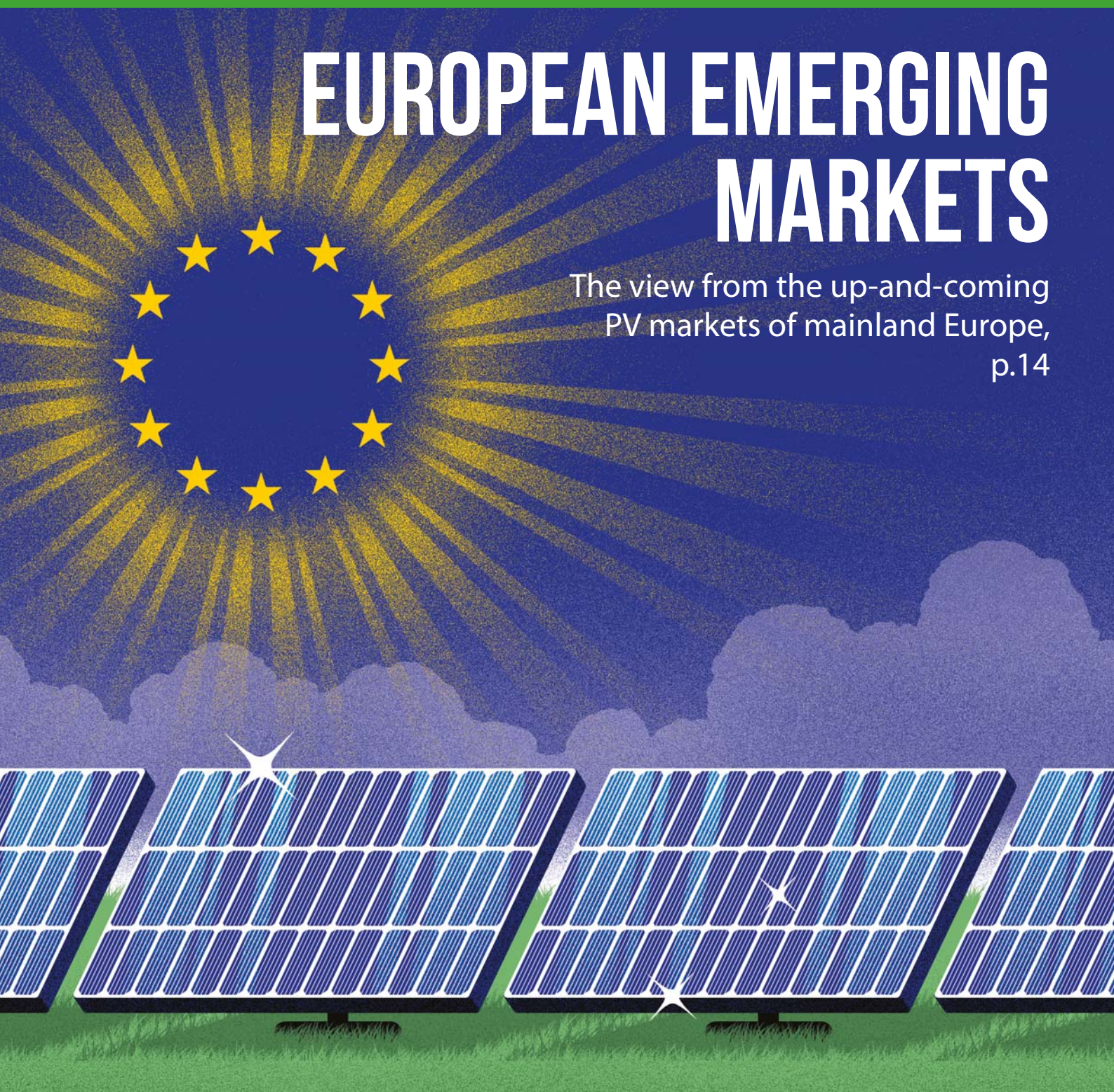


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The background of the entire image is a deep blue space filled with stars. In the upper left corner, there is a red square containing the 'LONGi' logo in white. The central focus is a large, glowing blue sphere representing Earth, showing the continents of Asia and Australia with city lights. A bright green and blue orbital ring with several small white dots representing satellites or stations encircles the Earth.

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# Introduction



Welcome to *PV Tech Power 35*, our second edition for 2023. We have dedicated this issue to the emerging solar power players of Europe to highlight that the steady march towards sustainable economies of the future is not just happening in the richer and more developed nations in the region. Established solar power markets such as UK, Germany, Spain or Italy may act as examples and sources of expertise and technical knowledge, but the political and business leaders of the comparably new players in the renewable energy arena know that their success at home will rely on finding local solutions to local challenges.

In PV Tech Power's main feature on the emerging European players (p.14) Jonathan Tourino Jacobo takes a closer look at Southern Europe, where more abundant sunshine creates a natural advantage, but also at the East of the continent, whose countries are making increasingly use of the benefits that European Union membership offers them in terms of access to funds and attracting solar energy specialists.

In dedicated features, Tom Kenning covers Poland (p.33), which has seen a strong growth in solar PV recently and may well become one of the strongest divers of the sector in the coming years, and Greece (p.23), one of Southern Europe's most promising solar PV markets. Finally a look at the renewables legislation in Bulgaria (p.28).

In the Market Watch section of this issue, we look at the challenges ahead from solar panels that will begin to reach the end of their 25-year life before the decade is out. What to do with technically obsolete and inefficient panels? Will Norman's recycling feature can be found on p.39.

In the Financial, Legal and Professional part of this issue, Lena Dias Martins dissects the UK government's Contracts for Difference scheme, and how its roaring success so far may be threatened by the rising cost of capital.

Architect Dr. Silke Krawietz wrote for this issue on Building-integrated Photovoltaics and how they can be used in existing and new buildings and urban structures to create built-up environments that harness the power of nature.

In our Storage and Smart Power section, supplied by Solar Media's Energy-Storage.news team, you'll find an article by Julia Souder, CEO of the Long Duration Energy Storage Council, detailing how energy storage can become the cornerstone of power grids of the future, plus there's a technical deep dive into the use of battery analytics for setting up and optimising energy storage projects from experts at ACCURE Battery Intelligence and TWAICE.

On page 114, our reporter Cameron Murray looks at the Italian grid-scale energy storage market which is set to become one of the most active in Europe in the next few years having been close to non-existent until recently. For his feature he interviewed executives from three developers looking to gain a foothold in the market: Aquila Capital, Field Energy and Innovo Group.

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

**Andre Lamberti**

Editor In Chief

Solar Media

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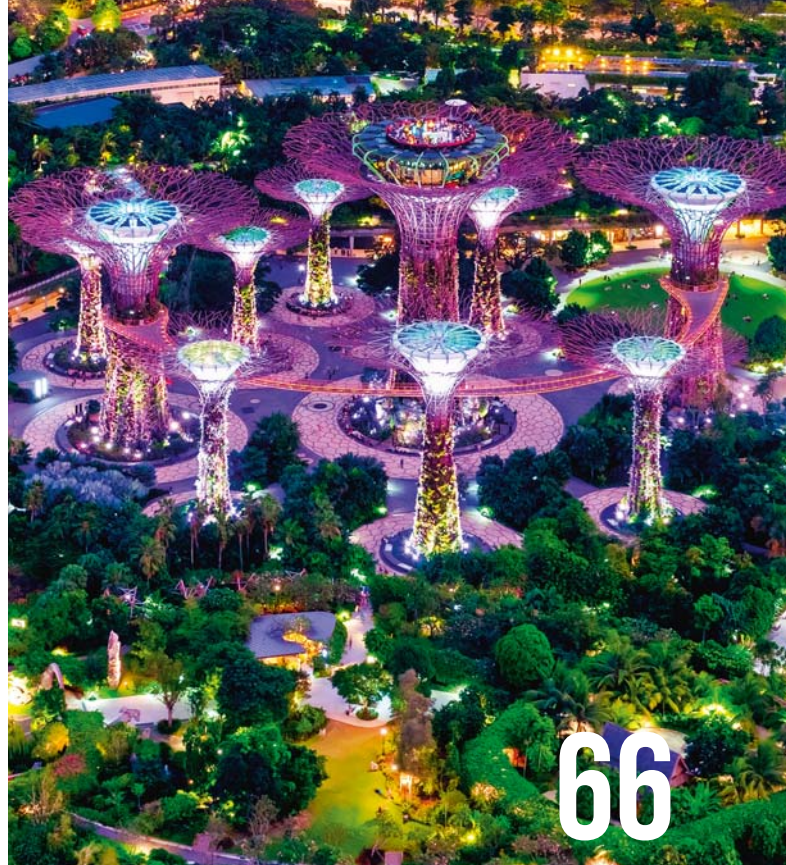
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## EUROPE

### EU Policy

#### European Commission rolls out Net Zero Industry Act

The European Commission (EC) has announced its proposed Net Zero Industry Act, addressing a number of technologies that can help achieve decarbonisation including solar PV. The act aims to scale up manufacturing of clean energy technologies, increase the competitiveness of net zero technologies manufactured in the European Union, and ensure that at least 40% of its demand for cleantech in the EU could be met by domestic production by 2030. Also, the act aims to reduce “the EU’s reliance on highly concentrated imports”. At the same time, the EC has announced the Critical Raw Materials Act to diversify its imports of critical raw materials. It admitted that Europe heavily relies on imports, which are often from ‘quasi-monopolistic third country suppliers’, and will not be self-sufficient in supplying such raw materials.

#### EU issues first cross-border tender for 400MW of PV projects in Finland

The EU has announced a request for proposals (RFP) for a 400MW solar PV tender for projects in Finland, with financing for the tender voluntarily provided by Luxembourg. It is the first cross-border renewable energy tender ever proposed in Europe. Issued under the Renewable Energy Financing Mechanism (RENEWFM), an EU financing vehicle that came into force in 2020, the RFP seeks solar PV projects between 5MW and 100MW in size, up to a total capacity of 400MW. Finland will host the projects awarded in the tender, whilst Luxembourg has committed €40 million (US\$43.7 million) in financing to support the process and ultimately have access to some of the power produced by the projects.

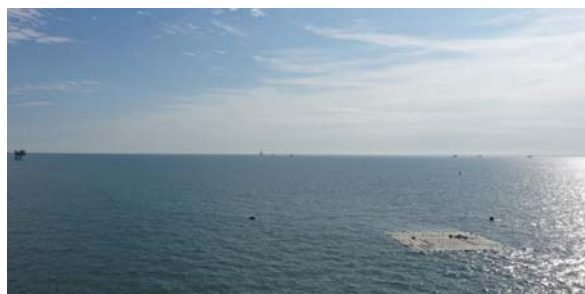
#### EU reaches provisional renewables deal with faster permitting

The European Council (EC) and Parliament have reached a provisional political agreement to raise the European Union’s renewable energy share target to 42.5% by 2030. Each EU member state will contribute to the common target which includes an additional 2.5% indicative top-up that would allow to reach 45% of energy consumption from renewables. The target increases upon the agreement reached by the EC in June 2022, as part of its ‘Fit for 55’, when it targeted for 40% of energy coming from renewable sources in the overall mix by 2030.

### Offshore solar

#### Oceans of Energy to build first commercial offshore solar project in North Sea

The contract for what is claimed to be the “world’s first grid-connected offshore solar-wind hybrid project” has been awarded to offshore specialist Oceans of Energy for a site in the North Sea situated off the coast of the Netherlands. Floating solar modules will be installed



Credit: Oceans of Energy

One of Oceans of Energy’s smaller test projects in the North Sea.

between the turbines of CrossWind’s 759MW Hollandse Kust Noord wind park. CrossWind is a joint venture between oil major Shell and Dutch energy provider Eneco. The wind project will be complete by the end of 2023, with the solar farm due to be in place in 2025.

### Acquisition

#### First Solar acquires Swedish thin-film company Evolar

Thin-film module manufacturer First Solar has acquired thin-film company Evolar to grow its PV capabilities. The transaction costs about US\$38 million and up to an additional US\$42 million to be paid subject to certain technical milestones being achieved in the future. According to First Solar, the acquisition aims to accelerate the development of PV technology, including high efficiency tandem devices, by integrating both companies’ capabilities, existing research and development (R&D) streams, intellectual property portfolio, and expertise in developing and commercially scaling thin-film PV. Evolar’s laboratory in Sweden will continue to conduct research activity after the acquisition, marking the first time that First Solar will have an R&D facility in Europe.

### Germany

#### German rooftop solar and storage soared in 2022

The number of residential solar and storage systems installed in Germany increased 52% in 2022 compared with the previous year, whilst three quarters of Germans would consider installing rooftop solar. According to research and calculations from the German Solar Industry Association (BSW), as well as comments to PV Tech, the last four years have seen a fivefold increase in residential solar battery systems and a quadrupling of standalone residential PV installations. Just in 2022 there was a 52% uptick in domestic solar-and-storage installations and an over 40% rise in domestic PV deployments. BSW found that three quarters of all homeowners would consider installing solar PV, and that one in five of those are planning to do so in the next 12 months.

#### Germany adds 2.6GW of solar PV in Q1 2023

Germany has added more than 2.6GW of solar capacity in the first three months of the year, according to The Federal Network Agency (Bundesnetzagentur). With nearly 3GW of solar PV added in Q1 2023, Germany has now passed 70GW of solar capacity installed as it aims to reach its target of 215GW installed by 2030. A target the current government increased by 15GW last year and which means the country would require to install an average of 22GW per year, which is still far away as last year it added 7.9GW of solar capacity, according to trade association SolarPower Europe. Bavaria was the region which added the most solar capacity in Q1 2023 with almost 600MW.

### Finland

#### OX2 acquires 475MW Finland solar PV plant

Solar developer OX2 has acquired the project rights to a 475MW solar PV project in Finland from Finnish PV developer SAJM Holding Oy. The Huittinen solar farm is currently in development, and once completed will be one of the largest solar PV projects in the country. This will not be the first large-scale project from OX2 in Finland as the company has a 500MW solar plant under development in Kauhajoki – also in the southwest of the country – expected to be operational in 2028. Another solar farm with a capacity of 60MW is also under development, in Loimaa in the southwest, and is expected to be operational in 2026.

## AMERICAS

## US

**US customs detained 2GW of PV modules in 2022 under UFLPA**

2GW worth of solar PV modules were detained at the US border throughout 2022 as a result of the Uyghur Forced Labor Prevention Act (UFLPA), representing 1,423 individual shipments. The US Customs and Border Protection Agency (CBP) released its 2022 detention statistics relating to the UFLPA, which were analysed by Bernreuter Research. US\$709.9 million worth of shipments were detained last year, which Bernreuter said corresponds to 2.09GW of modules based on a price-per-watt calculation from NREL which saw imported modules fluctuate between US\$0.3 and US\$0.6 per watt through 2022. Beyond that, in the first two months of 2023 a further 204 shipments were detained, representing 410MW and US\$134 million.

**Nearly 1TW of solar PV in US interconnection queues in 2022**

Nearly 1TW of solar PV capacity was in US interconnection queues at the end of 2022, according to research from Lawrence Berkeley National Laboratory (LBNL). With 947GW of generating capacity awaiting connectivity, solar had the largest share of generation capacity in the queue. Combined with wind, both technologies reached more than 1,250GW of capacity awaiting transmission access, nearly the same amount as the entire US power fleet currently installed.

**IRA will see solar and wind account for over 60% of US generation by 2030**

Solar and wind installations in the US could account for between 40% and 62% of total electricity generation by 2030, according to a report from the National Renewable Energy Laboratory (NREL). The forecast growth is due to the stimulating effects of the 'game-changing' Inflation Reduction Act (IRA), which came into force last summer and introduced US\$369 billion in incen-

tives and tax credits for renewable energy investment, and the Bipartisan Infrastructure Law (BIL) which focuses on jobs and infrastructure investment. NREL said that the combined support for climate initiatives and tax incentives from the two acts could exceed US\$430 billion through 2031, bringing deployments up with it.

**Solar industry reacts to Senate's vote to remove Biden's import tax waiver**

The Senate has passed a vote to repeal Joe Biden's two-year waiver on solar import tariffs, a decision which the Solar Energy Industries Association (SEIA) has previously said could result in US\$1 billion in retroactive tariffs for the industry and 4GW of project cancellations. Abigail Ross Hopper, CEO of SEIA said: "Any legislation that threatens 30,000 American jobs and weakens our nation's energy security to this degree should be dead on arrival. Unfortunately, politics won the day, and our legislators voted to pull the rug out from businesses that are investing billions of dollars and employing thousands of people in their states."

**Republican attempt to repeal US Inflation Reduction Act 'threatens economy, jobs and investment'**

Clean energy trade bodies ACP, ACORE and SEIA have denounced an attempt by Republicans to roll back the Inflation Reduction Act, which has spurred unprecedented investment in the US market. House Bill 'H.R.2811 – Limit, Save, Grow Act of 2023', put forward by Republican Representatives passed in the House at the end of April. It would significantly scale back the federal support for renewable energy and energy storage enabled by the IRA, which came into law this year, as well as other non-energy federal financial support schemes.

## Canada

**Canada announces plans for IRA-style solar and storage investment**

Canada will introduce tax credit incentives and invest in developing and manufacturing solar PV, energy storage and other renewable energy technologies in an Inflation Reduction Act-style scheme. The government of Canada has released its 2023 budget, which positions growing the clean economy as one of its core priorities. Under the budget, the government confirmed the 30% refundable tax credit on investments made by taxable entities into clean energy technologies like solar, battery storage and wind.

## Brazil

**Brazil to unlock solar and wind with US\$9.5 billion transmission investment**

Brazil will invest BRL50 billion (US\$9.5 billion) in new transmission lines and infrastructure to boost solar and wind deployments. The government said that it will hold at least three major transmission auctions this year, focusing on the northeast of the country and north of the state of Minas Gerais. The east and northeast of Brazil are its most populous regions. The new transmission investment will unlock new wind and solar capacity and allow for greater renewables penetration across Brazil. In its announcement, the ministry of mines and energy said that it wants to focus on hybrid solar and wind projects, whose dual generation can add greater stability to the country's grid.



US Solar A 250MW solar PV plant in California.

Credit: Brian Doll, SOLV Energy

## MIDDLE EAST & AFRICA

### South Africa

#### Cape Town invests in PV-plus-storage project

A solar-plus-storage project is being planned for Cape Town as the city looks to move away from relying on troubled grid operator Eskom and towards a load-shedding-free Cape Town. Cape Town Mayor Geordin Hill-Lewis says that the city would design, build and operate a solar PV plant with battery storage to the tune of 1.2 billion Rand (US\$65 million). The Paardevlei project near Somerset West will yield up to 60MW of renewable energy although the official size of either portion was not revealed. A media statement says that the project would protect the city against one full stage of load shedding from grid operator Eskom.

### Morocco

#### Morocco to develop 202MWp solar PV portfolio

The International Finance Corporation (IFC) and phosphate-based fertiliser producer OCP Group are co-developing 202MWp of solar PV projects in Morocco. Under the agreement, the IFC will provide the fertiliser producer with a green loan of €100 million (US\$110 million) for the construction of four solar plants located in the towns of Benguerir and Khouribga, home of the country's largest phosphate reserves. Construction of the projects will be carried out by the renewables arm OCP Green Energy, a wholly-owned subsidiary of OCP. The four solar plants will power OCP's Morocco operations towards reducing its carbon footprint and producing green fertilisers.

### Iraq

#### TotalEnergies reboots 1GW Iraqi PV deal

French energy company TotalEnergies revives its deal with the Iraqi government to develop a 1GW solar PV project in the Basra region, part of a larger US\$10 billion accord to also establish new gas generation and seawater treatment facilities. The deal was originally announced in September 2021 as TotalEnergies' second PV contract in Iraq, but the subsequent years have seen negotiations held up by political barriers and regime change. In this latest development, QatarEnergy enters as a new third party with a 25% stake in the solar, gas and seawater treatment deals. TotalEnergies and QatarEnergy have a history together, having joint ownership of an 800MW solar PV plant in Qatar through their respective subsidiaries.

### United Arab Emirates

#### UAE needs to boost its solar PV capacity 600% by 2030

The United Arab Emirates should increase its solar PV generation capacity sixfold by 2030, rising to 7.3GW, according to the latest report from the Emirates Water and Electricity Company (EWEC). In its Statement of Future Capacity Requirements 2023-2029: Summary Report, EWEC recommends that the UAE should add up to 4.1GW of solar PV capacity as of 2029, including the planned 1.5GW Al Ajban project set to come online in 2026. It also recommends adding 300MW of battery energy storage systems (BESS) to stabilise distribution.

### South Africa

#### Copenhagen Infrastructure Partners buys South African IPP Mulilo

Renewable energy investor Copenhagen Infrastructure Partners (CIP) acquires the majority share in Mulilo Energy Holdings, a South

African independent power producer. The acquisition will be made through CIP's New Markets Fund I (CIP NMF I). CIP will assume control of Mulilo and its assets, which constitutes a 25GW pipeline of onshore wind, solar PV and storage as well as 440MW of operational PV and wind projects. The company said that Mulilo currently holds an 8% market share in the South African renewables sector. The company believes that the company represents an attractive opportunity for CIP NMF I to invest in a growing developer.

### Niger

#### Savannah Energy inks 200MW solar PV agreement in Niger

British renewables company Savannah Energy signs a memorandum of agreement (MoA) with the government of Niger to develop up to 200MW of solar PV. The projects will consist of two solar plants and will be located in Southern Niger, near the border with Nigeria and within 20km of the cities of Maradi and Zinder. Each plant is expected to have an installed capacity between 50 and 100MW and once operational will increase the power generation in the country by 20%. Additionally, the company plans to reach an installed renewables capacity of 1GW across solar, wind and hydropower by the end of the year, according to Andrew Knott, CEO of Savannah Energy.

### Jordan

#### Masdar's subsidiary inaugurates 200MW Jordanian project

The joint venture of United Arab Emirates-owned renewables company Masdar and Finnish investment and asset management group Taaleri, the Baynouna Solar Energy Company, announces the inauguration of a 200MW solar park in Jordan. Developed through a power purchase agreement (PPA) between Masdar and Jordan's state electricity provider, the National Electric Power Company, the Baynouna Solar Park can produce over 560GWh of energy annually. Claimed to be the largest clean energy project in Jordan, the Solar Park adds to the already-operational 117MW Tafila Wind Farm and means that Jordan now produces 29% of its electricity from renewable sources. The country aims to increase that to 50% by the end of the decade.



Baynouna Solar Energy is a joint venture of UAE-owned renewables company Masdar and Finnish investment and asset management group Taaleri.

Credit: Masdar



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## ASIA-PACIFIC

### India capacity

#### India's solar manufacturing capacity to reach 110GW

India's domestic solar manufacturing capacity is set to reach 110GW of solar PV modules per year by 2026. According to a joint report from the Institute for Energy Economics and Financial Analysis (IEEFA) and JMK Research & Analytics, India would become the second-largest PV manufacturing country behind China and be self-sufficient in terms of domestic demand. Once India reaches a capacity sufficient for the domestic market in the coming two to three years, the country will require to focus on expanding further its reach to other markets as an alternative to the current dominant supply chain of China which exceeds 80% of all stages of PV module manufacturing, from polysilicon to modules.

### Uzbekistan

#### Masdar closes financing for 900MW PV portfolio in Uzbekistan

Masdar has reached financial close on three PV facilities in Uzbekistan with a combined capacity of approximately 877MW. The projects are expected to begin operations in 2024. Financing was secured from the Asian Infrastructure Investment Bank (AIIB), Asian Development Bank, the European Investment Bank and the European Bank for Reconstruction and Development. The AIIB confirmed that it had signed three project finance loan agreements with Masdar to the tune of US\$83.6 million as part of a larger US\$396.4 million debt financing towards the projects. Uzbekistan has a target of 7GW of deployed solar PV by 2030. Masdar already operates in the country, with over 700MW of PV already operational.

### China cell plant

#### FuturaSun to build 10GW solar cell plant in China

Italian solar manufacturer FuturaSun has signed a strategic agreement with the city of Huai'an in China to build a 10GW solar cell manufacturing plant. The company will invest €150 million (US\$163 million) in the new plant which will be carried out in two phases over the course of three years. Once completed and operational, the plant will produce n-type solar cells based on tunnel oxide passivated contact (TOPCon) technology. Starting in spring 2024, the production process will be highly automated and will supply both the Italian – which was recently announced, with a 2GW annual capacity – and Chinese module assembly plants.



The future solar cell plant in China will cater to the recently announced Italian module assembly plant along with the Chinese plants.

### India

#### Companies bid for India's solar panel manufacturing incentive

A number of solar module manufacturers are reportedly bidding for financial incentives offered by the Indian government to expand domestic manufacturing of solar panels. According to multiple media outlets, including Bloomberg, several companies submitted bids, such as conglomerate Reliance Industries, integrated power company Tata Power, US based solar panel manufacturer First Solar, Indian power company JSW Energy, green energy developer Avaada Group, and renewable energy company ReNew Energy Global, among others. The Production Linked Incentive (PLI) scheme guidelines state that the successful solar PV module manufacturer will be required to set up manufacturing capacities on GW scale for high efficiency solar PV modules.

### Australia

#### Australian Federal Budget commits new investment into clean energy transition

Australia's Federal Budget 2023-2024 includes AU\$4 billion (US\$2.71 billion) new investment in the energy transition, and confirmation of tenders for renewables and energy storage. The budget emphasises energy costs, supply reliability and environmental impacts in both the budget itself and the government's communications around it. The top headline figures are the AU\$4 billion commitment, which includes AU\$1.3 billion for household energy upgrades, of which AU\$1 billion will help provide low cost loans for double glazing, solar modules and other improvements to make homes easier and cheaper to keep cool in summer and warm in winter. This measure is expected to benefit 110,000 households. Other than household energy upgrades, a total of AU\$2 billion will be assigned to grow a green hydrogen economy.

### Green bond

#### ReNew Power raises US\$400 million to spur growth

Indian renewable energy independent power producer (IPP) ReNew Power is issuing green bonds to raise US\$400 million for its subsidiary Diamond II. According to the company, proceeds from the issue will be used to refinance existing dollar debt and fund various growth initiatives. The company adds that the corporate notes have been certified by the NGO Climate Bond Initiative, which mobilises global capital for climate action, and are aligned with the International Capital Market Association's Green Bond Principles.

### Solar/wind target

#### China to add 160GW of new solar and wind capacity for 2023

The Chinese government announced a target of 160GW of new solar and wind capacity to be added in 2023. On the National Energy Administration's (NEA) official website, the Guideline On Energy Work In 2023 specifies that the target for 2023 is to increase the use of non-fossil energy to 18.3% of total energy consumption and increase the proportion of non-fossil installed power generation capacity to 51.9%. Wind power and PV power generation will account for 15.3% of total power consumption. This means that in 2023, non-fossil energy will account for more than 50% of China's power generation capacity for the first time.

## MANUFACTURING

### Ohio assembly plant

#### LONGi, Invenery to build 5GW module assembly plant in Ohio

US renewable developer Invenery has partnered with solar module manufacturer LONGi to build a 5GW module assembly plant in Ohio. Through a newly formed company called Illuminate USA, Invenery will invest more than US\$600 million in the plant, which includes a US\$220 million commitment for the acquisition and construction of a 1.1 million-square-foot industrial building in Pataskala, Ohio. This marks the first US foray for the Solar Module Super League (SMSL) member LONGi, which recently invested US\$6.7 billion in building a new production base in China capable of manufacturing 100GW of solar wafers and 50GW of solar cell capacity per year.

### Romania module factory

#### AE Solar to build 10GW module manufacturing facility in Romania

German manufacturer AE Solar plans to build a module manufacturing plant with a 10GW annual capacity in Romania. In the first phase, the company would set up a 2GW production capacity, according to the Romanian government. The factory will require an investment of €1 billion (US\$ 1.06 billion), with the government looking to unlock European funding or state aid to support the construction of the project. Upon completion of the project and full integration of the production flow, the facility would reach an annual capacity of 10GW, representing a third of the European Commission's goal to reach 30GW of European manufacturing capacity by 2025 across the entire value chain.

### PV module prices

#### US to see world's highest PV module market prices

PV module prices are set to fall considerably in the next five years, though US market prices will remain higher than the rest of the world as its import policies and ongoing competition with China add a market premium, according to the Q1 2022 'PV Price Forecasting Report' from Colorado-based Clean Energy Associates. The report shows that falling polysilicon prices will see a steep drop in module prices from China over 2023, with Southeast Asian modules following suit in 2024.

### US encapsulant plant

#### Hanwha, QCells to deepen manufacturing presence in Georgia with solar encapsulant plant

Hanwha Advanced Materials Georgia (HAGA) – part of Hanwha Solutions – will increase its investment in the US state of Georgia to support the integrated supply chain plans of its PV manufacturing subsidiary QCells. HAGA will construct a solar encapsulant film factory in Bartow County, the same county as QCells' planned 8.4GW ingot, wafer, cell and module manufacturing facility expansion. The encapsulant – which is used to seal solar cells and ensure their lifespans – will then be supplied to QCells for use in their module production.

### India incentives

#### First Solar, Tata Power and Reliance Industries bid for India's PLI

A number of solar module manufacturers have reportedly bid for financial incentives offered by the Indian government to

expand domestic manufacturing of solar panels. According to multiple media outlets, several companies submitted the bid, including conglomerate Reliance Industries, integrated power company Tata Power and US based solar panel manufacturer First Solar, among others. However, it was reported that conglomerate Adani Group did not join the bid. According to the PLI guidelines, the successful solar PV module manufacturer will be required to set up manufacturing capacities on GW scale for high efficiency solar PV modules.

