult to site efficiently around typical obstacles found on commercial buildings. A smaller footprint combined with a high module efficiency of 21.3% enables superior energy density in many cases.

**Problem:** Modules seem to be continuously getting bigger and more difficult to handle, especially on windy days. Global issues are resulting in shipping and freight prices increasing. Staff shortages have also had a detrimental effect on logistics and product delays, while the cost of energy is escalating rapidly.

**Solution:** The Yingli Solar YLM 3.0 Pro 415W module has been specifically designed to address a sweet spot in the market, blending a physically smaller footprint with a high-power efficiency that requires fewer panels and less roof space to maximise energy production.

This smaller footprint also drastically reduces the number of containers needed to be shipped per megawatt, pallets to be processed by logistics staff and panels that need to be installed on a total kilowatt basis.



This product comes with 1200mm leads and Evo 2 connectors (1500V version of the genuine MC4) to enable a simple and quick installation when using mainstream brands of optimisers or microinverters. The black frame also enhances the overall look of the completed system where aesthetics is an important factor.

All modules have both a 25-year product warranty and a 25-year performance warranty irrespective of where it is installed.

**Applications:** The YLM 3.0 Pro 415W module can be applied in the residential and commercial markets.

**Platform:** At 1722 x 1134mm in size and weighing 21.5kg per module, the compact size and weight make the module easy to install for rooftops of all sizes.

This product has further advantages including:

- Higher durability: The multi-busbar design can decrease the risk of cell microcracks and conductive fingers fracturing. Multi-busbars reinforce the cell, reduce resistance and improve full sun performance.
- Half-cell design: Less energy loss through shading due to a new cell string layout and split J-box, and lower cell connection power loss using a half-cell design.
- The cells have a gallium-doped structure that improves high-temperature performance and stability.

**Availability:** The new 415W solar panel is now available across Australia through distributors including L&H Solar Plus, Middies and Raystech.





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# Distributed interconnection delays threaten US clean energy growth but solutions abound

**Grid** | Renewables deployment in the US is at risk of stalling unless distributed interconnection policies are improved to make them more efficient. Fortunately, there are a host of well-developed solutions for many of the major interconnection challenges being seen in the country today, writes Gwen Brown of the Interstate Renewable Energy Council.

**W**hile there are many factors at play in the pace and scale of clean energy deployment, there's a good case to be made that interconnection – the process by which clean energy projects are approved to safely and reliably connect to the grid – is the most critical.

Every single clean energy project connecting to the distribution grid must receive interconnection approval to move forward. Across the US, significant delays in the interconnection process are posing major challenges for clean energy developers, as well as for states trying to meet ambitious clean energy and electrification targets. Similar to the transmission interconnection process that has been receiving greater attention as of late, it is not uncommon for projects to spend years in distribution interconnection “queues” waiting for approval to interconnect.

Without significant improvements in interconnection policies to make them both more efficient and better aligned with newer technologies, it will be nearly impossible to meet bold climate and clean energy goals. Fortunately, there are well-developed solutions for many of the major interconnection challenges being seen today. Recognition of the critical nature of interconnection reform and commitment from regulators to adopting existing best practices will go a long way toward improving the situation.

In this article, we explore the current state of distributed interconnection in the US and dig into the available solutions to reduce delays and accelerate clean energy development.

## Interconnection at breaking point

The Interstate Renewable Energy Council (IREC) is one of the leading public interest

stakeholders working to reform interconnection policies on the distribution grid in the US, with the goal of enabling a 100% clean energy future that is reliable, resilient and equitable. For over a decade, and in over 35 states, IREC has engaged in interconnection proceedings, offering expertise on interconnection best practices for safely and reliably integrating distributed energy resources (DERs), like solar and energy storage, into the distribution grid.

Historically, IREC typically saw about two to three states with open interconnection dockets in a given year. That trickle has grown into a flood: today, more than a dozen states at a time are examining their interconnection policies.

Some do so proactively, recognising that changes in this area will be needed to support other goals such as 100% clean energy targets or new state-wide community solar programmes. However, it is more common for states to begin looking at interconnection only after significant problems have arisen in the form of major interconnection delays and queue backlogs. A complicating factor is that most states update their interconnection procedures only once every several years



Credit: Savion.

**Significant delays in the US interconnection process are posing major challenges for solar developers.**

– in some cases, the procedures haven't been updated in more than a decade – resulting in outdated practices that slow DER growth.

Among the many states that have been in the news for interconnection challenges are Minnesota (one analysis in 2021 estimated it would take 260 years to clear the interconnection queue at the current pace of utility review), Massachusetts, Maine, North Carolina, Illinois and New Mexico (both prior to recent reforms). California, which is generally a leader in developing forward-looking interconnection policy, is also beginning to see more challenges in this area as DER penetrations grow, and new data documents these interconnection delays.

## Interconnection rule updates put New Mexico in the lead on best practices

On 30 November 2022, the New Mexico Public Regulation Commission (PRC) adopted updated interconnection rules that represent a major win for New Mexico communities, clean energy developers and the environment. Prior to this update, New Mexico's interconnection rules had not been updated in over a decade and thus did not reflect the latest best practices for renewable energy technologies that have proliferated over that period.

Regulators recognised that multiple state commitments, along with growing consumer demand, positioned the state for rapid DER growth. In 2019, the New Mexico legislature had passed the Energy Transition Act, committing to source 50% of the state's electricity from renewable sources by 2030. In 2021, it had passed the Community Solar Act, creating a pathway for shared solar projects that could serve groups of customers, including those like renters who face technical or financial barriers to installing solar on their own property.

Knowing that outdated interconnection rules could result in significant delays as development increased, the PRC proactively undertook a significant revision of the state's interconnection procedures. The revised rules reflect the majority of best practices discussed in this article, including some newly developed provisions for the interconnection of energy storage projects.



## Interconnection best practices

While interconnection continues to present significant challenges to rapid and cost-efficient DER deployment, there are many vetted best practices available to help alleviate these challenges. Utility regulators – who govern state-level interconnection policies – can adopt these approaches to quickly improve the pace at which DERs can safely and reliably connect to the grid.

### Improve DER screening and study processes

The primary focus of the interconnection process is to evaluate whether upgrades to the grid are needed to safely and reliably connect a project. To this end, projects are subjected to screening and/or study processes to determine their impacts; projects that fail a screen are subjected to a more detailed review to determine their potential grid impacts. Some of these processes are more time-consuming than they need to be or are overly conservative.

One of the most foundational steps that regulators and utilities can take is to ensure that interconnection policies permit as many projects as possible to go through efficient screening processes that reduce the amount of time DER projects spend in review. In this area, there are several basic practices that have been in use for years that can make a significant difference:

- Raise the threshold of eligibility for fast-track/simplified review. Regulators should ensure that all projects capable of passing screens have the opportunity to go through the screening process. This may require changing the eligibility requirements for certain screens. For example, FERC's Small Generator Interconnection Procedures, used as a basis for many state interconnection rules, now recommend making projects as large as 5MW eligible for fast-track review, depending on the size of the line they are connected to and the distance of the project from the nearest substation. (This approach recognises that conditions vary at different parts of the grid, rather than setting a one-size-fits-all threshold.)
- Adopt the "100% of minimum load screen" in place of the "15% of peak load" screen. The 15% of peak load screen, used in most state interconnection rules, is one of the most commonly failed screens because it relies on a conservative rule of thumb. The "100% of minimum load" screen is a more

accurate alternative that results in fewer projects being unnecessarily flagged for additional review. Minnesota, New Mexico, and Illinois have all made this change to their interconnection procedures.

- Adopt a supplemental review process. A supplemental review process provides a middle ground between screens and full project studies. By adopting a more structured supplemental review process, utilities can enable more projects that fail initial screens to achieve interconnection approval without the need for a full study. This is a great option in cases where needed upgrades can be identified without a study.
- Allow minor upgrades without sending projects to full study for relatively straightforward upgrades (e.g., service transformer upgrades).

### Improve grid transparency

Another way interconnection can be improved is by creating mechanisms that give stakeholders greater transparency into conditions on the grid and how they will be evaluated in the interconnection process. When applicants have better information about what points on the grid are likely to be able to accommodate their projects, they are less likely to submit speculative interconnection applications – reducing the cost and time burden on both utilities and other interconnection customers.

There are a number of different options to increase grid transparency that vary in their cost and complexity to implement.

On the simpler end are pre-application reports. These are reports that a prospective applicant can request from their utility for a specific site before submitting an interconnection application. The report provides a range of valuable grid data including the number of queued ahead projects and data on peak and minimum load (which are used in certain screens as discussed above).

Having this data allows developers to make more informed decisions about where to site their projects to maximise the likelihood of being approved for interconnection. This can also provide macro benefits in the form of directing development into locations where it is easier for the grid to accommodate new generation (i.e., avoiding the need for costly upgrades).

On the other end of the spectrum, hosting capacity analyses (HCAs) are a

more complex grid transparency solution, but one that can offer greater benefits as well – such as helping states and utilities plan for a grid that optimises customer-driven DERs, such as rooftop solar, energy storage, or electric vehicle charging stations.

Often displayed in the form of maps with underlying datasets, HCAs can show where on the grid there is capacity for new generation or new load, such as electric vehicle charging stations, without the need for costly upgrades and/or lengthy interconnection studies. To create an HCA, a utility must map its distribution system and the equipment located at different points, and then simulate how power flows through the system. Validation processes need to be put in place to ensure the accuracy of the HCA's outputs. Additionally, stakeholders in a state should align on the desired use cases for an HCA before it is developed to avoid missteps and ensure the usability of the final product.

Once developed, the HCA can be an incredibly powerful tool. For example, California recently put in place a mechanism to use data from its HCA maps (which it calls Integration Capacity Analyses or ICAs) in the interconnection process, to fast-track the review of certain projects – thus significantly reducing the labour involved in some interconnection approvals.

### Fairly distribute the cost of grid upgrades

In most cases, when upgrades are needed to enable the interconnection of a new project, the costs of those upgrades are expected to be borne entirely by the interconnecting customer. Not only does this "cost-causer-pays" model unfairly distribute costs among beneficiaries, it is functionally problematic – in some cases presenting the biggest challenge to rapid, equitable and cost-efficient clean energy development.

Because these upgrade costs can be in the hundreds of thousands of dollars, they often make a project unfinanceable and the project is simply withdrawn. Even smaller grid upgrade fees, such as five to ten thousand dollars, can prove unsupportable for residential customers wishing to adopt solar or storage. In addition, grid upgrade fees can pose barriers to equitable access to sustainable energy, such as when they exacerbate existing up-front financing challenges for community solar projects that serve low- and moderate-income customers.



Credit: Nexamp

When multiple projects at the “front of the queue” are assessed grid upgrades they are unable or unwilling to pay, this can leave whole sections of the grid closed to future development for long periods of time. It also means that upgrades are not completed in a proactive manner that considers where they will be most valuable to future clean energy development and other grid needs.

There are multiple ways that this situation can be improved. Some states, like Minnesota, have established a “small project fee”, under which all small projects are charged a flat fee that contributes to a pool of funds that can be allocated toward grid upgrades when needed. This keeps development moving. (Minnesota has capped the cost of any upgrade at US\$15,000, however, which is likely to limit its effectiveness because needed upgrades will exceed this amount in many cases.)

Another approach is to develop a cost-sharing framework through which several interconnection customers can share the costs of grid upgrades. Group studies, in which multiple projects proposed in the same area of the grid are studied for their grid impacts jointly, can present an opportunity for improved cost sharing if the costs of the needed upgrades are shared across a pool of projects that will benefit from them.

New York state has experimented with other options for distributing upgrade costs. New York first adopted a pilot programme where applicants were required to fund the full cost of interconnection upgrades, with the potential to be reimbursed by projects interconnected later. This proved an ineffective solution because the “first mover” projects were unwilling to risk paying for the full upgrade costs and not having any subsequent projects interconnect. New York thus revisited the concept, adopting a

new programme that allows applicants to only pay for a portion of the capacity enabled by certain types of upgrades. The new programme allows cost sharing for upgrades identified by the utility as well as those identified by customers.

Finally, some states are looking at approaches focused on enabling more proactive upgrades of the distribution grid. For example, faced with grid conditions in which very few locations in the state could accommodate new large solar projects without unaffordable upgrades, Massachusetts regulators have explored a proactive hosting capacity planning approach. Under this framework (which is still in development), the local utility proactively completes needed upgrades and pays for the upfront cost. The utility is then reimbursed over a 10-year period by DER projects that interconnect and benefit from the upgrades, each paying a share of the total cost. A portion of the costs is also covered by ratepayers where the upgrades benefit them. Under the initial long-term planning proposal in Massachusetts, costs still uncovered after the 10 years would be recovered from ratepayers. Maryland has also discussed a similar approach, but one in which the cost causer would pay only its share of the upgrade cost, and other subsequent projects would also contribute over time.

Constrained grid conditions like those observed in Massachusetts are likely to become increasingly common as more DERs are interconnected, leading to the need for more – and more significant – grid upgrades in the future. In the long-term, IREC believes that taking a holistic and proactive look at where grid upgrades will be needed, and developing fair and efficient cost-sharing approaches that enable the upgrades to occur in a timely fashion, will be critically important to achieving a grid powered with high levels of renewables.

**Energy storage can be used to manage and control the export of electricity in a way that can mitigate or avoid grid impacts.**

### **Update interconnection rules to recognise and enable the capabilities of energy storage**

Energy storage has a critical role to play in enabling a grid powered by high levels of distributed renewables. The ability to store electricity when there is an excess and dispense it back to the grid when extra power is needed, or to mitigate the variability of renewables when solar or wind are not producing electricity, offers an essential solution to providing adequate clean energy during all hours of the day.

Storage also offers vital resiliency benefits, which are likely to become more and more desirable as we face increasing disruptions from extreme weather events, fires and other causes of grid outages.

Unfortunately, most state interconnection rules present barriers to utilising these valuable energy storage benefits. That’s because they don’t recognise the ability of storage to control imports from and exports to the grid, among other critical functions. Addressing these shortcomings is another of the most important ways that interconnection policies need to be updated to remove barriers to rapid and efficient clean energy deployment.

### **Recognise that storage can limit electricity exported from DERs**

Energy storage can be used to manage and control the export of electricity in a way that can mitigate or avoid grid impacts. Projects designed this way are referred to as limited- or non-export systems. Interconnection rules should be updated to specify different screening and study processes for limited- and non-export projects.

Screening and study processes should recognise the difference between nameplate capacity (i.e., the total amount of electricity the system is capable of outputting, often measured as the capacity of the storage system plus the capacity of the solar array) and export capacity (the actual amount of electricity it will export at a given time).

Because limited- and non-export systems don’t export their full nameplate capacity, using that as the metric for evaluation will often lead to significantly overestimating the impacts storage may have on the grid. For these projects, export capacity is the appropriate metric used to determine a project’s eligibility for fast track or simplified review processes and certain technical review screens.

States need to update certain techni-



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cal screens to specify that they are applied using a project's export capacity and not the nameplate capacity. Procedures should also be modified to require utilities to evaluate projects according to the export capacity during the study process. This is perhaps the single most important change that states can make to their interconnection processes to safely enable more clean energy on the grid without upgrades.

#### Specify acceptable methods of export control

To operate as a limited- or non-export project, storage systems need to interconnect with some form of export control method, such as a power control system. Since utilities require a high level of confidence that a limited- or non-export project will operate as intended and not have unintended safety or reliability impacts, they must be able to trust the export controls.

However, many states do not recognise export controls at all and may require a customised review of each control type. Evaluating the acceptability of export controls for every such project individually is time consuming and burdensome. For that reason, interconnection policies should specify acceptable and trusted methods of export control.

#### Enable storage to operate on a schedule

Another emerging area of interconnection reform geared toward making full use of the capabilities of energy storage involves rule changes to allow storage to operate on a schedule. Storage systems can operate on fixed schedules that are predetermined, as well as respond dynamically to different signals. While the latter option remains an area of emerging practice where interconnection best practices have yet to be defined, some states like California are moving ahead with innovations to enable energy storage to operate on fixed schedules. Other states, such as New York, are testing out more dynamic methods, known as flexible interconnection.

#### Utilise the latest smart inverter standards

Smart inverters have a critical role to play in enabling higher levels of renewables on the grid. They can help maintain the stability of the grid by detecting local grid conditions and responding intelligently, adjusting the amount and characteristics of the power sent to the grid by the DER they are connected to.

IEEE 1547-2018 is a technical standard that, among other things, specifies uniform

### New venues cultivate interconnection solutions

As interconnection has gained more recognition as a fundamental challenge in deploying DERs, new collaborations are also emerging to develop solutions:

- The Interconnection Innovation e-Xchange (i2X). Led by the US Department of Energy's (DOE) Solar Energy Technologies Office (SETO) and Wind Energy Technologies Office, the Interconnection Innovation e-Xchange (i2X) convenes diverse stakeholders involved in the interconnection of different types of clean energy resources to facilitate peer learning and knowledge exchange and inspire new interconnection ideas and capabilities.
- The BATRIES Project. Building a Technically Reliable Interconnection Evolution for Storage (BATRIES) is a three-year project focused on developing solutions to a suite of critical barriers to energy storage interconnection to the distribution system. It is led by IREC in partnership with the Electric Power Research Institute, Solar Energy Industries Association, California Solar & Storage Association, New Hampshire Electric Cooperative, PacifiCorp and Shute, Mihaly & Weinberger. Support comes from DOE SETO.
- GridTech Connect Forum. A new series of conferences from Clarion Events, GridTech Connect aims to enable the exchange of ideas, knowledge, and expertise to further innovation surrounding the interconnection of DERs.

requirements for smart inverters' "grid-support" functions to ensure safety and reliability. To unlock the benefits of smart inverters and maximise the volume of DERs that can be integrated, regulators should prioritise integrating the latest inverter technologies, certified in compliance with IEEE 1547-2018, into interconnection rules.

#### Track key metrics and ensure accountability

Finally, no matter how innovative a state's interconnection reforms, they mean nothing without accountability mechanisms to ensure that the rules are actually followed. This is particularly important with regard to timeline accountability. While delays can be caused by either utilities or developers at different stages in the process, developers face business impacts when their projects are delayed and are thus incentivised to be timely. Most utilities in contrast have no such incentive to avoid delays in interconnection.

It is important for regulators to hold utilities accountable for complying with the specified timelines and other requirements in their interconnection policies. To do so, however, they need to have data to inform their decisions. In many states, there are few or no data tracking requirements for utilities that would provide a basis for knowing when obligations are not being met. Regulators must prioritise both requiring the tracking of performance data, and acting on it when it indicates

shortcomings in interconnection performance.

#### Looking ahead: reasons for optimism or cause for concern?

So where does this leave us? Should we be optimistic about the many solutions already identified and being implemented, or should we be concerned about the scale of delays? Do we expect the situation to get better or worse?

On the bright side, more states are actively working to improve DER interconnection than ever before. This increased attention to interconnection, an issue that has long been under the radar, is encouraging – as is the growing willingness to take action to reform the process. States like New Mexico that are taking the issue seriously and making significant reforms offer a model for others.

At the same, interconnection reform at the scale and pace needed to help states achieve their climate and clean energy goals is by no means assured. It is critically important that regulators recognise the essential role of modern and efficient interconnection policies in achieving other goals – including climate, energy justice, resilience and clean energy objectives – in their states, and adopt available solutions. It is likewise an important moment for clean energy advocates and public interest stakeholders to seize and push hard for effective reforms.

In the long term, as more DERs are interconnected and grid conditions become more constrained, additional efforts by states to ensure grid upgrades are appropriately prioritised will become even more important.

In the meantime, we have many solutions for a clean energy future at our fingertips; we need to continue – and accelerate – putting them into practice. ■

#### Author

Gwen Brown is the communications director of the Interstate Renewable Energy Council (IREC), an independent nonprofit building the foundation for the rapid adoption of clean energy and energy efficiency. Gwen oversees efforts to increase awareness of IREC's programmes, which span regulatory engagement to improve interconnection and other key policies, workforce development to build an inclusive clean energy workforce and local initiatives to support communities' clean energy goals.





# A sea of challenges: how offshore floating solar can move beyond pilot projects

**Floating solar** | Building on the successes of floating PV projects installed on lakes and dams globally, offshore installations are an emerging opportunity for developers, potentially when co-located with wind farms. George Heynes explores how the industry can move beyond pilot projects to large-scale, commercially viable installations, detailing the challenges and opportunities ahead.

**A**cross the globe, the solar industry continues to see a surge in popularity with the variable renewable energy source able to be deployed across a range of different regions.

One of the latest, and potentially most important, methods in using solar has now come to the forefront of the industry. Offshore and inshore waters floating solar projects, also known as floatovoltaics, could become a revolutionary technology and prove successful in generating local green energy in areas which currently are hard to develop in due to geographical limitations.

Floating solar panels work much the same way as land-based systems. However, the inverters and the arrays are affixed on a floating platform. Combiner boxes collect the direct current electricity after generation, and it is then converted into alternating current by solar inverters.

Floating solar can be deployed in oceans, lakes and rivers in regions where building out the grid can be difficult. Areas such as the Caribbean, Indonesia and the Maldives could significantly benefit from this technology. Pilot projects have been deployed in Europe where the technology continues to see further traction as an additional renewable weapon to the decarbonisation arsenal.

Austrian utility EVN and BayWa. r.e. announced last year what they claimed at the time would be Europe's 'largest' floating PV installation, which is to be developed in Grafenwörth, Austria.

Alongside this, Norway and Belgium have both seen a mass influx of the technology via pilot projects. This enables



Credit: TNO.

several European testbeds to experiment with the technology and test its feasibility. Other pilot projects are being rolled around the globe and the technology is becoming increasingly likely to expand into fully fledged projects. But what are the opportunities associated with the technology?

## How offshore floating solar could take the world by storm

One of the many benefits of offshore floating solar is that the technology can be co-located with existing technologies to boost the energy yields of renewable generation plants.

Hydropower plants can be coupled with offshore floating solar to boost the productivity of sites. According to the World Bank's *Where Sun Meets Water: Floating Solar Market Report*, solar capacity can be used to boost the energy yield of

## Offshore floating solar can unlock new markets by avoiding land scarcity issues.

assets and may also help manage periods of low water availability by allowing the hydropower plant to operate in 'peaking' rather than 'baseload' mode.

The report also details other positive effects from the use of offshore floating solar, including the cooling effect from the water body potentially increasing energy yield, the reduction or even elimination of the shading of panels by their surroundings, the elimination of the need for major site preparation and easy installation and deployment.

Hydropower plants are not the only existing renewable generation technology that could be bolstered via the arrival of offshore floating solar. Offshore wind could well be coupled with offshore floating solar to maximise the yields of these mass structures.

This potential has seen significant interest in the North Sea with its many wind



Credit: SolarDuck

farms. These offer the perfect prerequisites for the development of offshore floating solar farms.

"We believe that if you combine offshore floating solar with offshore wind, the infrastructure is already there and so it is much faster to develop the project. This helps the development of the technology," says Allard van Hoeken, CEO and founder of Oceans of Energy.

Hoeken also refers to the amount of energy that could be generated from the North Sea alone should solar be coupled with existing offshore wind farms.

"If you combine offshore solar with offshore wind, you can easily generate 50% of all the energy that's needed in the Netherlands per year with only 5% of the Dutch North Sea," he says.

This potential showcases how important this technology could be for the overall solar industry and to countries transitioning to a low-carbon energy system.

One of the biggest benefits of using offshore floating solar is the available space. The oceans provide vast areas that could be utilised for the technology whereas, on land, there are many uses competing for space. This could also mitigate concerns over building solar farms on agricultural land – an area which has seen growing concerns in the UK.

This perspective is matched by Chris Willow, head of floating wind development at RWE Offshore Wind, who believes the potential for the technology is huge.

"Offshore solar has the potential to be an exciting evolution of onshore and lake-based technology and opens a new door

**Co-location with offshore wind can reduce capex costs thanks to shared export cables and substations.**

to GW-scale solar energy generation. The technology unlocks new markets by avoiding the issue of land scarcity," says Willock.

By providing a means to generate energy offshore, it removes the issues associated with land scarcity, as stated by Willock. This could see the technology utilised in small city-state countries such as Singapore, as referenced by Ingrid Lome, senior naval architect at Moss Maritime, a Norwegian engineering firm dedicated to offshore developments.

"Any country where you have limited space on land for energy production has great potential for offshore floating solar, Singapore being a typical example. A key benefit is being able to have electricity production next to aquaculture, oil and gas production sites or other energy-demanding installations," Lome says.

This point is crucial. The technology can create microgrids for areas or facilities that are not connected to a wider grid. This highlights the potential of the technology in countries with a lot of islands where it is difficult to create a national grid.

One area in particular which could be provided with a massive boost via this technology is Southeast Asia, in particular Indonesia. This region has masses of islands and less suitable land for solar developments. What the region does have in abundance are large water networks and oceans.

By presenting this technology, it could be influential in decarbonising areas that are located off the national grid. This market opportunity has been highlighted by Francisco Voza, chief commercial

officer at floating solar developer SolarDuck.

"We're starting to see commercial and pre-commercial projects in places in Europe like Greece, Italy and the Netherlands. But there are also opportunities in other places like Japan, Bermuda, South Korea and around Southeast Asia. There's a lot of markets out there where we see applications already commercial today," Voza says.

Clearly the technology could be used to radically scale the renewable generation capacity from the North Sea and other oceans in a bid to accelerate the energy transition at unprecedented rates. However, several challenges and obstacles must be overcome for this to be achieved.

### A sea of challenges

Utilising offshore floating solar comes with a range of challenges. Not only are these projects often very expensive to develop, but there is also still so much that is unknown about the technology and how it can affect ecosystems especially underwater.

"The biggest challenge is to develop offshore floating PV solutions (including the anchoring, mooring, float structures, PV modules and electrical components, cables) that are robust enough to withstand the harsh offshore circumstances (salt, moisture, wind, waves) while keeping a low and competitive LCOE (levelised cost of energy)," says Wiep Folkerts, who is responsible for Solar Energy Markets and Programs at Netherlands-based independent research organisation TNO.



"Before offshore solar becomes a commercially viable solution ready for deployment, scientific and technological R&D including small-scale pilots are needed to build up the know-how and practical guidelines regarding performance, long-term reliability of the full solution including the dynamic cabling towards a grid station, ecology and sustainability but also to learn from the failures that should lead to improved designs.

"The required robustness strongly depends on the location of the offshore water body. Circumstances at the North Sea for instance can be very harsh and wave heights above 10 metres are not exceptional, while in tropical regions the circumstances could be less demanding."

Alongside these issues, structural weight and fatigue life can be major challenges in the development of offshore floating solar.

"The main challenges we see are structural weight and fatigue life, which are closely tied to capex costs. It is not very difficult to design a floater that can withstand offshore environment for 30 years if the cost is not important, but the challenge is to find a solution that has sufficient life at an acceptable cost," says Lome.

"To improve fatigue life, the structure is often reinforced, and by reinforcing the structure the weight increases, the draught increases and the forces within the FPV park increase. Also, [the fact] that no PV module manufacturer is making salt-proof modules will be a challenge for commercial projects.

"Hopefully, they will come around and develop modules for offshore environment once they see that there is a market for it. Co-location with offshore wind could indeed be an important market. It will reduce capex costs as export cables and substations could be shared, and the energy output will be more stable as it often is sunny when there is now wind and vice versa."

As stated by Lome, co-location of assets could really help enable the technology to scale. This could be influential in the development of the technology. However, Vozza distinguishes a unique set of challenges facing offshore floating solar: regulatory frameworks.

"I think the main speedbump that we're really going to have to tackle as an industry is the lack of appropriate and harmonised regulatory frameworks," Vozza says.

"I think the main challenge is how the various markets are going to adapt regula-

tory frameworks to really accelerate the deployment. But this market is moving really quickly. It can really make an impact and will scale to GW-scale by 2030"

Having appropriate regulatory frameworks in place could enable offshore solar developers to plan for the future. However, there is a current lack of framework in place to support the technology. Despite this, as the market continues to pick up towards 2030, it is clear that decisions will be made on a political level and we could see further support implemented for the technology.

This perspective is backed by RWE with the company confirming a lack of regulatory framework could be a major obstacle.

"Offshore solar is a new technology with new risks and challenges. Currently, there is a lack of fit-for-purpose regulatory frameworks or policies to accommodate either hybrid or standalone offshore solar projects," says Willow.

"This absence of policy is likely to result in a large number of permits being required, which in some markets will involve several consenting bodies/stakeholders. In addition, there is a lack of discussion regarding how offshore solar should be integrated into the existing grid infrastructure."

Willow also believes there are technical issues to overcome prior to full commercialisation of offshore floating solar. Developers need to "understand how the units perform at sea in real conditions" in a bid to optimise the technology for use around the globe. Once this has been overcome, it could be a breakthrough for the technology.

### Offshore floating solar expansion in the North Sea

RWE and SolarDuck are two well-established companies both exploring potential offshore floating developments in the North Sea. One of which has seen the two companies partner on a 5MWp offshore solar demonstrator that will be deployed as part of RWE's Hollandse Kust West VII offshore wind project in the Netherlands. This is expected to be operational from 2026.

The project will provide RWE and SolarDuck with important first-hand experience in one of the most challenging offshore environments in the world. These learnings are likely to enable a faster commercialisation of the technology in the future.

Alongside this, the two companies are working together on the Merganser

project – a 0.5MWp offshore solar demonstrator in the North Sea, which is expected to be installed in 2023.

Vozza believes the North Sea provides the perfect test bed for offshore floating solar, not only due to its proximity to European countries and offshore wind, but due to the harsh conditions witnessed in this sea.

"If you can make it in the North Sea then you can pretty much make it anywhere," says Vozza.

"Offshore floating solar really has disruptive potential. If you look at comparable technology which made the move to offshore, I think wind is a classic example.

"It started inland, moving to near shore, moving to offshore, and then moving to floating offshore. Solar is much more affordable and a much more available source of energy. It makes sense for solar to follow the same path."

Willow on the other hand sees an opportunity in the co-location of offshore wind with offshore floating solar to generate vast quantities of renewable energy.

"The integration of offshore solar systems with offshore wind farms could enable efficient use of the sea space by allowing twice the energy production in the same area," says Willow.

"In addition, the complementary generation profiles of both technologies allow for a more balanced production profile. We also see synergies in the construction and maintenance of the systems."

### Commercialisation of floatovoltaics

Clearly offshore floating solar has an important role to play in the globe's renewable future. But one of the biggest questions is when the technology could be ready for wider commercialisation. With many pilot projects across the globe continuously innovating this solution and optimising the technology, the question of "when" becomes even larger.

Folkerts believes industrial-scale offshore floating solar generation could become a reality by the end of the decade. "Offshore solar could be deployed on a GWp scale in the future – this is expected to occur after 2027," he says. This prediction seems plausible considering the innovation within the sector and the progression of pilot projects being constructed around the globe.

When this technology does achieve wider commercialisation, its potential could be paramount in facilitating the energy transition around the globe. ■

# The European energy crisis: hybrid concepts for renewable solutions

Fossil energy carriers are too insecure, too expensive and too dirty. This is why the future lies in renewable energy. The problem: Green power generation is volatile. But there are solutions, and they will be presented at Intersolar Europe in Munich!

Natural gas is becoming scarce, the price of oil is rising and coal is being phased out. The European energy sector is undergoing fundamental changes, and Putin's war in Ukraine has propelled it into a crisis. Fossil energy carriers are no longer acceptable: They are too expensive, too dirty and the supply situation is too insecure. The transition to renewable energies is unavoidable. But where will we get our electricity during the "dark doldrums", when the wind doesn't blow and the sun doesn't shine?

## One problem, two solutions

One of the main criticism of renewable electricity technology is that the production of green energy fluctuates too much. But there are solutions for managing the volatility of renewable sources of energy: hybrid power plants and energy storage systems.

Hybrid power plants combine photovoltaics or wind power – or even both technologies – with large-scale storage systems. This has the advantage that the generation profiles of photovoltaics and wind energy complement each other: Wind farms produce electricity at night and on stormy, dark days in the fall and winter, while solar installations have their maximum yield on sunny days in spring and summer. Battery systems store electricity and feed it into the grid when it is needed. This enables the optimum use of available grid capacities and prevents bottlenecks.

It comes as no surprise, then, that storage systems are important elements of a resilient energy industry able to supply green electricity even in times of crisis. But that's not all: Private house-



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holds can make a contribution to grid stability. As prosumers, they feed any surplus energy from their private PV installations into the grid, which reduces grid load. Residential storage systems can be digitally connected to form a swarm where every participant makes part of their capacity available to everyone else. This allows more solar power to be fed into the grid without the need for additional grid expansion.

## Intersolar Europe in Munich – and across the world

The potential of these solutions is huge – and much of it is still untapped. This is why the integration of these energy systems will be a hot topic at the Intersolar Europe Conference, taking place at ICM – Internationales Congress Center München from June 13–14. Intersolar Europe is part of Europe's largest platform for the energy industry, The smarter E Europe, which will be held from June 14–16 at Messe München, Germany. More than 85,000 visitors are expected to see first-hand the innovations, services and products showcased by 1,600 exhibitor across an exhibition space of 176,000 sqm. Intersolar, the world's leading exhibition for the solar industry, is held across the world: in San Diego, Mexico City, São Paulo, Mumbai, Bangalore and Dubai.

More information: [www.thesmartere.com](http://www.thesmartere.com)



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# Rethinking optimum DC/AC ratio for solar PV

**DC/AC ratios** | Falling solar module prices in recent years mean it can be beneficial to oversize the DC capacity in PV plants. John Leslie of BTY presents findings from a study that suggests developers should, in certain cases, investigate using higher DC/AC ratio designs.

PV solar facilities have long been designed using an industry-standard DC/AC ratio of 1.2. A number of articles have recently started to re-examine this issue, and over the past few years a growing number of facilities have been constructed with higher ratios. We examined the hypothesis that due to steadily decreasing module costs the optimum DC/AC ratio may be much higher than 1.2, and that based on economics alone, it is closer to 1.6 or even higher.

This could have important financial benefits for developers repowering underperforming sites, or for new AC-constrained sites trying to maximise financial returns. It also could have huge implications for projects in deregulated power markets, where power pricing fluctuates significantly during the day and any additional power produced due to extra DC capacity in the late afternoon at high power prices could make a huge impact on project economics.

In the early days of solar power development, the high price of panels relative to the overall project cost dictated that system designers had to be judicious with the sizing of the DC side of the facility relative to the AC output to the grid: when panels cost C\$5 (US\$3.69) per watt there could be no waste. Steadily dropping panel prices over the last 10 years (recent supply chain disruptions and tariffs notwithstanding) have led to a situation where it can be beneficial to grossly oversize the DC capacity and where the trade-off between higher capital costs in return for that additional power to the grid is worth it.

## Methodology

For this desktop study we chose a 1MWdc, 1MWac design as the "base case". We based our study in southern Alberta, Canada, a good solar resource with long sunny days in the summer, and cold but sunny days with frequently snow-covered ground in winter. Alberta is currently the hot spot for renewable energy projects in Canada, with many

large projects under construction. Alberta also has a deregulated power market, where intraday power pricing in the summer can often exceed C\$140/MWh. For the study we used a standard 30-degree fixed-tilt ground-mount design, with mono-facial 400W rated panels and 100kW capacity string inverters. Row spacing and all other aspects of the design could be considered typical. We used a relatively small site simply to expedite energy model processing time: our results should directly translate to utility-scale facilities.

We then prepared an energy model using Helioscope software for the site using soiling parameters for the region (i.e. – snow accumulation) and typical site losses. We estimated the capital cost, yearly operating and maintenance (O&M) costs, and estimated the levelised cost of electricity (LCOE). We also calculated 25-year net present value (NPV) for the project, assuming historically average power pricing for the region and included greenhouse gas (GHG) credits at C\$40 per eCO2 tonne.

We then increased the DC side by 200kW increments for each case, keeping everything else constant (i.e. – holding AC capacity at 1MW). In other words, subsequent cases had DC/AC ratios of 1.2, 1.4 and so on up to 2.6. For each case we re-estimated the capital and O&M costs, LCOE and NPV. We used industry-standard principles to estimate soft costs such as design, permitting and project management as the DC side (but not the AC side) of the project steadily increased. Panel and racking costs were increased in proportion to DC capacity but other costs were factored based on estimating convention (i.e. – design costs for a 2MW site may only be 15-20% more than the 1MW base design).

Before we dive into the results and our findings, we should note some important disclaimers:

- Not a field exercise – desk study only
- We are following up on an actual rooftop

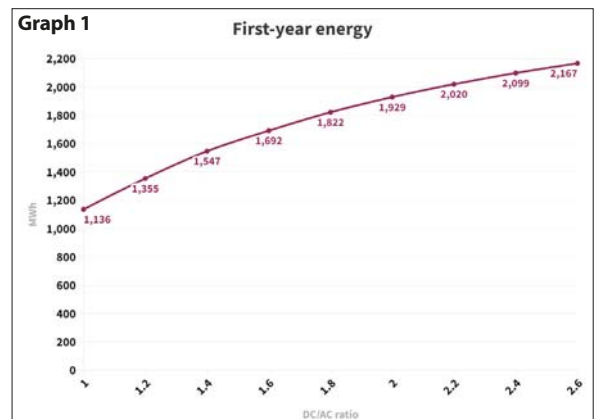
case we are involved with (1.8-2.0 ratio) regarding any long-term O&M issues, such as increased inverter failures or hot spots

- We are in discussion with inverter suppliers to determine their comfort level with these designs and discuss any warranty exclusions
- And lastly, keep in mind the purpose of this exercise was not to create a new design edict, but simply to get people rethinking project design, especially where high power prices prevail or where battery storage could be added

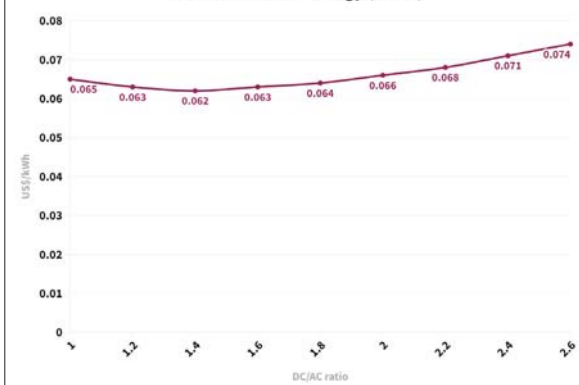
## Results

First-year energy production is charted against the design DC/AC ratio for each case. As the DC side is increased site output also increases but with diminishing returns, as one would expect. Keep in mind actual output to the grid is at all times limited to 1MW; all we are doing by increasing DC capacity is increasing the time that the site produces at maximum power. By oversizing we are able to facilitate more time at maximum power even on cloudy days, and get to maximum power faster in the morning and stay at that level longer late in the day as the sun starts to set.

But, as the DC side increases more and more power is lost. At DC/AC ratio of 1.4 losses due to inverter clipping are around



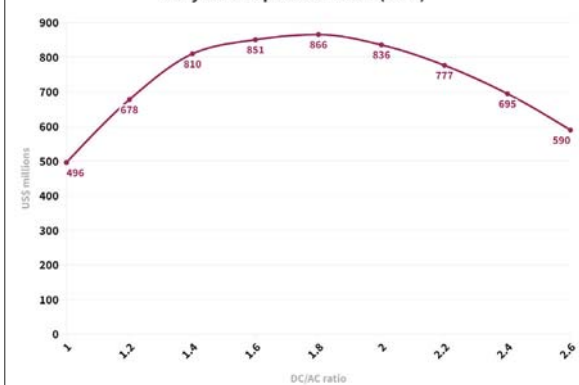
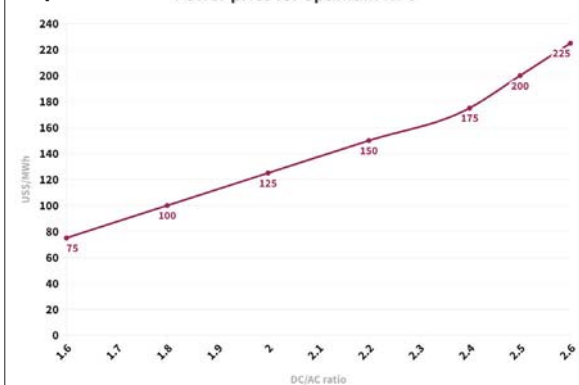


**Graph 2** Levelised cost of energy (LCOE)

3% but rise to almost 20% at a design ratio of 2.0. Keep in mind that all results are based on energy model software and there could be limitations in the software algorithms at very high ratios; actual clipping losses could be higher or lower in real life.

Graph 2 shows LCOE versus design ratio, indicating an optimum around 1.4.

We also calculated the 25-year NPV for each case (graph 3). This analysis is slightly different from the widely used LCOE, because it considers actual power pricing. We also included the revenue from GHG credits (i.e. – the credit for displacing grid power generated from burning fossil fuels with that generated using GHG-free solar power). We used C\$40 per tonne eCO<sub>2</sub>, the prevailing price of carbon in Canada, and escalated it annually according to regula-

**Graph 3** 25-year net present value (NPV)**Graph 4** Power price for optimum NPV

tions in place. What carbon pricing will be in the future and how it can be monetised is difficult to predict, and varies enormously depending on each location, but more and more, developers are realising that it needs to be considered in a project's economics.

Interesting to note that when actual power prices and carbon prices are included, the optimum design ratio at least on paper is closer to 1.8.

Using the NPV template, we also investigated the impact of higher power prices on optimum design ratio. Results are shown in the graph below. Again, not surprising that as power priciness climb, the revenue generated from the incremental power produced more than offsets the higher capital cost and pushes the optimum design ratio higher and higher. Again, we stress that this is a desktop exercise and are not necessarily recommending design at these ratios, but it is probably safe to say steadily increasing power prices in most places will continue.