### Texas TOPCon

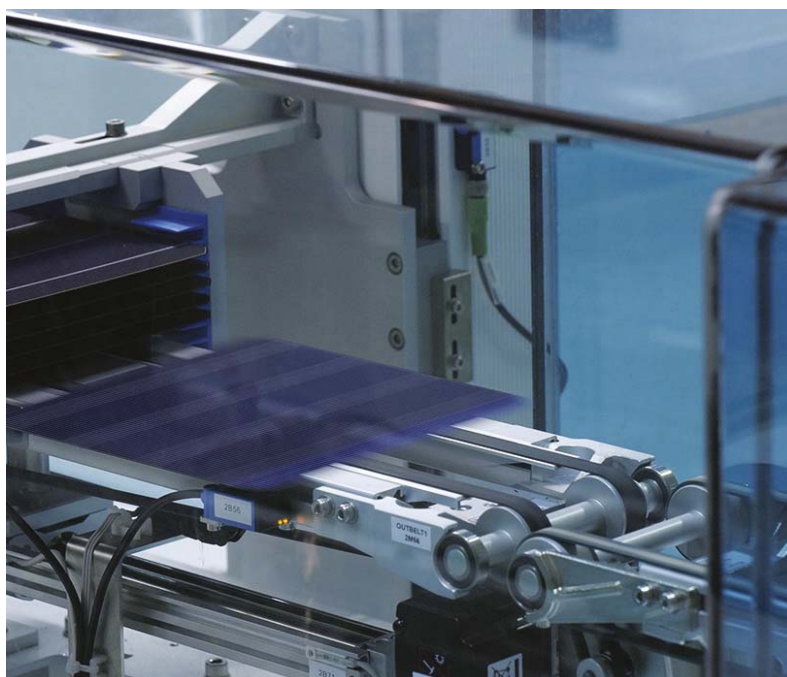
#### SEG Solar completes funding of 2GW Texas TOPCon module factory

US-based solar PV manufacturer SEG Solar has closed the acquisition of a 2GW PV module plant in Houston, Texas. The facility is set to produce in excess of 2GW of n-type Tunnel Oxide Passivated Contact (TOPCon) modules from 182mm or 210mm solar cells, with the first products forecast to roll off the production line in Q1 2024. SEG said that its investment in the facility will exceed US\$60 million once completed, including financing for equipment and facility improvements.

### France module factory

#### PV startup Carbon selects location for planned 5GW/3.5GW cell and module factory in France

French PV manufacturing startup Carbon has chosen a location for a proposed cell and module factory which it plans to bring into operation in late 2025. The plant would be Carbon's first production facility. A 60 hectare area in Fos-sur-Mer, on the perimeter of the Grand Port Maritime de Marseille (GPM), has been selected for the facility following meetings with the regional premier, president and chair of the GPM, Carbon said. The factory has a planned capacity of 5GW of cell and 3.5GW of module production which, if it comes to fruition, would make it the biggest PV manufacturing facility in Europe, larger than Enel Green Power's 3GW Italian plant.



**Bifacial solar panel production in the 3Sun factory in Italy, currently the largest facility in Europe.**

Credit: Enel Green Power

# Europe's emerging solar markets



Credit: BayWa r.e.

**Emerging Europe** | With the need to accelerate its decarbonisation and further secure its electricity independence, Europe is at the crossroads to a faster growth in solar PV deployment. Jonathan Touriño Jacobo explores how Eastern and Southern European countries have emerged in that race as key players for the European Union to reach 740GW of solar capacity installed by 2030.

For a long time now the hottest markets to develop solar PV in Europe were Germany and Spain, followed by the Netherlands, France and Italy. In the East of the continent, Poland has seen a surge in solar PV in recent years and is expected to be one of the most important European markets in the near future.

If Poland might be the foremost emerging country from Eastern Europe, it is not the only one that is likely to be a driver for solar penetration across the European Union, with Romania and Greece coming on strong and with a great potential to drive Europe's decarbonisation at a faster pace.

In this 35th edition of PV Tech Power we will explore which are the emerging European markets, with a bigger focus in Southern Europe and dedicated features

for Greece – one of the hottest solar markets currently in Europe –, Bulgaria and Poland. Hungary, Romania – which had its own feature in the previous issue –, the Czech Republic and other Balkan countries will also be explored here.

Regardless of the size for Southern European countries, the advantage they have to other countries in Europe farther north is their location and the fact that they have very strong merchant economies. "That's because the [electricity] load factors in these regions are really good, the further south you go, the better," says Panos Kefalas, senior associate for South Eastern European markets at consultancy Aurora Energy Research.

Obviously Greece and Romania are among the biggest markets both in terms of capacity, but also maturity. Greece

**BayWa r.e.'s Witnica 64.6MWp solar park in Poland, sold to Irish Alternus Energy Group.**

joined the likes of Spain, Germany, Poland, the Netherlands or France in the gigawatt-scale club last year, when it added 1.34GW of solar capacity in 2022 alone and has now a total capacity of 5.5GW. In a report published last year by trade body SolarPower Europe that featured a market outlook for European countries, the Greek trade association Hellenic Association of Photovoltaics Companies (HELAPCO) expected the country to reach a cumulative solar capacity between 13.6GW and 16.3GW by 2030.

Many of these countries share similar challenges – from grid capacity bottlenecks to skilled workers shortages – but a major challenge Southern European countries such as Romania, Bulgaria and Hungary are facing is an increased cannibalisation.

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**Commercial Rooftop solar project built by HEC Solar in Bulgaria.**

"What that means is that if you fill up Romania, Bulgaria or Hungary with solar capacity, the capacity of one country will directly affect the prices in another one. Meaning that a massive capacity increase in Bulgaria for example would not just reduce only the price there, if you have a lot of solar, but also in Greece and Romania," Kefalas says.

"This is because the correlation of solar production, even between different countries, especially in the sunny South is very strong. During the day you will feel the effects of extra solar generation from a neighbouring country, which will further collapse your prices and your revenues in a given hour," explains Kefalas.

However, Kefalas added that the threat of a cannibalisation of solar capacity between countries in the region would not be a 'deal breaker' for investors to be interested in going there, as the levelised cost of energy (LCOE) is still lower than the capture price. And even if at present the penetration of battery storage is still low and many of the countries lack a regulation about it, the fact that countries such as Romania and Hungary are expected to hold auctions for the technology, will be a positive factor for solar overall as it could kickstart co-located projects to be built and pushes up the capture price of solar, Kefalas says.

#### **Greece's PPA market set to boom**

With the Contracts for Difference (CfD) having been in place for a few years and

now in a more mature state, securing one has been more complex with increased competitiveness and lower prices, "which is good for the consumer" says Kefalas. However, he added that the auction held in September ended being undersubscribed for the first time. "Now banks are finally willing to consider merchant revenues for financing [a solar project], not just the government," adds Kefalas. The maturity of the market in terms of auctions and its consistency since 2018-19 opened opportunities to secure financing by signing power purchase agreements (PPAs).

And if less than two years ago financing a project through a PPA was a rarity, now banks are more inclined to finance projects which have a PPA signed for a solar PV plant. And the number of these will increase in the future. "Next year may be a very interesting year for PPAs," says Stelios Psomas, policy advisor at trade body HELAPCO.

In that same sense, the government has worked towards a more open market for developers to secure other means of funding their projects. Philipp Kunze, MD renewable project development in Greece at BayWa r.e., says: "The government has understood that auctions, public tariffs and CfDs are no longer necessary to fund these projects. And it has worked on setting up the right framework for these private PPAs to happen. The government just understood that less government intervention is necessary."

The Greek government recently submitted a PPA scheme to the EU that would help further accelerate investors' interest in the country. "We are still waiting for the approval of the European Union on the proposal made by the Greek government last year for the creation of the so-called green pool, which is a scheme working under the umbrella of the energy market exchange," adds Psomas.

This will facilitate PPAs and will bring producers and offtakers together. And they will also support it financially. The government will cover most of the expenses of an aggregator for balancing responsibilities, etc," says Psomas. This will also facilitate smaller companies to sign PPAs, similar to the European Commission electricity market reform design that also aims to give an easier access to small and medium business to sign PPAs.

Most importantly, and what might make signing a solar PPA more attractive now, is the fact that the government has made these one of the highest priorities for getting a grid connection. In the current scheme for connecting to the grid, long-term solar or wind PPAs get higher priority to secure a spot, says Kefalas.

Nearly 4GW of projects with PPAs have been given a priority from the Greek government, adds Psomas. "As far as I know, there are at least 5GW of projects that at least claim they have set a pre-agreement with some potential customers/offtakers. It seems that this market will thrive in the coming years."

The possibilities in terms of power purchase agreements do not end there, as they could also open a window towards virtual PPAs between countries in the coming years, says Kunze. "There are still some details missing. But you could theoretically also have a virtual PPA with a German offtaker, where we have a lot of clients, for example, that would be quite interested in buying electricity virtually."

This is just one aspect on how the Greek solar market is setting itself up as one of the key players in Europe for solar PV in the coming years, with power purchase agreements set to increase in the near future and showing how much of a mature market Greece has become. Another feature focused on this country can also be read in this edition of PV Tech Power.

#### **PPAs are driving Romania's solar growth, waiting for CfDs**

The solar market in Romania at the moment is on two tracks. With the Contract

for Differences currently delayed, many players have turned towards power purchase agreements to finance solar projects. "You can't just build a project and go to the spot market, because no bank will finance it," says Kefalas. Thus there is a higher activity in terms of PPA at the moment, which will start to get quieter due to developers awaiting to build their projects when the CfDs are released.

No matter what, Romania's solar activity is expected to accelerate in the coming years and it is unlikely to cease soon. "I think Romania is really at the brink of a second big wave of renewable penetration," says Kefalas.

The view is shared by Konstantinos Zygouras, chairman of EPC contractor Sunel Group – which is headquartered in Greece – who expects Romania to follow in the footsteps of Greece with project developments starting to increase from 2024 onwards.

"The infrastructure needs to be upgraded. But, in general, there is ability to connect to the grid and the consumption is there. Also there is the interconnection with the neighbouring countries. So in any case, there's not going to be any problem with connecting more and more projects in the future," says Zygouras.

The company partnered in April with renewables developer Ameresco to bid on 1.5GWp of solar PV and battery energy storage systems (BESS) across several markets in Europe. Greece and Romania make up between 25% and 35% of the total turnover, adds Zygouras.

For an EPC contractor, the major challenge at the moment is the lack of skilled workers, a problem that was first amplified with COVID-19 and now the war in Ukraine, says Zygouras, adding: "One problem that remains in most of these countries, is the availability of skilled workers and also experienced engineers."

Sunel's solution to attenuate this challenge has been to use the same subcontractors they have been working with for many years, and then managing everything locally in the company's centralised headquarters in Athens. This helps in terms of managerial resources, and workers that are not yet experienced, they can be supported by staff in Athens. The ease of free movement across the EU also helps moving workers from country to country and from project to project, if necessary.

A segment that will need a bigger focus is the rooftop solar market, where

Romania – along with Bulgaria – are the least developed. In both instances this is due to both countries not providing any interesting subsidies for it. However, with the increased appetite in utility-scale, residential solar could get a push too in the coming months. Proof of that was shown from the Romanian government at the beginning of 2023 when it announced a reduction in the value-added tax (VAT) for solar PV modules from 19% to 5% in order to boost self-consumption uptake in the country.

#### Poland's accelerated shift to solar

Poland's key policy driver for the growth of solar PV and renewables altogether comes from 'Energy Policy of Poland until 2040' (PEP 2040) which is currently updated. "The new version of the document is supposed to accelerate the energy transition to

Regardless of the size for Southern European countries, the advantage they have to other countries in Europe farther north is their location and the fact that they have very strong merchant economies.

renewables to ensure national energy security. Looking ahead to 2040, the goal is that half of the electricity generation in Poland comes from renewable sources. In 2030, the share of renewable energy in gross final energy consumption should be at least 23% and no less than 32% in electricity – mainly wind and PV," says Artur Marchewka, managing director at BayWa r.e. Polska.

Moreover, of all the countries in the EU, Poland is the most dependent on coal, which accounted for more than 70% of its energy mix in 2021, according to state body Energy Market Agency (ARE). Potential for renewables – both solar and wind – to cover for the closure of coal plants in the years to come is important.

With more than 11GW of solar PV capacity installed, the technology accounts for 10% of the energy mix, when only three years earlier the share was at less than 1%, according to SolarPower Europe. Poland is expected to reach at least 25GW of installed solar capacity by 2030.

The pace at which the country has added solar capacity has quickly put it only

behind Germany and Spain in terms of added annual capacity. And it is expected to continue to be at the forefront of the EU countries in the years to come, staying among the biggest five markets for several years.

Similar to what is happening in Greece, the market in Poland has matured enough for projects being able to secure funding outside of government subsidies or without the need to go through an auction. "In recent years, it has become common to build more and more solar parks without subsidies. In 2020, we were able to develop the country's first large-scale subsidy-free solar plant – a 64 MWp-park in Witnica, close to the German border between Poznań and Berlin. The commercial success of the project was possible due to a VPPA with HeidelbergCement, a vertically integrated building construction materials company," says Marchewka, adding: "PPAs are becoming more and more popular recently."

#### Czechia's unique capex investment

The Czech Republic's main driver currently for solar PV is its investment subsidies, and the country was the first one having the European modernisation fund active, which was launched by the EU to help 10 member states meet their energy targets. Two rounds of subsidies for utility-scale projects have so far been launched for almost 400 ground-mounted power plants allocated. This approach is quite unique in comparison with other markets in Europe as in the end, the subsidy constitutes more a capital expenditure (capex) rather than an auction or a feed-in-premium.

"Investors come with projects and if the project fulfils certain criteria, the ministry issues a preliminary agreement to pay out if the project is then connected," says Jan Krcmar, president of the Czech Solar Association.

The inconvenience of not having any solar tenders in the country is that it forces developers to seek investment through power purchase agreements (PPAs) if they are not successful in securing the government's capex investment.

However a lot can still go wrong adds Krcmar, as projects still need to go through securing land, grid access and project development, and the size of the projects that applied for the government's subsidy scheme varies from a few hundred kilowatts up to 50MW.

Ground-mounted is not the only segment in the country that is trying

to accelerate the growth of solar PV in Czechia. Through the national recovery and resilience plan launched last year, more than 6,000 applications were submitted for the commercial rooftop market. These subsidies were already implemented before Russia's invasion of Ukraine, says Krcmar.

So far the only implementation that has been done is targeted towards the residential rooftop market which raised building permit limits for panels from 20kWp to 50kWp, while the requirement for an energy license has been raised from 10kWp to 50kWp.

It will cover about 1,000 projects, and companies will not have to apply for a building permit below these limits. But it's nothing like Germany where you have go-to zones and a fixed compulsory percentages of land allocated to wind and solar," adds Krcmar.

The association has lobbied the Czech parliament to implement more policies aimed at accelerating the adoption of renewables in the country, such as having renewables projects above 1MW to be considered of public interest and implementing quicker procedures when it comes to changing the zoning plan of a project.

Another regulation that is currently being discussed is the implementation of a law regulating agrivoltaics (agriPV) which could be a boost for the country. "We have a lot of fruit growers who have problems now in this current climate, and agriPV could really help them. This could be a potential big driver," says Krcmar.

Currently the main driver for solar PV growth in the country comes almost entirely from residential rooftop installations, which accounted for nearly 95% of capacity

added in 2022, according to Krcmar, while the rest came from commercial rooftop. The current year should see an increase in terms of commercial rooftop with the first ground-mounted solar projects achieving commercial operation.

"The big boom, hopefully, in terms of ground-mounted projects should come next year and the year after that. Because the projects are now being developed," says Krcmar. This is due to projects receiving the government's subsidy have five years to be built, and thus the first batch of utility-scale projects are set to be operational in the coming years.

### Political instability in Bulgaria is slowing solar's growth

Of all the countries covered, Bulgaria is probably the one with the most uncertainty at the moment in terms of potential for renewables, let alone solar PV.

Most of the installed solar capacity in Bulgaria in the past years came from ground-mounted and commercial installations, while residential rooftop is almost non-existent. However, authorities in the country are looking to introduce a support scheme for 10,000 small residential installations of up to 10kW in a move that could kickstart interest in residential solar.

The country has yet to face a similar boom than its neighbouring countries Greece and Romania. But solar is slowly taking off. In 2021 the country added 100MW of solar capacity, while last year it increased by almost sixfold to 580MW, says Rumen Petrov, board member and secretary-general of trade body Bulgaria Solar Association. "The very high price of the electricity last year pushed the market for solar plants."

It's only a question of time before the solar PV market blooms, as there are nearly 20GW of capacity to be added in the next three years, according to Petrov. All this solar capacity is currently waiting to get its application approved in order to get grid connection.

Due to the dynamic of the energy market in Bulgaria, short term contracts – of one year – are being favoured for the offtake of solar projects, says Petrov.

Probably one of the major issues in Bulgaria is unrelated to the solar industry in itself, as it is about the political instability the country has faced since 2021 with five elections in over two years, and with the latest one in early April 2023. This instability has made more complicated to pass new renewable legislations or reforms of the Renewable Energy Act that could give a bigger push for solar PV to grow in the country. Currently passing of that act is not expected to happen before the autumn, according to Petrov. More on the subject in this edition of PV Tech Power from Vladimir Tabutov, CEO of HEC Solar and former deputy of the Energy Commission of Bulgaria.

"However, it's worth mentioning that what makes it attractive, is that it starts from zero. Practically. There's a huge space, once you remove two or three coal plants, and there's a need for the capacity, it opens up huge opportunities for everyone," says Kefalas of Aurora Energy Research. And unlike neighbouring countries, the grid in Bulgaria has not yet faced the same levels of saturation.

Another problem that is currently slowing down the pace at which solar projects are completed comes down to the slow process of which building permits and grid connection permits are handled in Bulgaria. "The application for grid connection should be answered from the distribution electricity company within one month, but in practice, they're answering three to five months later. And it's almost the same with municipalities in terms of building permits," says Petrov.

However, a positive development that is expected to accelerate the growth of renewables in the country is the effect of the Recovery and Resilience Plan (RRP), says Kefalas. "There will be auctions to support 1.4GW of renewables by 2026. And this will be co-located with 350MW of storage," Kefalas adds that solar will most likely be the dominant technology for the auctions.

In Bulgaria's plan submitted to the



Credit Chint Solar

European Union, the country aims to invest €1.7 billion (US\$1.87 billion) towards accelerating the deployment of renewables, electricity storage and interconnection capacities. The European Bank for Reconstruction and Development (EBRD) is working with the Bulgarian government to support the implementation of the reforms needed to boost renewables deployment.

Due to the nature of the projects being funded through the RRP, the projects will need to be delivered in strict time scales. "For the first time after nearly seven years or so, we will see some more potential for renewable capacity in Bulgaria to be installed," adds Kefalas.

These fundings will be necessary to kickstart interest in renewables in Bulgaria as merchant projects still have difficulty in securing funding from banks as they do not trust the current environment, according to Kefalas.

Given its vicinity with Greece, the country could clearly learn from what the government in Greece has done in terms of auctions for renewables and stating a clear target to decarbonise its electricity, especially given how unambitious its national energy and climate plan (NECP) is in terms of solar PV capacity, with a target of a mere 3.2GW by 2030. The cumulative installed capacity at the end of 2022 was of 1.5GW. A recent report from trade body SolarPower Europe expects Bulgaria to reach the target by 2025.

### Hungary's double-hedged inter-connection capacity

The activity in Hungary in the past two years has been quite low, says Kefalas, however the possibility that the government might reintroduce development of wind technology could help bolster the appetite in renewables, which was primarily driven by solar PV. At the end of 2022 Hungary had 3.9GW of total solar capacity installed.

Traction for solar PV is still lagging compared to other countries, despite launching the Metár auction a year and a half ago that attracted significant interest at the beginning, however, the latest auction ended up undersubscribed.

The current issue with projects not being funded through government subsidies is that Hungary set in place a 31% supplier income tax that affects any project that is not subsidised. "This means that if you secure a tariff for €50/MWh in the Metár auction, you're exempt from

The pace at which Poland has added solar capacity has quickly put it only behind Germany and Spain in terms of added annual capacity. And it is expected to continue to be at the forefront of the EU countries in the years to come

that. Now, if you want to sign up a PPA, you have to include a 31% extra cost in your calculation," adds Kefalas. For that same reason, so far not many PPAs have been signed as it makes it more complicated to secure an offtaker.

Hungary's power system, meanwhile, could be a major obstacle for faster adoption of renewable energy generation. Hungary is a massive net importer of electricity, which makes them dependent of neighbouring countries and can trigger high costs if these countries have a low renewable penetration. Currently Hungary has 8GW of interconnectors with surrounding countries and does not require much balancing capacity or energy storage, as opposed to other countries in the region, according to Kefalas.

This could open the door for cross-border PPAs between Hungary and other European countries that might have better economics, lower financing costs and better load factors among others to rather develop a solar plant there and then sell the power produced in Hungary, a country with an important industrial activity. Kefalas warns that some constraints might apply in terms of how much cross-border capacity can be exported through PPAs.

Within its own borders, Hungary still faces a major challenge with its grid capacity, which was in such a bad state that it stopped accepting any grid connection last year, according to Kefalas. "The grid connection in Hungary is extremely important for the development of solar."

In order to improve the grid strength, new projects submitted in the Metár auction would need to have 10% of the capacity co-located with storage.

### Other countries in the Balkans

Irrespective of the size capacity of any of the other countries in the Balkans (such as Croatia or Serbia), Kefalas does not

expect them to reach a similar potential as Greece, Romania or Poland. Currently both Croatia and Serbia are more focused on wind power.

Serbia is about to launch its first renewable auction seeking 400MW of capacity, however, solar technology has not been included. It is only seeking wind power, despite solar having good potential in the country, according to Kefalas.

In the case of Croatia, Hungary's situation of being a major net importer of electricity could be beneficial to attract developers and investors in Croatia to build solar plants in the country and later export the capacity to the neighbouring country, due to load factors being better in Croatia than in Hungary.

"In terms of fundamental economics, it would make more sense to overbuild in Croatia and export to Hungary," adds Kefalas. However, this would need to take into consideration the threat of price cannibalisation which would be one of the major challenges in the region once more solar projects become operational.

Zygouras adds that even though at the moment Sunel is not looking to expand but rather solidify its position in the markets it is present, moving to Bulgaria, Croatia or Serbia would not be an issue, but would depend on the needs of the customer. "We're more customer orientated, if a good customer has a project in Bulgaria, we'll go there and construct for him. If they have a project in Serbia, we'd do the same. But going directly to a certain market and start building projects is not part of our strategy."

Overall most of the countries in Southern Europe still have a lot of progress to make in terms of accelerating the deployment of solar PV across the region. Greece, Romania and Poland farther north have managed to get to a more mature stage in terms of solar deployment and in the coming years are expected to enter the top ten in terms of capacity deployed in Europe.

While all the countries covered here differ significantly in the degree that renewables have penetrated the respective overall power generation mix, all will require a much bigger effort in order to meet decarbonisation targets and contribute towards the European Union's stated target of 740GW of installed solar PV capacity by the end of this decade. ■

# JinkoSolar - AAA ranking, development plans and challenges



**Roberto Murgioni**

Following JinkoSolar's recent AAA ranking in the Q1 release of PV-Tech's ModuleTech bankability report and the release of its first-quarter results, PV-Tech's Simon Yuen caught up with Roberto Murgioni, the company's head of Technical Service and Product Management in the EU.

**PV Tech Power: Could you give us an update on JinkoSolar's current status, shipment records and trends, particularly regarding N-type products, and also tell us what the AAA ranking in the PV ModuleTech bankability report means to the company?**

**Roberto Murgioni:** Jinko has recently reported shipments in Q1 2023 of 14,490MW, including 13,038MW of solar modules. N-type module shipments were approximately 6GW and the company expects its annual production capacity for mono wafers, solar cells and solar modules to reach 75GW, 75GW and 90GW, respectively, by the end of 2023. We are confident in our ability to further increase our competitiveness and profitability in the global market, especially in the EU, with our continuously improved industrial chain and cutting-edge N-type technology and products.

By the end of 2023, we expect N-type to account for over 70% of our total cell capacity and we are confident of achieving our module shipment target set at the beginning of the year, with N-type modules account-

ing for about 60% of total shipments. We expect module shipments to be in the range of 16.0GW to 18.0GW for the second quarter of 2023.

With regard to the AAA Bankability rating in the PV ModuleTech report, this simply highlights our position as a leader in N-type TOPCon (tunnel oxide passivated contact) technology, which has been the catalyst for innovation and upgrade throughout the whole supply chain, from equipment to materials. This has resulted in fundamental changes to the technological advancement of the PV industry as a whole, with JinkoSolar's leadership, manufacturing excellence and open eco-system platform enabling the world's most advanced, cutting-edge technology to become commercially available for the first time.

**Can you provide more details on the development of the new business unit with a focus on residential and utility scale ESS?**

The new business unit is aimed at providing customers with efficient and reliable energy storage solutions. Our residential storage products are designed to provide users with more efficient and long-term product life, while also offering high performance, flexibility, safety and user-friendliness.

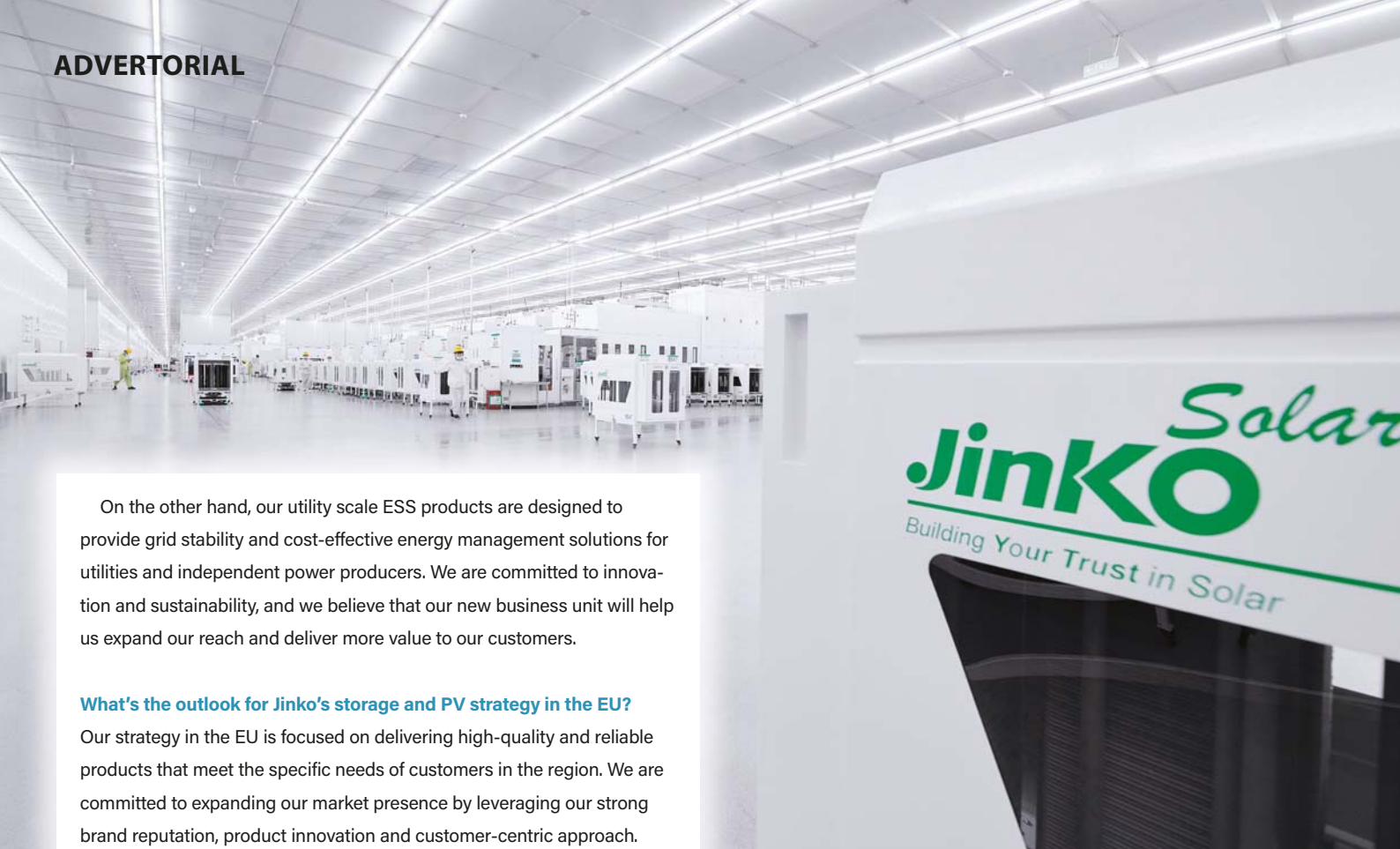


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On the other hand, our utility scale ESS products are designed to provide grid stability and cost-effective energy management solutions for utilities and independent power producers. We are committed to innovation and sustainability, and we believe that our new business unit will help us expand our reach and deliver more value to our customers.

#### What's the outlook for Jinko's storage and PV strategy in the EU?

Our strategy in the EU is focused on delivering high-quality and reliable products that meet the specific needs of customers in the region. We are committed to expanding our market presence by leveraging our strong brand reputation, product innovation and customer-centric approach.

The strategy is centred around offering a comprehensive range of storage and PV solutions that help customers achieve their sustainability and energy management goals. We are also focused on building strong partnerships with key players in the industry, including utilities, installers and distributors, to enhance our market position and grow our business.

#### What are the features of the new RESS product? What sets it apart from products from other companies?

The RESS product, the JKR-B1250~2750-A (high voltage G2 battery), is a high-performance energy storage system designed for residential and small commercial applications. It features a self-developed Jinko high-voltage battery with a single pack capacity of 3.84kWh, which uses a long cycle high-quality cell that can reach 6000 cycles at room temperature (25°).

The product supports a maximum of 5 racks in parallel, offering an 11.52~134.4 kWh capacity range to meet different clients' needs. It offers high performance, including up to 100% usable energy, 45A charging and discharging current, support for 3-7 packs per rack and no cables between packs. The product also has a high protection rating of IP65 to enlarge application scenarios and features a cell-level anti-fire design to ensure total safety.

What sets our product apart from others in the market is its unique heating system, which gives it a wider operating temperature range, two levels of isolation between cells and BMS protection logic to enhance safety.

We also pay a great deal of attention to the sustainability of the entire production process. It is completed via a fully automated production line, effectively reducing energy consumption, achieving a high degree of quality control, and improving efficiency. Aluminium, copper and even lithium materials can be recycled, with the industry having a mature recycling mechanism in place.

#### Are there any major plans the company is working on over the coming months?

JinkoSolar is always working on developing new products and technologies to meet the evolving needs of our customers and the market. In the upcoming months, we are focused on expanding our market presence in key regions, including Europe, and on enhancing our product portfolio by developing new and innovative storage and PV solutions that meet the specific needs of different sectors, including residential, commercial and utility scale.