## Conclusions

Our results clearly indicate that in certain cases developers should investigate using higher DC/AC ratio designs. While each site and region is different, our study indicates that a thorough investigation of the financial benefits of using a higher DC/AC ratio should be considered. We feel this has particular significance for sites in deregulated power markets, where much higher power prices often prevail in the late afternoon, and for repowering underperforming AC-constrained sites. These results also could be particularly valuable for projects coupled with energy storage, where depending on the configuration additional power generated can be stored and released to the grid as demand and pricing dictate.

We also replicated the study for a location with a poor solar resource (Ireland) and the results indicated that overbuilding DC may be even more beneficial at locations where output is often limited by heavy cloud cover, such as Ireland, the UK and Northern Europe.

## Next steps

This study was desktop only and left many real-life questions unanswered, primarily the impact of inverter performance at higher DC/AC ratios. Many inverter models may have limitations at higher ratios, and long-term impact on O&M costs and reliability need to be evaluated.

Other ideas to be examined in future studies:

- All costs were based on in-house estimates; working more closely with equipment suppliers and an EPC contractor could provide more confidence in the results
- More granularity is needed to evaluate the impact of incremental output versus intra-day power pricing
- Study should be repeated for sites coupled to energy storage
- The impact of carbon pricing needs to be evaluated further, particularly scenarios where future carbon pricing is significantly higher than today
- Impact of single-axis trackers and bifacial panels. We replicated the study using single-axis trackers and the preliminary results mirrored the fixed-mount outcomes but further work needs to be done
- Benchmarking the performance of actual sites long-term. We are working with a developer repowering a number of rooftop facilities on a big-box store chain (see drone photo), where ratios around 1.8-2.0 are replacing the original design that were closer to 1.1-1.2. The first of the new layouts were commissioned last year and we are tracking site performance to obtain real-life data on the O&M costs and inverter reliability

In particular we want to investigate the impact of actual intra-day power pricing on the results. Our next step is to estimate what portion of the extra power generated by moving to a higher DC capacity occurs at higher power prices, thus making the impact of higher DC capacity even more beneficial. Our preliminary estimate indicated that the roughly 70% increase in energy produced from using a 2.0 design ratio compared to the 1.0 ratio base case was rewarded with a 157% increase in revenue. This result certainly reinforces the incentive to further study this issue – stay tuned!

## Author

John Leslie is a senior technical specialist with BTY Group specialising in PV solar, energy storage and district energy facilities. He has been involved in the solar industry since 2013, primarily acting as independent engineer for lenders and equity providers for new and existing solar projects. BTY is an award-winning professional consultancy providing complete project solutions on energy and infrastructure projects including planning, development, operations and transactions.



# Shining a light on extreme weather events and the need for solar data

**Extreme weather** | Amid an increasingly unpredictable environment and a rise in extreme weather events, the solar industry must properly use its available data to protect assets and reduce risks, writes Gareth Brown, CEO of digital asset performance technology provider Clir Renewables.

**A**s our climate changes, extreme weather events pose an increasing threat to society and ecosystems globally. Over the last few decades, we have witnessed more frequent extreme weather patterns, leading to hotter days, increased snowfall, more intense lightning storms and larger hail. Such extremes are increasingly and significantly impacting our infrastructure and renewable energy is no exception.

In the case of solar, while everyday weather conditions can impact a project's ability to operate effectively and efficiently, surges in extreme weather events have a pronounced impact on the solar industry, prompting reviews of production estimates. Owing to the requirement for solar projects to maximise irradiance, solar panels are often located in exposed locations, heightening their vulnerability to climate-induced extreme weather events.

Faced with an increasingly unpredictable environment, it is crucial that we understand how solar assets can continue to operate effectively. And this is where understanding the data yielded by solar farms is essential.

At Clir Renewables, we use benchmarking data to guide service providers in addressing asset performance issues. In the case of wind, Clir's artificial intelligence analyses turbine health and performance data in the context of the industry and their environment. This allows owners to develop a true understanding of the behaviour of their assets, identifying not only when the turbine is underperforming, but the root cause of this underperformance and how it compares to peers. Despite being commonplace across other forms of renewables, this deep-dive analysis has, in many instances, remained an afterthought in solar.

## A sizzling summer for solar

According to AON Insurance's quarterly disaster report, in the first nine months of 2022 there were 29 extreme weather

events that caused more than US\$227 billion in economic losses. These events include record-breaking droughts in the northern hemisphere accompanied by two separate extreme heatwaves in Europe which disrupted the cooling systems of nuclear and fossil fuel power plants, lowered hydropower generation and reduced the efficiency of solar panels. Likewise, hail in Texas early last summer resulted in estimated solar losses of more than US\$300 million – more than twice as severe as other key renewable losses over the previous three years combined.

The evidence is plain – extreme weather events are increasing, and the solar industry needs to properly use its available data to protect assets and reduce risks.

A 2021 report into extreme weather by GCube Insurance highlighted that the average solar loss due to traditional natural catastrophes or extreme weather was almost 2,400% higher than the average non-weather-related solar loss in 2019, with 70% of solar losses in the last 10 years occurring since 2017.

The report states that "solar installations have sustained much greater damage than wind since 2020 in terms of both frequency and severity of claims, with both operational projects and those under construction equally exposed to losses".

Indeed, climate change is now the number-one concern amongst insurers globally, according to AXA Insurance's Future Risks Report 2022. When asked what aspect of climate change most concerns them, respondents overwhelmingly cited physical risks – such as floods, heatwaves, storms and rising sea levels – rather than other aspects such as risks related to liability for damages, or managing the transition to cleaner energy, as their primary concern.

## Extreme heat and solar

The physical risks relating to extreme weather can impact the entirety of a solar installation. Heatwaves in particular can

reduce the efficiency of PV modules, cause inverters to fail and worsen existing cell damage.

While weather such as hail can directly damage the modules themselves, the impact of extreme heat can be more nuanced. According to CED Greentech, a solar equipment supplier in the US, hot temperatures can reduce the output efficiency of solar modules by 10%-25%. With most solar modules having an 85 degree Celsius temperature limit, they are most efficient when operating at low temperatures.

Despite countries such as Germany announcing record-breaking solar power generation last summer, solar cells are likely not meeting their maximum capacity during such extremes – though these losses are more than offset by the additional yield. When temperatures soar above average, voltage is reduced, and the efficiency of the panels is presumed to decrease by 0.5 percentage points for every degree Celsius rise in temperature. Interestingly, while a lot of operators assume this is the case, data shows that the reality is closer to 1%.

While the impact of heat on solar cells is well understood, its effect on solar inverters is less clear. Although inverters contain semiconductor parts which lose efficiency as they heat up, these can tolerate high heat without breaking down – as evidenced by their presence in desert regions. Despite naturally generating heat through the conversion of DC power to AC power, heat in an inverter module needs to stay below a certain level to avoid degradation.

If an inverter becomes too hot, it usually switches itself off or reduces its power to such an extent that the higher ambient temperature does not cause it harm. This is known as temperature derating. During extreme weather, such as heatwaves, overheating warnings and derating become more frequent as the average temperature increases. While it is



Heatwaves can cause permanent damage to PV modules and risk downtime as a result of repairs or retrofitting.



Credit: Semptra Energy

unclear whether a significant correlation exists between temperature and warnings, they should be taken seriously to prolong inverter lifespans and ensure asset yield is not lost.

Inverters and cells aside, one of the biggest issues faced by solar when confronted by extreme heat is the temperature within the wider PV module. Climate change has caused an increased uncertainty around the accepted “territory” for expected environmental risks and, when building solar farms, developers consider pre-existing data that includes on-ground measurements and long-term satellite irradiation averages. With solar efficiency dependent on thermal design to ensure optimum performance in specific territories, existing PV assets are increasingly at risk as our climate continues to warm and extreme heatwaves become more prevalent and unpredictable.

With PV module designs tailored to suit average regional temperatures, assets are woefully unprepared for ongoing extreme heat, which risks damaging electrical equipment bereft of adequate ventilation. Depending on the design and the region, heatwaves can cause permanent damage to PV modules and risk downtime as a result of repairs or retrofitting. While expensive, it may be necessary for pre-existing solar farms in traditionally cooler climates to consider re-assessing their ventilation to reduce longer term ambient temperatures within the module. This can improve transformer lifetimes and decrease the chances of a catastrophic fire.

### Solar fire risk

Located within PV modules, electrical transformers can take only so much punishment and, with record-breaking heatwaves pushing up electricity use, transformers are at risk of rapidly ageing. With solar sites staying warmer in the evening during prolonged periods of heat, transformers do not get a chance to recover. The increase in loading on a transformer creates a higher chance of failure for the equipment, which can lead to a power outage and even a catastrophic fire, resulting in total loss of the asset.

The deterioration of solar equipment as a result of extreme heat is likely to increase the chances of an arc fault – a discharge of electricity. The arc flash generated can occur in electrical cabinets during hot weather and risks damaging the solar farm and surrounding environment. In the US alone, between 2015 and 2018, the Fire Administration reported 155 fires caused by solar installations, with 84 occurring in residential systems and 71 in non-residential.

According to a report by Firetrace International, “there is a high likelihood that instances of solar farm fires are under-reported”. A study conducted by European testing and certification company TÜV Rheinland – entitled ‘Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization’ – concluded that, in approximately half of 430 cases of fire or heat damage in PV systems, the PV system itself was considered the “cause or probable cause”.

Crucially, it notes that, within the solar industry, there remains “a severe lack of data on the prevalence of solar farm fires”.

### Data is key

This lack of data stems beyond fire detection in the solar industry. With solar owner-operators not understanding the risks, they aren’t able to properly protect their assets from extreme weather and understand its true impacts financially, operationally and reputationally.

At Clir, we want the renewable energy sector to be resilient amidst a changing climate. By combining benchmarking data, machine learning and years of industry expertise, we work to help renewable energy stakeholders maximise their financial returns regardless of heat, hail or hurricanes.

To best understand your solar farm, and how to ensure maximum operation and preparedness for extreme weather events, data is key. Last year alone, utility-scale wind and solar PV electricity generation could face losses of up to US\$22 billion from fixable technical underperformance issues relating to data.

Until recently, solar operations and maintenance (O&M) has been shaped by an over-reliance on inward-looking SCADA data. This data must be set in its geospatial context and be fed through a common model that considers all available on-site sensors, or else owners simply won’t know whether underperformance is due to a fault with the panel, cloud cover or shade caused by the immediate environment.

When monitoring a solar farm, we source data from multiple points across the solar array, with our automated detectors subsequently identifying instances of underperformance. These detectors range from partial performance detectors monitoring inverter derating, to soiling detectors analysing the impacts of both snowfall and intense rain, to curtailment and forced outage detectors. Through these, we are able to understand the impact of seasonal and extreme weather conditions across the year.

By evaluating historical weather forecasts and benchmarking against solar OEMs, assets in the field and industry peers, we train our artificial intelligence models to create adjusted production budgets. If there are significant discrepancies, owner-operators can potentially reassess their budgets or update their energy yield assessment. This enables better planning for day-to-day tasks like staffing, handling weather protocols and managing panel efficiency while understanding the risks impacting similar farms.

An understanding of inverter performance during heatwaves through our benchmarking offers visibility into issues associated with extreme weather and emboldens asset owners to decide whether these need to be addressed or simply managed in their current form.

We are currently developing detectors which will enable us to gain a deeper understanding of operational data, offering solutions into how solar projects can better withstand increasingly unpredictable climates. To cite a recent example, interesting learnings could come from the likes of Babcock Ranch in Florida and its ability to emerge from Hurricane Ian relatively unscathed.

With careful system planning, proper installation and professional maintenance, PV systems can still be operated reliably during heatwaves with inspection monitoring processes including heat-related sources of failure. If heat-related failures occur, the cause needs to be quickly identified and rectified to avoid lower yields, as well as technical damage.

### Difficulties inherent in renewable energy data

Despite the strides made above, difficulties persist when analysing data for the solar market. This was a main motivator

that led Clir to answer the call from our clients to apply our AI-driven monitoring and optimisation offering, and address glaring gaps in the solar data market.

Although the renewable energy industry harnesses an abundance of data, using it can be challenging. Stakeholders have limited time to ingest, standardise and analyse data, reducing their ability to truly dive into understanding it. When used properly, data can help to drive down the cost of insurance and financing on solar projects.

Along with managing the data, there are also inherent issues with solar energy data itself, in no small part due to a lack of industry standards. While we have witnessed the wind industry consolidate over the last two decades, the majority of solar projects tend to lack standardised data, with that available generally of a poor quality or availability. This stems from the fact that each OEM brings unique ways of recording event data and providing access to data. As projects are bought and sold, it's also difficult to gain access to historical data across the different OEMs and stakeholders, with assets coming with previous data monitoring structures that can be difficult for portfolio owners to consolidate.

This problem is compounded further by the sheer number of OEMs in solar when compared to the likes of wind, making scalability more difficult in mixed solar portfolios without the accompaniment of adequate software solutions – of which there are few.

Without clean and standardised data, there's also an issue with wasting time on false positives. Poor data quality can lead to errors when identifying issues with components. It's important to understand what issues are actually impacting your farm, along with what issues are solvable, instead of wasting time on problems that may not be easy to manage.

Finally, across the industry, stakeholders lack access to global benchmarking data. This means that easily solvable problems are being missed because of a lack of knowledge. Leveraging learnings from industry data enables proactive identification of errors and quantification of impactful optimisations, rather than relying on individual experience or biased data.

### More data means more protection and assurance

At Clir, our artificial intelligence analyses solar asset health and performance data

in the context of its environment. With our algorithms, we support owners in developing a true understanding of each asset's behaviour and its relationship not just to its peers, but to the fleet and, ultimately, the wider industry. This means that asset owners can identify the likely impacts of extreme weather events along with day-to-day performance issues.

A lack of O&M innovation in recent years has resulted in project owners missing out on the performance potential of their solar assets. The market has become a race to the bottom, with everyone spending as little as possible on O&M and asset management – a key part of which is high-quality, comprehensive and properly labelled data collection. This has not gone unnoticed by our long-standing wind clients that also hold solar assets.

Plenty of data exists for renewable energy projects, both from individual portfolios and within the industry. However, with solar data standards not yet as mature as those in the wind industry, a lot of assumptions are used based on older projects which are now invalid in newer projects exposed to climate change-induced extremes.

By harnessing and sharing the data we have, owners can find increased success in their projects, both through increased performance, and lower O&M costs. To maximise the value of portfolios and continue driving investments, advocating for clean and transparent industry benchmarking data will become imperative.

Solar installations most exposed to our increasingly unpredictable climate are those whose data will be most valuable when dealing with the inevitable increase in extreme weather events. This data will be crucial in reassuring investors, owner-operators and the general public that solar is a resilient method of renewable energy that can deliver no matter the weather. ■

#### Author

Gareth Brown is the CEO and co-founder of Clir Renewables, a provider of digital asset performance technology for the renewable energy industry. With over a decade in renewable energy, Gareth has experience leading the identification, development, construction, financing and operation of renewable energy assets for a technical consultancy. He is an entrepreneur, chartered engineer with the IMechE and has degrees in mathematics and mechanical engineering.







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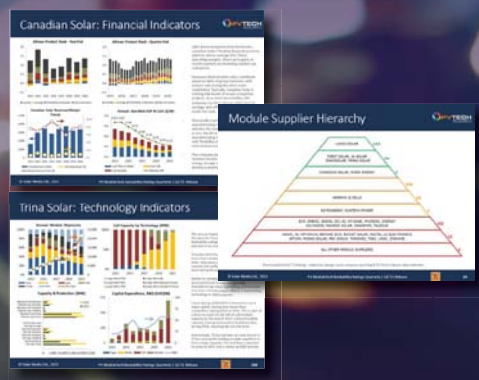


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# Challenges of bifacial module performance monitoring

**Performance monitoring** | While bifacial modules promise advantages in power production, they can create complex performance monitoring challenges. That will need to be resolved if project production uncertainties are expected to remain at levels and expectations currently set with the deployment of mono-facial modules, write Ajay Singh and Derek Jones of Campbell Scientific Inc.

Bifacial PV modules can produce electrical energy by absorbing light from both front and rear sides of the module, resulting in an additional gain of 10-15% more electrical energy output.<sup>1</sup> The primary difference between bifacial modules and traditional mono-facial modules is that the rear side of the cell also has a grid pattern for contact rather than completely covered by an aluminium contact. A glass or another transparent backsheets is used behind the solar cells to capture light reflected from the ground. More and more PV manufacturers are offering these modules and they are gaining marketplace acceptance. The additional gain depends on the amount of reflected light (albedo) reaching the rear side, which is highly dependent on the local site layout, ground cover, height of modules from the ground, distance between modules in a row, the distance between the rows, the time of day and the time of year. There is an increased uncertainty in energy forecasts due to the variabilities in albedo resulting from all these factors. These uncertainties compound the complexity and uncertainty of project design and can even be a hindrance in the adoption

of bifacial modules in the industry and hence have attracted a lot of research interest recently.<sup>2</sup>

Measuring incoming, front-side irradiance, is relatively simple compared to reflected irradiance on a site in that for a particular site under clear sky conditions the incoming irradiance will be spatially uniform at a given time, while reflected or rear-side irradiance can vary as acknowledged above and be confounded by other factors like racking. The solar PV community recognises the need to monitor rear-side irradiance and international standards organisations like the IEC have provided definitions and recommendations for monitoring rear-side irradiance. In IEC 61724-1 2021 there is guidance for the type, spacing and orientation of sensors for monitoring rear-side irradiance and horizontal albedo. Even following the provided monitoring recommendations provides limited spatial coverage which may or may not be representative of the entire site.<sup>6,7</sup>

Measurement of power production losses due to PV module soiling on bifacial modules is another area that is very important and suffers from variability and complexity of the albedo and

rate of PV module soiling at a site. This is all compounded due to the spectral mismatch of incoming and reflected irradiance which can vary over time and depends on the ground cover, racking and current ground conditions.<sup>3-5</sup> Figure 1 shows the spectrum of reflected sunlight from different ground surfaces. Another challenge is the anticipated differences in the rate of soiling on each side of a module (front and rear), and the fact that a bifacial module has only a single power output which gives no insight into irradiance or soiling losses to power production from incident versus reflected light.

There is still no clear consensus on the best methods to be used to determine losses due to soiling of bifacial PV modules. To date there is still no consensus on the best methodologies to measure soiling on mono-facial panels and for reasons discussed above bifacial panels add to the confusion around this topic. There are optical sensors that promise easy installation and relatively maintenance-free operation, but the data quality from these sensors has been questionable and does not correlate well with the production losses reported in the plant production data. Another methodology compares the output from two PV devices, one clean and one soiled. This methodology provides a soiling loss index (SLI) that best correlates to plant performance but requires expensive periodic maintenance and can be burdensome to implement. This method becomes more complex for bifacial modules for reasons mentioned above, as well as the fact that these panels have only one output and the contribution from the front and rear side cannot be separated easily.

Some early adopters of bifacial PV technology used four collocated modules with different cleaning routines to deter-

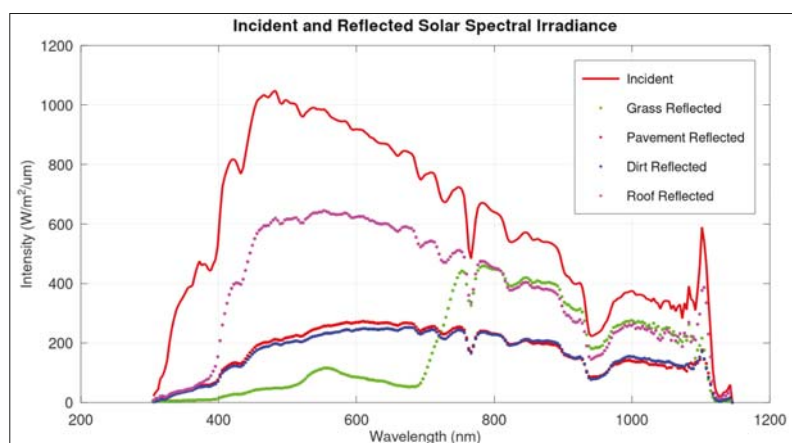


Figure 1. Spectrum of reflected light from four different ground materials.



mine soiling losses and to understand the different soiling rates of the front and rear sides of the modules. One module was cleaned regularly on both sides, a second was cleaned only on the front side (rear side left to soil naturally), a third was cleaned only on the rear side (front side left to soil naturally), and the fourth module was left to soil naturally on both sides. While this method is cumbersome, and the maintenance requirement is tedious it provides a good overall soiling rate, including separate rates of soiling for the front and rear sides which gives plant operators more useful information. In practice it is rarely implemented due to spatial limitations and maintenance requirements.

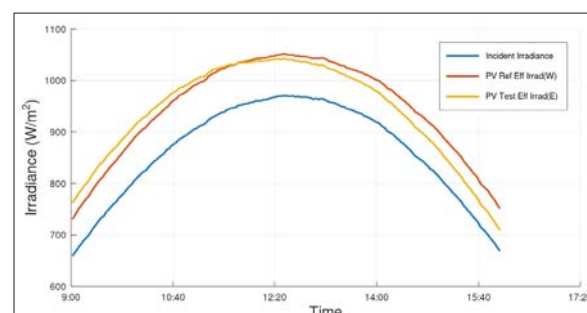
Another approach for monitoring soiling losses on projects using bifacial PV modules is to follow the Method 2 guidance in the IEC 61724-1 2021 and to compare the output from one clean panel to the output of a soiled panel assuming that on an average they see similar reflected irradiance.<sup>8</sup> If this method is deployed it is recommended that care should be taken to maintain the ground conditions the same behind both the panels. If all parameters are held equal behind two bifacial modules this methodology can be successfully implemented, but the operator will be left with a single SLI but with no insight into front versus rear side soiling.

In a recent study Campbell Scientific Inc. proposed a method to separate the contributions of incident and reflected irradiance from the output of bifacial modules and determine power losses due to soiling on the front and rear sides of a bifacial module. Two identical bifacial PV modules were installed side by side at the same tilt. Module performance on both modules was monitored following Method 2 outlined in Annex C of the IEC 61724-1 2021, wherein one module is maintained as a clean reference and the second is left to soil naturally. In our study short circuit current and temperature of these two modules were measured and an effective irradiance was calculated.<sup>9</sup> Additionally, in this study reflected irradiance was measured underneath each bifacial module with a small low form factor silicon pyranometer adhered to the centre of the rear side of each module. This was possible due to the use of half-cut cell PV modules deployed in this study.

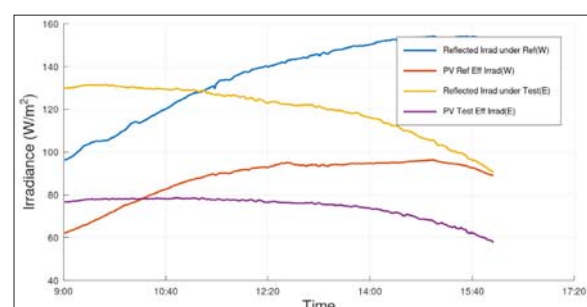
To draw a correlation between front and rear-mounted irradiance sensors and the output of the bifacial PV modules, on a clear sky day, the front side of the modules were covered with an industrial-grade thick black plastic sheet (thickness 0.15mm). This was temporary and the measured output of the modules in this state can be attributed to the rear-side contribution only. An in situ bifaciality gain can be deduced from these measurements and used in calculating front-side and rear-side soiling losses moving forward.

The aim of this study was to gain insight on and also to explore a methodology to separate the contributions to module output from front and rear sides. This method allowed the calculation of an overall SLI and individual SLI for each of the front and rear sides of the bifacial PV modules within the uncertainty of the measuring equipment. The results from this study were promising; the overall losses from soiling were dominated by soiling on the front side as expected, while the soiling loss on the rear side was minimal and may be affected by the spatial variations in the albedo across the two modules under comparison.<sup>2</sup> While the results from the study provided additional insights it is unclear if the methodology would be generally accepted in the industry. Sites with seasonal variability might also need to repeat covering the front of the modules for a seasonally dependent bifaciality gain factor which would be an additional hindrance to the widespread adoption of this method in practical applications.

In summary, while bifacial PV technology promises advantages in power production it creates performance monitoring challenges that prove to be complex, but that will need to be resolved if project production uncertainties are expected to remain at levels and expectations currently set with the deployment of mono facial PV modules on projects. The variability of reflected irradiance and soiling of PV modules over time and location will impact production and development of a project significantly impacts the site environment contributing to both of these factors. Either project owners and developers will learn to cope with higher yield uncertainties or new and better methodologies for quantifying production performance from bifacial PV modules will need to be developed.



**Figure 2. Irradiance as measured by a Si pyranometer, and effective Irradiance measured by two full-size bifacial modules. As we can see the effective irradiance is about 10% higher than the irradiance. This additional gain is coming from the rear side of the module.**



**Figure 3. Albedo underneath the two bifacial modules and the effective irradiances from the back side of the module. The top of the PV module has been covered with a 0.154 mm thick black plastic sheet.**

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## Authors

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# Guidelines for revamping and repowering solar assets

**Repowering** | Simone Mandica of asset manager WiseEnergy details how solar installations can be repowered to extend their service life and maintain high standards of technology.

Revamping usually involves the replacement of defective or obsolete PV technologies with modern, more efficient, and more reliable equipment. Most commonly revamping plans are implemented to address the problem represented by underperforming assets in comparison to the long-term expectations. If the improvement plan also results in increasing the original capacity of the plant, then it is referred to as repowering.

However, there are many facets to revamping and it would be misleading to associate it with an exercise that, although potentially challenging, is only limited to few specific technical actions, e.g. the replacement of the inverters or of the solar panels. Indeed, the full benefit of revamping is only realised when it is not limited to the immediate and urgent need to solve a particular issue but is based on a holistic approach. An approach that includes considerations about the expected health and condition of the plant in the remaining years of operations and results from a detailed understanding of the technical, planning, regulatory and financial aspects of the asset.

A revamping plan should start from reviewing the operational performance of the equipment, the engineering design of the PV project, its planning and regulatory compliance and continue with the assessment of how different scenarios would impact the plant over time. Each scenario will correspond to a different technical solution and, among all possible scenarios, the one delivering the best combination of financial and technical performance and of planning and regulatory robustness should be selected. Effective revamping will extend the plant's productive lifecycle, increase its commercial value, enhance its profitability, and make the PV project more bankable by retrofitting equipment with improved specification and design.

In the last three years, WiseEnergy has been supporting plant owners in modernis-



Credit: WiseEnergy

ing their fleet of 'first-generation' plants to secure revenue streams well beyond the assets' initially envisaged operational life of 20-25 years. From our experience, we can point to four useful metrics that can be assessed when considering revamping: (i) underperforming asset, (ii) unserviceable technology, (iii) ageing technology and (iv) investment opportunity, as discussed in detail below.

## i. Underperforming assets

Revamping is generally associated with solving the serious economic problem represented by a plant performing below the long-term expectations. For example, this is the case when the level of equipment anomalies or degradation is higher than expected and therefore the production of the plant is below certain predefined limits. Then replacing the defective or sub-optimal equipment can be the solution to increase the plant efficiency and to bring its production to or above the expected level. This situation may also entail remedying poor installation practices which might have been due to the rush imposed

**WiseEnergy has been supporting plant owners in modernising projects to secure revenue streams beyond the assets' initially envisaged operational life of 20-25 years.**

by tight construction schedules or the lack of experience when the plant was initially constructed.

## ii. Unserviceable technology

Expired or unenforceable warranties or the lack of technical support are becoming increasingly common reasons for deciding to replace PV equipment. Several module and inverter manufacturers have exited the market leaving serious challenges in terms of warranty claims and technical assistance behind them. In many instances, the most effective solution is the replacement of the modules or of the inverters with modern equipment from global, financially stable manufacturers that can also guarantee a robust after-sale service.

## iii. Ageing technology

The inherent ageing of the key PV technologies may represent a sufficiently strong case for revamping, independently of underper-



forming equipment or construction defects.

For example, after eight to 10 years of operation, inverters will start experiencing more frequent faults resulting in the failure of their most sensitive and valuable components (for instance, IGBTs) or even of the entire device itself. Thus, replacing the ageing inverters will result in improved availability and reduced operational costs and this can be a valid alternative to extending their warranty, which is usually costly, or to the procurement of spare parts, for which storage and installation costs should also be considered.

As for PV modules that have been in operation for 10 years or longer, they may have lost 10% or more of their output power due to natural degradation; this decrease in production can be compensated through their replacement. This is usually a viable option for plants benefiting from a high feed-in tariff, as is typical for older assets.

#### iv. Investment opportunity

Even if the performance of an asset is meeting the initial expectations, a repowering plan, designed to increase the value and bankability of the asset, can represent a very attractive investment opportunity, which becomes particularly valuable if the plant is going to be bought, sold, refinanced, or reinsured. The question 'Does the proposed price fully capture the value of the plant?' will trigger a series of considerations on the present and potential value of the asset to which repowering can provide the answer. The answer is not always the replacement of the old technology with new products, but revamping also entails the installation of additional technical solutions that can optimise the plant performance and increase it beyond the predefined base case.

#### Example: Italy

A market particularly favourable to revamping is Italy, one of the first countries in Europe where the PV market started developing back in 2008-2009. At that time, and for some of the following years, the PV industry was literally in its infancy and relying on certain construction practices and equipment that nowadays would be deemed as sub-standard.

The focus was mainly on reducing capex and on short-term performance, while disregarding or only marginally considering the requirements for the long-term health of the plant. It is then this opportunity to improve the performance of old assets, in combination with the high feed-in tariff from which the same first-generation plants

benefit, that makes the Italian market so attractive for revamping investments. These investments are made even more appealing by the fact that the process that must be followed to revamp old PV projects without compromising their original feed-in tariff is generally well defined and supported by an established practice. Indeed, the regulatory framework for revamping was defined by GSE, the Italian government regulator of the renewable energy market, already in 2016, and in 2020, new legislation was introduced to simplify the planning application for works aiming at modernising PV assets.

WiseEnergy has been designing and managing revamping projects in Italy since 2020. Initially, the key drivers for renovating old plants were mainly related to the need to replace underperforming or unserviceable technologies. An excellent example of this is the work we did on a portfolio of plants in preparation for its sale. The assets had been in operation for nine years or longer and had an aggregate capacity of approximately 100MWp.

We started reviewing the plants' historical operational performance, and the tests performed on the equipment to identify the most critical assets and technologies for which a revamping would be most beneficial. From our initial analysis it transpired that a staggering 35% of the portfolio's aggregate DC capacity corresponded to panels whose manufacturer exited the market long ago.

Not only were the associated panels not covered by a warranty, but also it was unsurprising to find that serious issues impacted their performance (e.g. excessive degradation, thermal anomalies, backsheet delamination or chalking, micro cracks) with a significantly higher incidence than that observed for the other modules. Our feasibility studies indicated that the case for replacing these modules was very attractive, with an internal rate of return (IRR) greater than 11%-12%. Based on these results, we managed the replacement of 12MWp of panels. This was a particularly rewarding project as our subsequent monitoring of the revamping costs and of the revamped plants' operational performance has shown that all interventions have had the predicted high IRRs delivered in practice.

From the second half of 2021, the approach to revamping in Italy became much more radical than simply replacing the modules or the inverters and was not necessarily related to solving the problem of suboptimal equipment and plant performance. Indeed, optimisation plans started

being implemented involving the replacement of the fixed structures with single-axis trackers, of the old solar panels with modern bifacial modules and of the existing central inverters with string inverters.

In essence, by just keeping the total DC capacity and the connection to the grid unchanged, it became evident that it was possible to modernise every other aspect of a PV plant and to increase the annual production of even normally operating assets by more than 25%. Crucially, the original feed-in tariff assigned to the plant is paid also for the increased generation and this may make the revamping investment feasible even for a plant that is meeting the long-term expectations.

#### Revamping portfolio

WiseEnergy is currently planning this type of revamping on a portfolio of 35MWp; our feasibility studies indicate that there is a strong financial case to proceed and the aim is to break ground in Q1 2023.

It should be noted that one of the aspects that facilitate the design of a very effective revamping plan involving the replacement of the fixed structures with trackers is the high capacity of modern solar modules. The benefit of these panels is that they make it feasible to use tracking systems with one panel in portrait (1P trackers), and these usually allow (i) an optimal use of the existing area to (re)install the original DC capacity minimising the inter-row shading, and (ii) to achieve a maximum height of the new panels not deviating significantly from that of the original modules. The latter aspect is one of the requirements to access the simplified planning application process available in Italy.

The high-capacity modules offer the additional opportunity to include in the revamping plan the development of a new subsidy-free section. Indeed, new panels with a capacity of 650Wp or bigger have at least three times as much power as the corresponding technology of eight years ago; this means that less than a third of the area is now needed for the same generation.

Therefore, if old panels are replaced with new higher capacity modules, then, in the space freed up by the revamping, a new subsidy-free section of the plant could be built. We have increasingly experienced that the possibility to expand plants is becoming one of the key drivers in designing repowering strategies. In addition, requests to assess constraints related to permitting or to power export which could prevent



the construction of a new section of the plant are made with increased frequency by owners. Further, it can be envisaged that as the market for grid energy storage systems grows, the freed-up space will also represent an opportunity to develop co-located battery systems.

### Example: UK

The UK is another country where WiseEnergy has been very active in revamping activities. The British PV market started in 2011, later than many other countries in Europe, and therefore some of the lessons learnt in Germany or Italy, for example, were applied to the solar projects that were being constructed in the UK. This resulted in assets that have generally better design and improved equipment specifications than, for example, the Italian first-generation plants. Nevertheless, the ageing of the PV technology and the lack of technical support from equipment manufacturers are still taking their toll on the performance of the PV projects in the UK.

Based on our direct experience, most of the revamping works in the UK involve the replacement of inverters manufactured by companies that either left the PV market (Emerson, for example) or that, after the expiry of the standard five-year warranty, find it difficult to provide the necessary technical support such as spare parts and corrective maintenance to operate their equipment (Fimer and Gamesa, for example). Therefore, inverter stoppages that could be resolved promptly, usually have an excessively long duration and result in high revenue loss. Further, it can be envisaged that in the long run, as the inverters' fault rate increases, this situation will make the operation of these assets unsustainable. We have worked on projects so badly affected by the inverters' underperformance that our assessments indicate that the investments for their replacement can be expected to have an IRR greater than 12% and a

pay-back period shorter than six years.

By managing the implementation of these projects, we have also had the opportunity to experience first hand another benefit of revamping: the newest inverters have a more robust design that guarantees their compliance with the latest development in the grid codes, therefore improving the integration of the variable solar resource into the electricity grid. It should be observed that while in the UK there are now established procedures that should be followed to guarantee the regulatory compliance of the inverters used in the revamping projects without compromising the energy tariff, the situation is not clear at all when it comes to the large-scale replacement of modules. However, WiseEnergy has been able to support customers through the lack of clarity and guidance from the regulator which is holding back many asset owners from embarking on modernising their portfolio following the example of the Italian market.

### Equipment management

One important aspect of revamping plans is the management of the equipment which is replaced. The old panels should be disposed of in compliance with the national legislation for treating electrical and electronic equipment. In the European Union, asset owners have the obligation to organise the collection, the waste treatment, and the financing of the disposal of electrical equipment (including solar modules) in compliance with the Waste Electrical and Electronic Equipment, or WEEE, directive. This is usually achieved by relying on the services of companies that offer tailor-made WEEE-compliant waste management. The positive news is that the main materials of PV modules have high recyclability; for example, as for silicon panels, aluminium has 100% recyclability, glass 97%, silicon 85% and copper 78%. However, how much of the material is

**Revamping represents a clear opportunity for owners to modernise their portfolios with the latest technology and achieve a significant economic benefit.**

recycled effectively depends also on the process followed at the waste management facility.

A similar approach is followed with inverters; but, it is also very common that replaced inverters are cannibalised for spare components that can be used on other compatible inverters. We have also seen that the remarketing of old modules is an economic opportunity that brokers in the solar sector have started to exploit. Used panels even of nine or ten years of age, still operating at the expected level of efficiency and with no visual defects, have a market in developing countries in the Middle East or in Africa.

In conclusion, revamping represents a clear opportunity for owners to modernise their portfolios with the latest technology, to meet our industry's evolving and new standards and to harness higher percentages of solar energy and ultimately to achieve a significant economic benefit. As the PV sector matures (also through the increased importance that investors, lenders and insurers are putting on higher levels of reliability, serviceability, and bankability), the 'revamping approach' should become an integral part of the initial project planning as opposed to an emergency solution to address operational issues.

In other words, considerations about improved technical specifications to guarantee plant longevity and stable revenues over the life of the system should not be postponed to the moment when it becomes clear that it will be challenging to meet the long-term expectations; rather, these considerations should be included in the initial planning process. The most beneficial outcome of the current revamping activities would be that their distinctive focus on improved, more robust specifications will become the cornerstone of the lifecycle of future plants. ■

### Author

Simone Mandica joined WiseEnergy three years ago and developed the company's team specialising in designing and executing plans to optimise plant performance. This includes technical advisory services for revamping activities, the implementation of novel technical solutions for increasing the production and the design of strategies for the long-term management of the assets. Prior to this, he spent three years as senior technical manager at Innova Capital and almost five years as technical advisor at Mott MacDonald.







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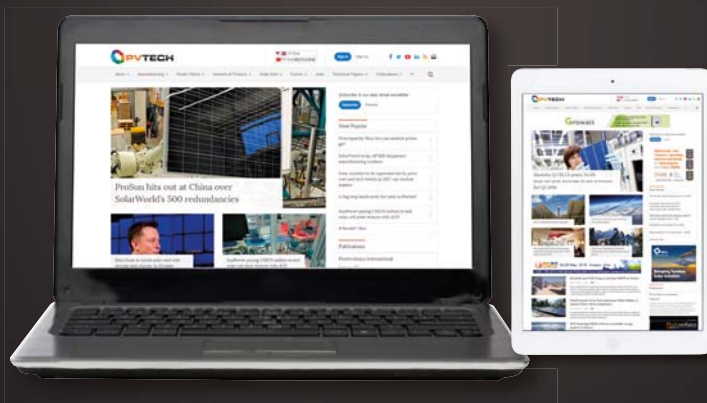


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# Supply chain issues inhibiting solar growth: how insurers and developers can work together to battle project losses and downtime

**Insurance** | A combination of supply chain disruptions and extreme weather events that damage operational assets can lead to extended solar project downtimes. Rosa van Reyk, a senior underwriter at GCube Insurance, explores how the industry can ease supply chain pressure by rethinking cost efficiency and increased collaboration between developers and insurers.



Credit: Nextrackr.

2022 was a challenging year for the solar industry in the US. Reports from the Solar Energy Industries Association (SEIA) suggest that solar installations fell by as much as 23% last year, despite the accelerated demand for renewables. The slowdown can be attributed in large part to supply chain issues, which suffered yet another year of choking setbacks.

After the Uyghur Forced Labor Prevention Act (UFLPA) came into operation in June, solar supplies have been held up at US borders. These cannot be released until producers provide documentation to prove that the supply chain has no activity

in China's Xinjiang region. To illustrate the impact this has had, Longi Green Energy Technology, Trina Solar and Jinko Solar – which make up a third of the US' panel supplies – all halted new shipments in fear that more solar modules would be blocked.

This might not be such a problem if it weren't for the fact that, in the last decade, Chinese manufacturers have been relied upon for 80% of the global supply of solar modules. This, combined with the rising cost of critical materials such as aluminium and polysilicon (both now cooling), has put the supply chain under intense pressure.

**In the face of extreme weather, it can be difficult for developers to have certainty that their assets will not experience downtime.**

In fact, in a joint report in December 2021, Wood Mackenzie and the SEIA found that year-on-year price increases for commercial solar segments were the highest they had seen since tracking began in 2014.

Meanwhile, the ongoing Russian war in Ukraine has increased the vulnerability of the global supply chain, creating inflationary pressures across the board. Soaring energy prices in Europe and increases in oil prices in the US further hastened the desire to decarbonise the energy landscape.

To make matters worse, extreme weather in the US wreaked havoc in 2022 and contributed to severe damage to solar



sites. As a result, operating downtime was exacerbated as sites waited for replacement supplies to be delivered.

As revealed in the 'Supply Another Day' report last year, GCube's business interruption (BI) claims data indicates that, though the volume of claims remained at a similar rate, the duration of BI periods in these claims has been increasing. This is because the supply challenges have caused BI periods to lengthen. Ultimately, this takes its toll on the solar industry and the insurance market that supports it.

### Why solar is especially affected

Solar is experiencing outsized impacts of supply chain disruption when compared to its renewable energy counterparts, such as wind. This is mainly due to the dependency on Chinese manufacturing and the lack of viable alternatives. This predicament is compounded by the fact that damage to solar modules generally requires a full replacement, as opposed to a repair option, and the technology for solar becomes obsolete at a faster rate.

GCube has observed a 50% increase across its solar book in the length of average downtime from 63 days to 94 days. Specifically, the length of average downtime in the US experienced a 78% increase from 78 days to 139 days. Not only does this emphasise how difficult the recent period has been for solar, but it also indicates how disproportionately US solar is suffering in the time it is taking to get projects back to full capacity following a loss.

Given that some developers are finding that their plants are down for double or triple the time they had planned for, the main exposure faced is exhaustion of their revenue protection which is typically only bought for a 12-month period. Losses resulting in a period of more than a year of downtime will fall to the owners' balance sheet. Some developers, keen to capitalise on the current high energy prices, have made the decision to pay large fees in order to excuse themselves from power purchase agreements (PPAs) and move onto variable rate tariffs – these are more common in Europe. With supply as fragile as it is right now, the flexibility to take such opportunities is strained by potential risk.

### Impact of natural catastrophe events

In the face of extreme weather, it is difficult for developers to have certainty that their assets will not experience downtime –

especially if their projects are located in areas that are traditionally more exposed to natural catastrophe (nat cat) events.

GCube's Nat Cat update last year recorded that hail losses in Texas exceeded US\$300 million. This proved to be twice as costly as other key renewable losses of the last three years combined, and ten times as costly as Hurricane Hanna claims in 2020. When compared with wind, solar installations have sustained greater damage since 2020 in terms of the frequency and severity of claims.