We are also committed to sustainability and are constantly looking for ways to reduce our environmental impact and enhance our contribution to the global energy transition.

#### What are the main challenges for the company and for the industry at present? How will JinkoSolar overcome these?

The renewable energy industry is facing various challenges at the moment, including the need for continuous innovation and development of new technologies, reducing production and installation costs, adapting to changing regulations and policies and the increasing competition in the market. For JinkoSolar specifically, one of our main challenges will be to maintain our position as a leading player in the industry by continually enhancing our products and services, investing in research and development and expanding our market reach. The company will also need to address the growing demand for sustainable energy storage solutions, particularly in the residential sector, and remain competitive in terms of pricing and performance.

Given the combination of our long-term excellence in R&D and manufacturing and our global presence, we are confident that we are well positioned to meet and overcome any challenges presented to us going forward.

# Unlocking grid bottleneck key to Greece's blossoming PV potential

**Emerging Europe** | Tom Kenning on one of the most promising up-and-coming solar power players of Southern Europe, Greece. He asked experts about the challenges and opportunities for PV in the country.



Credit: HELAPCO

With an energy history dominated by lignite power plants, driven by its plentiful lignite reserves, Greece has started to make strong statements regarding the energy transition and it has already started to shut down some of the old power plants. Industry commentators see Greece as one of the most promising of Southern European countries for solar PV at present with a foundation of clean energy auctions that have been taking place since 2018/19.

It now also shows potential for a promising PPA market that is discussed in our cover feature about European markets. Greece is a small market with roughly 10.5 million inhabitants and with tourism as its economic mainstay. It doesn't have much heavy industry meaning there is comparably low electricity demand. Nonetheless, there are huge numbers of PV project applications in progress and Greece has the highest standalone energy storage target in Europe.

"I see Greece both as an opportunity as well as a challenge," says Philipp Kunze, MD BayWa r.e. Projects Greece at Munich-headquartered clean energy company BayWa r.e., which has a pipeline of 1.3GW of solar projects in Greece. "The interesting aspect of the market is Greece really has understood the energy transition, especially on the electrical side, because Greece does have a lot of solar and wind resources."

There are multi-gigawatts of applications pending for PV making Greece "a

very contested market", adds Kunze. Due to the country's relatively limited load, the grid has a limited capacity, which has led to PV grid connections being executed very slowly by the grid operator. Nonetheless, the operator has "ambitious plans" to expand the grid, while the potential to have additional connectors to various directly neighbouring countries is being explored, including a much-debated plan for an interconnection with Germany.

"The government has also taken a very specific stance on providing priorities for grid access," Kunze says. "And that has also made some international companies more concerned about the longer-term viability or the attractiveness of a market like Greece for big companies."

Zooming out from the fundamental grid issue, most signs are highly positive for the Greek solar market going forward. Stelios Psomas, policy advisor at HELAPCO, an association for PV companies in Greece, says that all indicators, whether installed capacity, pending applications, money invested or jobs, are pointing towards a peak period. Despite many complaints by developers disappointed by waiting months for grid connections, for Psomas, right now is the "best time" for the PV industry in Greece to date and "the prospects are even better."

Although statistics are not published yet, HELAPCO believes grid connections may reach 2GW this year, which Psomas says is "huge, huge number" for a relatively small country like Greece.

## Solar power plant at Athen-Eleftherios Venizelos airport.

In 2022, the Greek market grew by 62% from the previous year to 1.4 GW, driven mostly by small ground-mounted PV projects up to 500kW, according to Solar Power Europe (SPE) in its 'EU Market Outlook for Solar Power 2022-2026' report. Positive growth trends were seen in both utility-scale and residential segments and PV was expected to win most of the renewables auctions between 2022 and 2025. SPE also expects Greece to add 10.4GW of PV between 2023 and 2026.

## 'Unambitious' to 'extremely ambitious'

For SPE, the progress has come about due the simplification of authorisation procedures in the summer of 2022 and supportive messaging from politicians, but again the major bottleneck lies in grid connections.

Looking forward, though only in draft versions to date, Greece is also set to propose "extremely ambitious" new targets in its National Energy and Climate Plan (NECP) with a shift of PV target from 7.7GW in 2030 to 14.1GW.

"This is a huge change and I think everyone actually believes that the previous [target] was rather unambitious," says Panos Kefalas, senior associate at Aurora Energy Research for South Eastern Europe. "Now this is pushing a lot more for things to happen when it comes to grid connection and investments."

The target sends a message that now is the right time to invest in PV in Greece with a clear direction to decarbonise.



Industry commentators see Greece as one of the most promising of Southern European countries for solar PV at present.

Credit: HELAPCO

"It's doable from our part... we can even achieve more than that," adds Psomas. "But obviously, it's a huge increase compared to the old target."

Kunze agrees that the key policy driver is the NECP, which also sets targets for wind and energy storage.

"In the past, the Greek solar market has been predominantly driven by auctions and by fixed tariffs for 20 years – that has changed significantly," he says. "The government has recently announced that there will be more rounds of auctions, which will, however, by far not cover the large capacities particularly of solar projects expected to be built."

This may not necessarily spell trouble for solar since the government has understood that solar power plants can run subsidy free just with PPAs, a market for which it has started to set a framework, and which is discussed in PV Tech Power's cover feature.

With an election looming, one industry commentator claims there is "a lot of uncertainty in the market" because a new energy minister coming in could change the trajectory. However, Psomas says the May 2023 elections are unlikely to affect the prospects for PV in Greece.

### Grid congestion and priority list drama

Most medium-voltage grids for small and medium-scale PV plants (8MW or less) are already congested, according to SPE's report, and the same is soon likely

to happen with the high and ultra-high voltage grids for the largest scale solar projects.

New applications are no longer being received for small systems, says Psomas, and while there are still some large capacities available, there are a lot of mature projects that already have grid connection offered and are being constructed.

For high voltage projects there are so many applications pending that a priority list for grid connection was released for such projects in August 2022, which led to numerous complaints from interested parties, especially international investors.

"In these grid permit [approvals], a lot of the grants were given to local Greek companies with a good bunch of the international investors having been left with few grants or no grid access," says Kunze. "That is one of the other concerns that international players do have a little bit about the current Greek market; to which extent is foreign investment really welcome in the market?"

Rome-headquartered renewable energy heavyweight Enel Green Power, for example, is in the final stages of selling all its operating plants in Greece and for projects in development, it has decided to adopt a stewardship model, where it keeps just 50% of the ownership. So, companies are pondering how to approach this market environment.

"It's just a bit of a sign how international players position themselves a little bit more carefully vis-a-vis the market," Kunze

adds, also noting that he believes the issues will be sorted out over the next few months.

"There seems to be the case that this grid connection priority list might need to be prioritised again to allow also for these project to come alive," adds Kefalas – adding that there is some positivity in that the DSO and TSOs in the country have said they believe the highly ambitious NECP targets could be reached.

### Extending the grid

To address the priority list complaints, the Greek government has created a roadmap for future grid enforcement and development.

"Of course, this is not a static situation, it's dynamic, and measures are [being] taken to increase the capacity of the grid," adds Psomas. "So, this is not the end, but obviously, the grid connection is nowadays the most important issue for an investment."

Both the grid operator ADMIE and system operators DEDDIE are obliged to present their rolling 10-year plans annually, taking into account the situation and revising their plans, which now includes strategies to extend the grid.

"I believe that they should be more aggressive on that," says Psomas, "The investor appetite is much, much higher than the grid operator's business as usual. Grids will continue to be a major problem for the next three or four years before we really find the balance."



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Psomas also asks for TSOs to be more transparent with publishing on activity at each substation and transmission line, which in theory they should release every couple of months.

"They're not doing that and this is really ugly," he says. "There is a lack of transparency, so mostly developers are just waiting without even knowing when their application will be examined."

Psomas says the current plan of the DSO is that the Greek system could accommodate up to 28GW of renewables by 2030, which seems very ambitious considering that at present there are 11GW of installed renewable energy capacity. There are also more than 11GW of projects that have already got connection terms and there are pending applications for connection of 25GW, along with an even higher number of extra applications for newcomers that have not yet reached enough maturity to apply for grid connection.

"We have almost 100GW of renewable energy projects [of which two thirds are PV] that have acquired the first license, the so-called product producers certificate," says Psomas. "Half of them – almost 50GW – have applied for grid connection, so there is a lot of people queuing there."

### **Curtailment prospects and other challenges**

Kunze expects the market to become more complex over time and start to require energy storage and new future market designs. Also if more downregulation of renewables because of overproduction occurs, this could lead to innovations using storage for saving energy during peak periods.

Having come from an off grid / island grid background, Kunze says more downregulation of renewables because of overproduction is something that the whole industry has to eventually come to grips with and he hopes that because Greece is committed to the energy transition, it will adopt new developments faster than other markets.

Konstantinos Zygouras, CEO of Sunel Group, an EPC company based in Greece, also notes that Greece is suffering from many of the same constraints as other markets at present, from COVID-19 and the war in Ukraine.

"We have problems with supply chain, transportation and we see prices fluctuation," he says. "Now things have become a little bit better. Of course, one problem

that remains in most of these [Southern European] countries is the availability of skilled workers and also experienced engineers. A lot of projects have been constructed in these markets and this creates this lack of people related to the industry for the installation and the supervision."

### **Auctions**

Current plans involve almost 4GW of renewable energy auctions, two thirds of which will be for PV. The first is expected around the end of the year, suggests Psomas. However, there is a greater focus at present on auctions for standalone energy storage systems because deadlines are looming for "some easy money" the EU is offering to support such auctions. Psomas believes the renewables auctions will come soon after and with a timeframe up to 2025 there is still plenty of time to hit the 4GW milestone.

An auction in September 2022 was undersubscribed for the first time, as developers saw the prospects of large revenues but low prices, with some focus straying towards merchant opportunities, says Kefalas.

### **Energy storage charging ahead**

A 'European Battery Market Attractiveness Report' from Aurora Energy Research in April this year stated: "The five most attractive markets for battery storage in Europe are (in alphabetical order) Germany, Great Britain, Greece, Ireland and Italy, Aurora assesses, considering factors such as policy support, revenue stacking opportunities and demand for low-carbon flexible energy. Ambitious deployment targets have boosted Greece and Italy's attractiveness – Greece aims to install 6GW of battery storage by 2030, the highest target in Europe."

Psomas says energy storage is "going amazingly well" in Greece. In 2022, the Greek parliament introduced a regulatory framework for storage involving an auction process.

"We have a lot of applications for standalone storage," adds Psomas. "We have over 23GW of projects that have already gotten the first production license and some seven more gigawatts pending. That is a total of 30GW of standalone battery storage."

Following the European coalition acceptance of Greece's storage auction plans, the aim is to have three auctions this year for a total of 1GW of battery

storage capacity, with the first one taking place in June (400MW), followed by September (300MW) and the last for 300MW by year-end. According to the scheme approved by the European Commission, there will be a double support scheme with those winning in the auction receiving a capex support equal to €200,000 per megawatt installed. They will also receive operation support for 10 years. The systems are to be installed by the end of 2025.

"This would be a very serious beginning of the storage market in Greece," adds Psomas – noting that there is no installed capacity in the country yet.

Standalone battery projects outside of the auction will have to survive in the free market, which Psomas believes will only be possible if a capacity remuneration mechanism, which does not yet exist, is put in place. Discussions on this mechanism are taking place as part of discussions between the Greek energy ministry and the European Commission.

Separately, Greece's Ministry of Environment and Energy has introduced a new €200 million subsidy programme for residential solar-plus-battery systems – the first such programme to support self-consumption for PV systems up to 10.8kW coupled with batteries. HELAPCO expects around 30,000 residential systems to be installed from now up to 2024.

### **Terrain and equipment**

Terrain in Greece is typically hilly and mountainous, with the larger plains dedicated to agriculture, says Kunze. Due to the shortage of flat land, most PV plants use fixed-tilt systems. Much solar development has taken place in an area called Kozani in the North where many lignite power plants had been located previously, so this area offers grid connection opportunities to PV newcomers joining the network that traditionally feeds the high loads in Southern Greece. However, solar will still be scattered around the country.

Projects are growing in size with juwi developing a 200MW plant and Baywa r.e. working on a system of up to 433MW. Some of the big Greek utilities and international utilities also have 100-200MW projects in the country. Zygouras also notes that there are plans for 500-600MW projects too.

Overall, it is clear that most prospects for Greek PV are positive, but the really large capacity additions in the pipeline remain reliant on solving the grid bottleneck. ■

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# Renewable energy legislation in Bulgaria



**Regulation** | Jonathan Tourino Jacobo caught up with Vladimir Tabutov, founder and CEO of Bulgarian solar power project developer HEC Solar, following Solar Media's Large Scale Solar Europe event in Lisbon, Portugal. They spoke about recent and upcoming changes in the Bulgarian regulations regime for adopting renewable energy technology.

**Rooftop solar installation by Vladimir Tabutov's HEC Solar**

**PV Tech Power: How will the new legislation help accelerate the growth of solar PV in the country?**

Vladimir Tabutov: During the last two Parliaments, Bulgarian legislation in renewable energy and solar in particular has made it much easier for different set of developers to realise their solar projects. Both the Renewable Energy Act

## Bulgaria's renewables legislation

During the last two parliaments, Bulgarian legislation in the field of renewable energy and solar energy in particular has made it much easier for various groups of developers to realise their solar projects. Both the Renewable Energy Law and the Energy Law have been amended in a way which significantly reduced the time and complexity of the development process. Both in the systems for own consumption of households and industrial users is drastically reduced.

Through the changes in the law, a new section, "Electricity storage", was created, which regulates this activity as an operator, a storage facility, equal access to the transmission and distribution electricity networks and equal access to all electricity markets and possible balancing mechanisms the capacity.

The proposed amendments to the Energy Law provide an opportunity for the operator of the transmission network to propose a temporary connection scheme for all or part of the requested power in cases where the purpose of connection is to carry out reconstruction and development of the network.

Thus, generators and customers will have the opportunity to choose whether to join after the relevant network changes have been made or to take advantage of the proposed temporary connection scheme by agreeing to join part of the requested capacity and/or reduce their production and/or consumption in system overload situations.

The total capacity of Bulgaria's network is designed and developed for about 12GW. But whether the current government will be able to push through the necessary legislative changes remains to be seen.

and the Energy Act were amended in such a way that the period and complexities of the development process were significantly reduced. For example, the development process for self-consumption of households and industrial users was cut from 6-8 months to 4 weeks legally limited duration.

Also, the process for small households up to 20KW was relieved by removing several of the development steps. Regarding the upcoming changes, there are several improvements planned in the procedure when it comes to the zoning of the capacities, removing certain steps from the development process and ultimately achieving a more transparent and much quicker development process.

### Are legislators looking at an accelerated approval of the nearly 30GW of solar projects awaiting grid access?

In the 48th Parliament we accepted a temporary measure to allow all reserve capacities at the existing substations to be utilised for the projects that were already in the application process which releases huge potential of imminent grid-capacity, nearly doubling it.

For example, an existing substation with 50kVA capacity would have a

secondary reserve transformer of the same size which could not be used for grid-connection purposes for new solar projects so far. We changed the legislation in such a way that this capacity could be temporary used by the project developer until the newly prescribed substation has been erected. This releases capacities in more than 300 of the existing substations in Bulgaria.

Another amendment that was circulated was to introduce a new reserve fee and an online public register of the applicants, which could have removed any financially unsecured developer interest. This change did however not pass due to the short life of the 48th Parliament.

### During the panel discussion you participated in during Large Scale Solar in Lisbon you stated that the key aspects to look at for developing the Bulgarian grid were the existing capacity and regulation and legislation. What is being done to help improve the grid?

It is a kind of a paradox that simplifying the project development procedure and bringing projects to a ready-to-build stage much quicker on paper would further slow down the realisation of the actual solar power plants unless both the grid physical and legal infrastructures are improved in parallel.

Bulgaria's total grid capacity was designed and developed for around

"Building international grid-connection capacities is crucial to the balance of the already integrated day-ahead market of Bulgaria, Greece and Romania."

12GW. Bringing all new renewable energy projects in the grid poses risks when it comes to the 'hardware' of the grid, or the substation and transmission line infrastructure. Very careful and technically savvy planning should be executed in order to make sure that the produced energy from all those plants is directed in an efficient way. For example, peak power consumption this winter was around 6,500 MW/h. The development speed of peak capacities outstrips the consumption tendencies and hence requires technical solutions to either direct the extra electricity for export (currently at an

average of around 2,000MW/h) or store it. So, building new grids, substations, lines, and storage facilities constitutes the hardware that we need. In order to do it at a comparatively fast pace, we need the proper legislation.

### Are there any challenges related to the growth of solar PV and/or the grid capacity in Bulgaria that the legislation might still not be able to fix or improve and that might require further work - either through newer regulations or work done by the TSO?

Building international grid-connection capacities is crucial to the balance of the already integrated day-ahead market of Bulgaria, Greece and Romania. TSOs from the countries are working closely to improve inter connectivity but actual realisations of such projects will take at least a couple of years. So ultimately, if inter-connectivity is not improved, there might be price differences in each of those countries depending on demand and supply within each country.

### Are there any innovative aspects of this new legislation that neighbouring countries such as Romania and Greece or other European nations have not implemented in their own legislations and that might be beneficial for the growth of solar PV?

One good example is that during the 48th Parliament, we amended the Energy Act by introducing definitions and procedures for energy storage, for example that building battery storage at an existing solar facility does not require a new construction permit. This would allow utilising funds and quickly develop the storage capabilities of the grid. ■

#### Author

Vladimir Tabutov is the founder and CEO of Bulgarian solar power project developer HEC Solar. He is member of the management board of APSTE - the Bulgarian Association for Production, Storage and Trading of Electricity. He also co-founded and managed the hydro-energy and financial management company Slice Crowd. Vladimir received a bachelor's in business administration from the Bruchsal international university in Germany. He served as an MP in Bulgaria's National Assembly in 2022 and was deputy of the country's Energy Commission during that time.



# Aiko Solar launches All Back Contact module in Europe



Christian Peter

Aiko Solar, one of the world's leading solar cell manufacturers, has announced the launch of its new 'All Back Contact' (ABC) module in Europe. Based on cells with entirely back-contact technology and no silver in the cell construction, Aiko claims it to be the most efficient option for the future of residential and commercial and industrial (C&I) PV markets.

Since 2015 the company has been mass-producing cells from its bases in China, developing both its PERC and back contact technologies to record efficiency levels at scale. In 2020, it established a European presence by opening SolarLab Aiko Europe, with a view to combining the mass-production knowledge of its Chinese operation with European research and development (R&D) expertise.

Christian Peter, Managing Director of SolarLab, sat down with PV Tech Power to discuss the rollout of the ABC module in Europe, the specifics of the technology and the history and future of solar R&D in Europe.

## **PV Tech Power: Tell us about the background of Aiko Solar's cell R&D in both Europe and China that has led to this new back contact tech.**

I've known Aiko since 2015, when the company was one of my clients. At that time, it was a pure PERC manufacturer, with one base in Foshan, where the company originated. Chairman Gang Chen had a really ambitious programme to further develop PERC and the company's success story has been tremendous. If you look at the current turnover, it shows an average CAGR of 77% over the last few years, and the National Renewable Energy Laboratory (NREL) chart from 2021 showed Aiko as the world's number one cell manufacturer.

In 2020 Mr Chen asked me if I would like to join Aiko to be a bridge between China and one of the most important markets, Europe. The general idea was to support Aiko in terms of R&D, customer relations and local production, so we opened SolarLab Aiko Europe in Freiburg, Germany.

Moving on to the subject of current technology, if you're not going in the direction of tandem cells, there are only three other options - TOPCon, heterojunction and back contact.

Heterojunction (HJT) offers a high efficiency potential and very low temperature coefficient thanks to the outstanding surface passivation enabled by its amorphous silicon passivating contact layers. The main issue is that I'm not sure if one can significantly reduce the usage of scarce materials like indium and silver. Additionally, the CAPEX is more than twice that of PERC or TOPCon.

TOPCon is more or less a 'PERC-plus-plus' cell, so you could in principle use your PERC production lines and retrofit them to TOPCon. TOPCon has a similar efficiency potential to HJT, but today has lower production costs.

You then have the back contact option. We ultimately opted to develop TOPCon and back contact in parallel, in collaboration with our Chinese colleagues. Following a technical assessment in 2021, there were some issues to overcome but, once I'd seen the ABC pilot line in Foshan, it was really amazing. We now have a module efficiency of 23.6% and, having analysed all the various technologies, we believe that back contact offers the highest potential.

## **There's been a big industry shift towards TOPCon as PERC begins to fade. Will you follow this trend, or will back contact continue to play a major role in Aiko's R&D?**

You always have to balance the R&D and business views. I don't yet have yield data for the production or balance of system costs – these are areas which are well covered by China – but in the end they have to calculate themselves which business model makes more sense. If you're looking at utility scale, particularly in terms of LCOE, a PERC module might still fit best. It's quite difficult, even for the more advanced TOPCon, to defeat PERC in terms of utility-scale costs. For a private rooftop I'd always recommend the best available module, as you have high installation costs and a variation in module related costs isn't so important.

## **Turning back to the ABC module: it's removed the need for silver from the cell construction. How and why was that change made?**

The reason is very easy - because silver is expensive. There's a paper by Brett Hallam from the University of New South Wales which I like a lot. He calculated the gross rate of PV growth and then the amount of silver on Earth and he found that, if we increase PV at the rate currently planned, we will completely exhaust the world's supply. So silver was always a problem for us and it's a good step to remove it. This has been a well-known issue for at least 10 years, with many ideas as to how to eliminate silver being discussed at industry conferences.





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You always try to introduce copper because it is the 'standard' conductor, but then you have to check the solderability and the diffusion of copper into the bulk material. That's the path that Aiko followed and we found a good solution. I'm not able to give full details but, basically, we replaced the silver with copper.

**The ABC module also does away with the front-face grid that we see on most PV units and has been dubbed the 'black hole' module. How much of a difference do these changes really make, and are we going to see gridless, silver free modules become more widespread?**

The modern PERC cells currently have maybe a 5% coverage with the front grid, so there's 5% you can add to your efficiency. Also, every grid line is a potential recombination area, so you have to open your passivation area if you want to have the grids. Grid lines are not only an optical loss, you also always have an electrical loss with grids - that 5% of 'shading' can be added on and, additionally, better passivation of the emitter can be achieved with back contact technology.

Our ultimate aim is to see the product used everywhere, but this requires interim development steps, of course. The first step was to provide high class modules for the residential and C&I markets. I'm not an expert on C&I, but I think you have high installation costs there and weight is an issue, so Aiko is developing lightweight modules to overcome this problem. We believe we have a great opportunity in this area and the markets for both are huge.

Utility-scale, as we discussed before, is totally price-driven. This means you're not selling watt peak but LCOE, and for a good LCOE you need a degree of bifaciality. If you have all the contacts on the back side then the bifaciality is lower and, while there are some ways to mitigate this, they simply haven't been optimised yet. This is something that Aiko is working on at the moment - improving bifaciality as much as possible and then checking the LCOE for utility-scale.

**What is Aiko's strategy for entering the European market with this product?**

We are focusing on the high-end, quality market. On the customer side, there are those who don't care about price, since they are mainly interested in offsetting the effects of climate change. Then there are others who

are more price sensitive and will calculate the cost themselves. Right now feed-in-tariffs are quite low, so it's not really about the sale of electricity to the grid, more about self-consumption. There are many different types of customer, but if they are totally price sensitive I don't think they will use our system.

They're looking for payback times. The capex is higher, but the payback time is still quite good. From analysis we have carried out, our expectation is that the energy generated with these modules can be 15% higher, based on the area, compared with other 'second best' modules. Not only do you have better efficiency, but also a better temperature coefficient and, if you take all that into account, it adds up to around 15%.

In terms of markets, we believe that Italy may be significant in the future. I think that France may also increase in potential, Portugal is developing quite well and, for sure, there's still a lot of potential in Germany. We have divided Europe into six regions and we will have dedicated offices to check out each market in detail, as subsidy schemes are often a deciding factor in take up.

**Can we expect to see more Aiko R&D and products entering Europe in the coming years?**

We have established Aiko Energy Germany in Düsseldorf and this will be the headquarters for the European operation. Aiko Energy is focusing exclusively on ABC modules and fully integrated systems (inverters, batteries, mounting material, EV chargers, etc.), with a strict separation policy in place so as not to compete with our existing cell customers. This will result in the company not manufacturing any PERC modules, because it's already delivering a lot of PERC cells to Europe, and not supplying ABC cells to any other module manufacturer.

TOPCon is something we already have in our portfolio, so it's a question of how much we will invest and whether we will have full mass production lines. If you look three to five years into the future, I think the next big development will be tandem cells and modules. There are always obstacles to overcome, but at the moment we are reaching the efficiency limit for silicon cells. With the all back contact cells, there may be a record efficiency around the end of this year of around 27% - and that's close to the limit of where you can go. If you want to go above this, you really have to adopt tandem technology.

# Poland's rise to European PV heavyweight

**Emerging Europe** | Tom Kenning reports on Poland, a fast-rising star in the European photovoltaic market, where recent growth has been fuelled by the prosumer segment.

Poland is still the largest hard coal producer in Europe so its attempts to decarbonise through renewables are critical for the climate mitigation agenda. With just 2GW of solar installed at the end of 2019, the country has seen a meteoric rise towards becoming the third largest solar PV market in Europe in terms of installations in 2022 with 4.9GW deployed during the year, according to SolarPower Europe (SPE).

Much of the rise has been driven by a thriving rooftop market in home prosumer installations supported by a net-metering scheme and government programmes giving financial assistance to households, but a change in law is hampering the segment. Meanwhile, large-scale PV is rising at a pace to spearhead a second strong rise in Polish solar deployment.

Around 8GW of the 12GW of cumulative installs by 2022 year-end was made up of prosumers, householders and small businesses driven by government support. The most recent boom in large-scale PV, however, was initially driven by the auction system under contracts for difference (CfDs), but the main push now comes from increased public support for PV, high energy prices and Polish industry's interest in securing solar-based corporate power purchase agreements (PPAs).

"Poland is a market that needs renewables," says Eyal Podhorzer, CEO of Econergy, an international developer with headquarters in Israel and a pipeline of more than 1.5GW of large-scale PV projects in Poland: "70% of Poland's electricity is based on coal. Obviously, it is looking to decarbonise as fast as possible."

More than 4GW of large-scale PV projects were installed in Poland in 2022 alone.

"It's quite a large number for a country like Poland," says Podhorzer, adding that



Credit: Green Genius

the Eastern European country is not seen as a top tier location for PV given its more northern location with less favourable irradiation conditions. But since the government curtailed the entry of new wind projects two years ago, investors have shifted their development efforts into PV. This has been supported by a reduction in capex in equipment prices that enabled projects to reach grid parity and become sustainable investments.

## Terrain

There is no standout region for solar development in Poland according to the developers that PV Tech Power spoke to. Econergy for example has PV plants all over the country.

It's a similar story for Green Genius, a renewable energy arm of Lithuanian company Modus Group, which has implemented 129 solar projects in Poland and has nearly 700 in development. Simonas Šileikis, the company's head of solar business, says there are few regional specifics other than the obvious benefit of higher efficiency in the south due to moderately better irradiation.

## Aerial view of a Green Genius solar project in Naklo, south Poland

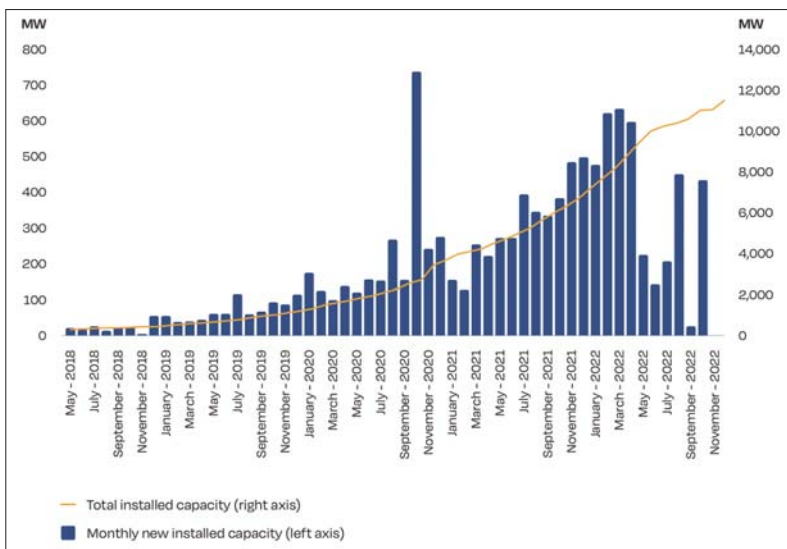
However, availability of the grid in the south is more suited to small and medium size (<100MW) power plants. Most developers are just aiming for projects wherever capacity is available across the country's five distribution grids.

Capacity should be available in the north, but this has been blocked for impending offshore wind installations, leaving PV projects stuck at the future development phase. Šileikis says that as a result Green Genius is looking for more southern locations.

## Grid trouble

Interconnection issues are the only impediment to the continued substantial expansion of Polish solar PV with grid operators unsure of when new capacity will open up. Likewise, an SPE report noted that the old grid requires modernisation for the energy transformation since "most of its components are over 25-years old, and a significant part is over 40-years old".

Juxtaposing these reports, Econergy says it has not faced any connection issues in Poland and it continues to build substations and heavily invest in ancillary services



and infrastructure for projects in order to connect to the grid.

"We priced it in our business model, but I don't see an issue on a national level," says Podhorzer.

Śileikis, on the other hand, says that although larger projects have started to become successful, with Poland's market seen as "stable, secure and predictable" and closing in on 12.5GW capacity, it suddenly became almost impossible to get grid connection confirmation for new projects since September last year.

The grid axis as a resource became very limited leaving Poland with a huge number of projects under development that have secured land but are struggling to get the connection confirmation from the grid. Green Genius, which is developing projects of around 5-50MW in size, has itself faced this grid issue.

Green Genius is confident the right conversations for these issues will be had in the near future so it will continue to develop projects knowing that Poland will sooner or later have to face up to the reality that new generation capacity is necessary to phase out the heavy dependence on fossil fuels.

"I'm quite optimistic towards Poland," Śileikis adds. "It's a question of when people will be ready to change. That's very much the political question as well as for the overall environment and European Union. Poland is a very important market."

### Entering the market

There are two general ways to enter Poland's PV market says Dr Dariusz Mańka, director of legal and regulatory affairs at Poland's solar association Polskie Stowarzyszenie

Fotowoltaiki. The first and fastest is to make an acquisition of one of the many projects on the market already.

However, Mańka warns that after a few years of the market booming, the projects that have not yet been purchased tend to have "more or less serious" problems relating to grid connection and construction permits, so it's quite difficult to get high quality projects to build and to operate.

The second way is to develop green-field projects. This appears to be more difficult, but there is growing industry demand for solar, so developers can work in tandem with industry partners to develop projects with a direct line to the off-taker using the corporate PPA model.

Meanwhile, local governments will also be looking for cleaner and cheaper energy this year, offering another option for partnership.

"There's going to be a mandate from provinces in Poland to get renewable capacity and those provinces will have to take it upon themselves," says Mańka. "So, it will be a decentralised push."

### Rooftop driven by EU goals

Poland had 1.13 million PV micro-installations of under 50kW capacity installed by the end of summer 2022, driven by the original support systems for prosumers, according to SPE. Along with no distribution fees for using the grid, prosumers had benefitted from a net-metering scheme. Poland's solar growth started in this rooftop segment as a government strategy to avoid internal issues with the grid.

"It was easier to give money to people that install small PV than to invest in the

**Only grid connection is seen as a barrier to continued rapid growth.**

large-scale infrastructure, because the main obstacle for large-scale PV is the lack of infrastructure, lack of grid," adds Mańka.

The government was under pressure from EU renewable energy goals, and the prosumer market was seen as the easiest way to achieve those targets as opposed to large-scale PV. However, rooftop solar's rapid rise has been checked by recent changes in law.

### Rooftop progress hampered

In April last year, the net-metering system was replaced by a net-billing system. In this case, prosumers are compensated for energy fed back into the grid but still pay for consuming electricity like normal customers, which has led to a drop in rooftop PV popularity.

Distribution system operators (DSOs) which are 90% state-owned, had seen huge numbers of rooftop solar additions and started to question whether this was destabilising the grid, says Mańka. So, they pushed the government to introduce a new system that would force the prosumers to contribute to the cost of maintaining the grid.

On the other hand, there has been a change to the Mój Prąd (My Electricity) scheme which is favourable to prosumers. From mid-December last year to the end of March this year, residential solar

It was easier to give money to people that install small PV than to invest in the large-scale infrastructure, because the main obstacle for large-scale PV is the lack of infrastructure, lack of grid

subsidies have been increased by 50% from 4,000 PLN (~US\$900) to 6,000 PLN (~US\$1,350) per system, while the rebates on battery installations were more than doubled to 16,000 PLN (~\$3,590).

### 'Constant growing need for large-scale PV'

While the government is supporting rooftop PV with new regulations on housing in cities, Mańka does not forecast a major change in the development of rooftop growth. On the other hand, there is a "constant growing need for large scale

installations" both for industry and state-owned industry. It was unfortunate from the large-scale PV industry's perspective that rooftop deployment had created an image that there are large capacities of PV in the grid already and the country does not need anymore.

Nonetheless, power purchase agreements (PPAs) are a promising route for large-scale projects and both the potential and demand is growing for the sector, although there is also a growing list of obstacles.

Šileikis says that Poland's early auctions were an attractive and successful support scheme for several years that brought competition and a wave of developers to the country.

"This looked like a really stable investment, which was easy to finance, easy to attract the final investment or long-term investors," says Šileikis – adding that unfortunately, there were problems with the pricing in the latest auctions in 2020 and 2021 which combined wind energy with solar projects of above 1MW in size.

Nonetheless, Šileikis believes utility-scale projects will keep catching up as there are a number of huge projects already being constructed in Poland including a 200MW hybrid wind and solar project.

"There are similar projects under construction, which definitely will change the shapes of growth of those two sectors – prosumers and the utility-scale. However, for the new developments, new installations, it's a little bit of a challenging time right now, just because of the grid connection."

Econergy has now started work on its first Polish project, the 52MW Resco plant. Podhorzer, says: "In the last 12 months, I would argue that most of the growth actually came from large-scale PV. We see the level of interest of new international investors coming in and entering the market and obviously, none of them is looking for small rooftops.

"In Poland, we have the CfD, which is very active. We have a good mature PPA market. So, it is possible to close good long-term PPA agreements and all these obviously contribute to a faster development process and growth of the large-scale PV projects."

### Auctions stutter

Originally, the main incentive for large-scale solar in Poland was the auction system under the CfD scheme, which now

separates projects into two categories above and below 1MW in size, with those above 1MW also competing with wind. However, with growing energy prices, more and more companies decided to sell energy on the market rather than go into the auction system, says Mańka. Though a change on price cap regulations did allow the auction system to make a comeback, this year's auction was a disappointment

Despite the auction hiccups and the changes in rooftop subsidy, Poland is seen as a stable PV market going forward, though for large-scale solar to grow, significant investment in the various power grids will be necessary

because the reference price was too low compared to the market price even after the price cap was brought in.

Mańka is not expecting the price to change for the next auction, but nor does he believe that this necessarily spells the end of auctions, because from a bank and financing perspective, large-scale PV projects won through these auctions are seen as a stable source of revenue.

Podhorzer, for example, praises the CfD for the flexibility it offers over other kinds of subsidy and the PPA schemes, which involve commitment to rigid agreements for 10 years or more.

"On the CfD side, you can decide how much you commit. If you're not happy after three years or two years with the agreement, you can stop it, you can renew it later. You have 42 months from the moment you're granted with a CfD until you can start producing and selling to the grid."

CfD projects can also be combined with PPA or merchant solar arrangements, for example giving 30% of your capacity to the CfD scheme but going merchant for the remaining capacity or combining with a PPA. Econergy is currently looking at options for a combination of CfD, PPA and merchant for its 52MW Resco project ahead of its completion in June.

Podhorzer does expect the government to make changes for the next auction. Ideally, the minimum reference price would not be in the range of the

unsustainable current market prices and they should be at least in a level that developers and investors feel comfortable to commit to for the next 15 years.

Offering a less flattering view, Šileikis of Green Genius says that combining large projects of wind and solar in the same auction "was not a good idea", because the pricing of wind and solar have different models.

"Due to the war in Ukraine, the demand for the electricity prices has rocketed in Europe, including Poland," he adds. "Then the auctions have become absolutely unnecessary. They just don't work because they were far below the market level of the prices. So, the participation was rather very low in the last auction. We have not been even looking into this."

He also does not expect the regulator to adjust the ceiling price for the next auction and believes that investors will be looking at the longer term – adding: "It's not worth going into the auction with the low price because definitely after the [energy] crisis, the market will regulate itself."

Anywhere in Europe where government bodies try to regulate the market, they end up with investors looking elsewhere to those markets which are not regulated, says Šileikis, noting an outflow of interest from Europe towards the US at present.

"This auction system played its role very well. It absolutely launched the fast development of solar and it helped a lot, but right now, it becomes less and less relevant."

### Future

The Polish market looks set to add 21.8GW of solar over the next four years under the medium scenario, and up to 29.8GW under the high scenario, according to SolarPower Europe's report 'EU Market Outlook For Solar Power 2022 – 2026'.

Despite the auction hiccups and the changes in rooftop subsidy, Poland is seen as a stable PV market going forward, though for large-scale solar to grow, significant investment in the various power grids will be necessary. The country is said to be already facing a shortage in energy production capacity giving solar PV an excellent chance to grow with its unique ability for projects to be commissioned in very short timeframes. ■

# TW Solar aims to provide a more sustainable, reliable module with its Terra range

TW Solar's Terra range of shingled PV modules aims to provide end users with a sustainable solution that combines reduced risk of micro-cracks with excellent performance in harsh conditions.

A globally recognised integrated company in the PV industry chain, TW Solar's silicon and cell shipments have ranked first in the world over several consecutive years, its annual production capacity for high-purity crystalline silicon in 2022 reaching 230,000 tonnes, with capacity for solar cells standing at 70GW, a figure the company plans to increase to 80GW in 2023.

In terms of TW Solar modules, analysts have indicated that one in seven European households installing residential PV panels are now choosing its Terra products.

Comprising Terra-5K, Terra-5E, Terra-5C and Terra - S6 options, the module line has been deployed at rooftop, commercial and utility-scale sites across Europe and Asia, as the company continues to ramp up production to meet demand.

The Terra modules are manufactured by connecting cells with adhesives, forming a power generation array through multiple series and parallel connections that result in a high-density layout to ensure optimal performance in power and efficiency.

The conductive adhesive interconnection method adopted by the shingled technology gives the modules ultra-high flexibility, reducing the risk of micro-cracks, the conductive gel absorbing the stress generated during the modules' compression process, leading to fewer hidden cell cracks occurring during transportation or installation.



## High latitude suitability

Thanks to the complete parallel circuit design, module power loss is reduced when shading occurs, meaning the product is particularly suitable for high-latitude and land-intensive areas that tend to have more shade.

"The modules have higher resilience with a better shadow management system and they have a more advanced appearance," commented Chen Xun, CEO of Austria-based international supply chain management firm Minlea, which has deployed the Terra-5K product. "They are ideal for private roof installations in central and western Europe. People here care more about the quality and appearance of the product and are not so concerned about the price/performance ratio."

Lijuan Huang, sales director for western and northern Europe for C&D Clean Energy, added that her clients have chosen 166 x 60 full black, 5C monofacial and bifacial shingled modules.

"They are attractive for small sized modules, more aesthetically pleasing than regular PERC modules. They perform well and deliver the desired power for a large 550W module. Smaller modules are more practical for households in Europe. For larger modules, my clients mainly use roofing and floor installations for industrial and commercial roofs. The Terra modules have lived up to expectations and clients are very satisfied with their quality."

## Sustainability benefits

In order to reduce the carbon footprint during manufacturing, TW Solar uses flexible adhesive technology that allows modules to incorporate thinner cells and be compatible with wafers as thin as 90µm, resulting in a 40% reduction in silicon use compared with other products on the market.





Top 3 global shingled module manufacturer  
by production capacity



**TOP 3**

**Must Be TERRA**

In Europe, 1 out of every 7 PV households #MustBeTERRA



The electrically conductive adhesive used to connect cells replaces solder ribbons, which are made with heavy metals such as tin and lead that can have a negative impact on the environment. The main film and layer of the Terra panel's backsheet are made of fluorine-free materials to reduce pollution.

The Terra modules have been awarded carbon footprint certification (ECS) by French testing body Certisolis, required by the French authorities for all products entering the country for use in projects of over 100kW.

### Sleek design

Thanks to thermal laser separation technology, the structure of the Terra panel is optimised, reducing cell spacing to increase the light-receiving area.

The attractive appearance of the modules has also proven popular with customers. With no solder ribbon, all Terra 5K and 5E panels feature dark glass and black frames, backsheets and busbars to enhance their integration with roofs.

"The Terra full-black shingled module can be viewed as both a power generating and aesthetically pleasing product," commented Yecheng Guo, general manager at Oss Energie. "It not only has a practical value, but also enhances the architectural appearance, making it an important part of the overall aesthetics of a building.

The shingled module is an ideal choice if you have large roofs or flat areas. Like a mirror, it presents a black reflection effect, improving the appearance of the whole wall or roof."

### 'Better results than with any other panel'

Martin Zhelev, COO at Zhelev Commerce, a company which has used the 5E monofacial module for roof installations and the S6 bifacial module for ground-mount PV systems, added: "The shingled technology provides great benefits in partially shaded areas, low point resistance and hot

spots. TW Solar's shingled modules have exceeded expectations in real world conditions and we have seen better results than with any previous panels. Our clients are all delighted with their investment, even if we factor in the slightly higher price of the Terra range."

With a power output of up to 415W and an efficiency of 22.4%, the Terra modules have a 25- or 30-year warranty for linear power output and a first-year degradation of less than 2%.

TW Solar recently secured a new 100MW supply deal with Minlea, representing a significant milestone in the ongoing success of its products in the European market. The company is also poised to launch the Terra-N, the first n-type product in the Terra portfolio.



# Recycling and end-of-life in the PV industry

**Solar Panel Recycling** | As solar power projects mature, panels increasingly lose efficiency. What do operators do with solar panels once they have reached the end of their lifespan? Will Norman finds out.



Credit: Solarcycle

In 2022, recyclable materials from end-of-life (EOL) solar panels were worth around US\$170 million globally; by 2030, according to research from Rystad Energy, global recyclable PV materials will be worth in excess of US\$2.7 billion, a fifteenfold increase. By the time the global net zero alarm clock goes off in 2050, the value of these materials is forecast to be over US\$80 billion.

As the PV industry reckons with its social and environmental impact and the byproducts of its processes, beyond the near-term questions over provenance, manufacturing ethics and the supply chain, concerns about modules' end-of-life are coming more and more into focus.

The average lifespan of a solar panel is around 25 years; the fleets of modules

that were installed in the 2000s are close to reaching the end of their lives, and whether through repowering, decommissioning or manufacturing loss, each year will bring a more-or-less exponential increase in retiring panels.

Long-term thinking is embedded in the PR of PV companies, working as they are to ensure a more sustainable future for a habitable Earth based on clean energy from the planet's life-giving star. To be genuinely sustainable, the industry needs to make sure that it doesn't create a new problems in solving an existing one.

As of last year, the world has over 1TW of PV capacity installed via billions of panels. This threshold took decades to reach, and SolarPower Europe predicts that the second TW of PV energy will be

**Decommissioned solar panels at Solarcycle's recycling plant in Odessa, Texas, ready for recycling and reuse.**

on the ground by 2025, with the third possibly following more quickly still. That 1TW will need to expand between 15 and 60 times over to meet 2050's net zero targets.

With the huge – and important – growth that solar is seeing, and recent policies like the Inflation Reduction Act (IRA) and Green Deal Industrial Plan which have pushed hard on solar deployments, what is going to become of the sheer volume of *stuff* going out there?

## What's lacking?

Government PV EOL and recycling programmes around the world are dragging their feet.

In Australia, the Queensland state government has announced plans



Credit: Solarcycle

**Laminate pulled from a solar panel before recycling.**

to ban the disposal of PV modules in landfill within the next decade, pending sufficient public and industry proposals. It also committed AU\$250,000 (US\$168,000) to a pilot Solar Stewardship Scheme which will identify locations and participants to recover materials from decommissioned modules and then establish collection, recovery and recycling processes. This is, however, all a decade away and still at the public RFP stage. A lot of modules can go out of commission, break or be repowered by then.

At the time of writing, the US has no concrete EOL legislation in place and the National Renewable Energy Laboratory (NREL) has said that current recycling rates are around only 10%. Impetus isn't present to make recycling a financially viable process, as landfill proposes a cheaper and simpler option.

The US Department of Energy released over US\$8 million in investments for research and development (R&D) projects into recycling and EOL in April 2023, the first meaningful (if only just) investment into EOL that the US has made. The projects that received funding covered both material recovery and manufacturing research designed to make panels – and their recycling processes – cheaper. Scaling those processes is still yet to be acted on.

Europe is the only place where solar EOL policies really exist, included in the Waste Electrical and Electronic Equipment (WEEE) programme which came into law in 2003 and includes solar materials in its remit. It's enacted by PV Cycle, a member-based recycling organisation accredited to comply with the scheme.

Europe also has its own fledgling Solar Stewardship Initiative, a member-based collective of companies designed to focus on the responsibility that the PV industry holds for the entirety of their operations.

And whilst WEEE may be a good baseline, the CEO and founder of US-based solar recycling company Solarcycle, Suvi Sharma, told PV Tech Power that the process in Europe calls only for recycling by 85% weight: "If you take the aluminium frame off and some of the cables off and get the copper out of there, and you just grind and crush the rest into some kind of asphalt mixture, you have complied with EU regulation."

The value of a solar panel isn't necessarily tied to where the bulk of the weight comes from.

The true bulk of recyclable PV material hasn't yet crested the horizon, and most likely won't for a few years, but the backlog is racking up at every new solar farm that breaks ground. For government policy, looking at the manufacturing, deployment and investment expansions that the US has seen following the IRA might provide an early-stage example of the fact that legislation can be effective in pushing industry forward.

### **Working from within – a recycling ecosystem?**

Solarcycle, Sharma's company, specialises in PV recycling with a view to establishing a circular solar economy in the US and, ultimately, worldwide. The company recently received US\$30 million in Series A funding to expand its capacity and capabilities at its Texas facility, and a

further US\$1.5 million of R&D money in the DOE's recent end-of-life investments.

"It's forecast that by the end of the decade there'll be over 10 billion panels," Sharma said to PV Tech Power. "Even 1% of that coming offline in a given year, that's 100 million panels." Scaling operations will be key to dealing with that volume, and the emergence of a circular solar economy, but in the face of an arid legislative landscape the only incentives are coming from the industry itself.

Sharma said that Solarcycle's strategy is to work with leading US asset owners – SunRun, Silicon Ranch for example – to commit them to their long-term recycling programme through strategic partnerships.

In comments to *PV Tech Power*, chief product officer at US PV manufacturer First Solar, Pat Buehler, said that their in-house thin film recycling programme runs on a similar premise.

"We are fortunate to work with customers that share our values and principles, and that includes understanding that recycling is the right thing to do," Buehler said. "We offer Recycling Service Agreements to all our customers, and we consistently see demand for our recycling services continuing to grow."

First Solar was one of the first manufacturers to factor recycling into its operations as far back as 2005, and it has since shipped over 50GW worth of modules, Buehler said. These partnerships and established trends are important for fostering a recycling 'culture' and norm in the industry, particularly regarding pipeline or future projects which can have recycling plans and agreements baked into them from conception.

Fundamentally, manufacturing companies that are willing to spend more to back up their ESG credentials are really important, but the issues of scale and incentive still stands to be reckoned with.

In terms of major manufacturers, both Qcells and JinkoSolar stake claims to recycling their own modules. Neither responded to inquiries to elaborate on how they do it or plans for the future, but have publicly announced recycling processes that focus on recovering bulk material from their panels. Jinko claims that 92% of the materials in their panels can now be recycled via thermal and mechanical separation processes to access the different layers of module and cell and extract the different components.

Qcells said that they comply with

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regulations in every region where they operate and deploy modules, though as we've seen that can be a low bar in some cases; NREL's study says that around 90% of US modules aren't recycled.

As the US' primary module producer, First Solar is a somewhat different story. In comments to *PV Tech Power*, Buehler said that "While most PV recycling processes today focus only on bulk recycling or recovering high-mass fraction materials such as the glass and frames, our high-value recycling process goes further by providing closed-loop semiconductor recovery for use in new modules."

First Solar is a significant US manufacturer with well-established roots and a host of long-term supply deals, but its in-house recycling processes only deal with its own modules and its own segment of the PV market. The majority of US modules come from other producers who – significantly – use other technology: First Solar's Cadmium Telluride cells and modules use different processes and materials that will need to be recovered and recycled separately.

Suvi Sharma said that manufacturers who recycle their own panels are "focusing mainly on their own manufacturing yield loss. It's not this broad recycling infrastructure that has been set up."

These manufacturers are doing a good thing, of course, but Sharma said that the difference between them and a dedicated recycling company is "Focus, and core competency. The reason I formed Solar-cycle was I believed that the industry needed a dedicated, specialised, comprehensive recycling company to take all of these volumes, develop the technology, the equipment, the processes and raise capital to do it."

He likened the situation to mobile phones: "You don't have Apple recycling their own cell phones, you have companies that really specialise in that. I see the same thing happening in the solar industry."

### Following the money

As mentioned above, the key to being able to responsibly deal with the deluge of modules coming down the pipe is scale. Legislation and incentives are one solution to force, or coax, scale, but it's almost always slow. Sharma said that he believes that recycling will be able to scale alongside deployments, partly by becoming cost-effective to developers and manufacturers.

"The competition is always landfill. What we're trying to do in terms of our technology and equipment is to make it so that the cost to recycle with us is a minimal difference [compared with landfill]," he said. "It's not there today, today there's a premium to recycle with us, but we're working to drive down the cost curve and drive up the value curve on the materials we're getting."

He continued: "We decided at Solarcycle to focus on very advanced recycling. It's not really 'go for the gold', it's 'go for the silver' because that's what's [valuable] in the panels."

Mining the silver from the panels, along with the polysilicon, glass, metal framing, creates a genuinely high value process that can save customers money in the long-term, as the company has goals of feeding recovered materials back into the solar supply chain.

Not only does this allow companies to ensure the traceability and ethical sourcing of their raw materials, it can also reduce the cost of having to buy or mine new resources at a premium and increase the return on every recycled module.

Silver itself is going to become another long-term concern for the industry. A well-known December 2022 paper from the University of New South Wales forecast that, if PV deployment rates stay on track until 2050, between 85-98% of the world's silver reserves will be used up by the PV industry. Even by 2027 we will see PV manufacturing use up 20% of the currently available silver above and below the ground.

The Georgia Institute of Technology received funding in the DOE's recent round of investment to look into replacing the silver contacts in solar cells with copper- and aluminium-based pastes that can be applied more cheaply and to most silicon-based technologies. Reduced costs could incentivise recycling by bringing the premium down for the process.

Other silver-replacement research is ongoing at various institutions, and some modules that don't use silver are already on the market for rooftop and C&I markets, but the overwhelming majority of projects that are deployed, in construction, in pipelines or awaiting approval are going to be silver-based PERC for the coming years.

The research to replace silver with other, more abundant and cheaper materials will surely take hold eventually,

### The near-term

Not all recycling and EOL is a decade down the line. Suvi Sharma spoke about repowering – the practice of replacing old, out of date or broken modules with new ones:

"For example, [an asset owner] could run their plant for another 10 years, but they'd be better off repowering with newer panels that are much more efficient. We're already seeing that on the residential/commercial [markets] in a pretty meaningful way, and we're going to start seeing it on utility-scale next year and in a few years it's really going to accelerate."

Module tech and cell efficiencies are constantly improving and the accelerating shift towards n-type and TOPCon/HJT modules is only going to make high efficiencies more available to asset owners with older, less efficient systems. Those old panels have to go somewhere.

"It's actually happening in Europe quite a bit," Sharma continued, "in Italy, Germany and some of the early markets that developed in Europe there's going to be gigawatts being repowered in the next few years. And that's simply for better land use, bringing the power plant up to a higher nameplate capacity on a given piece of land to maximise the kilowatt hours per hectare."

Asset owners and manufacturers aren't going to refuse the energy production and sales boosts that repowering can bring because they're waiting for a responsible place to put the old panels, and extreme weather damage, age and the increasing production of high-efficiency modules is going to make repowering an attractive prospect very soon.

but in the meantime the usage is going to continue growing at ever-increasing rates. The parallel with PV recycling is clear enough: the work that companies are doing will take hold, but until that point the size of the problem only gets bigger.

The logic runs: if you achieve enough financial or industry incentive for companies to recycle – either by high-value material recovery or the example set by significant players in an ecosystem – you don't need to rely on government legislation. But the challenge will be reaching that point without some impetus from outside the industry.

Pat Buehler of First Solar said that they expect landfill costs to increase in the coming years, which will in turn make recycling more affordable and attractive alongside advances in the process to drive its cost down.

Sharma summed up the state of the issue: "The waste problem is just starting. If you look at the grand scheme of things from an E-waste standpoint, solar panels are a very small percentage of that, but it's going to see exponential growth."

"That's what we're working to address, to get out in front of and set up the technology and infrastructure. We have to get more solar on the ground. For us, recycling technology is really a way to make solar more sustainable and scalable."

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# Dialogues with global PV buyers: On module selection, pricing and traceability

**Supply Chain** | Carrie Xiao on a recent workshop held by TÜV Rheinland where PV developers, buyers and investors exchanged views on module quality and buying strategies.



Source: TÜV Rheinland

TÜV Rheinland has held a 'Global PV Buyers' Workshop', inviting some 20 representatives from the industry's downstream players to take part. These included investors such as Brookfield Renewable, BayWa, Engie, TotalEnergies and Lightsource BP, and companies mainly engaged in development and operations such as ACWA Power, Bouygues and ECADI, the idea being to share their thinking from different perspectives on module quality and procurement strategies.

"Our company purchased TOPCon

modules last year, and have recently purchased more," Yanyee Chen, Technical Representative at Atlas told PV-Tech.

Chen Liang, Project Procurement Manager for APAC at Lightsource BP agreed with this strategy, adding: "One of the major considerations for developers is ROI. A quick way to increase ROI and reduce levelised cost of energy (LCOE) is to adopt new technologies and make innovations. To maximise the technological payback it is better to adopt earlier than other developers."

It has been reported that Lightsource

## PV buyers at TÜV Rheinland's recent workshop.

BP currently deploys TOPCon modules for some of its projects and this is not the first time that the company has been among the earliest to choose cutting-edge technology, already reaping the benefits of its purchase of bifacial modules.

Compared with Atlas and Lightsource BP, Engie and TotalEnergies have taken a more cautious and conservative approach, but they too have started purchasing n-type modules.

The trend of switching from p-type to n-type modules is not only gathering momentum on the PV manufacturing



## 2022 - 2023 Global PV New Installation Forecast

**2022**
**244-294 GW** newly installed

### Key Drivers:

Rooftop deployment in China, renewable energy demand highly increased in European countries, US, India etc.

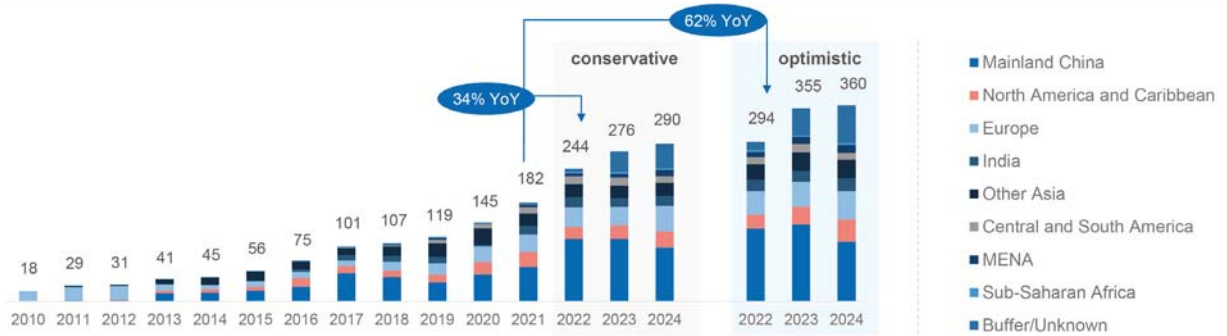
**2023**
**276-355 GW** newly installed

### Bottlenecks:

Local Labours, shortage supply of inverters & other non-module components.



## PV new build, historical and forecasts to 2024 (GW DC)



**TÜV Rheinland**  
Precisely Right.

side, but also gradually being followed by end users. Facing the conversion in technology and capacity, as well as the emergence of new products and players, major developers, buyers and EPCs each have different considerations, which provides module suppliers at different levels with opportunities to sell and grow.

Whether for TOPCon, HJT or IBC, new technologies often require new production lines. Power plant developers and investors don't have other choices, and they also have to take risks.

Ling Jin from TotalEnergies commented: "Some of the suppliers we work with have shifted a large portion of their production capacity quota to TOPCon, so we are also switching from p-type to n-type for the capacity we have contracted. In fact, n-type modules first appeared a couple of years ago and we knew then that the manufacturers would move in this direction. However, considering corporate culture, financing needs and risk assessment, we have been relatively cautious. Of course, we remain open to new technologies and fully welcome innovation so, with the right level of quality control, we have already planned for some projects to use TOPCon."

"New technologies will inevitably bring new products and new risks. Since we can't avoid this, we will evaluate each new product and test it in small quantities first. As for how fast to adopt a new product, I think every buyer has its own timetable in mind." Atlas' Yanyee Chen

### Analytic report of Global PV Buyers' Workshop.

added that, while it is necessary to show initiative, it is also important to find the balance of not being the 'guinea pig' or the very last one to move.

He went on: "In addition, we need the assistance of our dealers and partners. In this way, we can learn more about new production lines at different module factories and bases, their management, production teams, or even operators, because even if from the same brand and factory, the product quality can be different. With all the information to hand, we will then select suitable products to reduce our risk."

### Pain point for module buyers

Of course, there is another pain point for some module buyers. If they do not have enough knowledge about the new products at the outset, or do not purchase enough products to carry out meaningful testing, they are sometimes unable to get the answers they need to solve their problems. Therefore more effective verification methods are needed.

Zhang Yonggang from Engie China said: "For us, one of the effective ways to avoid risk is to seek professional support from a third party such as TÜV Rheinland. Whether it is production line evaluation or testing and verification of product quality, reliability and stability, TÜV Rheinland always has proven methods. We pay special attention to technical contracts and quality control. It is a method we frequently use when introducing new

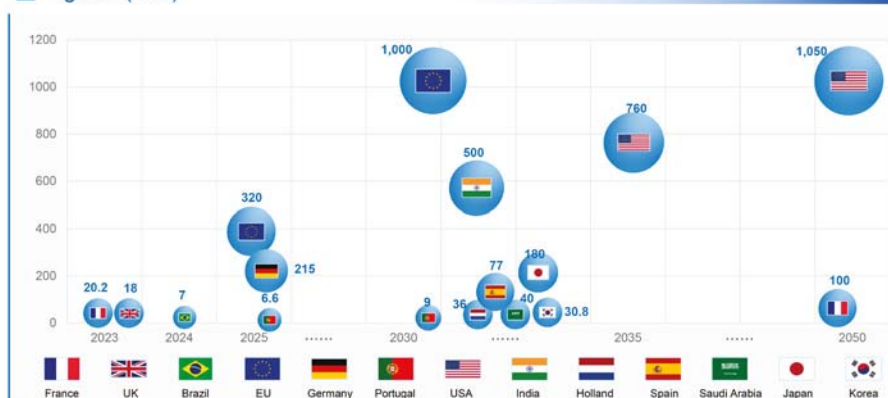
technologies and new suppliers."

In this regard, Ju Shangshang, Department Manager of Solar PV Systems at TÜV Rheinland Greater China, Solar & Commercial Products, explained: "Technologies are upgraded at a very fast pace. When serving purchasers, we will consider more targeted verification methods with faster feedback. We test new products within the shortest time possible, so as to integrate into the market faster."