In the last few years, reports of nat cat-related solar losses exceeding sub-limits of up to US\$50 million have grown increasingly common. Adverse weather events were both more destructive and more common last year, culminating in losses across a higher number of projects. Evidently, this is not

*"In the last few years, reports of nat cat-related solar losses exceeding sub-limits of up to US\$50 million have grown increasingly common"*

a sustainable way for the solar industry to continue to function and requires greater collaboration between developers and insurers.

With nat cat damage comes a surge in replacement solar modules. The sudden and high demand would stretch even a free-flowing supply chain. Solar is in uncertain territory when it comes to anticipating the lead time on equipment. The wait for panels, which was previously around six months, has crept, in some cases, to 14 months. Similarly, the wait for a main step-up transformer is now up to 16 months when it was previously 12 months. Considering the additional time required for installation, issues with items have the potential for significant loss of revenue. Proactive risk management and, in particular, the foresight to stock spares is likely to have a positive impact on insurance terms and conditions.

Extended project downtimes following weather damage are escalating the size of claims faced by insurers. This, combined with rapid growth in the sector is leading to a natural constraint of insurance capacity, especially in locations which model poorly.

### Supply pressures on new projects

Supply chain issues are causing developers to take the unusual step of placing orders for modules before executing their PPA – the opposite of what has historically been considered normal practice.

The Inflation Reduction Act (IRA) will doubtless provoke growth across all renewable energy in the US. As it stands, projects are taking upwards of 12 months longer than expected to break ground. This disruption has an impact on various factors such as engineering, procurement and construction contracts, PPA negotiations as well as insurance pricing, which is generally only guaranteed for 30 days following a quote. In response to delays, we have seen the prices of solar PPA contracts rise by 33% in the last year, which gives a strong indication to the extent of the uncertainty around timeframes at the moment.

Large-scale developers, who may be working on multiple projects at once, have the potential to distribute resources and parts according to their needs; small-scale developers can do nothing but wait until the supplies arrive, occasionally jeopardising existing contracts.

As a 'grab what you can' mentality emerges in solar, smaller developers do not have access to the same coping strategies, nor the same networks to rely on. Given that solar technology evolves quickly, having the ability to redevelop sites or to pay to expedite critical parts is an important advantage when constructing a new project or following a claim.

### Ways to ease supply chain pressure

While the supply chain is causing problems that are largely outside of the control of insureds and insurers, this does not mean that there aren't some solutions. There are three approaches that can be taken to address these issues.

#### 1. Diversifying the supply chain

There has been positive news for developers as some big-name Chinese manufacturers have been returned to approved lists (in the US) following approval that they meet UFLPA standards. Moreover, the downward price of the polysilicon index promises to have a positive impact on the price of modules and, in turn, applies a downward force on the price of solar technology and projects.

Nonetheless, this is not a case of business as usual. With demand so high, it is very much a seller's market and developers are likely to find themselves disap-

pointed in their quest to find manufacturers who can fulfil orders to schedule, if at all. Manufacturers are in a position to push more risk onto the buyer, especially when it comes to shipping terms.

The need to diversify the supply chain, then, still exists. Supply chain managers have been sourcing successfully from Indian and German manufacturers; these stocks have, however, been strained by the surge in demand for solar panels. Identifying suitable new suppliers comes with challenges. Buyers need to be assured of the financial robustness of companies which, for solar modules, traditionally offer 12+ year warranties. A transparent and compliant supply chain is critical.

The IRA has galvanised confidence in the US's green energy aims; this is significant in an environment where policy has previously felt uncertain. A freeze on orders at First Solar has thawed following increased capacity to take new orders. Meanwhile, Hanwa Qcells is spending US\$2.5 billion to expand its operations in Georgia. Although a considerable amount of US domestic capacity is catered towards the residential sector, this is a move in the right direction. Clearly, there is cause for manufacturers to feel more bullish about investment in the US.

## 2. Rethinking cost efficiency

Although cost efficiency is paramount in the renewable energy market, and the levelised cost continues to decrease, this doesn't necessarily indicate that the cost of insurance claims is reducing. For instance, in the solar space, thanks to continued research and development, panels are becoming thinner, and using fewer costly materials. What this overlooks is that these panels can also become weaker and more likely to be damaged in harsh weather conditions, resulting in high replacement costs.

Similarly, the temptation to drive down initial costs by developing sites in undesirable and, therefore, cheaper locations comes with inflated risk. Sites exposed to extreme weather are becoming increasingly hard to insure as insurers caution around the effects of nat cat on solar claims. A project owner who experiences the negative effects of natural perils could find themselves in a position where it is economically unviable to transfer their risk to insurers in the following policy year.

Cost volatility of insurance in the Southeast of the US has led to project cancellation, post permitting. If projects continue



Credit: Nextracker

to generate unsustainable losses to the insurance market through damage and downtime, the ability of insurers to make medium-term commitments on rating is affected. It is becoming increasingly important to consider the fluctuating costs of insurance, which have traditionally been considered reasonably fixed, but latterly have had the ability to meaningfully affect margins.

### Hail damage at a PV plant in Texas.

Ongoing supply chain pressures which have combined with unprecedented losses have created a perfect storm of escalating costs for owners and their insurers

## 3. Collaboration between developers and insurers

From an insurance perspective, greater communication between developers and insurers can do much to support the solar sector through supply chain difficulty. Insurers have powerful networks as well as specialist knowledge which can help developers in various scenarios. This includes a pool of experts who have access to spare parts, ways to expedite deliveries as well as pre-construction advice on reducing risk. The quicker developers are to notify their insurer of a loss, the greater the chances are of insurers helping to source spare parts.

Part of this network includes a strong relationship with manufacturers, as well

as other clients, who may have excess inventory. Owners and developers can take advantage of this and make substantial revenue savings, especially given they will be expected to retain the first 30-60 days of any loss of revenue.

Plans for the growth of solar projects have been energised by the IRA, but a frenetic approach to adding green MW to the grid will result in poorly planned, resourced or situated solar sites. Rushed decisions are generally reflected in insurance terms and conditions and these costs can mount to such an extent that the economic viability of the project is jeopardised. Thoughtful risk management such as site planning, supply chain management as well as disaster recovery plans create an advantageous position from which to access best insurance terms.

Evidence suggests that the levelised cost of solar will continue to decrease even if the risks facing certain geographies do not. Ongoing supply chain pressures which have combined with unprecedented losses have created a perfect storm of escalating costs for owners and their insurers. This presents an opportunity for insurers, lenders and owners to work together more closely in order to find creative solutions to support the collective mission of reaching net zero. ■

### Author

Rosa van Reyk is a senior underwriter at GCube Insurance and provides clients and brokers with support for onshore wind and solar risks. She specialises in insurance solutions for clients with assets across North America.





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# How innovative PPA contract structures benefit solar asset owners and offtakers

**PPAs** | Innovative power purchase agreement structures enable solar asset owners to boost returns and leverage their positions while providing offtakers with the opportunity to protect against increasing electricity prices and enhance their decarbonisation efforts. By Norton Rose Fulbright partners Rob Marsh and Laura Kiwelu, counsel Suncica Miletic and associate Charlie Winch.



Credit: Solarcentury

Corporate power purchase agreements (PPAs) are not a new phenomenon, with the first deals occurring well over a decade ago (and some of the telecoms and retail giants entering into renewable PPAs as early as 2008). However, the size and frequency of deals – particularly in the US and more recently in the UK and Europe – has picked up in recent years.

Leading global corporations are increasingly focused on their need to decarbonise (driven by a mix of shareholder and consumer pressure, as well as increased regulation around emissions) and renewable PPAs provide an attractive solution.

An increasingly diverse spectrum of corporates are now looking at new markets for energy procurement solutions and there has been a meaningful shift in focus in the last 12 months in reaction to turbulent power markets.

We are of the view that this growth in appetite for corporate PPA solutions is set to continue, with both sellers/generators and buyers/offtakers willing to consider new innovative structuring solutions. This will be an important feature in aiding the rapid growth of solar development across the globe.

A renewable PPA can assist a corporate in the delivery of its sustainability goals.

**Long-term corporate PPAs are evolving and are now being structured to provide a more flexible hedge against rising electricity costs.**

The net zero agenda is gaining importance globally, with an increasing number of corporate, commercial and industrial players setting general “net zero” commitments or articulating targets on a more granular level with ambitions to source most or all consumed electricity from renewable sources in the short to medium term.

Achieving such targets and goals can be done relatively simply through the purchase of renewable power directly from their electricity supplier, a generator or a third-party aggregator, and accompanying it with the purchase of renewable energy certificates or guarantees of origin that



substantiate that the relevant volume of power consumed is renewable (such as guarantees of origin in the EU and UK, renewable energy certificates in the US and international renewable energy certificates more globally).

These certificates are increasingly being demanded by corporate offtakers globally, with a key consideration in corporate PPA negotiations being the need to safeguard the issuance and transfer of the required number of certificates to the offtaker. The provenance of these certificates and the ability to verify and audit the same is a key focus, as the spectre of greenwashing looms ever larger in the public domain. Some corporations wish to go further, beyond purchasing schemes, and are seeking other opportunities through which they can demonstrate additionality, such as helping to invest directly in a local solar PV project or offtaking electricity directly over a private wire.

In various emerging markets around the world, as regulation develops and matures and the grid opens up to private generators as the decarbonisation agenda accelerates, linkages can now be formed between intensive users and generators that were not previously permitted, and PPAs are often the go-to means of making that connection. However, clear and stable legislative frameworks are critical to attracting this investment and developing a true corporate PPA market to further enable the penetration of solar into the energy mix.

In emerging markets in particular, a defensive or bureaucratic energy regulatory regime may be a hindrance to putting in place the innovative PPA structures that generators, corporate offtakers and their stakeholders desire, and therefore understanding the energy regulatory regime at the outset is key. The role of government in each such jurisdiction remains fundamental – as we have seen in more mature markets in Europe and North America, subsidy free does not mean policy free.

Early corporate PPAs adopted simple pricing structures, such as a fixed price escalating in line with inflation under predetermined mechanisms. Although they may act as a hedge if prices rise, they also create an exposure to the risk of market prices falling instead. Long-term corporate PPAs are evolving and are now being structured to provide a more flexible hedge against rising electricity costs. This is highly attractive in an era of erratic and extreme rises in wholesale energy markets

The 300MWp Talayuela solar project in Spain.



Credit: Solarcentury

and even as energy prices stabilise in due course, the experience of 2022 and 2023 will not be quickly forgotten. With some governments trying to de-link the electricity price from gas prices, which should inevitably lead to lower electricity prices, corporate offtakers are becoming increasingly nervous to commit to long-term fixed prices. As a result, new sophisticated pricing structures have started to emerge that allow for the reopening of pricing mechanics if there are significant market movements – a “change-in-market” condition akin to some “change-in-law” mechanics. Another innovative approach involves floating price structures with a cap and

buyers will naturally not want to be exposed to such high prices or the risk attached from an unknown future.

PPA structures which allow for upside sharing first arose in the US and are yet to become widely used in the UK or Europe, but that may soon change. They allow generators and buyers to agree on a lower fixed price and share the reward of potential upside from higher wholesale prices as well as the downside from lower price levels, giving each a partial hedge in both directions. In comparison, in a standard fixed-price PPA, the buyer assumes the whole risk and reward of being locked into a fixed price.

#### Stacking smaller buyers

As corporate and industrial demand for clean and green energy grows, developers are finding innovative new ways to offer their services to smaller offtakers as well. The aggregation of buyers together can allow smaller entities to benefit from renewable generation sources, as well as offering generators a diversification of credit risk. The challenge for developers however is getting all buyers to commit to the same contract terms and dealing with interface aspects, as different buyers may have different requirements.

#### Shorter tenure PPAs

While large tech corporates can and do offtake long-tenured PPAs (10 or 15 years

“PPA structures which allow for upside sharing first arose in the US and are yet to become widely used in the UK or Europe, but that may soon change”

floor to provide mutually acceptable risk mitigation for both the buyer and seller.

#### Sharing price volatility risk

Investors in solar PV projects will want to capitalise on the extremely high current wholesale prices, though it is not clear how long prices will stay so high. Likewise,

being standard), smaller companies, and even more conservative larger companies, are not used to long-term power contracts and the idea of contracting for their electricity a decade in advance is an alien concept. PPAs and power products more broadly are still not standardised or easily accessible, and the costs of negotiating and executing such agreements can be off-putting.

To date, shorter-term power contracts are most obviously seen in the futures power markets, where the liquidity in longer-term contracts is still limited beyond two or three years. Even if liquidity increases through the supply side, a

*“PPAs and power products more broadly are still not standardised or easily accessible, and the costs of negotiating and executing such agreements can be off-putting”*

standard 10- or 15-year PPA is for many potential offtakers just too long, and too big of a jump from their current power supply arrangements. For such companies, shorter-term PPAs of three, five or seven years in length might prove a convenient and alluring introduction to PPAs, particularly due to the uncertainty of the long-term direction of power prices.

For generators, short-tenure contracts have historically been thought to mean higher merchant risks, which leads to higher costs in raising debt or equity or a restriction on the debt tenor that is available. More recently, though, uncertainty about long-term market conditions have made accepting shorter PPA maturities more palatable and the banking market is beginning to take a longer-term view on merchant risk for renewables (albeit in more mature markets to date). Short-tenure PPAs will in practice also come from older projects where their original subsidy packages may soon expire. Refinancing of such older projects may need to bridge the last few operational years, making short-term PPAs an attractive option, but offtakers seeking additionality may be unwilling to offtake from such projects.

### New contracting structures

We are also very recently seeing energy trading companies developing structures whereby they would be the direct offtaker

of a renewables project and would then enter into a virtual PPA or financial hedge position with one or more corporates for a matched or fixed volume of electricity (together with the accompanying guarantee of original or renewable energy certificates).

### Storage and sell side flexibility

Whilst the balancing risk usually sits with the offtaker, generators can offer innovative ways to help offtakers manage that risk. One way a solar PV project can address imbalance risk is to co-locate or otherwise integrate some form of energy storage that can then be used by the

generator to smooth out its electricity output, provide some coverage of evening peak periods or even generate additional revenues through the provision of ancillary services. Batteries allow solar projects to store up any excess energy produced during periods of high generation but low demand (for example, on a warm sunny day) and export this to the grid during more profitable periods of higher demand. With such enhanced output flexibility a generator is able to much better shape risk, and potentially even offer an output guarantee to buyers, which would make PPA offerings far more attractive to such offtakers as well as helping improve the general bankability of the solar project. We are also increasingly seeing hybrid forms of renewables in direct wire corporate PPAs such as in emerging markets, enabling a smoother and more predictable output profile.

This behind-the-meter approach to co-location of battery storage with solar PV is still at a relatively early stage of implementation, but there have been many recent technological improvements, falling costs and growing investor interest, including the emergence of specialist battery storage funds.

### Buyer demand side response

As well as the generator smoothing its output profile through the use of storage

technologies etc., buyers and direct offtakers too can shape imbalance risks by either increasing or decreasing their demand to match the output profile from the solar PV site they are contracting with. This will obviously only be practical and attractive to certain offtakers, but large industrial consumers are already using smart technologies to optimise their energy usage to when power is cheapest or renewable power is more available. A logical extension of that trend is buyers adapting so that when, for example, a generator signals that there is lower generation than expected or that the grid faces an imbalance, then the buyer can either switch off non-urgent equipment or bring online its own behind-the-meter storage options. Such strategies could allow a corporate buyer to manage all or even just part of the shape risk itself, potentially resulting in more attractive pricing options under its PPA arrangements. ■

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# Introduction



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

For this first edition of 2023, I'd like to thank everyone that worked with us to make 2022 so memorable.

First and foremost, you, the readers, but also all the great companies, organisations, experts and individuals that have contributed to helping us bring you the news, blogs and insights that we're proud to deliver throughout every year.

Figures just in for 2022 show that the US and UK markets have had another record-breaking year for battery storage deployment, and we're excited to see other markets around the world either coming back to life or emerging into greater maturity.

At the same time, 2022 was obviously a memorable year for many of the 'wrong' reasons too, including war and worsening climate crisis conditions. For the industry, challenges to the supply chain were among obstacles that needed to be overcome.

Still, the resiliency of the clean energy industry can be seen in the enormous steps it has already taken in the right direction, and there is a sense that at least on some of the major issues, governments are listening to stakeholders on energy storage.

In the previous edition, Julian Jansen and Lars Stephan from Fluence talked about Europe's Electricity Market Design: the role energy storage and other flexibility resources can play on the grid, and how that can be value and captured through market reforms.

This time out, Naim El Chami and Vitor Carvalho of consultancy Clean Horizon offer a deep dive into the

evolving business models for energy storage in Europe, taking the examples of some leading regional markets.

It's a fascinating look at how, from capacity mechanisms to tenders for renewable energy with co-located energy storage, different opportunities for storage are already present. In years to come it will be even more fascinating to see how the business models today compare to what comes into place as that Electricity Market Design piece progresses.

Across the pond, we have an interview with someone very much in the public spotlight, solar industry veteran, clean energy investor and sometime podcast co-host Jigar Shah. Shah speaks with Energy-Storage.news reporter Cameron Murray about his role at the US Department of Energy's Loan Programs Office and how its billions of available loans could move the needle to effect positive change.

Cameron also writes in this issue about physical security of battery storage projects. With cybersecurity often the top of peoples' concerns, physical security is something you might not have considered important. However, as the article shows through interviews with experts, it's likely to become a growing concern as the industry grows too.

Finally, while New York has long been considered a fertile energy storage market waiting to take off, it hasn't. With a 6GW storage deployment target by 2030 in place, that needs to change rapidly. My article in this edition looks at how the state's Energy Storage Roadmap 2.0 could be the catalyst for that change, especially as it pertains to grid-scale energy storage.

**Andy Colthorpe**  
Solar Media



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## US' tax credit incentives for standalone energy storage begin new era

The Inflation Reduction Act's incentives for energy storage projects in the US came into effect on 1 January 2023.

Standout among those measures is the availability of an investment tax credit (ITC) for investment in renewable energy projects being extended to include standalone energy storage facilities.

Alongside the rest of the act's US\$369 billion package of climate spending, the change has been forecast to transform the US clean energy industry, bringing certainty for investment into deployment as well as manufacturing.

Previously, storage projects were only eligible for an ITC if paired directly with solar PV and the storage system charged directly from the solar.

## Lithium battery pack prices up for first time in annual survey

Lithium-ion battery pack prices have gone up 7% in 2022, marking the first time that prices have risen since BloombergNEF began its surveys in 2010.

The finding that average pack prices for electric vehicles (EVs) and battery energy storage systems (BESS) have increased globally in real terms to US\$151/kWh confirms the consequences of what the industry has been confronted with in recent months. It follows years of consistent declines of close to 10% every 12 months.

It comes just two years after the research group reported finding pack prices at sub-US\$100/kWh benchmarks and made a prediction that averaged costs would fall to US\$101/kWh by 2023.

In fact, from 2010 to 2021, average costs fell by 89%, to US\$137/kWh across the EV and stationary battery storage markets worldwide. Last year, the drop was just 6%, to US\$131/kWh.

## Tesla deployed 6.5GWh energy storage in 2022

Energy storage deployments by electric carmaker and tech company Tesla grew 64% year-on-year, reaching 6.5GWh in 2022.

Tesla's fourth quarter 2022 financial results showed increases in both its solar and energy storage deployments for the quarter as well as for the full year.

The company combines the technologies in its revenue figures, making it difficult to assess the relative performance of each segment, but the total equated to US\$1,131,000,000 for the previous quarter versus US\$688 million in Q4 2021 for its energy generation and storage activities.

On a quarterly basis storage deployments went from 978MWh in Q4 2021 to 2,462MWh in Q4 2022, a 152% increase.

## EU announces its own 'Inflation Reduction Act' for renewables and energy storage

The European Union (EU) has unveiled its plans for its own Inflation Reduction Act-style support package, the Green Deal Industrial Plan, for clean energy technologies including energy storage.

Senior policymakers raised concerns that the US' recent US\$369 billion investment plus incentives package for both upstream and downstream renewable energy sectors was taking potential investment away from Europe.

"It is no secret that certain elements of the design of the Inflation Reduction Act raised a number of concerns in terms of some

of the targeted incentives for companies," von der Leyen said.

In response, the bloc has a new "...plan to make Europe the home of clean tech and industrial innovation on the road to net zero."

## Southeast Asia's biggest battery storage project officially opened in Singapore

Singapore has surpassed its 2025 energy storage deployment target three years early, with the official opening of the biggest battery storage project in Southeast Asia.

The opening was hosted by the 200MW/285MWh battery energy storage system (BESS) project's developer Sembcorp, together with Singapore's Energy Market Authority (EMA).

The BESS is located on 2 hectares of land on Jurong Island, which is heavily industrialised and features much of Singapore's energy generation and infrastructure.

It is equipped with lithium iron phosphate (LFP) battery cells in 800 separate containerised units, and will be used to help balance the supply and demand of electricity on the grid, and for various ancillary services.