TÜV Rheinland provides customised solutions based on each company's requirements. While providing testing and certification services, it delivers feedback at different levels and adds extra value for customers. For example, new problems often emerge when testing new technologies and products, thus additional verification methods and communications are required to provide customised solutions, strengthen the quality control of suppliers during manufacturing, identify problems in supervision and inspection procedures and solve these in timely fashion, so as to ensure the integrity of the modules when delivered to the end user.

PV-Tech noted that among all the evaluations of current n-type products, TOPCon products are given priority by all types of buyer, conservative or not. One of the main reasons is that TOPCon is not so revolutionary compared to PERC, enabling many manufacturers to adopt it. This also means that its risk level on the buyer's side is not that high.

Regions/countries around the world have set short-term or long-term PV installation goals (GW)



Source: Governments, public news.

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Yanyee Chen: "There are now multiple module manufacturers producing TOPCon, which means we have alternatives. Choosing new technology based products involves considering the supply capability of the manufacturer and the maturity of the industrial chain. We cannot run the risk of delayed delivery because of failure in the supporting links."

Chen's point resonated with all buyers present at the workshop. In the past three years, prices within the PV supply chain have fluctuated frequently, coupled with the impact of Covid-19 and unfavourable shipping conditions. Many module suppliers have encountered delivery challenges, resulting in the delay of a significant number of projects.

Chen Liang: "PV projects are very time-sensitive and are often subject to policies, such as China's 630 or 1230 policy. In fact, there are similar policies in many other countries and regions. Once a corresponding time or related subsidy is missed, or when potential fines are introduced, the entire project may fail. So delivery capability is very important. For us, the loss caused by delivery problems far exceeds the cost."

Ling Jin: "In order to have delivery guarantees, we have now adjusted our strategy. When negotiating framework agreements with leading companies, we now require the supplier to have delivery capabilities in different regions of the world, such as the United States and Europe."

### Price Sensitivity and Purchasing Strategy

Another key topic being discussed by all buyers is pricing. Pricing is directly linked

to the rate of return and many international buyers sign module purchase contracts or framework agreements 1 year or even 1.5 years in advance.

Ysabel Hao, Procurement Director at Brookfield Renewable: "We need to predict what will happen next in the PV market and what the module prices may be. This requires us to drill down more with our suppliers on the products to be purchased and their whole supply chain, even up to the supply of silicon materials. We must collect enough information to have a deeper understanding of the industry, supply chain and market."

In this context, buyers are paying close attention to the overall development of the industry chain, the progress of new technologies and product 'substitutability'.

Chen Yan, Global Category Manager for modules at Lightsource BP: "For risk control during procurement, we would not choose some relatively unpopular product, because once it's out of supply, you will have to overturn the design of the entire project, which time doesn't allow, especially for a large project. Many of our ground projects are scaled from a single-unit station of 50, 80 or even hundreds of megawatts, and are unlikely to switch suppliers once the design has been finalised."

Yanyee Chen: "Last year, there was a significant difference between TOPCon and PERC module pricing, but this year it has obviously changed. The gap narrowed from 2 cents to 1 cent, and now the difference is 0.4 cents or even the same. Behind this phenomenon is an improvement across the entire supply chain, providing more alternatives."

### Analytic report of Global PV Buyers' Workshop.

In view of the previously mentioned sharp fluctuations and uncertainties in pricing within the industry chain, many buyers have adjusted their procurement strategies and supplier screening standards. Relatively speaking, international buyers have a higher tolerance for price than their Chinese counterparts, and tend to put more emphasis on delivery ability and certainty.

Chen Yan: "Since the fourth quarter of last year, we have adjusted our module procurement strategy. For example, we have adopted different procurement mechanisms during periods of price volatility. Our revised strategy ensures that when prices are rising, the ROI will not fluctuate too much. In a period where prices are moving downwards, we make effective adjustments through a floating price mechanism and link to key materials to avoid problems in case of early order-sealing. We may not be able to get the best price, but at least we can ensure that the supply price and cost are relatively certain, so there will be less risk attached to a project. If a project does suffer from temporary losses, we will be forced into a passive situation."

### Supply chain fluctuations

According to PV-Tech's understanding, almost all those buyers present had experienced module price adjustments and contract changes, with some even considering litigation. In their view, in addition to constantly updating industry chain information and adjusting procurement strategies, re-screening of suppliers is also part of the process.

Ysabel Hao: "In the past two years, the supply chain has seen significant fluctuations, from key raw materials to shipping costs. We value those suppliers who take a long-term approach to solving problems and continue to look for strategic partners that are in line with Brookfield's long-term strategy."

In addition to new technologies and products, the advent of new players and cross-over companies has also been a prominent feature of the PV industry in recent years.

When an industry is on the cusp of a technological upgrade and many new companies pour in, it is likely to result in a challenging period of instability and risk for module buyers, power station developers, EPCs and end users.

Chen Liang: "We value a company's technical strength and sustainability. As



## Rising demand on PV module to European countries, accounted for >50% of total export in 2022

### Europe:

83.8GW ↑ 90.7% YoY

- Renewable energy target increased with stimulating policies adopted
- Energy security risk due to Russia Ukraine War
- High YoY growth country: Spain, Germany, Poland

### Asia Pacific:

28.5GW ↑ 27% YoY

Majority export share in AP market for India, Japan & Australia

### America:

24.8GW ↑ 50% YoY

Brazil was the main export country from China

Source: CPIA; PV infoLink



## Top 10 Export Destinations accounted for 71% of total export from China (GW)



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a power station operates continuously for more than 20 years, both the manufacturer and the product need to exist for a long time, otherwise it will be very risky for the developer."

Buyers have doubts about the ability of new players to deliver, and EPCs are even more cautious.

Yu Jianping, Deputy General Manager of PowerChina Huadong Engineering Corpo-

### Analytic report of Global PV Buyers' Workshop.

ration's International Company Supply Chain Department, commented: "If we choose an inappropriate new product and its power generation cannot reach the ROI set in the original input model for the owner once the EPC finishes construction of the project, this gap will have to be filled and the risk is on us. Therefore, we are quite conservative about new technology and products. Under the premise of

minimum pressure, we will not choose new products unless there is a relatively significant positive impact on the ROI."

Big brand manufacturers are also in a favourable position in terms of overseas distribution and commercial and industrial markets, which are not so sensitive to pricing as ground mounted power stations.

That said, buyers say they do not necessarily resist new players, but are aware they have a choice carrying both risks and opportunities.

"We can't just be tied to a few leading companies forever, so need to keep an eye out for the next dark horse," said Yanyee Zeng. "Some new companies have professional teams that we have previously contacted and recognised, which is acceptable to us."

Ling Jin also pointed out that some products from smaller manufacturers have unique advantages in specific market segments. "We will also consider them under the premise that they have received good reviews and feedback in previous cooperation. As orders increase, we will be able to gradually establish a long-term stable relationship."

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# The first PV connectors for harsh environmental conditions

**T**he requirements for operating electrical installations in ambient temperatures over 70°C or at altitudes higher than 2,000m above sea level (asl) differ from the requirements for standard installations. However, it is precisely areas with such harsh conditions, like deserts and high mountain ranges, that offer large unused spaces and optimal solar radiation for efficient photovoltaic systems. The original Stäubli MC4 connector portfolio has a proven track record for such applications and is the first in the industry to be certified by TÜV Rheinland.

We had the opportunity to talk to Guido Volberg, Senior Consultant for Product Regulatory Affairs at Stäubli Renewable Energy, who explains more on that topic and reveals some technical details.

**Guido, we can see more and more PV installations in our alpine regions, some of them mounted on altitudes higher than 2,000m asl. Why are these installations considered as systems in harsh environment? Is it because of the low temperatures?**

No, it's not because of the low temperatures. On the contrary, low temperatures make the use-case interesting as the efficiency of solar modules increases because the energy yield improves in the cold. The harsh environment is created by the altitude. Not only in the Alps, but especially high altitudes in South America, e.g., in the high plateaus of the Andes, are increasingly used for the installation of PV systems due to the ideal conditions such as low temperatures and high solar radiation. But the decreasing air pressure with increasing altitude can be a challenge.

**So, what exactly is critical about low air pressure?**

In addition to the materials used for insulation, the most important factors concern sufficient dimensioning for the safe insulation of an electrotechnical product. This includes the distance or the shortest air path between two conductors, the so-called clearances. The dimensions for the clearances are described in the product standards, but are historically designed for

altitudes and the air pressures, observed at up to a maximum of 2,000m asl. As the air pressure decreases in higher altitudes, the risk of air ionization, and therefore of voltage flashover, increases.

Therefore, the clearances through the air in an electrotechnical product for use at altitudes higher than 2,000m must be dimensioned for these low air pressures. This also concerns all the components of a PV system.

**Following this, it would mean that not only the PV modules have to meet more critical requirements, but also the components?**

Yes, that's right. The whole system with all components: PV modules, inverters, junction boxes, combiner boxes and of course the PV connectors.

**And the Stäubli connectors meet these requirements?**

Indeed, most of our components can be used at altitudes of up to 4,000m asl. In fact, the MC4 and MC4-Evo 2 cable-connected connectors can even be used at altitudes of up to 5,000m asl. We have had this tested and verified by TÜV Rheinland.

**Let's move from the cold heights to the warm, or rather hot areas.**

**Here, too, Stäubli's PV connectors have been tested and verified by TÜV Rheinland for use in areas with high ambient temperatures.**

**What is the background here?**

Our connectors have always been designed for use in areas with high ambient temperatures. However, it's only due to a change in the PV module standard and the subsequently drafted IEC TS 63126 that this can now be categorized. This means that the PV modules and their components must meet the additional requirements of IEC TS 63126 when used in temperatures higher than 70°C. Here, two different levels are used. At an upper limit temperature of 95°C the PV connectors can be mounted to level 1 modules (operating temperature of up to 80°C). At an upper limit temperature of 105°C, they can even be connected to level 2 PV modules (operating temperature of up to 90°C). Again, TÜV Rheinland has verified that Stäubli connectors are suitable for use on Level 2 PV modules.

**This means that the same Stäubli connectors can be used both at high altitudes, such as the Alps or the Andes, but also in hot areas like deserts?**

Absolutely. But our connectors can be used not only in these extremes, but also in other environments that are becoming more and more interesting for the PV industry but are not yet covered by existing standards.



**Guido Volberg, Senior Consultant for Product Regulatory Affairs at Stäubli Renewable Energy**





up to 5000 m a.s.l.



up to 105 °C

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**AlpinSolar PV plant in the Swiss Alps at 2,500m above sea level, operated by Swiss energy service providers Axpo and IWB**



**Solar power plant in the Atacama desert, Chile**

## What kind of environments would those be?

Currently, there is a lot of talk about floating PV (FPV). A market that has grown rapidly with systems installed on inland lakes, near-shore or even off-shore, i.e., in the open sea.

## Are there already normative requirements for such FPV systems?

Unfortunately, not yet. In the standardisation committee, we recently started with an installation standard for floating PV systems on inland waterways, i.e., rather calmer waters. However, at Stäubli we researched in advance what requirements are placed on PV connectors in such floating PV systems under certain conditions, e.g., when the modules are submerged for a few days by a high snow load.

## And Stäubli has taken precautions here as well?

The good thing is that we didn't have to take any additional precautions on our connectors. We have again subjected our existing connectors to tough tests and have again received confirmation from TÜV Rheinland that they have a degree of protection against the ingress of solid foreign bodies and water in accordance with IEC 60529 of IP 68 (1m/168h). This means - referring to the second code number 8 - that the MC4 as well as the MC4-Evo 2 can lie in a water depth of 1m for a period of 10 days without water penetrating.

## Are there other examples of use in harsh environments?

We also see more installations of PV systems in the agricultural sector, also called Agri-PV. Agri-PV goes from installations on animal sheds to PV modules as roofs of greenhouses. Additionally, outdoor installations as protection against strong winds, or as shade in the field, are being used more and more.

## What additional requirements are to be faced here?

Standardisation for these types of installations is still in its infancy. But some experience has already been gained from the field. For example, it has been known for some years that increased resistance to ammonia is required for PV installations on the roof of animal stables. And yes, our connectors meet this requirement as well. Other influencing factors, such as higher temperatures and humidity in greenhouses, or potential effects from chemicals, are currently being investigated.

## Do you see more examples of harsh environmental conditions?

Well, for example, additional requirements for PV plants in terms of salt mist resistance, for installations near the sea. Our MC4 PV connector portfolio is also tested and approved according to IEC 61701, which means they are salt mist resistant.

The PV industry is growing rapidly, and the applications are becoming more diverse - and so are the requirements for the technical components. At Stäubli, we will continue to do everything we can to find solutions with our components, even for new applications.

Thank you, Guido, for this interesting conversation.

[www.staubli-renewable-energy.com](http://www.staubli-renewable-energy.com)

# Advanced Grid Functionalities in State-of-the-Art Inverters for Solar Photovoltaic Systems

**Inverter Technology** | Gamesa Electric's latest white paper explores the advanced functionalities that solar and battery inverters should be able to provide to enable greater integration of renewables into the grid and thus contribute as a key element to enhanced grid reliability and stability.

The world is going through a significant transformation in the energy sector as renewable energy sources, distributed generation, decarbonisation, and demand increase are rapidly changing traditional sources of energy. In this context, solar photovoltaic (PV) and battery storage inverters must fill the gap left by synchronous generators and be able to offer the same services to ensure stable and secure grid operation.

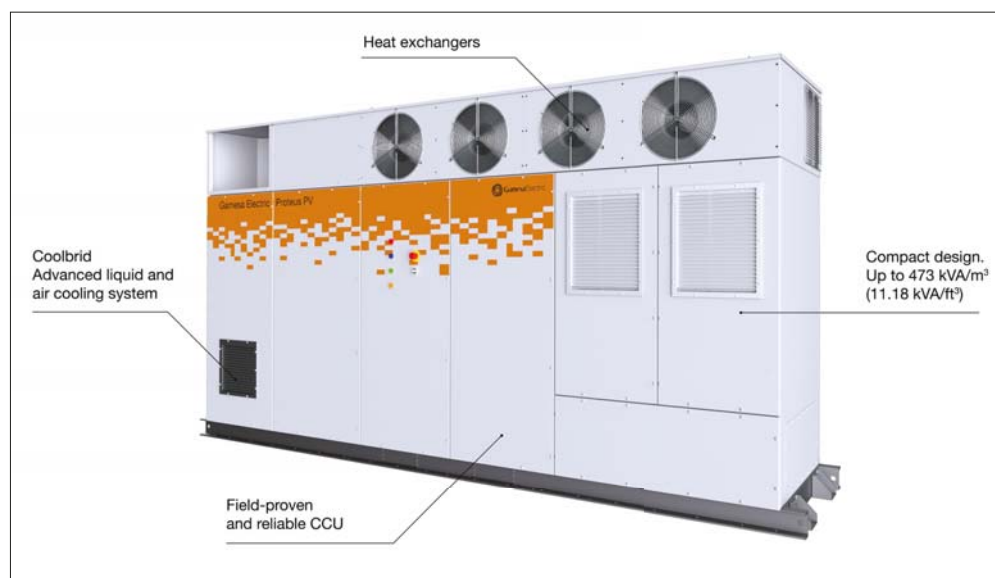
The reduced inertia present in the grid, due to the decommissioning of large power plants and the intermittency of renewables, poses significant challenges to its stability. As a result, frequency variations caused by momentary imbalances are higher and recur more often.

In this article, we will discuss the grid functionalities that state-of-the-art inverters should offer in order to meet the most demanding grid requirements. We will take a look at the challenges faced by grid operators and the contribution of the Proteus family of state-of-the-art inverters from Gamesa Electric to address these challenges.

## Grid stability and control

In traditional generators, the most widely used device is the synchronous generator, an electrical machine whose shaft speed has a direct relationship with the frequency of the grid. This allows it to adjust its voltage output and respond to changes in grid frequency by modifying its operating point. These devices greatly contribute to the power grid stability due to the damping they provide against disturbances. The stability of any power grid is achieved by controlling parameters such as voltage control, frequency control, and rotor angle control.

Voltage control is performed by controlling the reactive power through devices



such as synchronous generators (which allow the dynamic control), capacitor banks, or inductive loads. Frequency control is achieved by balancing the power generated and the power consumed, ensuring a steady grid frequency. Variations of any value will cause a frequency change that has to be corrected by modifying the active power. The rotor angle control is related to the stability of the synchronous generator's rotor angle and its capacity to keep synchronism after a disturbance.

## Challenges faced by grid operators

The decarbonisation process of the energy sector is leading to the substitution of traditional large generators by renewable energy sources such as solar, wind, and energy storage, based on power-lowered decentralised units composed of electronically controlled devices (power converters). The progressive substitution of large generators is becoming an increasing challenge for transmission system operators (TSOs), which must ensure grid reliability and stability despite the entry of

## A Gamesa Electric PV converter of the Proteus product family

these new players while maintaining a null impact on end-users.

As a result, TSOs are forced to impose new features and functionalities on these new energy sources to ensure proper grid operability, coining new terms such as smart grid, grid-forming, or black-start.

## Power electronic converters and grid stability

The addition of new energy sources based on power electronic converters to replace rotating electrical machines is leading to variations in the grid behaviour during frequency control regulations. Power electronic converters have a completely different performance compared to rotating machines.

On the one hand, they have a very short timescale response, and on the other, they do not contribute to system damping created after a frequency change due to the absence of massive rotating shafts. This decrease in inertia capacity affects grid control and, in the worst case, it could destabilise it. To address this, grid opera-

Functionality	Grid-feeding Inverter	Grid-forming Offgrid	Grid-forming Ongrid <sup>2</sup>
Voltage regulation	✓	✓	✓
Power factor control	✓	X	✓
Active power ramp rate	✓	X	✓
External setpoints (secondary frequency control, energy shifting, trading...)	✓	X	✓
SI (Synthetic Inertia) <sup>3</sup>	✓	✓	✓
PFR (Primary Frequency Response) <sup>4</sup>	✓	✓	✓
FRT (Fault Ride-Through)	✓	✓	✓
POD (Power Oscillation Damping)	✓	X	✓
Islanding operation	X	✓	✓
Black-start	X	✓	X
VSM (Virtual Synchronous Machine)	X	✓	✓

tors are imposing grid support capabilities to ensure grid stability.

Grid-following inverters are capable of provide synthetic inertia (also known as virtual inertia), where the electronic device can emulate the inertia that used to be provided by rotating machines. However, providing virtual inertia is not enough, it is necessary to provide additional ancillary services to ensure grid stability, such as fast frequency response, black-start, or power quality support.

### Advanced grid functionalities in state-of-the-art inverters

In this context, state-of-the-art inverters are the new generation of equipment that incorporates the necessary functionalities to be active elements in grid operation. These functionalities include Fast Frequency Response (FFR) and Black-Start, among others.

In grid-forming mode, the converter is a voltage source (it can create the electrical grid by itself) with the ability to control both the active and reactive power, thus creating and maintaining a stable grid voltage and frequency. The control strategy used is known as Virtual Synchronous

Machine (VSM) where the inverter control can emulate the synchronous generator performance.

Fast Frequency Response (FFR) is a service provided by power converters to compensate for short-term frequency deviations in the grid. This service requires a fast response time from the converter to ensure grid stability. FFR is essential because small deviations in frequency can cause large changes in the grid and lead to instability.

For example, if the frequency of the grid decreases, the active power generated by the power converters must increase to compensate for the deviation. Conversely, if the frequency of the grid increases, the active power generated by the power converters must decrease. Without the ability to respond quickly to frequency changes, the power converter would be unable to stabilise the grid, leading to power outages.

The response must be fast enough, which is why they are normally requested at the inverter level to avoid communication delays. However, one of the main advantages of the Gamesa Electric Orchestra controller is that its quick response time

allows it to perform the FFR functionality at plant level rather than at the inverter level.

Black-start is a service that allows the power converter to restart the grid after a blackout. In the event of a blackout, the power converter must be able to start generating power immediately, even without a grid connection, to restore power to critical loads. This requires the power converter to be able to operate in island mode, where it generates power independently of the grid, and then resynchronise with the grid once power has been restored. Black-start is an essential service because it ensures that power can be restored quickly after a blackout, preventing extended power outages.

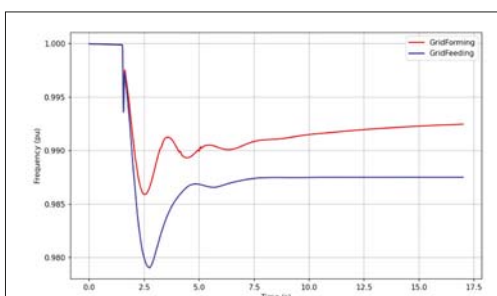
Gamesa Electric's Proteus family of inverters is designed to meet the most demanding grid requirements and offers all of the advanced functionalities required for grid support. The Proteus inverters are capable of operating in both grid-following and grid-forming modes, providing the flexibility required to meet the needs of the grid. In addition, the Proteus inverters offer fast response times and the ability to provide virtual inertia, ensuring that the grid remains stable even in the face of large frequency deviations.

To demonstrate the capabilities of the Proteus inverters, Gamesa Electric conducted a series of real-world tests on the equipment. The tests were designed to simulate a variety of grid conditions, including black-start scenarios and frequency deviation events. The results of the tests showed that the Proteus inverters were able to respond quickly to changes in grid conditions and provide the necessary ancillary services to ensure grid stability.

In conclusion, the transition to cleaner energy sources is essential for achieving a zero-carbon future, but it also presents significant challenges for the power grid. The reduced inertia of the grid due to the decommissioning of large power plants and the intermittency of renewable sources has made it necessary for PV and battery storage inverters to fill the gap left by synchronous generators and provide the necessary grid support services to ensure stable and secure grid operation. Grid-forming inverters such as Gamesa Electric's Proteus family offer the advanced functionalities required for grid support, including fast frequency response, black-start, and power quality.

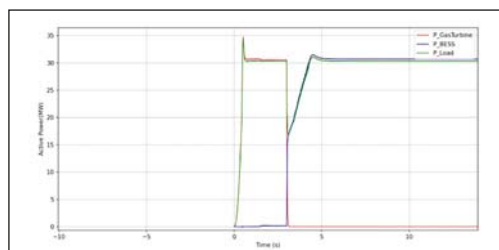
The White Paper can be viewed on Gamesa Electric website:

[www.gamesaelectric.com](http://www.gamesaelectric.com)

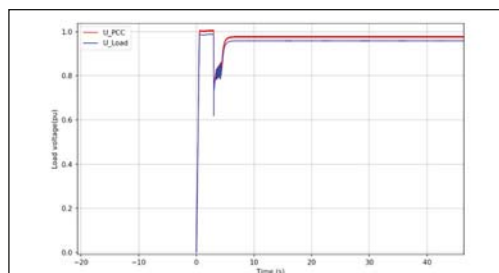


### Grid-feeding with FFR droop vs Grid-forming with FFR droop

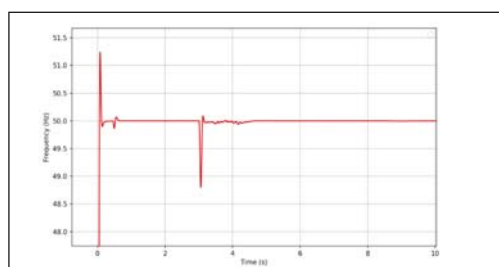
The power response of a BESS with grid-forming is greater and faster than grid-feeding operation, since a system with VSM has greater inertia as well as greater damping. Therefore, in addition to the power that the BESS injects thanks to the droop, another very rapid increase in active power is added due to the contribution of the inherent virtual inertia of the VSM.



**Power evolution.** After gas turbine power dropping (red line) the load power (green line) is quickly restored by Proteus PCS (blue line).

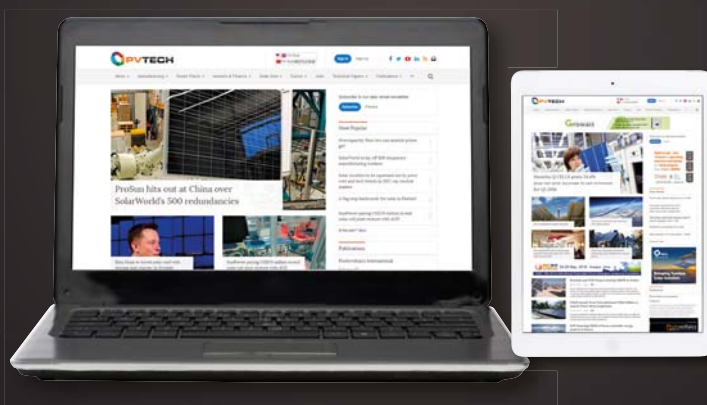


**Voltage and frequency variation.** The grid is recovered and controlled by BESS working as *grid-forming* (parallel operation). Microgrid can be sustained over a long period of time while waiting for the gas turbine or any other synchronous generator to recover from a fault.



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# Q&A with Juan Barandiaran

Following publication of the white paper, Andre Lamberti caught up with Gamesa Electric's CEO Juan Barandiaran and spoke with him about the history of the company and the development of the technology it deploys.

## **PV Tech Power: Can you give a brief outline of Gamesa Electric's journey towards equipping the renewable energy sector?**

Juan Barandiaran: Gamesa Electric has a long tradition as a manufacturer of electrical equipment with a long experience of more than 90 years in the business and a track record of more than 60GW manufactured. Its creation dates back to 1930 when it started as a small manufacturer of electric motors and generators. The milestone that set its course towards renewable energies was the acquisition of the company 20 years ago by what is today Siemens Gamesa. As part of Siemens Gamesa, Gamesa Electric expanded its product portfolio by adding inverters and converters for wind, solar, storage and hydrogen applications to the aforementioned generators.

Today, Gamesa Electric has eight production sites on three continents and employs more than 800 people, a quarter of whom are engineers. Its business is mainly wind power, but in 2022 it tripled its orders for solar and storage inverters, partly thanks to the great success of its Proteus product.

## **When did the company first consider making grid-forming and black-start inverters? How has the technology developed since then?**

Our engineers started years ago developing software that would allow inverters to be an active element in grid stability, but the fact is that the demand from the market and customers has come later, when the penetration of renewables forced the search for technical solutions that allow intermittent renewable sources to offer grid services similar to those traditionally offered by conventional power plants.

In countries such as Australia, these functionalities are already required and valued by the market and the trend of retiring conventional synchronous generators, and adding renewable generation will lead more and more markets to establish requirements related to the

advanced grid functionalities provided by grid-forming inverters.

In addition to compliance with future grid codes, we anticipate that customers will demand this technology in order to access additional revenue streams through ancillary grid services.

## **How does Gamesa Electric's grid-forming technology differ from what is already in place? Do you see it ultimately replacing traditional grid generators?**

There are no technological limitations that prevent us from seeing a 100% renewable electricity mix at some point. The limitations are probably permitting-bottleneck-related, grid-related or in terms of supply chain capacity, but the technology exists and is fully capable of replacing conventional generators.

As for Gamesa Electric's experience, I would say that what makes it stand out the most is the experience accumulated over years of development, validation and real projects. Siemens Gamesa has a hybrid wind, solar and storage farm where it tests and validates all developments.

In addition, Gamesa Electric has already implemented advanced functionalities in its converters in commercial wind projects. All this experience results in continuous improvements applied to our Proteus and Orchestra products.

## **What are the main challenges to the renewables industry adopting the technology?**

It is important not to underestimate the calibre of the challenge ahead. We are talking about replacing in a few years a conventional generation fleet that has taken decades to build, especially in the more developed countries. Undoubtedly, grid-forming technology in renewable sources is a key part of the energy transition, but there are other equally key areas such as storage, demand-side management and smart grids, among others.

I believe the main challenge we face in the sector is to be able to fit all the pieces together and to do so with the necessary

speed to meet the net-zero objectives. Therefore, the challenge goes beyond the purely technological and has very important operational and policy aspects.

## **Where do you see the biggest opportunities in the European market and why?**

Europe has just increased its target for the share of renewables in total energy consumption to 45%. To get closer to this ambitious target, a massive deployment of renewables will be needed alongside the electrification of society. This process of 'renewable electrification' is already providing great opportunities and will undoubtedly create even more.

In addition to well-known and mature technologies such as wind and solar, we will see massive deployments of different types of storage, not forgetting the key role that hydrogen can play as an energy vector not only for storing energy but also for decarbonising hard-to-abate industries.

The market will undoubtedly grow exponentially, and it is therefore crucial that the legislative proposals made in recent months to protect and support Europe's renewable industry are successful, as it will be very difficult to meet this challenge without a strong and healthy local supply chain. ■

## **Author**

Juan Barandiaran is the CEO of Gamesa Electric, a global power electronics leader in the renewable energy industry. With engineering and MBA background and over 30 years of experience, Barandiaran has a proven track record of successfully leading and directing various companies and divisions within Gamesa, including wind, photovoltaics, energy storage and hydroelectric generation. Under his leadership, Gamesa Electric has expanded its operations to multiple countries and increased its market share in these sectors. Barandiaran is known for his strategic vision, strong leadership skills, and commitment to innovation and sustainability. He also serves as VP of CIC energiGUNE energy storage research centre.





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# Managing Solar Portfolios by Performing Device-Level Analytics: Using AI and Data Science

**AI Analytics |** Stuti Gupta, Solar Lead at Prescinto, an AI-powered asset performance management platform for solar, wind and energy storage assets, and Prescinto Performance Excellence Head Abhishek Puttanna on the role of artificial intelligence in monitoring and optimising photovoltaic assets.



Credit: Wikimedia, Kallena

## Need of Advanced O&M Solutions for Managing Solar Assets

Operation and Maintenance (O&M) of Solar (PV) Farms/Plants impacts the industry's growth and performance levels as a whole. The O&M sector comprises many processes - Technical Asset Management, PV Plant Operation, Plant Maintenance, Data Monitoring, KPI-based plant Performance Tracking, Spare Parts Management, and Revamping & Repowering. Currently, O&M service providers are developing advanced solutions that are more data-driven to meet the market demands, raising the bar for performance enhancements each coming year.

Analysing a plant's overall performance is typically done using a top-down approach. We first assess the low-performing devices by digging deeper into the project-level, inverters and, finally, the string-level. However, this process is not very time-efficient and mainly depends on subject-matter experts (SMEs) identifying bottlenecks to rectifying underperformance issues faster. In addition, these corrective measures are not exhaustive for the vast sizes of current Renewable Energy portfolios.

Big Data Analytics can bring added value at any stage of O&M objectives: from analysing collected information, fault detection and diagnosis to optimisation via advanced monitoring system recommendations. This report aims to review the usage of Analytics and AI to manage the component-level performance of

**Prescinto makes the case for artificial intelligence-enabled monitoring of solar assts. Pictured here is the Andasol 150MW power plant in Andalusia, Spain.**

PV plants in response to the pertinent problems in present-day PV O&M. Among the solutions discussed in this article is the role of AI and Data Analytics in solving these problems, where models are applied to solar plant data to identify performance issues successfully. The highlight of the article is that we detail these approaches applied to investigate and identify the underperformance issues at various levels in the project.

### Introduction to Solar PV O&M

One of the key branches in the photovoltaic industry (PV) that have evolved into a key player is Operation and Maintenance (O&M). The quality of O&M services rendered significantly affects PV plants' long-term reliability, generation and ROI expectancy.

It is universally acknowledged that

Source: BNEF Data as on November 25, 2022

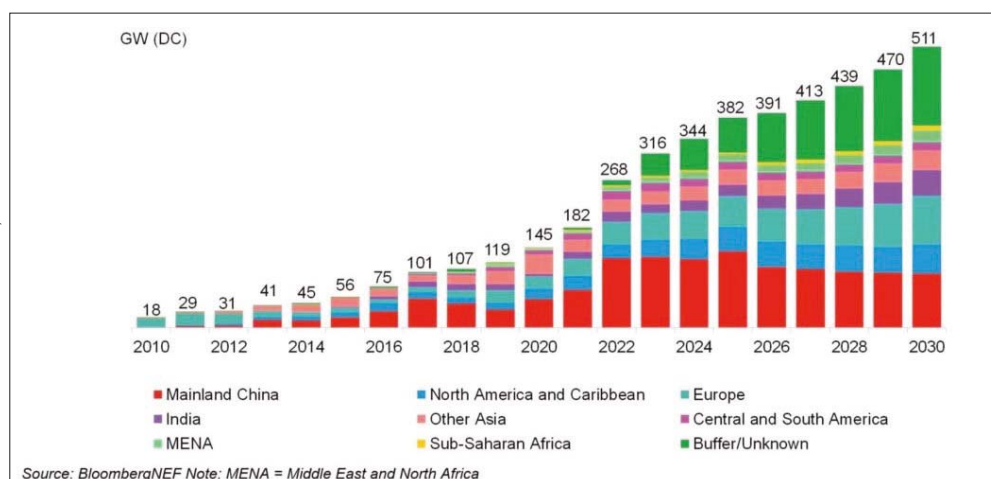


Figure 1: Annual Project Capacity Addition.

Source: Wood Mackenzie (based on Q3 2021 update)

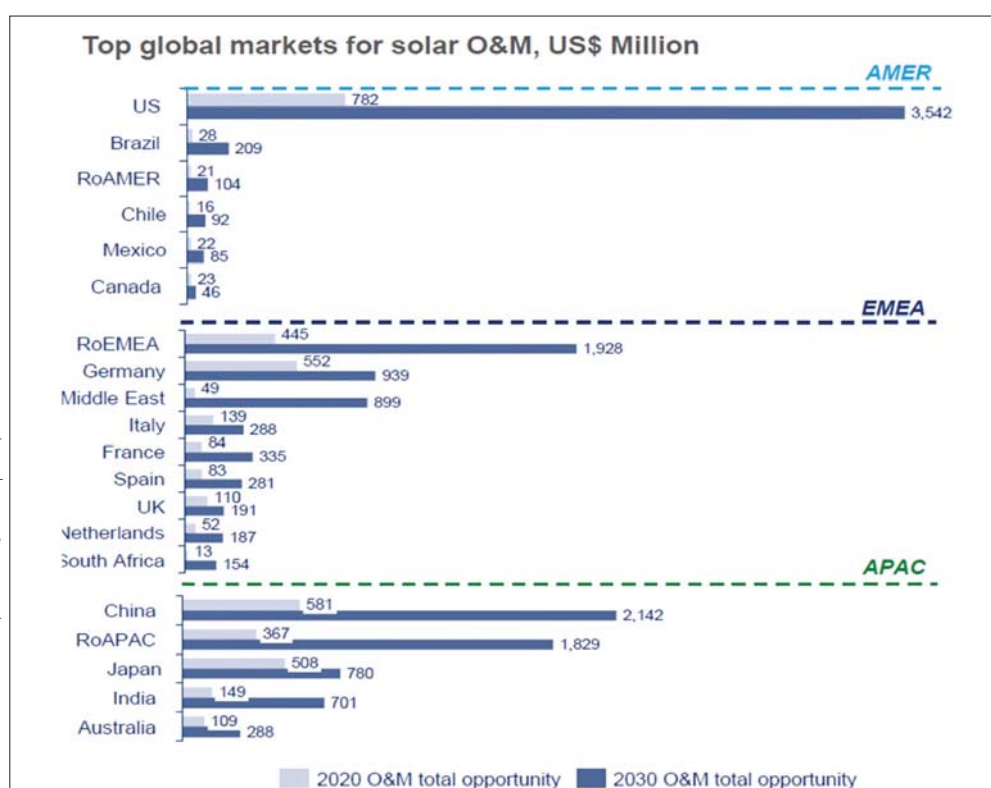


Figure 2: Top O&amp;M Market players.

Source: Wood Mackenzie (based on Q3 2021 update)

O&M costs by project size, 2020 US dollars								
Market	20kW (US\$/kW)	1MW (US\$/kW)	5MW (US\$/kW)	20MW (US\$/kW)	50MW (US\$/kW)	100MW (US\$/kW)	200MW (US\$/kW)	500MW (US\$/kW)
Australia	47.22	11.99	10.80	9.65	9.51	9.01	8.93	8.68
Brazil	28.24	4.30	3.99	3.12	3.10	3.03	3.02	2.98
Canada	36.44	8.76	8.29	6.80	6.70	6.32	6.27	6.08
Chile	26.10	6.29	4.75	3.51	3.48	3.37	3.35	3.30
China	26.25	3.41	2.85	3.04	3.01	2.91	2.89	2.84
France	43.02	8.77	9.03	9.11	9.00	8.60	8.54	8.34
Germany	48.01	11.42	9.66	9.58	9.45	8.96	8.89	8.64
India	32.40	5.17	4.84	4.72	4.68	4.53	4.51	4.44
Italy	39.48	7.50	7.34	7.89	7.83	7.57	7.53	7.41
Japan	45.21	9.71	9.58	11.10	11.00	10.63	10.57	10.38
Mexico	24.13	6.02	3.98	2.90	2.89	2.83	2.82	2.79
Netherlands	47.63	10.64	10.54	10.63	10.48	9.94	9.86	9.58
South Africa	33.70	4.72	3.80	5.11	5.09	5.06	5.05	5.03
Spain	36.95	7.58	6.57	6.73	6.67	6.41	6.38	6.25
United Kingdom	48.04	10.54	9.19	9.22	9.12	8.74	8.68	8.49
United States	53.84	12.31	11.53	9.73	9.58	9.01	8.93	8.64

Figure 3: O&amp;M Scope Costs.

high-quality O&M services can help reduce potential risks, reduce the levelised cost of electricity (LCOE), and positively impact the investors' return (ROI). According to the Solar Risk Assessment Report, incorporating 70% corrective maintenance into the annual service fee (fixed rate) of O&M can reduce the overall O&M cost by 28%, which can boost the equity returns by 10%, with typical ROIs for solar assets ranging between 10-15%. Moreover, in today's highly competitive O&M market, manual albeit standardised practices can be challenging to implement, while advances in the sector's digitalisation are paving the way for improvements and cost reduction.

### Market Dynamics

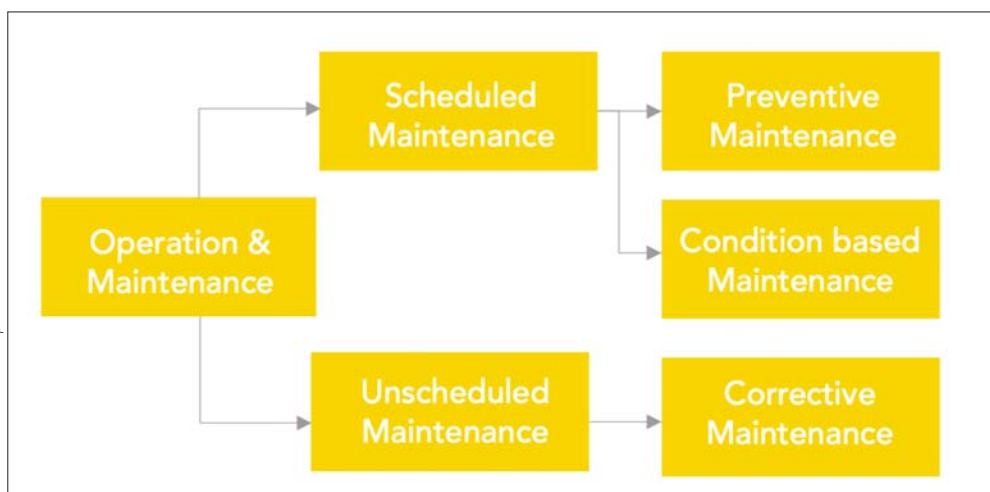
The Bloomberg New Energy Finance (BNEF) report estimated that global solar PV installations will grow at an annual average of 8% from 2021 to 2030. In 2023 alone, 316 GWDC of annual capacity addition is expected, with the utility-scale sector dominating the overall global installed solar capacity (Figure 1). Needless to say, future large-scale installations provide vast opportunities for growth and capital investment in this segment.

The O&M market is expected to grow at a steady pace of 14%. The Asia-Pacific market is expected to reach nearly US\$5.7 billion by 2030, followed by Europe, the Middle East and Africa with US\$5.2 billion and North, Central and South America with US\$4.1 billion. Of this US\$4.1 billion, the US alone will have a significant market share of US\$3.5 billion in 2030, making it the largest market (Figure 3). This emphasises that the O&M market segment has a huge potential market to attract investors.

To estimate the competitiveness among O&M providers, an important metric would be the monetary compensation (say, in dollars) per kW. As per the table in Figure 3, the per kW O&M cost undergoes only a marginal change as the project size increases, indicating limited economies of scale. Hence, there is a scope for identifying improvements in the O&M segment to lower the O&M costs and boost the ROI.

### Current Best Practices in O&M

Solar Power Europe (SPE) leads and coordinates the development of O&M best practices and is a significant member-led industrial association representing over 260 companies involved in the entire solar value chain. The Lifecycle Quality Workstream also produces the O&M Best Practice Guidelines report, updated



and launched every two years. The fifth edition (the most recent from 2021) is based on work that has resulted from the contributions of over 30 solar experts from about 20 global companies, including O&M service providers, asset owners and managers, energy consultants, and technology and digital solutions providers.

This Solar Power Report recommends proper hazard identification, careful planning, regular documented inspections, and maintenance. It also covers personnel and training, technical asset management (TAM), power plant operation, and maintenance. TAM involves supporting activities aimed at ensuring optimal solar power plant operation, including maximising energy production, minimising downtime, and reducing costs. These guidelines are a powerful tool for asset managers to adopt the best practices for the existing installations.

The key focus is O&M optimisation through scheduled maintenance and reducing the losses incurred before corrective maintenance is implemented. Figure 4 explains how maintenance is broadly classified. Scheduled Maintenance (SM), because it is planned in advance and done periodically, can prevent faults from occurring. Some desired practices involve scheduling these tasks in accordance with the manufacturer's endorsements and conducting them during non-peak hours, preferably during night hours. SM aims to attain an optimum balance between the cost incurred and the increase in the life and yield of the system.

#### Digitalisation and Innovations in Plant O&M

With the solar industry aiming at achieving an ambitious global scale, the industry has its eyes set on modern technological innovation to drive this growth. These

modern-day technologies are gaining steam owing to immense benefits & the returns they promise to offer.

#### Information Modeling

Solar O&M professionals across the world are aiming to build more efficient processes, reduce costs & risks and drive O&M profitability. Stakeholders across the PV lifecycle are now adopting the BIM (Building Information Modelling) principle to achieve the same.

As reported by the Trust PV Project, BIM, a Data Management Framework, is a proven technique for ensuring the availability of all asset data at the right time and place. The BIM principle closely syncs with digital technologies, implemented across the PV plants' lifecycle stages. It involves chalking out the processes and components that produce information at different stages. BIM solves the core challenge of information loss as the solar asset switches ownership or project stages. It achieves the same by producing a Single Source of Truth and keeping a dynamic track of all plant components – for example, configuration changes, repowering Initiatives, etc.

Using BIM, an O&M contractor can leverage a central information powerhouse to analyse historical performance and plant metadata, give the right inputs and carry out proactive actions. This can include, for example, analysing key KPIs, contractual obligations, field data & inspections, anomalies & more, thereby producing a future-proof intelligent O&M engine.

#### Digital Twins

Another innovation that has caught the eye of the industry is the concept of Digital Twins.

As the name suggests, the Digital Twins concept thrives on producing a Virtual Model or a Digital Copy of the solar asset.

It creates a simulated environment with all plant configurations, design & structural information replicated, in addition to the performance history of the plant. Furthermore, the virtual twin thus created operates in tandem with the live plant and receives the latter's status, performance & health data throughout the lifecycle. In contrast to traditional software, a Digital Twin factors in the precise environmental, geographical & locational information, thereby ensuring accurate plant replica creation for more detailed experiments.

An ideal Digital Twin, once created, centralises plant information and feeds the same into AI/Machine Learning algorithms. These algorithms help process, conceptualise and model the real-world responses of the plant. Furthermore, the live flow of plant sensor data ensures that the algorithm undergoes constant learning and transforms into a self-adaptive intelligence system.

Numerous other innovative mechanisms are also emerging in the evolving solar O&M sector. To quote a few examples, Drone Technologies are becoming a popular choice for thermal inspections of solar sites. O&M professionals are adopting them to achieve an impeccable 70% reduction of cumbersome manual activities. Similarly, Automated Cleaning Processes powered by robotic brushes and wipers are making significant strides. They are replacing traditional water mechanisms and offering the support of Dry Cleaning Robots for areas with severe water shortages.

Last but not least, asset owners are now adopting Digital Solutions as the missing piece of their ever-growing solar asset puzzle. These solutions enable solar professionals to connect the dots between the sensors and plant data to deliver insights for plant generation optimisation. In addition, they're also introducing the solar industry to AI/ML algorithmic powerhouses to provide value using predictive plant performance analytics.

## Big Data Analytics for PV O&M

#### Data Acquisition

A report by MarketsandMarkets estimates that the DAS (Data Acquisition System) market holds the potential to grow at an impressive CAGR of 5.5% in the coming years till 2026. Therefore, it's safe to say that

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as the solar industry grows, DAS systems will continue to achieve stronger adoption for PV monitoring applications.

A Data Acquisition System lies at the core of a PV monitoring system. It helps fetch a wide variety of data from numerous pieces of equipment on the solar farm. Data Acquisition for most plants begins at the sensor-level. Various sensors, such as thermocouples, anemometers, pyranometers, etc., help capture data points such as temperature, humidity and irradiance and more. Once captured, these sensors convert the physical information into electrical signals for further processing. The weak signals generated by sensors are then conditioned to ensure noise isolation and ultimate conversion into a digital signal with the help of an ADC.

The network layer helps connect the different on-ground devices to the plant SCADA for a seamless data flow. It achieves the same using either a Wired Network based on Ethernet/RS-485 Serial Interfaces (with Modbus Protocol) or a Wireless Network designed on Zig-bee, LoRA, Wi-Fi or GSM-based communication. Modern layers may also use Cellular Networks based on NB-IoT/5G communication. The network layer may sometimes include a Data Processing module, popularly designed using Raspberry Pi, Arduino or PLC-based microcontrollers, which helps process the incoming data and pushes the data to the application layer for interfacing & analysis of the equipment performance.

### Data Aggregation

A Data Aggregation mechanism is then used to aggregate the data a solar plant and its associated equipment produces, to extract actionable insights and make data-driven decisions for plant optimisations.

However, what makes Data Aggregation a mammoth task, is the sheer volume and, more importantly, the diversity of data a plant produces. Each solar plant houses a wide variety of equipment as its

core components. These include panels, inverters, meters, relays, transformers, weather stations, and more. As essential as they are for seamless operation, the pieces of equipment generate data in different formats at different frequencies. All this information may even reside at different locations and in different time zones, introducing time-series irregularities – these differences create data inaccuracies, errors and raise security concerns. In addition, they further induce data quality concerns such as junk values, outliers, false positives and more. The granularity/frequency of data generation (1-min, 5-min, 15-min and even 60-min intervals) makes it further more challenging to integrate this data and build a cohesive dataset.

As suggested in the O&M Best Practices report by SolarPower Europe, one of the best ways to tackle Data Aggregation concerns is to have a robust data quality module. Ensuring that the PV monitoring platform has automated data filtering capabilities is critical for an asset owner. Similarly, performing data validation analysis over time spans of 1 to 15 mins helps eradicate time-series irregularities in the plant data. To further streamline Aggregation, there must be an emphasis on transforming data into a normalised/standardised format that follows standards such as IEC 61724.

### Data Monitoring and Performance Analysis

The aggregated data collected from plants should be analysed on the following levels:

- Portfolio/Plant Group Level – Minimum Analysis Requirement
- PV Plant Level – Minimum Analysis Requirement
- PV Inverter Level – Minimum Analysis Requirement
- PV String Level – Recommendation for Insightful Analysis

The monitoring system collects this plant data from various sources. Taking the example of irradiance and radiation data, these are collected by irradiance sensors and pyranometers, respectively. Here, as an industry best practice, having at least 2 pyranometers in the solar plane array, with a data record granularity of at least 15 mins, is recommended for rich data collection. In addition, high-quality satellite data services Solcast/SolarGIS can also be leveraged as data sources here. These are of great help in the event of losing data from faulty sensors as well.

Similarly, the temperature data from the weather monitoring station (WMS), essential to calculate key KPIs like Temperature-corrected Performance Ratio (PR), is also collected. As a best practice, module temperature data should also get recorded at a granularity of at least 15 mins. More sensors may also be required across large plants to capture module temperatures at different representative positions. For example, capturing temperature variations between modules located in the centre and the edge locations of the plant. Apart from temperature data, meteorological data such as wind direction & speed, rainfall, ambient temperature, snowfall, etc., are also acquired from weather monitoring systems, anemometers and shielded thermometers.

In addition to the above, inverter and energy meter data is utilised for calculating performance KPIs. While it is often used for invoicing, energy meter data is the best reference for measuring energy and calculating plant PR and yield.

A typical central inverter project without string monitoring has approximately 300 tags (parameters). Assuming a data frequency of 1 min, the average number of data points received daily would be a minimum of 432,000. This value increases to approximately 1.44 million data points for a string inverter project with about 1,000 tags. Handling such a significant volume of data points and performing analysis requires technological sophistication.

### Portfolio-Level Analysis

Portfolio-level performance analysis & data monitoring for large-scale projects can present numerous hurdles. However, the primary challenges associated with managing a sizeable solar portfolio include the following:

- Conditional Diversity: Including Shading, Inclination, Orientation, etc.
- Asset Scale & Multitude: Utility-scale projects with MW scale plant capacities.
- Lack of Expertise: Larger team and stakeholders who aren't solar professionals.
- Equipment Variations: Multiple inverter brands, tracker systems and solar panel technologies.
- Regulation Variations: Various national and local regulations and contractual obligations

On the other hand, digitalised platforms successfully address the above challenges at various stages of performance monitor-

**Figure 5: DAQ Systems Global Market Trends.**



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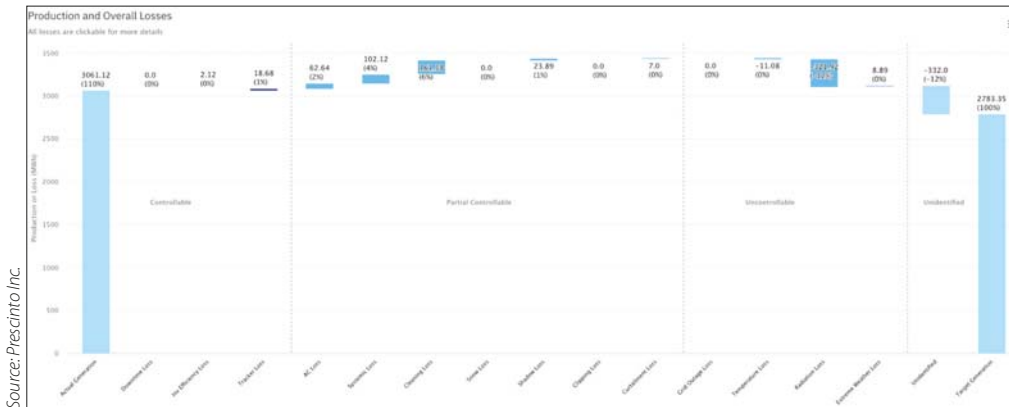
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ing. The following points outline the benefits of a digital solution:

- Digital solutions enable remote monitoring of PV plants, reducing man-hours and increasing O&M effectiveness.
- Digital solutions can create databases for equipment that can be replicated to configure various devices in the system.
- Data-driven corrective maintenance through digital solutions reduces the burden on solar professionals who can't be deployed at multiple locations simultaneously.

### Distributed Project Portfolios

Managing a variety of projects spread across different geographical locations often poses additional challenges:

- Clipped effects may cause errors in yield analysis.
- Season-dependent shading effects (for example, trees, chimneys, etc.) may also introduce inconsistencies in yield analysis.
- Monitoring databases can often encounter incorrect/missing base parameters such as tilt, orientation, etc.
- Localised irradiation measurement at each project can often be too expensive.

### Project-Level Analysis

#### Generation Forecasts

The project-level analysis includes generation forecasts that typically leverage

weather and satellite data, theoretical module degradation rates & statistical forecasting methods to offer accurate predictions. In addition, as an industry best practice, experts utilise two key KPIs, RMSE (Root Mean Square Error) and MAE (Mean Absolute Error), to validate the accuracy of these prediction reports.

#### Key Performance Indicators (KPIs)

Plant performance is tracked through fundamental categories of Key Performance Indicators: Plant KPIs and O&M Service Provider KPIs.

The Plant KPIs offer quantitative indicators that represent plant performance and yield. These include Reference, Expected and Specific Yield, Performance Ratio, Temperature Corrected PR, Energy Performance Index, Technical Availability (Uptime) and Tracker Availability. On the other hand, O&M Service Provider KPIs capture time-series data and maintenance aspects of the plant. These include Acknowledgement Time, Intervention Time, Response Time, Resolution Time, Schedule Attainment and Preventive v/s Corrective Maintenance Ratios.

#### Loss Bucketing

A fault-induced generation loss is considered a significant cause of concern when it impacts the Performance Ratio (PR) & Plant Availability beyond a threshold - measured

**Figure 6: Loss Bucketing of a PV Plant.**

throughout the monitoring/reporting period. As a best practice, the threshold should be set at 1% of Plant Availability or 1% of PR for a 1 month long reporting period.

The current state of the art in loss bucketing depicts a more detailed categorisation into the following verticals – Controllable, Partially-controllable, and Uncontrollable Losses – with further sub-categories. This is demonstrated in Figure 6.

A robust analytics engine can also offer corrective/recommended action-based next steps.

### Device Analytics

#### Fault Classification: From Plant to Inverter to String

Remote fault detection can be a suitable replacement for various investigative and inspective tasks traditionally performed by operation engineers.

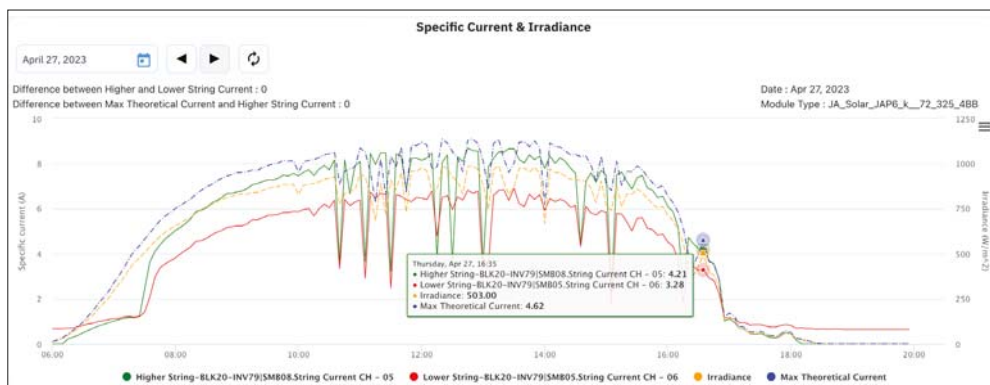
Inverter-level faults can result in the following plant losses: AC Loss, Downtime Loss, Clipping Loss and Inverter Efficiency Loss. Systematic losses, on the other hand, include Shading and Cleaning Losses. In addition, there can also be other losses, such as Irradiation Loss. In such situations, using a top-down approach helps in functional analysis. It allows for identifying the faults straight from the inverter to the string-level and categorising them accurately to chalk out the required corrective actions. A typical 1MWac plant has approximately 100 strings (assuming 400 Wp module wattage, 28 modules/string and an AC/DC ratio of 1.2). With utility-scale plants of almost 200 MW, performing string analysis on 20,000 strings can be quite challenging.

The following image [Figure 7] shows the performance of strings based on their current w.r.t, the best-performing strings, and their digital twins. This kind of string-level device analytics helps us rank string performance by estimating the deviation of the string current w.r.t the best-performing string and their digital twins.

With the introduction of bifacial module technology in the solar industry, asset owners focus on adopting trackers in utility-scale plants. Performance Generation at the string-level can also be analysed through losses from trackers not operating correctly. The following image [Figure 8] shows the loss of energy generation due to the misoperation of trackers.

Big Data Mining algorithms can thus help in performing failure root-cause identification for larger portfolios as well.

**Figure 7: Device Analytics of String.**



Source: Presciento Inc.



**Figure 8: Device Analytics of Tracker.**

### Conventional Approach: Physical Models

The conventional approach to identifying issues in the solar plant is through physical models. For instance: Common photovoltaic faults associated with PV modules are generally one of the five key categories: Hot Spot Faults, Degradation Faults, Short Circuit Faults, Open Circuit Faults and Shading Faults.

Each fault category corresponds to a specific physical phenomenon and is identified using I-V & P-V Curves and models such as One-diode Model. However, this approach is highly time-consuming as it requires an in-depth analysis of large data values and requires a lot of subject matter expertise. AI-driven data models can address this issue by training large data sets on particular algorithms and making the process much more efficient.

### Artificial Intelligence Data-Driven Models

Data-driven models with an Artificial Intelligence core are often applied across data preprocessing, processing and post-processing techniques.

For example, the Pattern Recognition approach can identify shadow-related losses. Additionally, the correlation of plant parameters like irradiation w.r.t. string currents can be an ideal approach

to perform string-level analysis and identify the string performance. Here, type analysis of the fault phenomenon associated with photovoltaic systems determines the appropriate Artificial Intelligence algorithms for fault detection modelling. For instance, Residual Neural Networks (ResNet), Bayesian Neural Networks (BNN), Probabilistic Neural Networks (PNN), Fuzzy-logic techniques, Artificial Neuron Networks (ANN), etc., and more.

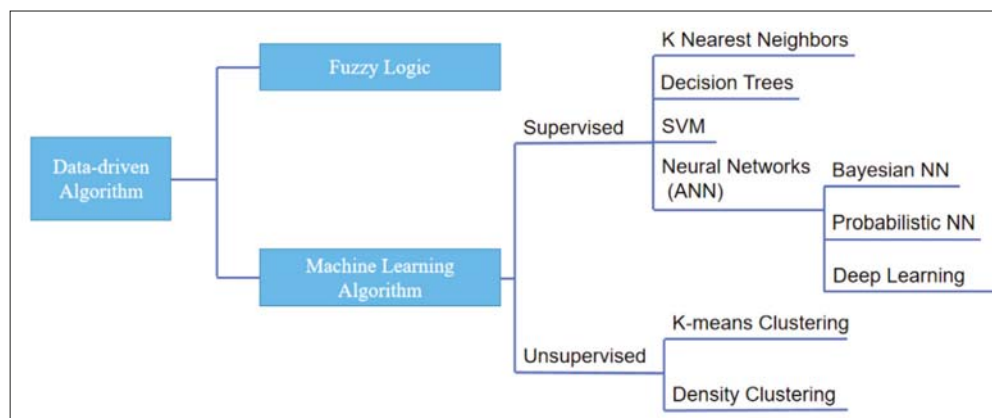
Apart from fault identification, data preprocessing forms an assignable part of AI applications in the field of Solar Energy. Many experts have attempted, e.g., Kalman Filter Fast Fourier Transformation (FFT), to achieve clean data availability for expediting calculation speed.

### Recommendations Challenges and Way Forward

Globally, the size of Renewable Portfolios is now accumulating to meet the ever-increasing energy demands and net-zero emissions targets set by various world countries. For example, the US aims to achieve a total solar installation capacity of 850GW by 2030, eventually reaching a net-zero emission target by 2050.

Challenges for managing scale include requirements for additional subject-matter expertise, workforce and technological advancements in the future.

**Figure 9: Methods used in Data-based Fault Detection Algorithms for PV Systems**



Including new devices and ever-advancing technologies further makes overall performance analysis even more crucial. Another challenge is the complexity of projects to drive/operate hybrid projects that integrate Solar Energy, Wind Energy and Battery Energy Storage Systems. Upgrading module technologies from standard Mono-facial Modules to HJT/TOPCon Technologies might pose unique challenges in field performance. Similarly, in BESS, adopting new battery technologies like Solid-state/Sodium-ion Batteries would require in-depth analytics from a performance point of view. These altogether result in making performance analytics even more sophisticated.

### Conclusion

An effective approach is necessary to improve the underperformance identification process and reduce the time required to resolve device issues. In addition, this solution should allow for drilling down from the portfolio level to the string level quickly and efficiently. This would drive cost savings through reduced manpower requirements and increased energy generation. A digital solution, commonly called an Asset Performance and Management (APM) platform, to address these requirements is thus an essential means for renewable asset owners and operators.