With just one project, EMA has achieved and exceeded Singapore's deployment target of 200MWh of energy storage by 2025.

## Europe's largest transmission-connected BESS begins 'world first' reactive power services contract

A battery storage system in the UK has begun delivery of reactive power services to the grid in what has been claimed as a world first contract of its kind.

Developer-investor Zenobe Energy also said that its 100MW/107MWh battery energy storage system (BESS) in Capenhurst, Chester, is currently the largest battery project directly connected to the transmission grid anywhere in Europe.

Zenobe began construction on the project in June 2021, having secured a financing deal with partner Santander. The pair began working together on other deals in 2019.

The BESS will reduce the amount of curtailment of renewable energy, particularly wind, in the Mersey region of north-west England where it is located, as well as reducing the amount of gas-fired generation needed to balance the supply and demand of electricity.



Zenobe Energy's 100MW/107MWh BESS at Capenhurst, UK.

Credit: Zenobe Energy



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# Evolution of business models for energy storage systems in Europe

**Markets and revenues** | Europe's energy networks are united in their common need for energy storage to enable decarbonisation of the system while maintaining integrity and reliability of supply. What that looks like from a market perspective is evolving, write Naim El Chami and Vitor Gialdi Carvalho, of Clean Horizon.

## New opportunities emerge to offer stable revenues as the need for storage is rampant

As markets gain in complexity and require extensive trading measures, some opportunities such as capacity auctions and storage-related tenders help ensure a "stable" revenue that supports financing decisions and mitigates market risks.

### 1. Capacity mechanisms help solve the missing money problem for generating assets while pushing towards energy decarbonisation

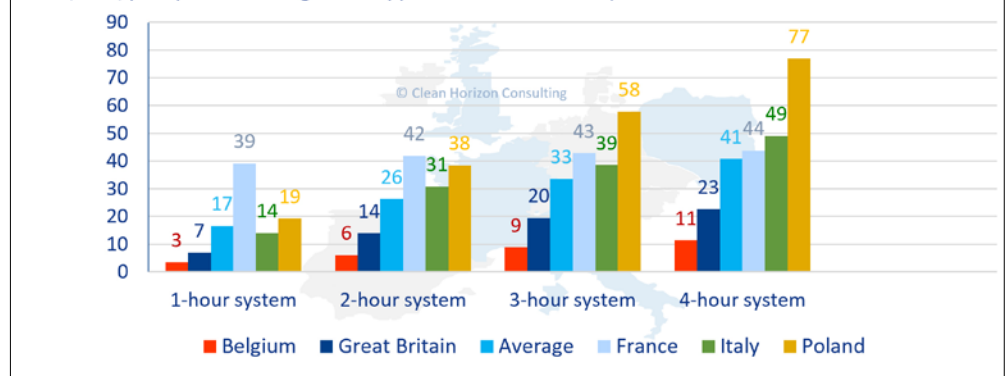
In order to support their decarbonisation efforts while maintaining adequate capacity thresholds to ensure power system security, diverse countries such as Italy, the United Kingdom and Poland (among many others) have created capacity mechanisms.

As most of the revenues for large generating assets operating in a liberalised market come from wholesale energy markets (often led under the pay-as-clear mechanism), expensive thermal peakers are progressively being pushed out of the selection thresholds. As such, these assets risk going out of business due to the lack of sufficient revenues, jeopardising system security.

That is why capacity markets aim to solve this 'missing money' problem by providing revenues to new and existing generating capacity without interfering with the wholesale markets by ensuring:

- An additional revenue stream to wholesale revenues via a capacity payment (TSOs are not allowed to interfere with the energy markets)

**Battery system remuneration for the last available auction held in the corresponding country**  
In k€/MW/year (with de-rating factor applied for each duration)



**Figure 2. Available payment for a storage system under several capacity markets**

- Visibility through long-term contracts for investors.

In the last few years, energy storage systems gained traction within many European markets and became eligible in capacity markets of several states such as: France, the United Kingdom, Belgium, Italy and Poland.

Often called "limited energy reservoirs", energy storage systems are characterised by finite capacity limits and have their limitations when compared to generation assets such as thermal or hydro power plants. That led to the establishment of "de-rating factors" that are used to assess the capacity value of a generating unit by calculating the expected amount of time for which a unit will be available to generate electricity and reduces the unit's capacity value accordingly.

These de-rating factors differ among countries based on their own system safety margins and are often indexed on the discharge duration of the energy storage

system (the higher, the better). The table below represents common de-rating factors that were applied in some of the latest capacity auctions in the abovementioned countries:

Among others, the Polish and Italian markets have been gaining remarkable interest from storage developers as they offer long-term capacity contracts for hefty annual payments, which eventually supports final investment decisions in their project.

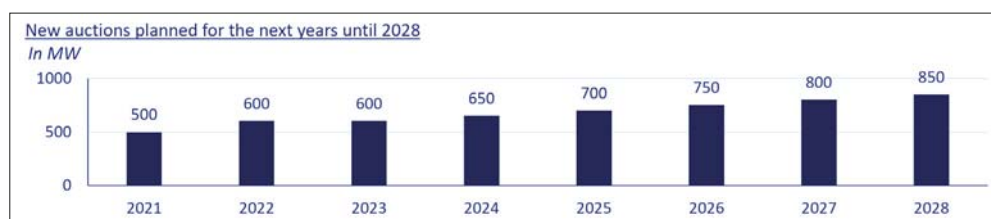
For example, the two latest Italian capacity auctions offered 15-year contracts to new-build assets with an annual capacity payment of €75,000 (US\$79,150) /MW/year (2019 auction for delivery in 2023, without de-rating) and €70,000/MW/year (2022 auction for delivery in 2024, without de-rating). Actual de-rating factors vary on a regional basis depending on specific capacity and system needs. Figure 2 above represents the typical capacity remuneration in different countries based on the last capacity auctions (as of January 2023).

**Figure 1. Common de-rating factors for some European capacity markets**

	De-rating factor (%) per discharge duration				Comment
	1-hour system	2-hour system	3-hour system	4-hour system	
France	85%	91%	93%	95%	-
Great Britain	19.96%	40%	56%	65%	T-4 2025/2026 auction
Belgium	11%	19%	28%	56%	T-4 2025 auction
Italy	10 – 30%	30 – 50 %	50 – 60 %	60 – 80 %	Values differ on a regional basis
Poland	24%	48%	71%	95%	Main T-5 2027 auction

**2. Renewable-plus-storage auctions as a means to accelerate the energy transition**  
**German Innovation Tenders** – In 2021, Germany's Federal Network Agency (*Bundesnetzagentur*) launched Innovation Tenders that provide developers with fixed





**Figure 3. Volumes of Innovation Tender auctions out to 2028**

Company size	Small	Medium	Large
Expenses associated to hybrid renewable-plus-storage systems located in the mainland	60%	50%	40%
Expenses associated to hybrid renewable-plus-storage systems located in island territories	65%	55%	45%

premiums on energy injected onto the grid for a period of 20 years to encourage renewable-plus-storage deployment throughout the country. This tender is set to occur on an annual basis with an expected procurement of 5,450MW of total capacity by 2028.

Under this process, battery storage systems must be charged from the renewable asset and need to have the ability to provide aFRR (automatic Frequency Restoration Reserve) services (with no obligation to participate in aFRR). In terms of sizing, the storage system needs to have the ability to provide 25% of the aFRR capacity in the upwards direction with a 2-hour discharge duration.

Namely, a total of 258MW of solar-plus-storage projects have been awarded in May 2021 and 155MW in August 2021. The average fixed premium was at €43/MWh with values between €33/MWh and €49/MWh.

#### Spanish Innovative Hybrid Tender for renewable-plus-storage projects –

Launched on 18 January 2023 with an expected conclusion on 20 March, this tender is set to provide new flexibility sources to the Spanish grid while deploying renewable energy assets. Eligible energy storage systems must be larger than 1MW or 1MWh with a minimum discharge duration of 2 hours. The storage-to-plant capacity ratio (in MW) must be larger than 40% and smaller than 100%.

Selected entities will benefit from grants of up to €15 million per project and €37.5 million per company. The grant value will be assessed based on the company size, location and a series of evaluation criteria.

#### As energy storage systems become less expensive and competition grows, trading strategies gain in complexity

Until recently, European energy storage systems relied on “traditional” revenues that were mostly reliant on frequency control services such as the Frequency Containment Reserve (FCR) in countries like France or Germany.

In some cases, arbitrage revenues were also considered as an additional revenue – even though their impact on project profitability has been somewhat limited over the past few years, especially before the start of the Russo-Ukrainian War and the tensions that hit the energy markets.

However, the ever-growing competition among market players has pushed towards more complex trading strategies that aim to capture a maximum of revenues – both existing and new.

The following parts of this article will showcase the opening of the secondary reserve market under the PICASSO project in central Europe taking Germany’s case as a reference point. The final part will present an illustrative example that demonstrates a more-complex market participation strategy in the United Kingdom.

**Figure 4. Map of the PICASSO implementation timelines**



#### 1. The secondary reserve market: a new opportunity to storage systems

Frequency control reserves are crucial in order to maintain system stability by countering frequency drifts then restoring it to normal levels. Among these services is the automatic Frequency Restoration Reserve (aFRR), which has witnessed an overhaul over the past few years under the ENTSO-E’s PICASSO (*Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation*) project.

Across Europe, 26 states have already expressed their interest in joining the PICASSO platform with each having its own timeline, presented in the image below.

The German aFRR market has been mutualised with Austria and Czech Republic countries via the PICASSO platform since June 2022, making these nations the first to implement the new market reform.

Hence, the rest of this section will present the German case as an illustration of the new aFRR market.

#### Presentation of the new aFRR procurement mechanism

The main goal of the PICASSO platform is to create a common aFRR activation environment that will allow all member states to solicit assets from other countries – an approach that is similar to the now-mature FCR Cooperation.

This platform does not interfere with local pre-qualification or selection rules for “reserved” capacity but rather sets a clearer process and a mutualised one for activations. So, prequalification processes and capacity reservation will be at the charge of the national TSO while activation will be done at the European level.

The aFRR provisioning is remunerated via two market mechanisms:

- **Capacity reservation** bids to reserve assets. Capacity reservation is not symmetrical, meaning that two bids are possible for an energy storage system:
  - o aFRR UP (or positive): to help counter an under-frequency event
  - o aFRR DOWN (or negative): to help counter an over-frequency event
- **Energy activation** (UP and DOWN) bids in real time to remunerate the energy injected or withdrawn from the grid by the energy storage system.

#### aFRR reservation

On the **national level**, every prequalified asset can place a capacity bid (in € per MW per 4 hours) for up to six four-hour slots and for the UP, DOWN or both directions. This

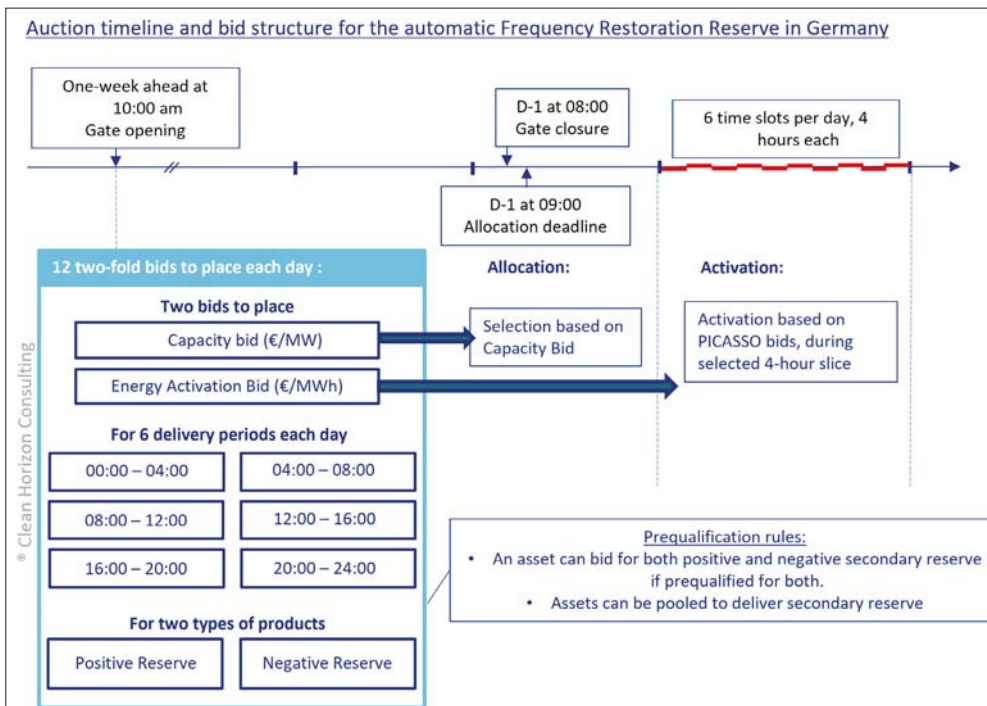


Figure 5. aFRR auction timeline.

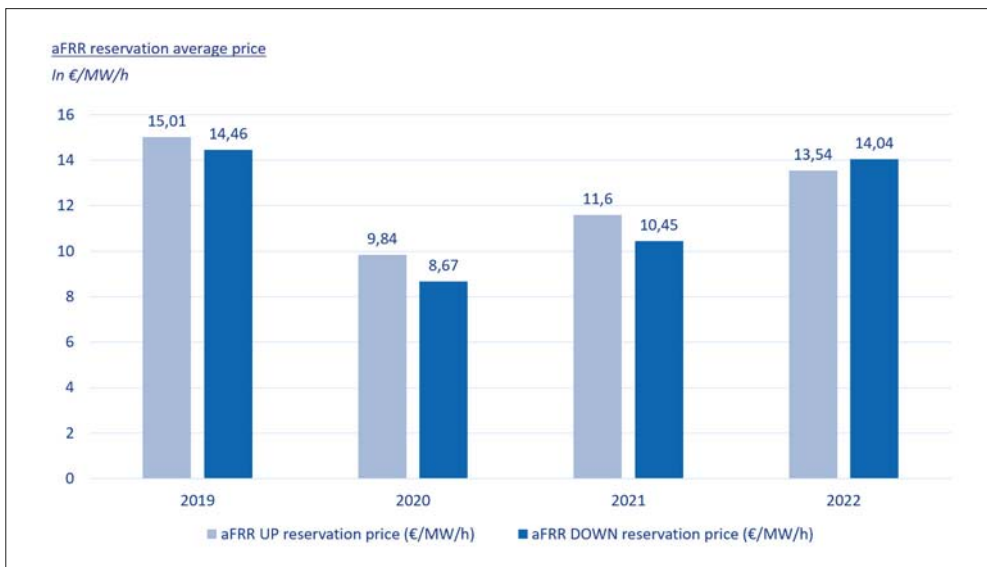


Figure 6. Average aFRR reservation price.

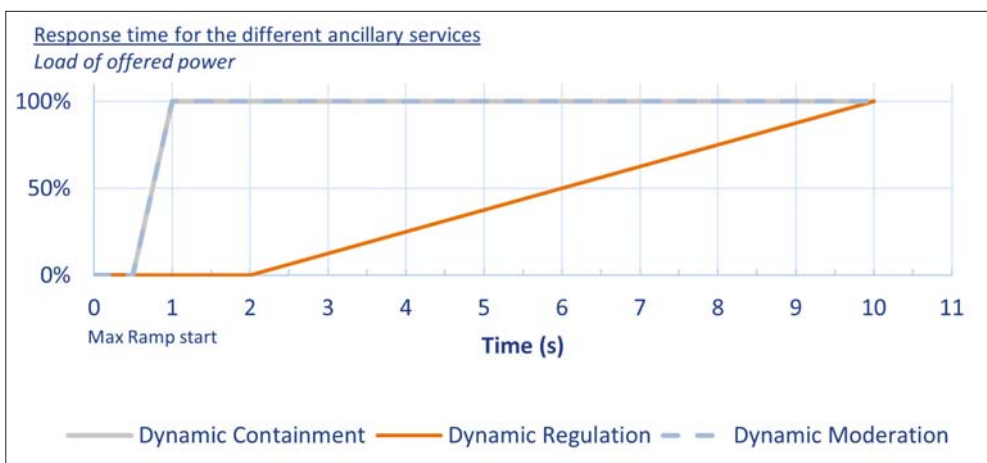


Figure 7. Response times for the DR, DC and DM services in the UK.

asset may or may not get “reserved” based on the local transmission system operator’s (TSO) specific selection process (pay-as-bid in this case).

The following image presents the typical auction timeline that is developed under the updated aFRR procurement framework.

While the aFRR marginal reservation prices have remained quite stable over the past four years (2019 – 2022), the average ones have witnessed spike since the end of 2021 following a previous decline between 2019 and the start of the energy crisis.

On a **supra-national level**, reserved assets can be activated via the PICASSO platform over a pay-as-clear process that is based on activation prices that each bidding asset placed simultaneously with the capacity bid.

Figure 6. shows the rolling average over seven days for the aFRR PICASSO historic prices since May 2022 when the PICASSO platform was launched. As the prices have a 4-second step, the 7-day rolling average is the method to show trends in both markets.

On delivery day, the PICASSO energy activation bid gate closes 25 minutes before delivery, which gives storage owners an interesting opportunity to review their bids based on current market conditions and the asset’s state of charge.

Relying on a high-level approach, the average activation price over 15-minute timeslots can help assess the average daily spread. As such, Since the launch of the PICASSO platform on May 1st 2022, **the average German daily spread on a 1-hour basis is €760/MWh**. Assuming a BESS does one cycle per day over a year, it can generate a revenue of €235,000/MW<sub>aFRR</sub> so a revenue of €115k/MW<sub>installed</sub>/year assuming an efficiency of 85%.

## 2. As the competition gets bolder, intri-cate market participate strategies become essential

According to the Clean Horizon Energy Storage Source (CHESS database), there is more than 1.7GW of operational utility-scale battery storage in the United Kingdom, which makes it the undeniable leader in Europe.

In addition to the insular state of the national grid, the increasing penetration of renewables has created a lack of inertia, which eventually resulted in the launch of a fast frequency regulation product called Enhanced Frequency Response (EFR) back in 2016.

The fleet of products of National Grid has

	Rated Power (MW)	Energy Capacity (MWh)	Commissioning Date
Battery 1	41	41	22/01/2019
Battery 2	50	50	23/06/2021

<sup>1</sup>Data obtained in order to perform this comparison was obtained from open sources such as <https://data.nationalgrideso.com/> and <https://www.bmreports.com/bmrs/?q=help/transparency>

since changed and three new products are currently being procured by National Grid as part of the frequency response:

- **Dynamic Containment (DC) low and high** procured since 15th September 2021
- **Dynamic Regulation (DR) low and high** procured since 9th April 2022
- **Dynamic Moderation (DM) low and high** procured since 6th May 2022

The goal of these products is to provide a fast reserve to stop frequency drifts, as it is shown in the image above with the time activation for each one.

These services are activated in response to any deviation in the grid's frequency and are called differently based on the magnitude of the deviation. For Dynamic Containment and Dynamic Moderation, the maximum ramp start must occur at 0.5 seconds. For Dynamic Regulation, it must start at 2 seconds.

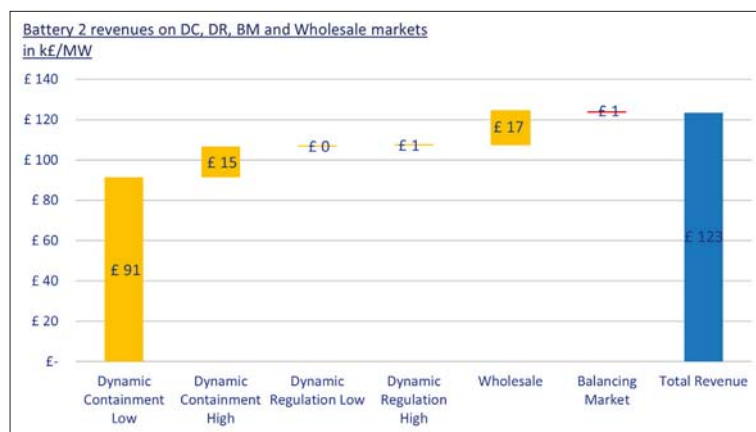
Besides the above mentioned services that are accessible to energy storage systems and could prove to be quite lucrative, other revenue streams remain accessible and worthy of the attention of storage owners:

- The Day-Ahead Energy Market
- The Balancing Market
- The Capacity Market (through T-4 and T-1 auctions)

That being said, unique trading strategies have been advanced by several developers and route-to-market players in order to optimise accessible revenues.