### Authors

Stuti Gupta is the Solar Lead at Prescinto, an AI-powered asset performance management platform for solar, wind and energy storage assets. Stuti brings a wealth of experience of working in the solar industry, focusing on asset management, design & engineering, and solar module technology. Besides her technology management role at Prescinto, she's an alumna of the Indian Institute of Technology (IIT), Bombay, and holds a Master's Degree in Renewable Energy Science.



Abhishek Puttanna is the Performance Excellence Head at Prescinto. Abhishek has worked in the renewable energy industry for more than seven years. He has rich experience in leading Digital Transformation, Performance Management & Operations of Utility-scale/C&I Solar and BESS projects. He holds an Electrical Engineering Degree from Delhi College of Engineering.



# Product reviews

## Trackers Vanguard 2P bifacial tracker and high performance Vertex N (NEG21C.20) modules

### TrinaTracker achieves yield and performance with higher wind stability:

Trina Solar is launching the second generation of its fully integrated Vanguard 2P bifacial tracker and high performance Vertex N (NEG21C.20) modules. Developed in collaboration with wind engineering consultancy, Rowan Williams Davies & Irwin Inc. (RWDI), the tracker offers a complete solution of stability under extreme weather conditions.

**Market & Applications:** Trina Solar is the only solar module manufacturer that can provide an integrative module and tracker solution with its Vanguard 2P bifacial tracker for utility-scale PV power plants with high winds and uneven terrain.

**Industry challenges:** The trackers are designed to withstand difficult weather conditions: high heat and humidity, extreme cold temperatures, flood inundation, heavy



snow loads and high winds – even cyclonic winds. The shorter and wider piling post for the 2P Vanguard tracker, in combination with its patented spherical bearings,

enables deployment on sites with extremely uneven terrain.

**Technical solution:** The first-generation trackers were powered by a single electric motor which operated multiple drive points through a mechanical drivetrain, the second-generation tracker has multiple motors to reduce installation and maintenance time, improve uptime and ensure improved tracking synchronisation at all times. The Vanguard 2P second generation tracker enables angle alignment through the mechanical action of three actuators powered by individual motors, therefore

significantly reducing the balance of system (BOS) cost over the product's lifecycle.

**Unique features & benefits:** All Trina Solar 'Vertex' modules use larger-size solar cells, 210mm long, that generate more power than earlier generation, smaller-size cells. The company's solar modules incorporate other market-leading technologies, such as: multi-busbar (MBB) for greater light absorption; non-destructive cutting for better mechanical performance; and high-density packing to maximize the surface module area. The tracker includes the TrinaTracker with 'Supertrack' algorithm that optimises the panel tilt - to maximise light absorption and electricity generation – using topographical and machine learning from real time data on weather and inter row shading. Bifacial modules can reduce the levelised cost of electricity (LCOE) by 4% and significantly boost project investment rate of return (IRR) for investors, according to the company.

## Microinverters Hoymiles HMS-C series of microinverters

Smart energy provider and microinverter manufacturer Hoymiles has released new microinverters that are expected to lower the upfront cost for customers while not compromising the overall performance. The new HMS-C series of microinverters are available in Europe, North America and Oceania, and the HMS-D series of microinverters are available in Latin America and Asia Pacific.

**Market & Applications:** Commercial and residential rooftops with new mainstream high performance PV modules

**Industry challenges:** Using traditional inverters, even one under-performing



module can influence the size of your overall harvest. Microinverters realise the true potential of

solar by giving seamless, always-available performance. If one module fails or runs into issues, the rest of the system stays up and running at peak performance in 4-in-1 microinverters.

**Technical solution:** These microinverters are the cost-effective versions added to

Hoymiles' classic HMS series. The C and D series all come with 1600VA, 1800VA and 2000VA output power PV module options. Output power up to 2000VA.

**Unique features & benefits:** The new HMS-C series have four input channels, meaning that one microinverter can be connected with four into one (4-in-1) solar panels at once, for the same capacity demand. CEC peak efficiency is up to 96.7%, promising greater solar yield, lower per-watt costs and shorter payback period.

**Availability:** Currently available in Europe, North America and Oceania Latin America and Asia Pacific.

## Piling robot Built Robotics RPD 35 autonomous solar piling system

Built Robotics has launched the robot piling drive RPD 35, the world's first fully autonomous solar piling system for large-scale PV power plants. The 'Exosystem' installed on excavators enables the machines to operate autonomously. It includes an all-weather enclosure and full-vision safety -sensors.

**Market & Application:** An autonomous h-beam piling system for rapid, safe and precise piling on large-scale PV power plants.

**Industry challenges:** Piling is a complex construction activity at the heart of every

utility-scale solar project. Solar piles are generally steel H-beams 12 to 16 feet in length and up to 200 pounds in weight. A typical solar farm requires tens of thousands of piles to be installed.

**Technical solution:** The RPD 35 combines all the steps in the piling process – survey, pile distribution, pile driving, and inspection – into one package. With the robotic pile driving (RPD 35), a two-person crew can install over 300 piles per day.

**Unique features & benefits:** The 'Exosystem' is installed on excavators to enable



the machines to operate autonomously. It includes an all-weather enclosure, proximity radar, 360° cameras, GPS tracking, and a powerful liquid-cooled computer.

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# Transforming the Urban Landscape: BIPV and Nature-Based Solutions for a Greener, New Era of City Living



Credit: Shutterstock, chanchai duangdoosan

**Building-Integrated PV** | Architect Dr Silke Krawietz on how Building-integrated Photovoltaics can be used in existing and new buildings and urban structures to create built-up environments that harness the power of nature.

As the world continues to face the challenges of climate change, pollution, and depleting natural resources, there is an increasing need for transformative approaches to urban development. One such approach is the integration of Building-integrated Photovoltaics (BIPV) and Nature-Based Solutions (NBS) in city planning and design.

This article explores the potential of these innovative technologies in shaping a new era of urban living that is both sustainable and harmonious with nature. It also delves into the collaboration of

stakeholders in the real estate and finance sectors for urban transformation, as well as into the impact of the new IPCC report on urban planning and decarbonisation efforts, and key drivers and trends shaping the future of urban living.

Building-integrated Photovoltaics (BIPV) solutions offer a unique opportunity to harness solar energy by incorporating photovoltaic modules into the fabric of buildings and urban structures, enabling them to generate clean, renewable energy on-site. This not only reduces the reliance on fossil fuels but also improves the

**Singapore, Supertrees at Gardens by the Bay. The tree structures are fitted with photovoltaic panels.**

aesthetic appeal of buildings and urban spaces.

On the other hand, nature-based solutions involve harnessing the power of nature to address urban challenges, such as stormwater management, enhancing green spaces, promoting biodiversity, improving air and water quality and climate adaptation. Nature-based Solutions (NBS) leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future.

NBS are defined by the International

Union for Conservation of Nature (IUCN) as “actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.”

By combining these two strategies (BIPV and NBS), cities can transform their urban landscapes into greener, more resilient, and energy-efficient spaces, paving the way for a environmentally friendly future. Moreover, incorporating NBS in urban design, cities can foster a sense of connection between people and nature, promoting well-being and enhancing the overall quality of life.

In the face of the new IPCC report and the urgent need for decarbonisation, cities must embrace a whole-system interliving approach that characterises communities in nature. This requires re-greening cities, enhancing BIPV solutions for electric vehicle charging infrastructure, and implementing innovative and inclusive climate action emerging from cities.

### The importance of renewable energy generation in urban areas

With more than half of the world's population now living in urban areas, there is an

ever-increasing demand for energy to power cities. This has led to a growing reliance on fossil fuels, which are not only finite but also contribute to air pollution and climate change. In order to mitigate these negative impacts, cities must focus on generating renewable energy from clean sources like the sun, wind, and water.

Renewable energy generation in urban areas not only helps to reduce greenhouse gas emissions but also creates local jobs and stimulates economic growth. Furthermore, it enhances energy security and reduces the vulnerability of cities to fluctuations in global energy markets. As cities continue to grow and evolve, embracing renewable energy technologies is crucial for ensuring a sustainable and resilient future.

The international net-zero targets cannot be met without considering the importance of buildings and in particular cities, based on the fact that worldwide, buildings are responsible for 37% of global carbon emissions and 34% of energy demand (Source: GlobalABC Status Report 2022). At a global level, cities consume more than two-thirds of the world's energy resources and are

responsible for around the same share of CO2 emissions (C40, Energy & Buildings).

According to the IPCC report the global energy use in buildings could double or even triple by 2050, as the world's population living in cities is projected to increase further in the next decades. Therefore, on-site generation of electricity through integration of renewable energies and in particular building-integrated photovoltaics (BIPV) has a huge untapped potential.

### Collaboration of stakeholders in the real estate and finance sector for urban transformation

The finance sector can also contribute to the cities' transformation by creating new business models that support the adoption of BIPV and NBS. This may include climate finance solutions that incentivise the development of projects incorporating these technologies, as well as collaboration with the real estate sector to ensure the availability of suitable properties for such projects.

Achieving urban transformation requires the concerted efforts of stakeholders from various sectors. In particular, collaboration between the real estate and finance sectors is crucial for developing

**Singapore, Aerial view of the artificial island Gardens By the Bay.**



Credit: Shutterstock, Only Fabrizio



**Singapore, Supertree detail with PV modules**

new business models that promote the adoption of BIPV solutions and NBS in cities. These stakeholders play a critical role in providing the necessary resources, expertise, and support for the implementation of innovative urban solutions. This collaboration can take various forms, such as joint ventures or public-private partnerships, which can help mobilise the necessary resources and expertise.

For example, real estate developers and investors can contribute by prioritising sustainable building practices and incorporating BIPV and NBS into their projects. This not only helps to create more sustainable cities but also enhances the long-term value and attractiveness of their assets.

Another example of successful collaboration between the real estate and finance sectors is the development of green bonds, which are used to finance projects with environmental benefits, such as renewable energy generation, energy efficiency, and climate adaptation.

This includes providing climate finance solutions that promote investment in BIPV and NBS projects, as well as supporting the development of innovative financial instruments that enable cities to access the necessary resources for urban transformation.

By investing in projects that incorporate BIPV solutions and NBS, the finance sector can support the decarbonisation of cities and help them reach vital climate targets.

Furthermore, collaboration between these stakeholders can lead to the development of innovative financing mechanisms, such as performance-based contracts, which link financial returns to the environmental performance of projects. This can help incentivise the adoption of BIPV and NBS, as well as encourage the continuous improvement of these technologies.

### Re-greening cities and creating harmony with nature through BIPV and NBS

Re-greening cities through the integration of BIPV and NBS is essential for creating harmony with nature and fostering a new age of urban living. By incorporating green spaces, promoting biodiversity, and investing in clean energy technologies, cities can significantly improve their ecological footprint and enhance the quality of life for their inhabitants.

For example, Singapore has embraced the concept of a 'City in a Garden' by integrating green spaces and BIPV solutions throughout its urban landscape. This includes the creation of parks, gardens, and green corridors that not only serve as recreational spaces but also promote biodiversity and improve air quality.

### Gardens by the Bay, Singapore

BIPV in Singapore has become a popular solution for the city's energy needs. The

Supertrees, located at Gardens by the Bay, are a great example. These Supertrees incorporate photovoltaic panels into their design. The electricity generated from these panels is used to power the lights that illuminate the Supertrees at night.

Of the 18 Supertrees in this urban parkland, 11 are fitted with solar photovoltaic systems, creating electricity that provides light within the site's conservatories.

The Supertrees act as vertical gardens, generating solar power, acting as exhaust air towers for nearby conservatories, and collecting rainwater.

### Marina Bay Sands Hotel, Singapore

Among other buildings in Singapore that have adopted BIPV technology is the Marina Bay Sands Hotel, which has a rooftop solar panel system. This technology is not only environmentally friendly but also cost-effective for building owners.

To further improve energy efficiency, Marina Bay Sands installed a 145 kWp solar power system atop the Sands SkyPark – the highest location of solar panels in Singapore. Covering an area of 880 square metres atop the SkyPark walkway, the roof of the restaurant Spago, and the roofs on the elevator shafts of Tower 1 and Tower 3, the 536 solar panels generate enough energy to power all lighting on the Sands SkyPark and will enable Marina Bay Sands to reduce carbon emissions.

The government of Singapore has taken proactive steps to promote BIPV technology in the city. They offer subsidies and incentives to building owners who install BIPV systems. This has encouraged more

**Singapore, Marina Bay Sands Hotel.**





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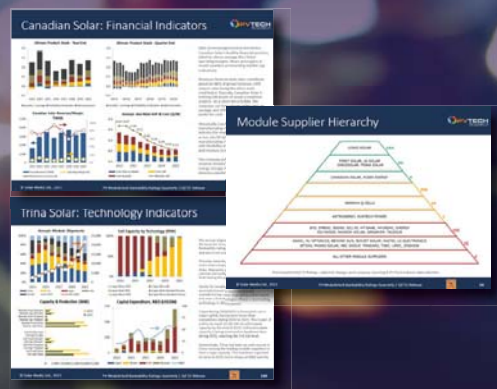
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Credit: Shutterstock, Ollat

building owners to adopt this technology and contribute towards a sustainable future.

In conclusion, BIPV in Singapore has become an essential part of the city's sustainability strategy. With increasing awareness about environmental issues, more and more buildings are adopting the technology.

The Supertrees and Marina Bay Sands Hotel are just a few examples of how BIPV technology has been incorporated into Singapore's urban landscape. With the government's support, it can be expected to see more buildings adopting BIPV technology in the near future.

Tokyo in Japan and Kuala Lumpur in Malaysia are two cities that have also taken significant steps towards integrating BIPV and NBS in their urban landscapes. In Tokyo, various initiatives have been implemented to promote the use of solar energy in buildings, such as the Solar City Tokyo project, which aims to install rooftop solar panels on 100,000 homes by 2030.

Tokyo implemented the world's first urban Cap-and-Trade Program (TCTP) already in 2010, requiring CO<sub>2</sub> reductions from large commercial and industrial buildings. This programme also supported the adaption of BIPV solutions in the city.

A city-to-city collaboration for

#### **La Seine Musicale, Boulogne-Billancourt, France.**



Credit: Shutterstock, Christopher Geroge

#### **La Seine Musicale, Innovative BIPV solution.**

low-carbon society between Tokyo and Kuala Lumpur has been created, focusing on initiatives for buildings to decarbonise.

The Malaysian capital, on the other hand, has adopted the River of Life project, which involves the revitalisation of the city's river systems using NBS, such as rain gardens, bioswales and wetlands. By learning from these case studies, cities around the world can develop their own strategies for re-greening and creating harmony with nature, including use of solar energy in buildings through innovative BIPV solutions.

#### **La Seine Musicale, France**

In Europe there are also exceptional landmark examples for BIPV, such as La Seine Musicale featuring an egg-shaped auditorium and a wall of solar panels that move to follow the path of the sun. The Japanese architect's Paris-based office Shigeru Ban Architects collaborated with local architect Jean de Gastines on the complex near Paris, located on the Ile Seguin close to Boulogne-Billancourt.

The ovoid structure's latticed laminated-timber frame is sheathed in glazing and sheltered from direct sunlight by a sail-

like surface covered with photovoltaic modules.

The triangular sail is mounted on rails that allow it to follow the path of the sun, therefore increasing its efficiency and ensuring the lobby behind is shaded throughout the day.

### Envisioning a sustainable future: whole-system interliving in urban communities

Building-integrated Photovoltaics and Nature-based Solutions in urban design can pave the way for a sustainable future characterised by whole-system interliving, where communities in cities function in harmony with nature. This vision entails the development of urban spaces that are resilient, adaptive, and self-sustaining, with minimal reliance on external resources and energy inputs.

Achieving this vision requires a shift in the way cities are planned, designed, and managed, with an emphasis on the interconnections between various elements, such as energy, water, food, and waste. By adopting a systems approach, cities can optimise the use of resources, minimise their environmental impact, and enhance their resilience to climate change.

### Integrating NBS and BIPV in urban design

The integration of NBS and BIPV in urban concepts is a critical step towards transforming cities into greener, more resilient spaces. This can be achieved by incorporating these technologies in various aspects of city planning, such as zoning, building codes, and urban design guidelines. For instance, cities can encourage the adoption of BIPV solutions by offering incentives, such as tax breaks or subsidies, for property owners who install photovoltaic systems on their buildings.

In addition, cities can promote the use of NBS in urban design by incorporating green infrastructure, such as green roofs, vertical gardens, and permeable pavements, into their planning and development processes, in combination with BIPV solutions. This can not only enhance the aesthetic appeal of urban spaces but also provide various environmental benefits, such as improved air quality, reduced heat island effects, and enhanced biodiversity.

### The new era of urban living: key drivers and trends

The new era of urban living is characterised by various key drivers and trends, such as the growing awareness of the need for sustainable development, the increasing demand for energy-efficient buildings, and the rising importance of climate resilience. These drivers are shaping the adoption of BIPV solutions and NBS in cities, as well as influencing the way urban spaces are planned, designed, and managed.

One of the main drivers of this new era is the growing awareness of the need to reduce CO2 emissions to mitigate climate change. This has led to the development of various initiatives, such as the C40 network, which brings together cities from around the world to share knowledge and best practices for reducing emissions and enhancing climate resilience. The new IPCC report also highlights the importance of decarbonisation efforts in urban areas, given their significant contribution to global emissions.

Another key trend in the new era of urban living is the increasing demand for energy-efficient buildings. This has been driven by the rising costs of energy, as well as the growing recognition of the environmental and health benefits of energy efficiency. BIPV solutions offer a unique opportunity for cities to meet this demand by harnessing solar energy and incorporating it into the built environment.

### The untapped potential of BIPV for electric vehicle charging infrastructure

The integration of BIPV solutions in cities not only offers the potential for renewable energy generation but also presents an opportunity for the development of electric vehicle (EV) charging infrastructure. With the global push towards electrification of transportation, there is a growing need for accessible and reliable charging infrastructure in urban areas.

BIPV systems can be integrated into the design of EV charging stations, providing a clean and renewable source of power for charging electric vehicles. This not only reduces the reliance on fossil fuels but also contributes to the decarbonisation of the transportation sector. Furthermore, the incorporation of BIPV in EV charging infrastructure can also enhance the aesthetic appeal

of these facilities, making them more attractive to users and the surrounding community.

### Conclusion: Embracing the power of BIPV solutions for cities and nature-based strategies for a sustainable future

In conclusion, the integration of BIPV solutions and nature-based strategies in city planning and design offers a unique opportunity for transforming the urban landscape into greener, more resilient, and energy-efficient spaces. By harnessing the power of renewable energy and natural processes, cities can address various environmental challenges, such as climate change, air pollution, biodiversity loss and resource depletion.

The various opportunities described above for integration of photovoltaics into urban structures could be applied by city administrations for enhancing renewable energy production in cities and to enhance the quality of life of its inhabitants.

To realise this vision, it is essential for stakeholders from various sectors, including the building industry, finance sector, and local governments, to collaborate and develop innovative solutions that promote the adoption of BIPV and NBS. By working together, these stakeholders can pave the way for a new era of urban living.

By embracing the power of BIPV solutions and nature-based strategies, cities can create a new era of urban living that is not only environmentally friendly but also economically viable and socially inclusive. Now is the time for cities around the world to seize this opportunity and work together to create a sustainable and resilient future for all. ■

#### Author

Dr. Silke Krawietz is an architect specialised in biophilic design, sustainable buildings and renewable energies, in particular Building-Integrated Photovoltaics (BIPV). She earned her Ph.D. with honours at TU Darmstadt, Germany. She collaborated for many years with the European Commission and the European Institute of Innovation & Technology (EIT), EIT InnoEnergy. Dr. Krawietz is the CEO and Founder of SETA Network, an architectural consultancy which aims to combine the environment, technology and architecture and help create buildings that harness the power of nature, through BIPV, Biophilic Design and Nature-based Solutions. Dr. Krawietz is member of the Global Alliance for Buildings and Construction (GlobalABC), Paris.



# The smarter E Europe: enormous potential of parking lot PV

## Solar Promotion Group writes on the benefits of carports with integrated photovoltaics

Ambitious climate protection goals and the energy sovereignty pursued by many countries are turning photovoltaics (PV) into a game changer. In addition to solar installations in open fields and the roofs of private homes, alternative spaces are on the rise: Parking lot PV, which includes PV installations on carports as well as roofing over vehicle parking lots.

These applications come with many advantages: Twice as much use can be made of developed areas, the roofing provides sun and weather protection and, in conjunction with wallboxes and charging stations, the electricity can be used right where it is generated.

With parking lot PV, companies in the industrial sector and properties used for commercial purposes are able to secure their own supply with solar power, while large parking lot facilities can contribute to the development of a comprehensive charging infrastructure for electromobility and, in turn, to the transportation transition as a whole.

As another positive side-effect, operators gain a considerable boost to their reputation: By producing and using clean electricity, they fulfill their climate protection obligations and generate added value from parking lot areas. In addition, the roofing protects the surface of the parking lot.

According to Market Data Forecast statistics, in 2022 the global solar carport market reached a record high of US\$524 million and is predicted to grow to US\$685 million by 2028.

In Germany alone, the potential for parking lot PV is enormous: Almost a quarter of the 215 gigawatts (GW) of installed PV capacity targeted by the German government for 2030 could stem from parking lots, says Fritz Haider from the Fraunhofer Institute for Solar Energy Systems ISE. According to his calculations based on OpenStreetMap data, parking lots cover a total area of 47,060 hectares with around 360,555 parking spaces.

Calculations based on a technical surface area potential of 284 square



kilometers result in a specific yield of 930 kilowatt hours (kWh) per year, assuming PV is applied to the entire surface of these spaces. This would correspond to a technical capacity potential of 59GW peak (GWp).

## Long planning times and high investment costs

However, parking lot PV has several obstacles to overcome to make its big breakthrough: Owing to regulatory building specifications, both planning times and standards are currently higher than for traditional roof-mounted systems. Investment costs are also higher, as specialist roofing structures are included in the calculations.

There is also a lack of incentives for existing parking lots. At least some German states have introduced a PV obligation for new parking lots. When it comes to the German Renewable Energy Sources Act (EEG), there is also room for improvement: Parking spaces with PV roofing are considered to be other structural installations, which makes them subject to base remuneration.

This does not currently reflect the fact that investment costs are up to 50% higher than for regular rooftop installations, and leads to parking lot PV only





being considered economically viable in conjunction with self-consumption and electromobility integration solutions.

### **Slimline structures made from natural materials**

The installation of parking lot PV systems has a lot to offer in the way of creative scope: Besides building a roof across the entire parking lot area, another option is to cover the parking spaces only. Aesthetically pleasing carport structures are possible thanks to developments aimed at keeping steel frames and roofs as lightweight as possible, as well as promoting the use of natural materials such as wood.

A good example of this is the PV carport located on the premises of utility company EnergieDienst in Rheinfelden, Germany. The 504 PV modules form a semi-transparent roof covering. A hybrid structure comprised of wood and steel was used to construct the roof. The installation also features 14 wallboxes, each with a charging power of 22kW alternating current (kW AC), and a 110 kWh battery storage system.

### **Pioneering projects in parking lot PV**

The world's largest parking lot PV system is currently located in Biddinghuizen in the Netherlands: This 35MW solar carport has 90,000 solar panels and covers 15,000 parking spaces connected to an events venue, where several large music festivals are held every year. Just 1% of the electricity generated is used to operate the festivals and the rest is fed into the grid. During the periods when no festivals are taking place, sheep graze on the 35-hectare site.

The automobile manufacturer Ford utilises parking lot PV as a way to help achieve its company goal to exclusively use climate-neutral electricity by 2035. Ford has installed a 13.5MW parking lot PV system with 30,226 solar modules

at their Silverton Assembly Plant production site in Pretoria, South Africa. It covers 3,610 parking spaces, meeting 35% of the plant's electricity demand.

The largest PV parking lot in Germany is currently being built at the MOSOLF Group's logistics centre in Rackwitz, Saxony. The installation will span an area of nine hectares and consist of 35,000 solar modules, reaching a peak capacity of 16MW and covering approximately 6,000 parking spaces. The green energy produced is fed into the grid and the installation generates 40 times more electricity than the company itself consumes.

Another large-scale project was carried out in Germany, at Düsseldorf Weeze Airport. A 4MW solar installation is mounted over 66 carports, which covers 1,350 parking spaces, and the electricity produced is used directly by the airport.

### **Solar carports at The smarter E Europe 2023**

The latest trends and innovations for PV carports will be presented at The smarter E Europe, the continent's largest platform for the energy industry, and its four parallel exhibitions Intersolar Europe, ees Europe, Power2Drive Europe and EM-Power Europe from June 14–16 at Messe München. The outdoor area features an exhibition segment on solar carports.

At these exhibitions, visitors will learn more about the latest applications and intelligent combination solutions. They can expand their expert knowledge at the four accompanying conferences, seven topical exhibition forums as well as numerous side events. More than 2,200 exhibitors will be showcasing their products on 180,000 square meters across 17 exhibition halls and an outdoor area. More than 85,000 international visitors are expected to attend.

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# Nationally Significant Infrastructure Projects: A key enabler of the UK's energy transition

**NSIPs** | George Heynes explores how the UK's Nationally Significant Infrastructure Projects regulations support the transition to a green energy economy



Credit: Wikimedia, ANeely2020

In the UK, renewable power generation technologies grow in both scale and number, with impending decarbonisation targets looming in the coming decades.

But with planning constraints impacting the rollout of solar and other renewable energy projects across the UK, Nationally Significant Infrastructure Projects (NSIPs) could be required to bolster the generation capacity of the nation.

NSIPs were first introduced via the Planning Act 2008 in a bid to streamline key developments for the UK to achieve targets in the fields of energy, transport, water, waste and wastewater.

As the Russian invasion of Ukraine in February 2022 plunged much of Europe into an energy crisis, the UK government stressed the need to both decarbonise and improve energy security. For this, NSIP projects could become an important tool.

The current process involves several stages. These include pre-application, acceptance, pre-examination, examination, recommendation and decision as well as a post-decision. The process is conducted by

## UK solar project

the Planning Inspectorate, a government agency which became responsible for NSIPs under the Localism Act in 2011.

The process has been regarded as positive since its inception and has reduced the time to achieve development consent to an average of around four years instead of the eight years, for example, it took to consent Heathrow Terminal 5 via a conventional planning inquiry.

Multiple solar projects are currently being explored as part of the NSIP scheme in the UK. But how have NSIPs already supported the renewable and solar sector? And how could the reforms benefit the wider UK energy system and bolster energy security prospects?

## How NSIPs are supporting the UK energy transition

The NSIP process, according to Matthew Pixton, head of planning for SSE Solar and Battery, was created to streamline and improve England's planning regime when it was introduced in 2008.

He says: "The NSIP process set up a 'one-stop-shop' for projects to gain

consent, which combines planning permission with a range of separate consents from different agencies. Crucially, it also set time limits for various stages, requiring the Planning Inspectorate to determine whether to accept an application within 28 days, examine it for six months and then make a recommendation to the relevant Secretary of State, who is then given a further three months to decide whether to grant it.

"While it may not have gone as far as many in the industry would like, this process has facilitated the accelerated deployment of much-needed solar, helping bolster generation capacity and energy security."

Indeed, the NSIP process has seen several successes within the energy industry, especially in the solar sector where 10 projects have been explored as part of the NSIP regime.

The first solar project to be accepted under the NSIP process, the 373MW Cleve Hill Solar Park, started construction in late April 2023. Once complete, which is scheduled for the end of 2024, it will be the UK's largest solar and battery site featuring more than 150MW of battery energy storage.

Jon Chappell, senior policy adviser at the National Infrastructure Commission (NIC), believes NSIPs can further enhance the solar industry by helping deliver massive projects, much like Cleve Hill, at a rapid pace. For this however, the planning system must be flexible.

"With the cost of solar generation continuing to drop and the technology further improving the yields available from new projects, we think it's important that the future planning system is flexible enough to recognise the changing nature of the market, the technologies, and the potential for delivering at scale," Chappell says.



Credit: Pexels

"For example, the threshold currently in place for solar projects to qualify as NSIPs is too low, and no longer reflects how the technology is delivering a much higher yield for the same amount of land. Under the local planning system, projects below 50MW can get approved in less than a year."

Chappell adds: "But with projects under the NSIPs process taking anywhere up to four or five years to get approval, this means only the largest projects – above 200MW – make commercial sense for developers to take forward. The end-result is a gap in the market for medium-sized projects, and we think this could create pinch points in the solar market, with negative implications for future capacity."

"Securing grid connections has been challenging, and one of the long-term solutions to this is the rollout of new electricity transmission infrastructure, which is usually delivered through the NSIP system. That's why the Commission has recommended that delivery of new transmission infrastructure be treated as a high priority by the government."

Grid connection delays have caused major issues for the UK energy market with many projects now having to wait until 2030 to connect new large-scale renewable generation projects. Speaking at the Aurora Spring Forum in March 2023 in Oxford, Octopus' CEO Greg Jackson branded connection delays as 'unacceptable' as he confirmed that Octopus had been offered

**Multiple solar projects are currently being explored as part of the NSIP scheme in the UK**

a 2035 date for a solar and storage site in Durham.

NSIPs, as discussed by Chappell, could be one method in removing this obstacle and still allowing large-scale renewable energy to be connected to the grid.

**Obstacles when constructing NSIPs**

With the UK's NSIP scheme having first been introduced to support the creation of key, large-scale infrastructure projects up and down the UK, several challenges and obstacles have come to light.

One of the most important challenges to overcome is community perception. Often these large-scale projects are met with resistance from local communities. This occurred for one of the UK's largest proposed NSIPs – Botley West, an 840MW solar project in Oxfordshire.

Project developer PVDP launched a public consultation in November 2022 with aims to submit a Development Consent Orders (DCO) application to PINS by the end of 2023. The project would be split across three sites in Cherwell, West Oxfordshire and Vale of White Horse.

PVDP has been working with both landowners and landlords to support the project in the local area and support its renewable journey. This includes Blenheim Estate, with whom PVDP is working to ensure that the project plans are aligned with the landowners' long-term strategies.

"These consultations reveal not only

a public ignorance, but also an absolute vacuum in public policy," says Mark Owen-Lloyd, project lead for the Botley West solar project, in response to the public consultations on the Botley West project.