**Figure 8: Revenue stack of battery**



**Figure 9: Revenue stack of battery 2**



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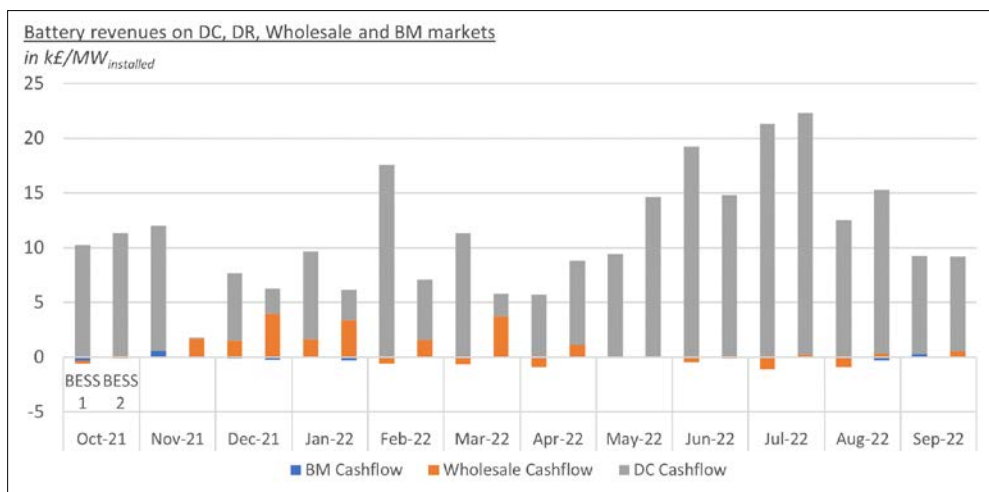



Figure 10: Monthly revenue stack for the two batteries

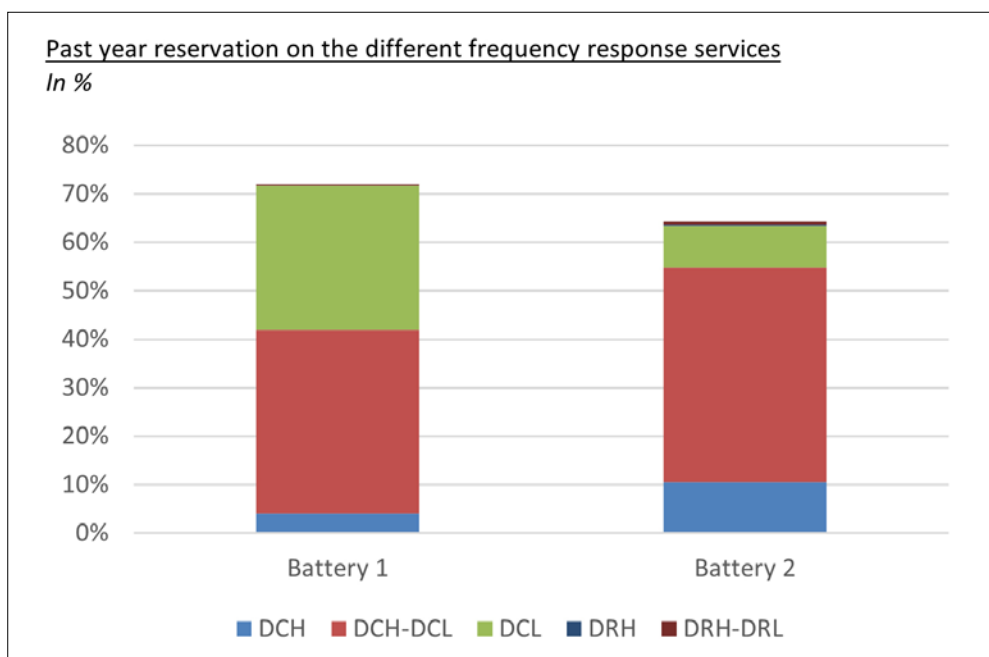


Figure 10: Percentage of participation of both selected batteries in the different frequency response services

### Business case for two typical UK projects

The revenues of two battery storage projects over the period between October 2021 and September 2022 were analysed in the following section. These two batteries' parameters are the following<sup>1</sup>:

Over the period between October 2021 and September 2022, Battery 1 and Battery 2 generated a total of 5.8 million £ (141,000 £/MW) and 6.2 million £ (123,000 £/MW) respectively. The stacking of revenues from the different markets is slightly different between the two batteries, however the main revenues are generated in the dynamic containment low market (86% and 74% of the total revenues for Battery 1 and Battery 2 respectively).

The two figures below show the revenue stacks for the batteries over the past year:

The wholesale revenue might be under-

estimated, because the traded energy in the wholesale market (day-ahead and intraday) is publicly available, but only the day-ahead prices are available. Therefore, the wholesale revenue was calculated assuming all the energy was traded in the day-ahead market.

Figure 9 above shows the stacking of monthly revenues for the two batteries:

Battery 1 is adopting mainly a full Dynamic Containment strategy, except for the months of November, December and January where the battery generates a more important revenue from arbitrage compared to the other months. These months correspond to the months with highest daily spreads over the analysed period. During these months, Battery 2 has generated more revenues from the wholesale markets than from the Dynamic Containment markets. However, the overall generated revenue per MW is lower than

the revenue generated by Battery 1 on the Dynamic Containment market.

This figure shows that both selected batteries have both been very active on the DC service over the past year. It can be noticed that the Battery 2 has been regularly providing a symmetric frequency response service where Battery 1 has more often participated in DC low alone.

This analysis of the different batteries in Great Britain shows two things:

- Strategies for each asset are very different, even within the portfolio of a single route to market player. This can be explained by different cycling constraints, degradation guarantees, and strategies desired by project owners.
- Some route-to-market players show clear strategies of exploiting frequency response revenues as much as possible, while others prefer diversified strategies that include the wholesale and balancing markets.

### Authors

Naim El Chami is Training Manager and Senior Energy Storage & Hydrogen Analyst at Clean Horizon. His main expertise covers market and regulatory analyses, techno-economical and financial assessment of energy storage and hydrogen systems as well as the management of GWh-scale procurements. Naim completed two Engineer's degrees at CentraleSupélec (Energy Conversion) and Saint Joseph's University (Electromechanical Engineering). He also obtained a Master's degree in energy market regulation, design & economics from Paris Dauphine University and École Polytechnique.



Vitor Gialdi Carvalho holds degrees in Energy and Mechanical Engineering from the Federal University of Rio Grande do Sul in Brazil and École des Mines, Paris. As an optimisation support and market analyst at Clean Horizon, Vitor uses his expertise to support the company's operations. He has participated in the sizing of energy storage projects in various regions including Africa, Europe, and the Middle East. Vitor is also actively involved in the writing of Clean Horizon's monthly analyst note "Update from The Field". Founded in 2009, Clean Horizon is a consultancy fully dedicated to energy storage with offices in Paris, France and Miami, US. Clean Horizon offers a wide variety of services spanning from market & regulatory analysis to technical consulting and project procurement.



# Jigar Shah on US battery ecosystem, recycling and reuse, the EU's IRA response and the waning dominance of lithium-ion

**US |** Cameron Murray caught up with Jigar Shah, Director of the US Department of Energy's Loan Programs Office and one of the most influential figures in the US executive department's drive to build out clean energy technologies.

**T**he Inflation Reduction Act and its US\$369 billion package of support and incentives for the US' clean energy industry has already had a huge impact on the market just six months on from its passing.

As director of the Department of Energy's Loan Programs Office (LPO) with responsibility for up to US\$100 billion in loans and more in other forms of support, Jigar Shah is one of the senior figures in enabling the US' scale-up of its clean energy technology sectors.

In this interview he discusses the broad trends he is seeing, sustainability in the battery sector as well as Europe's reaction to the level of state intervention the Act entails. With decades of experience in the clean energy sector, we also got his thoughts on when lithium-ion would be displaced by the numerous new chemistries, arguably the hottest topic in energy storage at the moment.

## US\$100 billion-plus in loan requests

The LPO, which Shah has headed up since March 2021, had at last count US\$120 billion in loan requests covering all energy sectors. Within that, 'Advanced Vehicles & Components' which includes EV battery manufacturing, is the biggest single sector, potentially accounting for US\$20-30 billion based on LPO infographics. Storage, which includes all non-lithium forms of energy storage, could easily account for another US\$5 or US\$6 billion.

This shows how much emphasis is being placed on the battery sector and the EV market that is driving it. Shah says that the country is already on track to achieve its stated goals here.

"It's now a foregone conclusion that we will achieve this administration's goal of 50% of vehicles being EVs by 2030. We've counted at least 800GWh of battery

manufacturing being announced which is how much you need to hit that target. The trends started before my time in office but have certainly ramped up in the last few years," he said.

Recent loans sanctioned by Shah include US\$197 million for ICL's LFP cathode material plant in St Louis, US\$700 million for the Rhyolite Ridge lithium carbonate processing project in Nevada, US\$2.5 billion to Ultium Cells for its three lithium-ion gigafactories and another US\$2 billion to Redwood Materials for its closed loop cathode and anode material production facility in Nevada.

Alongside the upstream investments needed to deploy the adequate capacities of renewable energy and EVs for the transition, a lot of attention is also being placed on ensuring the sustainability of the battery sector, a stick often used to beat the technology by opponents.

*Energy-Storage.news* has written extensively about recycling and reuse of EV batteries in second life energy storage systems (ESS). Recycling appears to be much further ahead from the standpoint of coming to the LPO for loans to commercialise, although Shah is keen to emphasise the department has no preference.

"Battery recycling is represented in our loan requests. The vast majority of second life companies that we've talked to are still in the beta testing phase, and coming to us is really the last step of commercialisation," he said.

"What's important to highlight is that the US government, unlike other governments, does not favour any particular technology. We want both sectors to give it a go as long as they can raise private capital. The LPO is government-enabled but private sector-led."

The LPO is probably most well-known for two big name companies it backed,



Jigar Shah.

Credit: Miljøstiftelsen ZEPH.

with very different outcomes. One is Tesla which now regularly ranks in the top most valuable companies globally. The other is Solyndra, the now-defunct California-based thin film solar cell company which received over US\$500 million in LPO loans by 2009 only to file for bankruptcy two years later.

Shah has pointed out in other interviews that at the time, the LPO office had 12 people, and is now at over 200, but that in order to meet its climate goals it will nonetheless need to take "real risk".

The LPO has a failure rate of around 3.3% for its loans, about in line with a commercial bank, Shah has pointed out in other interviews. Unlike a commercial bank, however, the LPO lends at US treasury rates and has a tenor of over a decade.

## Response to European policymakers complaints

The DOE recently trumpeted the fact that US\$92 billion has been invested in the US battery supply chain in the two years since President Joe Biden took office. Although much of that pre-dates the Inflation Reduction Act's passing in August 2022, the US'



planned battery manufacturing capacity growth has been double Europe's since the Act was passed in August 2022, according to data from Benchmark Mineral Intelligence.

That came after years of Europe surging ahead of its North Atlantic neighbour, and the change in fortunes has ruffled feathers there. Senior European policymakers called in late 2022 for immediate action to prevent an outflow of investment from its battery ecosystem. Those calls resulted in Europe's response to the Act, its Green Industrial Plan, revealed in February 2023.

Shah's view on this minor war of words is clear: "Several years ago the European Union was demanding that the US get in the game and be more aggressive on climate change. Now that we're being more aggressive, people might not be used to that."

"The US has been in the innovation business on climate change for years but now it's firmly in the commercialisation business, and that is only a good thing."

### Lithium-ion's dominance of the market

The discussion naturally moved on to what battery chemistry these billions of investments should be going towards. Senator Tim Manchin, whose about-turn was pivotal in getting the Act passed, recently urged more investment in non-lithium energy storage technologies.

The vast majority of even new gigafactories are set to build lithium-ion batteries to serve the EV and, to a lesser extent, ESS

### A lithium-ion gigafactory from Ultium Cells in Tennessee, which has received a US\$2.5 billion LPO loan for its three US projects

markets. This is largely reflected in the DOE's financial support, whether it's lithium-ion battery projects receiving all of the US\$2.8 billion in grants from the bipartisan Infrastructure Investment and Jobs Act (IIJA), or the vast majority of the LPO loans approved being for lithium-ion-related projects.

Shah is nonetheless confident that the technology's dominance will start to wane in the downstream grid-scale ESS market soon.

"Lithium-ion NMC batteries will not dominate forever. The amount of innovation in the battery space is so high that it is hard to see any of the existing incumbent technologies in their current form having dominant market share in 7-10 years. It could be sodium-ion, it could be solid-state technologies, I don't know who's going to win," he says.

"But I do think that the automotive industry will price out the utility-scale industry in lithium-ion, so you will see a rapid shift away from lithium-ion in the utility sector towards other chemistries, which is happening as we speak."

The non-lithium battery storage sector has yet to take off in a substantial way in the ESS market. An increasingly diverse set of buyers of flow batteries and other chemistries is starting to emerge, but lithium-ion remains the technology of choice for nearly all large-scale projects including those being launched today.

Part of this is due to non-lithium chemistries' higher upfront cost and part of it just down to having less of a track record than lithium-ion, highly relevant for utilities who

are rightly and highly risk-averse. However, Shah thinks a ramp-up in their manufacturing capacities is inevitable.

"When I talk to people on my side, they're saying that they're being quoted two year wait times to get (lithium-ion) batteries. So if they want to build their project sooner, they're going to have to switch to a different chemistry."

"Going for a non-lithium chemistry is more certain in the long run. If you're a utility company, and you're bidding on these new projects, do you believe the tightness in the lithium-ion market is going to get better or worse over the next three years? It's not hard to ramp up a non-lithium battery technology to move faster, but it does require you to make a commitment."

To be able to make those commitments, however, non-lithium-ion battery manufacturers need to know they will have willing customers. This chicken-and-egg conundrum should wane over the coming 12 months, Shah says, as companies broadly start to secure customer orders in the 1GWh-plus range.

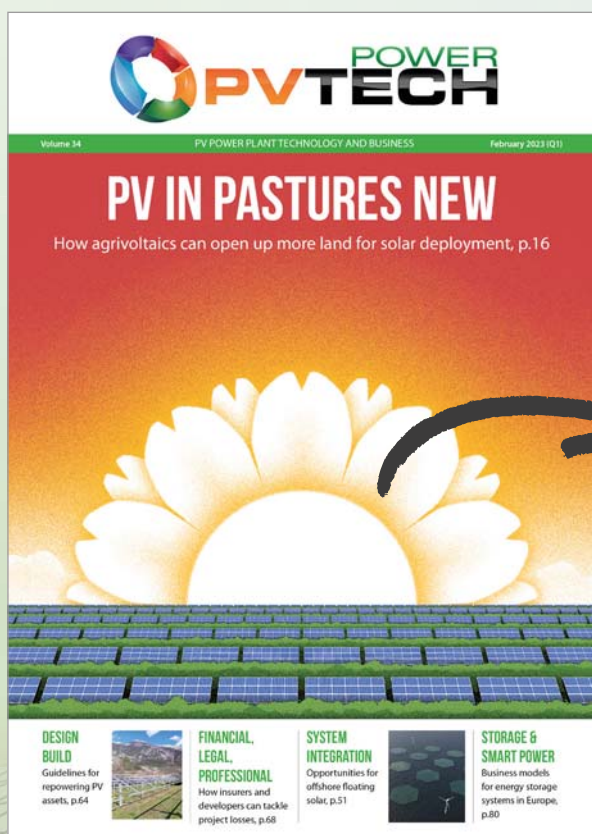
"And then they'll have three years to prove that they can reduce costs. And if they can, then they'll have a permanent advantage over time. And if they can't, then at some point, people will decide to overbuild lithium battery technology to meet their needs."

*Energy-Storage.news* is only aware of four non-lithium energy storage firms that have achieved this: EnerVenue (nickel-hydrogen), Form Energy (iron-air), Eos Energy Enterprises (zinc) and Ambri (liquid metal). ■





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# Hunting the 'missing money' in New York's energy storage market

**New York** | It's often considered among the leading US states for energy storage, but to date this reputation New York enjoys has been based more on ambition and favourable policy direction than action. Andy Colthorpe hears why this is expected to change in the next couple of years.



Credit: Key Capture Energy

**"N**ew York, New York," goes a popular song from 1978: "so good they named it twice".

Energy storage industry observers may have been reminded of those words in early 2021 when New York governor Kathy Hochul doubled the state's energy storage target from 3GW to 6GW, to be achieved by 2030.

That upping of the target set under Hochul's predecessor Andrew Cuomo is in line with the New York Climate Leadership and Community Protection Act (CLCPA) and its goals, which include achieving a carbon-free electricity system by 2040.

Along the way, 6GW of distributed solar PV will be installed by the end of 2025, 70% of New York's electricity will come

from renewables by the end of the decade, and offshore wind will grow to 9GW by 2035. Ultimately, net zero emissions will be achieved by 2050, should all go to plan.

It's also important to note the relevance of the 'Community Protection' part of the legislation, which was enacted in 2019. Along with standards on labour and job protection, and stimulating the statewide economy, there is a strong intended environmental justice aspect to the CLCPA.

New York's fleet of thermal power plants includes about 6GW of peaker plants, often the most polluting to run among fossil fuel assets – and some of New York's peaker plants run on kerosene or heavy fuel oil, which are even dirtier than natural gas. Those were often built in poorer areas of

**Key Capture Energy's KCE NY 1 project, New York's first grid-scale BESS.**

New York City, which also housed many communities of colour.

Towards the end of 2022, the New York Climate Action Council, convened to oversee the CLCPA's implementation, published its Scoping Plan. This was followed by the publication of the long-awaited Energy Storage Roadmap 2.0 by the New York State Energy Research and Development Authority (NYSERDA) and the state's Department of Public Service, which set out how that 6,000MW energy storage target will be achieved.

Due largely to its favourable policy landscape, New York has sometimes been grouped among the US' leading states for energy storage. However, unlike the leaders Texas on roughly 2GW and

California with double that for cumulative grid-scale installations, New York only had just over 116MW, albeit 1,230MW had been awarded or contracted for already by the end of 2021.

So, what has held New York back? And can Roadmap 2.0 put it into the fast lane?

### ‘Missing money’

One answer to the first question above is “missing money”, according to CEO Jeff Bishop of energy storage developer-owner Key Capture Energy.

“We’ve been developing in New York state since 2017, and we have a portfolio of about 1,000MW of projects that are under development there, including two projects that are currently in operation, KCE NY1, KCE NY 3, [and] we have one that is at the very end of construction now,” Bishop says.

“For the rest of the state, the key question has been: how do you get the missing money? Where New York doesn’t have the volatility of a market like Texas and so hence, there’s not really the same value proposition there is down in Texas.”

However, with its goals under the CLCPA, New York will need storage, and lots of it, to integrate all the new solar, wind, enable the retirement of fossil fuel plants and so on.

Regular readers of *Energy-Storage.news* will have seen that a key component of Roadmap 2.0, as it pertains to utility-scale energy storage – or ‘bulk storage’ – as the state defines it, is the planned introduction of tenders.

Those solicitations are still at the proposal stage, require regulatory approval and may change before being rolled out, but they appear likely to be an effective way to structure a market for battery storage, Bishop says.

“We really think that after this goes through all of the regulatory processes, and once they start issuing requests for proposals (RFPs), that this will be a way that we’re going to be seeing storage really taking off in New York State by 2025.”

### Market design

KCE NY 1 was New York State’s first-ever grid-scale battery energy storage system (BESS), and the 20MW project was also among the few to avail of the Market Acceleration Bridge Incentive Program. KCE NY 6 will also get those dollars, but it is understood that of the US\$130 million of funding available, only a fraction has been taken up.

That’s largely due to the cost of construction rapidly going up in the past couple of

years, says Bishop. There were also other challenges, and the Roadmap 2.0 authors “did a lot of talking to industry to understand what the challenges were” to the deployment of bulk storage – defined as facilities of 5MW output or more – says Dr William Acker, executive director of trade association and technology accelerator New York BEST (NY-BEST).

“One is the uncertainty in the future independent system operator (ISO) market in New York State and the revenue uncertainty that goes with that. So, there was a desire to create a programme that created some further ability to reduce that risk,” Acker says.

The result of that is the proposed Index Energy Storage Credit (IESC) programme. Similar to a Renewable Energy Credit (REC) mechanism, developers bid a strike price into a state-led procurement, indicating the revenue levels they need to realise to make a project work economically.

This strike price is benchmarked against a reference price indicator set by the state, in other words a “mechanism to look at what the project can reasonably earn in the standard ISO markets for capacity and day ahead energy,” and then pays the developer the difference between reference and strike prices.

It preserves some of the best features of renewable energy procurement programmes, Acker says, keeping sufficient performance risk on the developers and encouraging their market participation.

The Market Acceleration Bridge Incentive Programme and Roadmap 1.0 (published in 2018) did help kick the market off, particularly for commercial and industrial (C&I) and community-scale, or what New York defines as ‘retail storage’. But Acker and NY-BEST applaud the state for recognising a straight incentive was not the best fit for bulk storage “...and crafting what we believe is a very good structure,” he says.

### Challenging timing

The Index Energy Storage Credit is the main mechanism to create some long-term certainty for developers, but at the same time, the Roadmap 2.0 enabled dispatch rights contracts to be signed for 15-year terms, versus 10 years previously, points out Vanessa Witte, senior energy storage research analyst at Wood Mackenzie Power & Renewables (WoodMac). That means an extra five years of contracted revenues before assets are put to play in whichever merchant opportunities are available.

“In other markets, you maybe don’t want that [longer contract] because you might want to be able to have ownership and dispatch rights taken back sooner rather than later. But I think in New York, where there just isn’t a tonne of volatility right now, and of course looking in the future, there’s all these different dynamics, increased load and increased volatility from solar, but still, overall wholesale prices are going to be decreased. The certainty of having a 15-year contract is still going to be a positive,” Witte says.

The big risk, and the big persistent challenge, is that of timing, according to the analyst. With NYISERDA unlikely to open up RFPs until 2024 at the earliest, it remains unanswered whether the state is able to hit its target in time.

Around 1.3GW to 1.5GW of the 6GW total target will be distributed retail or residential energy storage, but that still amounts to 4.7GW of bulk procurements that need to be made and delivered in time, with NYISERDA expected to start with 3GW of procurements in the first tranches.

The New York ISO market is “not an easy market to construct in,” and 2030 may be “cutting it close,” Witte says, observing that a couple of developer contacts have expressed that opinion. New York will get to its targeted 6GW and likely surpass it, “but when is that really going to happen?”

There has also been frustration, Witte says, that New York utilities such as Con Edison have not been procuring large volumes. RFPs issued have set prices that aren’t reflective of market value. That said, this is the sort of challenge the Index Credit has been created to solve.

One other immense boon for energy storage development is the passing of the Inflation Reduction Act (IRA). While there are many facets to that legislation, the introduction of the standalone energy storage investment tax credit (ITC) could unlock opportunities for New York developers.

With a densely packed urban environment in the south and large areas of rural land Upstate in the north, New York has few opportunities towards the city to build large-scale solar or onshore wind, but energy storage’s much smaller footprint could be accommodated.

That includes sites like existing or decommissioned thermal power plant sites, which would meet environmental justice requirements through repurposing to house energy storage. That has the extra economic benefit of triggering



Credit: Wikimedia user rhododendrites.



**Ravenswood Generating Station, New York's biggest thermal power plant, is being repurposed as a clean energy hub, including energy storage.**

adders for both state and federal incentives.

"Having that standalone tax credit is such a game changer, New York just lends itself so much to standalone energy storage," Witte says.

"There's definitely positivity, [but] there's just hesitation on the part of developers about whether they want to enter into that market, or do they feel like a different market's a little bit easier?"

### Developers keen despite uncertainties

"Companies like mine are attracted to states that have aggressive policies, and goals and that are backing those up with opportunities to have stacked revenue streams around energy storage," says Kelly Sarber, CEO of Strategic Management Group, a developer of more than US\$6 billion of US clean energy projects, and on the Board of Directors at NY-BEST.

New York doesn't quite have those fundamentals in place, with utility-scale storage only able to play into capacity and wholesale arbitrage markets, which "doesn't support building big merchant energy storage projects," Sarber says.

Sarber has been working with Hanwha Group subsidiary 174 Power Global on the only project to date to get a contract with Con Edison in New York so far, a 100MW/400MWh BESS in development at a former fossil fuel plant site.

Roadmap 2.0's proposals would help adjust prices to a level that can entice more developers into contracts, and the developer says Strategic Management Group is optimistic on that, but as Vanessa Witte says, there's a wait ahead.

One question that Kelly Sarber says is still unanswered around the Index Storage Credit is whether awarded projects can attach other revenue streams outside

of those contracted through NYISERDA's procurements.

"California and Texas are leading the nation in the deployment of energy storage, and it all has to do with the way that those markets are constructed, and developers are not afraid of risk," the developer says.

"You've got different revenue streams that are more predictable in those markets. You've got the benefits of energy storage being able to be monetised in those markets, to a degree that they're not currently being monetised in the New York market."

Nonetheless, Sarber has "probably 3,000MW incubating" in the New York market, with sites and substations acquired. In fact, as of April 2022, there was 12GW of energy storage in the NYISO interconnection queue, double the 2030 target.

That congested queue could however give the impression, or an "artificial comfort level" that achieving the goal will be relatively easy, due to a lot of developers seeing an opportunity coming, possibly with a view to flipping projects and selling them on.

New York's urban regions in particular mean expensive real estate, and the Fire Department of New York has strong views that large-scale facilities should be sited on industrial land, ideally close to water – land that is at a premium.

As to putting energy storage on fossil fuel plant sites, natural gas plant owners in New York are all "looking at pivoting those resources to energy storage," Sarber says, including peaker plant sites owned by New York Power Authority (NYPA) and Long Island Power Authority (LIPA).

Polluting power plants are now hit with restrictions on when they can be run, due to rising air quality standards and the plants' permits.

"That being said, they're still getting hundreds of millions of dollars in standby fees, so from their point of view, in some cases it's easier just to wait until that market catches up to them, and they continue to get paid for that natural gas plant as a standby."

Kelly Sarber says there's a friction between New York's environmental justice goals of shutting down peakers, versus the difficulty of repurposing them quickly to host energy storage. For all these reasons, it's likely companies that do business in the state's energy storage market will have to be financially strong and with "patient money".

Those successful players will also likely invest in market desks, figuring out what sort of merchant opportunities will come, and they will also be able to manage lithium-ion supply chain risks, she says. While those well-documented supply chain risks affect every market and not just New York, it's another dynamic that brings "an additional complexity to a development path that is already complicated".

### 'Good projects will always get built'

Sarber says, however, that as a prolific developer, she is bullish on the New York market's growth path ahead. The type of energy storage projects Strategic Management Group is working on are "necessary" for the state, and backed by strong policies, New York can achieve 6GW.

"I'm just nervous about the time that's going to take, and whether we have enough time to get 6,000MW of energy storage built in New York by 2030, based on where we're at today."

Fellow developer Jeff Bishop at Key Capture Energy is similarly bullish and says the company has been encouraged by the state's proactive approach and "massive amount of work" by stakeholders, citing that it's a question of when, not if, New York's bulk storage buildout will happen.

"My macro view is: good projects will always get built. It's just a question of timing. As we're looking at New York, with all of their climate goals, 6,000MW is going to be the minimum of storage, quite frankly, where they're going to be needing longer duration storage coming up, they're probably going to be needing some clean hydrogen. I learned a long time ago not to ever bet against New York and New England, where they definitely will achieve the climate goals that they have in place. Sometimes it takes longer, but [they] always get there."

# Physical security for battery energy storage

**Security** | Cameron Murray talks to industry experts about the physical risks to battery storage sites, and how the security and insurance aspects of operating BESS sites are evolving.

**A**s battery energy storage technology becomes more widespread and well-known in today's mature markets and, increasingly, new ones, the risk of attack and theft is also likely to grow.

In this report, we talk to those active in emerging markets as well as an energy asset security expert from Sandia National Laboratories (SNL) - one of three research and development labs of the US Department of Energy's National Nuclear Security Administration - about the main risks versus other types of clean energy assets, and how to mitigate them.

Just before this article was about to go to press, a high-profile theft incident was reported at a grid-scale battery storage site in California, the first we are aware of.

From December 2022 through January 2023, more than 100 LG Lithium Power Cell Batteries were stolen from the Valley Center Energy Storage Facility in San Diego County, the San Diego County Sheriff's Department said on 16 February, 2023.

The battery modules contain JH4-P LG NMC lithium-ion battery cells and are valued at around US\$3,000 each, the Department added. Terra-Gen is the developer behind the 140MW/560MWh project, which came online in early 2022.

## How big is the risk?

Notwithstanding the Valley Center incident, it's fair to say the risk of battery storage site break-ins for either theft of components or battery modules or for sabotage has been relatively small with few occurrences to date.

Whilst the dollar value of energy storage systems relative to their geographical footprint compared with other renewables like solar and wind is several times higher, this also makes them easier to monitor and protect.

"A wind farm has a huge footprint

because you could be tens of kilometers from one end of the site to the other and there have been cases of people coming in and stealing turbines while work was being done elsewhere on-site. On a battery storage project you might be one kilometer from one end to the other so you're unlikely to have that sort of thing happen," says Adam Terry, technical director at consultancy Harmattan Renewables, which has worked on renewable energy projects across the developing world.

But there is still a risk and this is expected to grow as energy storage becomes more prevalent and, more importantly, grows in importance for the stability of the electricity grid. Jeffrey Hoaglund is project lead at Sandia National Laboratories (SNL) where he focuses on physical protection systems (PPS) analysis and design for critical energy infrastructure.

"There's anecdotal evidence of physical attacks on the US, for example, where individuals have used firearms or vehicles to take out certain critical nodes of an electricity network - of which energy storage could be an example - or transformers to take down a grid for criminal or domestic terrorism purposes," he says.

"Energy storage could increasingly be targeted because it is a critical node in the energy infrastructure pipeline."

SNL is a national lab which focuses on using science and technology to meet US national security concerns. It is operated by international technology firm Honeywell which acts as contractor to the US Department of Energy's National Nuclear Security Administration (NNSA).

Physical security is starting to evolve along with the threat at hand, Hoaglund says, and in the next section we go through some of the measures being deployed.

## Risks to increase

Alejandro Fajer, managing director of Mexico-based battery storage solutions



Credit: Valley Center Sheriff's Department

**An image of battery modules issued by the Valley Center Sheriff Department, which it said are similar to those which were taken.**

firm Quartux, shared his experience from a country with an elevated security risk compared to, say, the US or Europe.

"Our main risk is not once the system is installed, the risk is during the process of it being transported and installed. Mexico has a lot of highway thefts. We have patrols on every shipment and everything is obviously insured all the way from the factory to the client's facility," he says.

Similar issues exist in Brazil, says Harmattan's Terry. "When we've done projects there, even getting the staff to site, we run the risk of them getting hijacked. The main advantage with battery storage is that it's all containerised but there is still a security risk. We don't travel at night and have not suffered any intercepts yet."

He then points out that although there is a physical security risk, fire safety is on people's minds a lot more.

"In terms of the risk of these systems being stolen, I don't think anybody's really got their heads around it yet because everybody's too focused on the systems catching fire. There are a lot of requirements for security around a battery site for insurance but I wouldn't say it's more expensive because of any theft risk."

Whilst comparing the risk of a fire safety event to a physical break-in or sabotage on a percentage likelihood of occurrence is difficult, the reputational risk is unquestionably higher with fire safety events. But, Fajer points out, a downed system loses money all the same whether that's from a fire event shutdown or from sabotage or theft.

"The projects are insured for theft and damage. But, the bigger risk and what isn't covered by insurance is the downtime that might result from someone taking out a key component. That is the main risk."

"Our main application is peak shaving and if the system is down for even five minutes of the month, then the entire month's savings will be eliminated. That is what will be an expensive loss. The components which can be removed and taken are not that expensive themselves."

### Threat of theft

Hoaglund does expect the security threat of theft to increase. "Some of these battery systems are high value and very technologically advanced, especially the newer ones, so they are critical target areas for sabotage but also for theft. That could be for nefarious use or just to sell those components on the black market."

"Theft is going to become a more likely target vector in the future as these systems become more advanced whereas sabotage has been historically the vector of choice."

Both he and Terry pointed out copper components and cabling are the most likely components to be taken from a site, while Terry and Fajer both say that battery storage technology itself is physically quite hard to steal.

"The one big deterrent you have on the batteries themselves is the weight of them which means they're not easy to steal without something like a forklift. Obviously there is still a risk of that because there is a response time for somebody getting to the site," Terry says.

For example, the stolen Valley Center modules are 1.5 feet by 3.5 feet, 4.5

inches thick and weigh about 250 lbs (113kg) each.

"For the remote ones, it's very complicated to take the whole system due to its size and weight. We once had a situation where we believe people did break in but didn't see anything of value to take," Fajer adds.

One big factor making a lot of battery storage projects high risk is their remote location which entails a lengthy response time should a security or police force need to be dispatched to the site.

Another big security challenge that battery storage projects face and which

"Theft is going to become a more likely target vector in the future as these systems become more advanced whereas sabotage has been historically the vector of choice"

other renewables don't is that they require much less of a physical presence. A substantial solar farm is likely to have people on-site to do panel washing and general maintenance, whereas there isn't much to do on even a large battery project, Terry says.

If the battery project is big enough it will tend to have people on-site for day-to-day management and security which reduces the risk.

"But I think as the technology matures, what you'll actually find is that the risk might go up because you will be less likely to bother putting people on site when you realise there's nothing for them to do and that all they're really doing is being glorified security guards," he says.

### Measures to take

The three core pillars of any battery storage physical security system are detection, delay and response, Hoaglund says.

Detection and assessment about knowing the threat is there and involves layers of security including cameras, infrared sensors, microwave sensors or other detection methodologies at both the outer perimeter of a battery storage site and the inner security area. These

can and should also be on the battery storage containers themselves.

The second, delay, is about increasing the amount of time available for the third pillar, response, to take effect.

"That kind of investment is dependent on the criticality of the site. So if it's just a few battery systems where there's redundancy built into the grid, then you may not have that kind of investment. If it's a larger scale site, or it's co-located with a more critical energy site, then they may share resources or may dedicate more of these resources to that battery storage facility," he says.

Terry agrees: "Co-locating with a renewable source is one way around this and definitely reduces the risk. For solar PV, for example, you'll have electricians and operators around so there's just more of a presence."

Fajer says that Quartux has strategically placed control centres covering its network of deployments: "We have four control centres in Mexico and aim to be two hours away from any installation giving us a two-hour response time. These aren't systems that can be de-installed quickly."

Hoaglund adds that although energy storage containers have evolved to become more robust and resilient to cutting power tools, this can only do so much and really effective 'delay' portions of security design need a 'defence in depth' strategy.

"If somebody just has one layer of delay to cut through, and the response force is hours away, it doesn't matter how resilient that one layer is. But if you have multiple layers, meaning assets, control points and a ring around those critical target areas, intruders will have to breach multiple areas or layers in which they can be detected and assessed."

"That gives the response force longer to get there. So the actual storage units, yes, they're becoming more robust, the materials are becoming more robust and the technology employed to protect those at that last critical layer are becoming more robust. But the way to get more delay time is to expand the security into multiple layers that an adversary would have to penetrate."

### Additional precautions

Terry and Fajer shared some extra precautions they are taking on some ongoing large-scale projects.





Credit: Patrick Finnegan.

**Transformer substations have been attacked in an effort to take down a local grid, Hoaglund says.**

Quartux recently revealed on Energy-Storage.news that it will soon deploy a 25MWh system at a tourism complex, which would be the largest system in Mexico and the largest C&I-located one in all of Latin America.

"For our upcoming 25MWh system, we'll obviously have those patrols, cameras and alarm systems. We're increasing the amount of cameras and having a more elaborate alarm system on it," Fajer says.

Terry meanwhile is working on a battery storage project in Malawi which will be a standalone and therefore unmanned site.

He says: "Alongside the normal physical precautions and remote monitoring, we're going to have a lot more in the way of intrusion detection and motion-activated cameras. We'll probably have intrusion detection inside the shipping containers as well. We were just doing a fencing specification the other day for that and we've gone for two metre-tall fencing and then another half a metre of barbed wire on top of that."

Two other aspects of battery storage site security which Hoaglund has written about in DOE reports are access control and mitigation.

Access control is about controlling access into the facility. A smaller site might simply have a security padlock on a chain link fence gate while bigger or more critical systems will have more checks in place. Quartux typically locks its battery storage system with access only available

to on-site engineering directors or the company's own engineers.

Mitigation involves ensuring that a successful attack on an energy storage facility does not result in a cascading failure. In other words, ensuring that the failure of, or damage to, an energy storage system does not spread to connected systems and potentially the wider grid. This could be done by a control house rerouting power or by ensuring there is timely communication about a system's breach or failure to transmission control centres in order to shut down the site.

### Insurance

Since these projects are typically insured against the risk of physical theft or sabotage and, as mentioned above, the reputational risk of such events is fairly low, most of the thinking around this is left to insurers.

Insurance is therefore a big chunk of the cost that developers will have to put towards the security of their battery storage sites, but it appears that the cost of this is in general falling as the technology becomes bigger in scale and more familiar to insurers.

"If you take into account insurance, then physical security is roughly 3-5% of Quartux' overall running costs. But this figure is in general decreasing as we scale, because the security we had on our first, smaller projects is similar to the new, bigger ones," Fajer says.

"Insurance for battery storage is relatively expensive for us given it's a

new technology that insurance companies aren't that familiar with. But we've started to get better deals over time as the technology becomes more familiar."

Charley Grimston, executive director of specialist battery storage insurance firm Altelium, also says that insurance costs are falling because of improving loss experience and a better understanding of the risks involved.

"Physical security is a responsibility that we take as a system integrator although we do insist on the client getting certain insurance on the installed system and its effect on the grid," Fajer says of Quartux's approach.

### The future

As Terry alluded to earlier, most attention is placed on fire safety risk than physical security risk, and rightly so. But, Hoaglund says, the industry is transitioning and starting to think more about physical security.

"I think we're at a point where it's transitioning. There's been a lot of mitigation and redundancy built into systems and not that much invested into physical security. But as these systems have become more critical, yes, I think they're starting to take it very seriously. Especially with the increase in attacks on these critical nodes, from transformers being shot to theft of critical components, critical metals materials, and other potential sabotage scenarios with transnational criminal or terrorist organisations," he says.

"So I have seen a change, especially over the last 10-15 years, where they are taking it more seriously and doing a more systemic analysis of all these sites being interrelated and also the physical security systems at individual sites."

He also sees a trend of the US government becoming more involved in standardisation and analysis of battery storage sites on home soil. As battery storage projects grow in scale they will become more important parts of the grid meaning the government will increasingly exercise its overarching oversight of where and when they should be installed.

Ultimately, the risk of thermal runaway and other fire events will remain the primary concern for those involved in battery energy storage projects and insurers for some time, well ahead of physical security. But it's clearly worth giving serious thought to the physical security risks facing the technology, particularly with the most valuable, critical or remote projects being deployed. ■

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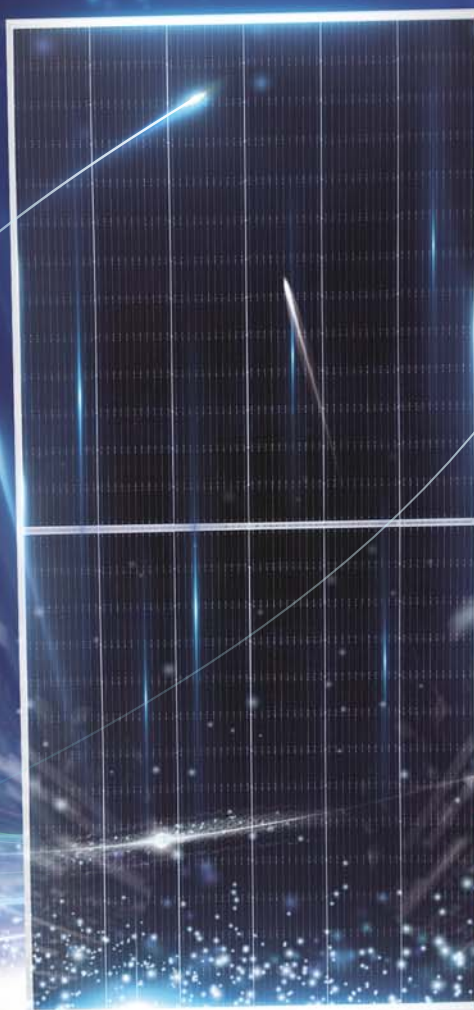


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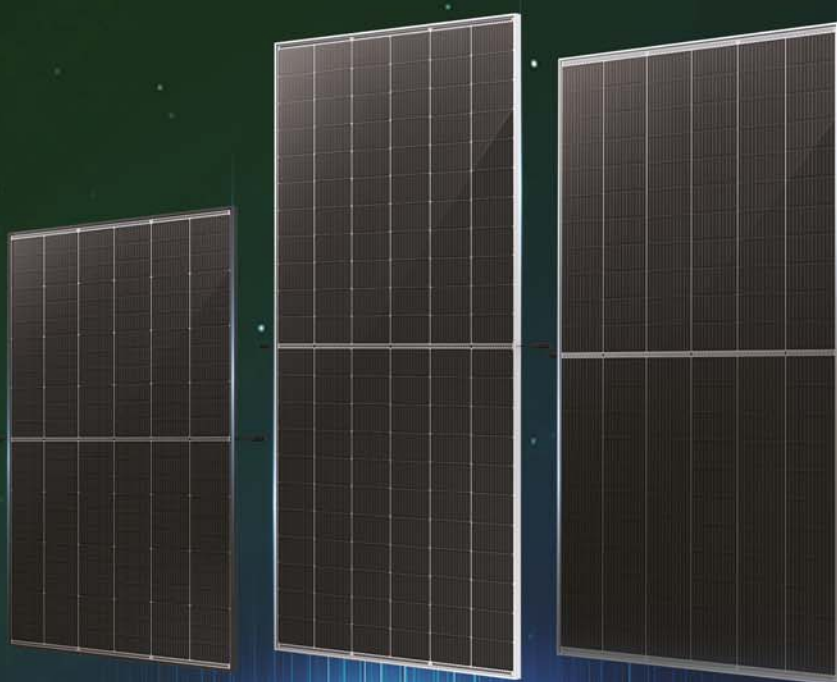
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