"[The Botley West project] is a hard sell to immediate neighbours such as people who are located three fields away from the project – they don't want the countryside to change, which you can understand, with West Oxfordshire already saturated with housing applications."

Public consultations grant several opportunities for project developers to engage with the local communities and answer any concerns that may be presented. To this end, public consultations can provide educational opportunities to inform the general public. This could be invaluable to projects currently in development, and Botley West is no different.

"There's a lot of education you can do via consultations, and this is really important because a lot of people who come to them are open to being persuaded. We've had a very high attendance so far and interestingly, the parish councils have been very supportive," Owen-Lloyd says.

"It's good to get out there and talk to people about it and I think we got a lot of support. The feedback coming on our channels has been about 50/50 of support and condemnation, so we're hitting the spot with some."

As stated by Owen-Lloyd, the public

consultations have been an opportunity to guide not only their initial proposal for Botley West, but also to educate the general public on the project and alleviate some of the concerns surrounding it.

SSE's Pixton also believes there are benefits in aligning the project to support local communities – helping to improve the general consensus for large-scale NSIP projects. Pivotal in achieving this is public engagement.

"Delivering a major infrastructure project is no mean feat, wherever your project is located. However, securing community buy-in is crucial, regardless of location. Best practice developers have found equity, a cornerstone of our engagement strategy, to be a key driver of this," says Pixton.

"We're confident that as a country, there is widespread support for the green economy, and solar and battery technologies already play a vital role in this. However, some cynical developers have done a poor job at communicating the need for their project, its benefits, and what it will entail for nearby communities – which will inevitably lead to opposition. As they will affect more people, due to their size, this often equates to more backlash.

"By seeking opportunities to maximise the benefits of our projects for the communities we operate in and thoroughly engaging with local people on this, we are aiming to deliver a new generation of best practice schemes, efficiently and fairly."

Community support is also referenced by Chappell as a key issue to address for NSIPs. However, instead of community engagement, Chappell believes that "improving the way those trade-offs are managed and communicated in any planning application will help increase trust in the process".

Chappell says: "Trade-offs between national and local needs are always going to be feature of major infrastructure projects, but improving the way those trade-offs are managed and communicated in any planning application will help increase trust in the process."

"That's why we've recommended government develops as soon as possible a framework setting out how different tangible benefits – such as proximity-based payments for households, or funding for local projects – are applied, to make it clear to communities as early as possible what they, as well as the country as a whole, will gain."

Alongside this, another crucial aspect has entered the NSIP debate – the average

speed of consent. If the UK is to meet its 2035 decarbonised power system target, there is a fundamental need to speed up the development process of NSIP projects, particularly for renewable generation.

"In the last decade, the average speed of consenting has shifted from 2.5 years to over 4 years, and much of that can be attributed to the delays caused by local objections and the frequency of judicial reviews. That delay creates significant costs, adds to frustrations on all sides, and delays delivery of the infrastructure we need," Chappell says.

But with the average speed of consenting rapidly reducing, and set to be resolved as part of NSIP reforms by the UK government, what else could be included to bolster the support from NSIPs?

### Reforming the NSIP process

Earlier this year, the government stated that the current NSIP system does not move with the focus and speed that is required – something that is becoming increasingly concerning with regards to the UK's decarbonisation targets.

The government disclosed several reasons why there is a need to reform the NSIP process, one of which includes an increase in the average length of time it takes for a case to reach decision. The time it took to reach a DCO increased by 65% between 2012 and 2021 from 2.6 to 4.2 years.

Along with this, more projects are requiring multiple extensions of time at the decision date. This is a key issue in the process for offshore wind projects, with the government citing the technology as having some of the largest quantities of deadline extensions in the statutory stages.

To solve the issues around the NSIP process, the UK government has committed to reforming key areas. This includes setting a clear strategic direction, bringing forward operational reforms to support faster consenting, realising better outcomes for the environment, recognising the role of local authorities and strengthening community engagement and improving system-wide capacity and capability.

The government is hoping to pilot some of the aspects of the reforms in September 2023 with hopes to review the proposed reforms from 2025.

On what Pixton would like to see included within the NSIP reformations, he says: "The government should be considering how the process can be further streamlined while also ensuring cynical

developers invest in understanding the communities they work in and bring them on the journey to net zero. Incorporating this consideration into any reform would benefit the sector as a whole by reinvigorating developers' licences to operate – raising the bar in terms of accepted practice while driving equity in surrounding communities.

"Shifting perceptions away from projects being done to them, without meaningful consent, would also reduce the likelihood of them receiving the kinds of opposition that can cause serious project delays. While tied to bad practice, many in the industry see these unfortunate outcomes as symptomatic of a system that fails to provide certainty."

"At SSE Solar and Battery, we have set a target of energising 1GW of solar and battery capacity by 2027. To deliver on our ambitious goals, we need a regime that is efficient and projects certainty."

Streamlining the NSIP process could be fundamental to ensuring not only the development of the UK's renewable generation sector, but also in securing investment to ensure the nation's energy sector maintains its competitiveness and attractiveness with the US and the EU.

The NIC recently released a report detailing several recommendations to help support the NSIP process and UK renewable sector. One of the key areas it believes should be reformed is the planning system to speed up the process in developing NSIPs.

"Expanding the UK's use of solar power is an essential component in delivering a low carbon economy through a successful shift to fully renewable, resilient electricity generation. Despite the success of the contracts-for-difference in delivering new solar capacity at lower prices, the planning system can sometimes create uncertainties for large solar projects," says Chappell.

"It's essential that we speed up the planning system for NSIPs to ensure delivery of the new renewable generation infrastructure the country requires."

"The recommendations we've made to government in our new report – such as five-yearly updates of National Policy Statements, better sharing of environmental data, and more tangible benefits for communities hosting new projects – should, if accepted, help deliver a planning system that's faster, more flexible and better able to balance the needs of operators, investors and communities." ■

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# Texas PV market ripens as major global investors drive financing flurry

**US Solar |** Tom Kenning looks at the rise of solar power in Texas, a US state better known for its role in the oil and gas industry, where a beneficial tax regime and an abundance of project land work in favour of building out solar power generation.



While California has traditionally dominated solar headlines in the US, Texas is now set to become the leading market in the country, demonstrated by a spate of financing deals and PPA signings in recent months. Texas' interest in PV has also skyrocketed since the Winter Storm Uri left millions of Texans without power as snow and ice paired with ultra-low temperatures caused widespread disruption in February 2021.

Unlike natural gas infrastructure above ground, solar can still work in freezing conditions. Recent months saw agri-voltaic specialist Pristine Sun bag funding for Texas projects, as did PV developers like Leeward Energy; and further upstream, manufacturers like SEG Solar and solar recycling specialists Solarcycle also obtained financial backing. Few industry commentators had any substantial concern about the infamous fall of Silicon Valley Bank, which was a major investor in community solar.

Most of the latest projects announced for Texas require large amounts of land, but compared to other states in the US, Texas has plenty available, and big spaces that are close to transmission lines, says Sylvia Leyva Martinez, senior research analyst at Wood Mackenzie. Texas also has a huge production of oil and gas that can be accessed by factories requiring high energy loads. Taxes are also very low in Texas with no state tax, making it less expensive than many other states that mandate local tax, state tax and federal tax.

"For renewable projects, the processes for interconnection, transmission and distribution are easier compared to other states," adds Martinez. "You only need local approval to get a large project ongoing compared to state approval, or having more entities involved, so it takes less time to develop a big project."

The Southern state also offers transparency to clean energy developers. The

**SEG Solar's 1.7MW parking lot solar project at Austin International Airport in Texas**

different transmission and distribution providers in Texas make public all the requirements for interconnection, which streamlines the process. Permitting is also said to be far easier in Texas than in most other US states.

## Texas the lone ranger

Texas plays by its own rules in a number of areas including permitting, isolated grids and a lack of labour unions. The Electric Reliability Council of Texas (ERCOT), which runs the Texan grid, for example, is not under federal regulation and has its own regulatory practices.

"One thing that is very different in ERCOT versus other ISOs or RTOs is winterisation of assets," says Martinez. "ERCOT does not require assets to be winterised, so there are lower costs compared to developing in other regions. It's easier and to some extent less expensive to develop projects in ERCOT just because they have

their own regulatory frame that is less strict compared to a federal level.”

This sentiment is backed up by Jim Wood, CEO of SEG Solar, a Houston-headquartered PV module manufacturer which produces both TOPCon and N-type PV modules at its Texas factory.

“Look at states like California,” he says. “It’s very onerous to build out there whether you’re building a solar power plant, or you’re building a manufacturing [plant]. First and foremost, there’s significantly more permitting regulations, versus Texas which isn’t as onerous.”

There’s very little unionised labour and there’s a very good supply of non-union labour, which brings down all the costs, whether to build a plant, or even a factory, Wood adds.

### CREZ dividends

The current solar momentum in Texas can also be traced back to its Competitive Renewable Energy Zone (CREZ) initiative, begun in 2005 and completed in 2014, which aimed to drive massive new wind energy capacity addition, says Troy Helming, founder of Pristine Sun, a community and utility-scale PV developer specialising in agri-voltaics. As solar matches wind in terms of generating power at different times of the day, this push for wind in Texas meant that PV could come in to fill the gaps.

While there is capacity on the transmission lines for solar, which makes it attractive, getting into the interconnection queue is not so easy.

“It used to be a year or two,” says

Helming. “Now, it’s probably three to five years to get through interconnection.”

### Texas was always a global energy hub

Texas is by far the largest producer of crude oil in the US and has a history immersed in oil and gas production.

“At a very high level, Texas has always been a global energy hub, so it’s no surprise that as solar becomes the king of energy, Texas will become the king of solar,” says Jesse Simons, chief commercial officer of Solarcycle, a pioneering PV recycling specialist which has a facility in Texas. “Connected to that Texas is the fastest growing solar state in the country. It will soon have more solar than any other state.”

The state is so large that land is relatively cheap and it benefits from high irradiation and an extremely flat geography making it very easy to install the largest-scale multi-gigawatt solar projects.

Given its history of energy infrastructure, the Texan workforce is also well trained and versed in the energy landscape.

“Even though they’ve mostly been working in oil and gas, there’s a reason why BP Solar, Shell and these other companies are stepping in and leading on a lot of big wind and solar and storage projects,” adds Simons. “They understand energy and this is essentially just another form of energy.”

### Market changes not regulation changes

PV Tech Power asked industry commentators whether any regulatory changes had spurred the sudden financing surge,

but no policy changes were highlighted. Instead the change has come through the backdoor with a shift to power purchase agreements (PPAs).

Historically, getting long-term PPAs is difficult in Texas, says Helming. Thus, many wind projects were built under merchant contracts, which brought more risk due to uncertainty over future power sale prices. However, corporate buyers for renewable energy, including big tech companies for data centres, Fortune 2000 companies, and manufacturing facility developers, have started entering the market in recent years.

“Your customer for a solar farm isn’t just utilities anymore,” adds Helming. “It can be corporate buyers and they’re often willing to sign 10- or 15-year contracts, which is long enough to raise the financing to build a project, and those customers are investment grade and highly credit-worthy. So, it’s a market condition rather than a regulatory condition that has improved the attractiveness of getting your customer offtake.”

### Financing players and SVB calm

According to Wood Mackenzie’s database, amongst operational and development projects, some of the largest financiers and investors for Texas solar appear to be CIT Group, Bank of America, Morgan Stanley, U.S. Bank, Wells Fargo, and North America Development Bank. However, Martinez adds the caveat that there could be other large players in the market since the analyst firm’s financing data captures about 10% of all such capacity in Texas.

Martinez has not heard of any major concerns around the demise of the major community solar investor, Silicon Valley Bank (SVB), in terms of its effects on other banks. Instead, she notes that most industry players are more concerned with the forthcoming definition of the US’ domestic content regulation, which will incentivise the use of certain pieces of domestically sourced equipment. Several manufacturers have said their plans will adapt in direct response to whatever the final guidance is.

For PV power plants, most of the large utility-scale global players, all of the major banks and the standard tax equity, finance players are in Texas, says Wood.

“They’re all there financing, especially on the tax equity side for projects, and there’s some large funds out there that companies are using and those funds are looking for more of a fixed return or an alternative to bonds or other types of fixed income.

“It’s similar to most of the US. All the

**SEG Solar’s photovoltaic (PV) module manufacturing plant in Texas, US**



projects need tax equity financing, and because tax credits play a large part of that, it's all the major companies and financial institutions that make profits and have lots of taxes. That's who's financing."

Ultimately, commentators said that there is far more capital chasing investments in Texas than there are projects.

"It's basically to the developers' advantage because it's driving down the cost of capital as there's more competition for debt, tax equity and sponsor equity," says Helming. "It's been the case for probably about the last four to five years and it's accelerated pretty substantially here in the last two years."

### Storm Uri

Storm Uri was a game changing moment for Texans' relationship to power since blackouts hit most of the state for a few days in February 2021, impacting not just electricity but also water supplies. Some of the wind turbines did not have cold weather packages to help with de-icing the blades during the storm and were affected by the freezing conditions, but Helming says most of the turbines have now been upgraded in response. While solar production during the day matches up well with the large air conditioning demand for nine months of the year during hot days in Texas, one of the biggest attractions for solar PV is its ability to perform in freezing conditions.

"There's still a lot of above ground natural gas infrastructure where the pipeline pops up out of the ground to go through a pumping station," says Helming. "And most of those are gas powered pumps, rather than electric pumps. So if the gas is frozen, the pump shuts off. But solar doesn't have that problem. It doesn't matter if it's really hot or really cold, it keeps producing."

### Developing PV projects

One of the biggest problems in Texas is that generation and load can sometimes be far away from each other, and it can be complicated to develop PV projects close to load centres due to land availability. Wood Mackenzie's analysis shows that the top counties for projects in development (by MW capacity) at present are Wharton, Lamar, Falls, Swisher, Milam, and Fort Bend. This is a noted shift from the top counties in terms of operational capacity, which are mostly located in the ERCOT West zone – Pecos, Andrews, Upton, Brazoria, and Denton counties.

"Developers may be looking to avoid higher curtailment risk in a region where much solar has already been developed," adds Martinez.

The PV sector in Texas is dominated by large utility-scale projects using economies of scale to overcome financing hurdles, so there are far fewer 5-30MW medium-size projects.

"In Texas, projects tend to be 250MW and up for the most part and so you really need scale to make it work," says Wood. "It's economics work because the land is really cheap and labour is cheap."

"On the residential side, Texas works great. It's an unregulated market so there's quite a bit of residential solar."

Wood again referred to the outages during Storm Uri and how the crises created a lot of demand for household PV.

Wood, whose manufacturing firm SEG Solar is located in Houston, says: "There's a famous hockey player named Wayne

*"The Southern state offers transparency to clean energy developers. The different transmission and distribution providers in Texas make public all the requirements for interconnection, which streamlines the process"*

Gretzky who once said 'you go where the puck is going not where it's been'. When you look at subsequent years, the Texas market is going to become the largest market in the US in both residential and utility-scale. So, when you look at that market, for us, it makes a whole lot of sense to locate in Texas, because it cuts down on transportation costs, there's a port there, and labour is very competitive.

"There's a lot of talent. There's a lot of folks that work in the energy industry. And as we see a transition from traditional natural gas, oil and other types of power, I think we're going to continue to see a lot of those folks look for jobs in renewables."

### Agri-voltaic opportunities

Helming's firm Pristine Sun develops agri-voltaic projects, an idea born a number of years ago out of regulatory challenges at a time when the American Farm Bureau Federation was trying to stop PV projects in the US.

Transmission is a key driver in decisions

over where to locate PV Projects. It is easy to find land in Texas, but hard to find it near a transmission line that has capacity. Secondly, agri-voltaics can be chosen as a way to keep landowners happy with royalty payments or lease payments from the developer as well as continuing to draw an income from a rancher wanting to graze livestock on the property or, if the soil is appropriate, a contract farmer growing crops.

"In some rare cases, we're buying the land, because we've noticed in Texas, there are a lot of landowners who are ageing, and the kids are not in the family business," says Helming. "They're not interested in being a rancher or a farmer and so they want to sell the land rather than sign a 25-35-year lease. So that's new for us. We're starting to figure out how to partner with investors who want to help us buy the land."

Pristine Sun always uses trackers spaced out far enough from each other to allow agricultural practices to continue. Most plants have livestock around them, but it can involve simply planting native wildflowers to support bee colonies as a minimum. Farmers can also grow alfalfa for livestock or vegetables amongst these projects, taking advantage of 3-4 hours of extra shade each day from the solar panels.

### Future transmission unlocked

Most of Texas is part of an island grid run by ERCOT with little movement of energy back and forth, which contributes to transmission bottlenecks, which is the key challenge for solar development. However, Pristine Sun is collaborating with a sister company, Earth Grid, to develop underground transmission lines to be able to import and export large quantities of energy into and out of ERCOT.

"That will help solve some of the grid challenges in Texas and it will also enable vast new resources of both solar and wind to get to the load centres of the big cities in Texas," adds Helming – noting that transmission is the biggest impediment to the growth of clean energy not just in Texas but in most places across the globe.

"I am very bullish on the Texas market for solar, mainly because the economics of solar compete very well," says Helming. "It's way cheaper than coal and nuclear and slightly cheaper or way cheaper than gas depending on where you are in the state. So the economics will drive significant growth in solar for at least the next five to 10 years."



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# From Niche to Necessity: Insuring Renewable Energy

**Insurance** | Jason Kaminsky, CEO, kWh Analytics, on how renewable asset owners and their insurers are adapting the way they assess risk from natural catastrophes and extreme weather events.

In recent years, there has been a significant shift in the role of insurance and the way policies are written for renewable energy projects. The rapidly declining cost of the technology, federal policy changes, and energy price inflation have brought about a surge in the development and use of renewable energy sources, and along with it, the need for specialised insurance coverage to protect these projects. Inherently a risk transfer vehicle, insurance has become an essential part of the project finance puzzle. Simply put, if an asset is uninsurable, it is unfinanceable.

Although opportunities abound in the renewable industry, rapid, massive growth does not come without challenges for insurers. Clean energy is a fairly nascent asset class with the first projects of material size built in the early 2000s. Early on, renewable energy found its way into the hands of underwriters who analysed adjacent asset classes (like power or oil and gas), whose view on the risk, at the time, did not demonstrate a significant loss profile. In the years following, as carriers gained more experience, insurance coverage for wind, battery,

and solar was regularly underwritten, and became more prevalent in the market, with generous terms for the insureds.

That was, until 2019.

A few factors contributed to a change in how projects were underwritten and priced. First, as an industry, we began building solar projects in regions that had greater exposure to natural hazards, such as hail storm risk in Texas. Second, cost pressures on power purchase agreement (PPA) rates resulted in tightened operations and maintenance budgets, and some of the basics in risk management (such as vegetation management) were overlooked. These two factors, combined with significant fire, flood, and hail events between 2019 and 2023 resulted in outsized losses for many renewable energy assets.

At the same time, global carriers were facing an array of losses across all business segments from the increasing impact of natural disasters, which led to a generally conservative approach to pricing property risks across the entire insurance industry. Asset owners began to experience tightened capacity and stricter terms and condi-

tions, with some unable to secure insurance for their assets at all. We entered into what's called a 'hardening market,' meaning vital insurance was more expensive and more difficult to obtain.

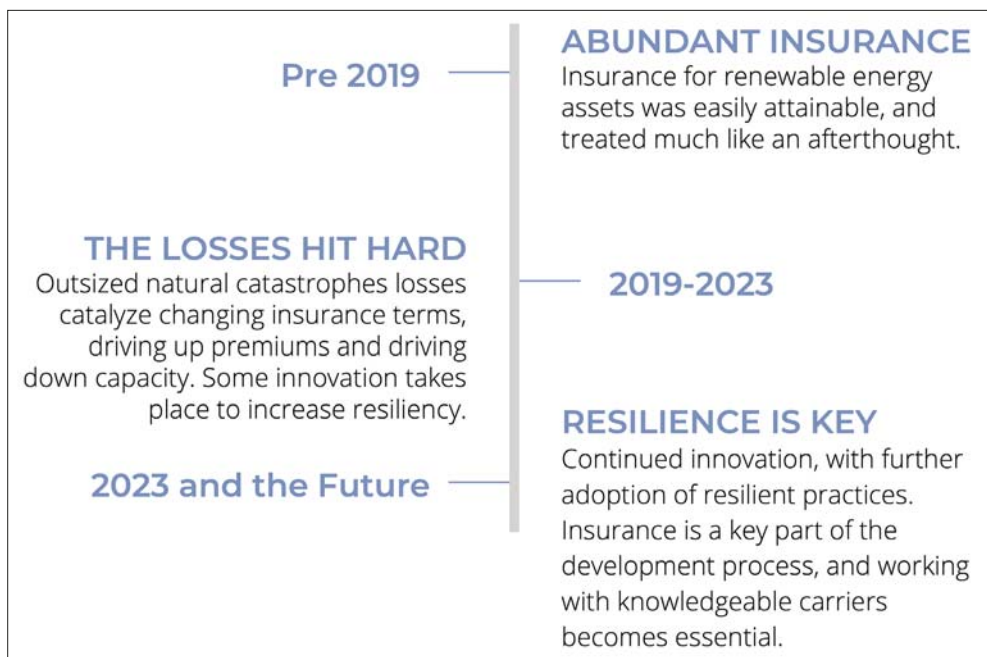
Today, renewable asset owners and their insurers are undergoing an evolution in the way they approach risk. Using the influx of available data for solar, wind, and battery assets has become key to better understanding and protecting against exposures from natural catastrophes and extreme weather events.

## Natural Catastrophe Models in Evaluating Extreme Weather Risk

To assess the risk of a renewable energy facility, underwriters typically evaluate the exposures in two categories: natural catastrophes (broken into six primary perils: hurricane, earthquake, wildfire, severe convective storm (including hail and tornado), winter storm, and flood) and attritional risks (risks that are not associated with catastrophic events, such as theft, equipment breakdown, etc). For solar assets, many of the losses are driven by natural catastrophes, while the attritional risk profile is generally stable. In contrast, equipment failures have been more significant loss drivers for both offshore and onshore wind sites.

Extreme weather risk is typically evaluated and understood using natural catastrophe ('nat cat') models. A typical nat cat model utilises a stochastic event set for each peril, simulating tens of thousands of hypothetical events, which yield a frequency and severity profile of events at a given location, such as the number and magnitudes of earthquakes or the number and maximum wind speeds of hurricanes.

Each event in the stochastic event set is then transformed into a loss prediction using a vulnerability function. In essence, this function converts a wind speed of X into a distribution of predicted losses (in dollars) of Y. The models typically allow a user to select many characteristics of the



underlying building type to generate a loss forecast: a brick building will behave differently than a steel building in an earthquake, and both will behave differently than a solar power plant. However, given the rapid growth in the solar market and more limited data available to model developers, they often use a proxy building type to mimic what they estimate may happen to a solar power plant.

As an output from the model, an insurance underwriter then receives a result that is not dissimilar from the P-values often associated with a solar generation forecast. An 'exceedance probability' curve conveys the results in terms of return periods: for example, a 1-in-100 year loss is a P99 risk. These are generated on a peril-by-peril basis for any given location, and are often distilled into commonly used metrics: average annual loss (AAL) – the average value of annual losses over the modeled period – and probable maximum loss (PML) – a loss expectation that is expected to be exceeded once over a defined period, such as 250 or 500 years.

While this sounds very elegant, some context is warranted about why these models are not a panacea. First, the models were developed for insurance companies to model portfolios of assets. Insurance companies purchase insurance themselves (in the form of reinsurance) and if a carrier has exposure to 10,000 homes along the Eastern seaboard, they want to know their exceedance probabilities for a bad hurricane. The models have been extended to price individual locations, but there is an element of false precision at this level of granularity. Second, there are multiple models available commercially, and some proprietary models developed by large carriers. Third, the models are most accurate for the key perils where most insurance is purchased globally, such as hurricanes, earthquakes, and flood. The underlying models to support the events most important to the solar industry, such as hail, are simply not as robust or as accurate. Fourth, the models generally lack any data on how solar assets perform, and proxy asset classes inaccurately represent solar. To put it another way, the vulnerability curves are wrong.

When you put it all together, the act of pricing an insurance policy becomes challenging. Solutions have emerged to help address these deficiencies in the market. Insurance underwriters, like kWh Analytics, have used real industry loss data to model renewable energy assets more accurately in any given location. Third party consultants,

like ABS and VDE, have developed their own models to incorporate industry expertise into the results and generate a loss forecast. Testing labs like RETC and PVEL have demonstrated that not all modules handle hail the same way and that the tilt angle of the module on a tracker can weigh heavily into the odds of a significant claim versus minor damage. Leading asset owners are developing strategies to be informed when hail is impending in order to send signals to their operators to put the trackers into hail stow.

The good news is that innovation is happening quickly, and the industry is collectively figuring out how to best apply the models and data that exist. These models and data come into play in an important debate happening right now in the industry over how much insurance should be required for an asset owner to secure project financing. Tax equity investors and lenders are not underwriting natural catastrophe risk, but they are at risk of losing their invested capital if a significant, uninsured loss happens on the site. Up until 2019, it was not atypical for an owner to be able to easily and cheaply procure full limits for their assets.

### Managing Risk Through Effective Modelling

After the insurance carriers began demonstrating significant losses, it became much more expensive to procure full limits for all of the underlying perils, and in some cases impossible. Underwriters began pushing more of this risk onto the asset owner, asking them to hold higher deductibles and 'sublimiting' the limits for key natural catastrophe perils. This presents a challenge for the bank and asset owner alike: while we can model these risks for an exceedance probability curve, what the industry has come to appreciate is that actual losses and claims have at times exceeded even some of the worst forecasts out of these models.

As the industry continues to face various challenges, the importance of managing risk through effective modelling techniques becomes increasingly critical. With the help of data, models are now able to leverage large data sets of loss data and meteorological data to improve their stochastic event sets, leading to more accurate physical loss and performance estimations.

A critical aspect of managing risk in various industries, including insurance, finance, and even healthcare, is actuarial modelling. This statistical method utilises

historical data to estimate the likelihood of future events, such as accidents or natural disasters. Actuaries use this information to set insurance rates, estimate reserves, and manage risk.

Data allows for more accurate and efficient modelling techniques. Traditionally, property insurance was based on COPE information (Construction, Occupancy, Protection, and Exposure). With the rising emphasis on the value of data, modelling firms are now able to leverage large sets of loss data to more accurately fit vulnerability curves, as well as more expansive historical weather data to improve their stochastic event sets. While nat cat modelling agencies have broadened their capabilities across industries and new construction types, model developments have lagged for renewables and especially PV, as they are relatively new asset classes with minimal historical loss data publicly available.

Generally, carriers use the recommended proxy structures, valuing a portion of the site as a building, a portion as electrical equipment, a portion as substations, etc., but not accounting for the various electrical or glass components included in this asset class, or for protective measures sites may have in place. While insurance companies have begun to address this with modifiers and credits/debits to adjust for some resiliency factors that are becoming more well-understood, e.g. stow, there are many factors which remain unaccounted for in typical insurance underwriting.

Different entities have approached enhancing solar modelling differently. For example, VDE Americas, an engineering advisory company for renewables, has developed its own hail risk assessment tool based on a blend of radar- and spotter-identified hail events to yield a theoretically more accurate event set. However, the lack of available data, intentional data collection, and rapid PV technology transformation in the industry has led to slow improvement in risk modelling for these assets, further contributing to the current hardened property insurance market. As more industry stakeholders recognise the value of data, potential efficiencies in modelling, risk transfer, and asset resiliency will continue to become unlocked. Once insurers begin to utilise the power of data to incorporate site maintenance, resiliency measures, and thorough underwriting into their risk assessments, the burden of the hardening market may ease for asset owners.

Risk model vulnerability curves are adjusted on a peril by peril basis to best

align with the loss database. A consistent, but not surprising, issue is that industry standard vulnerability curves are drastically underestimating PV losses due to hail. Buildings are not a sufficient modelling proxy as most of the damage is isolated on the roof. The potential risk for a roof is also measured differently than it is for a glass panel, as the hail crack size and the value of the roof is a minor fraction of the asset compared to the value of modules at PV sites. Solar farms are also more spatially expansive and value should not be modelled as single points.

### Vulnerability

The REAL model also makes further adjustments to take site resiliencies into account, shifting the vulnerability curve up or down to represent the increase or decrease in risk respectively. In the case of hail, research has been completed to suggest that stowing modules ahead of a severe convective storm can significantly reduce the impact energy of hailstones. While loss data can give indications of the impact of resiliency factors on risk of loss, evaluation of some technological improvements may rely on physics based models or lab based testing to collect data until robust field data is able to be collected and evaluated.

### Addressing the Discrepancies in Renewable Energy Production Estimations

Asset energy production is another area where modelling and data can be critical, and independent engineers play an important role in the renewable energy

## Case Study

kWh Analytics has begun to address some of the modelling deficiencies caused by the lack of industry wide data by utilising their own extensive renewables database. The REAL (Renewable Energy Adjusted Loss) model accounts for equipment, performance, and management data from over 300,000 operating assets and over US\$50B in loss history at solar sites to give a more accurate and fair representation of potential risks for these assets.

**Site Maintenance:** Properties with operations and maintenance logs and well-laid plans for vegetation management, torque audits, and general inspections of the site have a different and often more positive risk profile than other sites lacking comprehensive O&M plans.

**In-depth underwriting:** Nat cat models for traditional real estate utilise secondary building characteristics which consider each characteristics' influence on modelled building exposures. Similar model modifiers and technical considerations must be made for solar to get an accurate view of risk. Example points from the REAL Assessment include:

- **Hail:** Stow programs considering monitoring capabilities, time to trigger hail stow, stow angle, glass thickness, and tempering will have an altered risk profile.
- **Flood:** In the case of flooding, solar modelling best practices have been adopted to model a solar site, as opposed to an individual building, with the implementation of site gridding (placing many points overlaying a site footprint). However, with the rapid development of solar and relatively infrequent flood map updates, models often do not consider the updated topography of a site and any site prep or build considerations. Many large utility scale sites are not laid out in a neat square. Instead they follow the natural topography and may have site cut-outs to allow for flood drainage, elevating where possible to bring sites above the 100 year or 500 year flood plains.

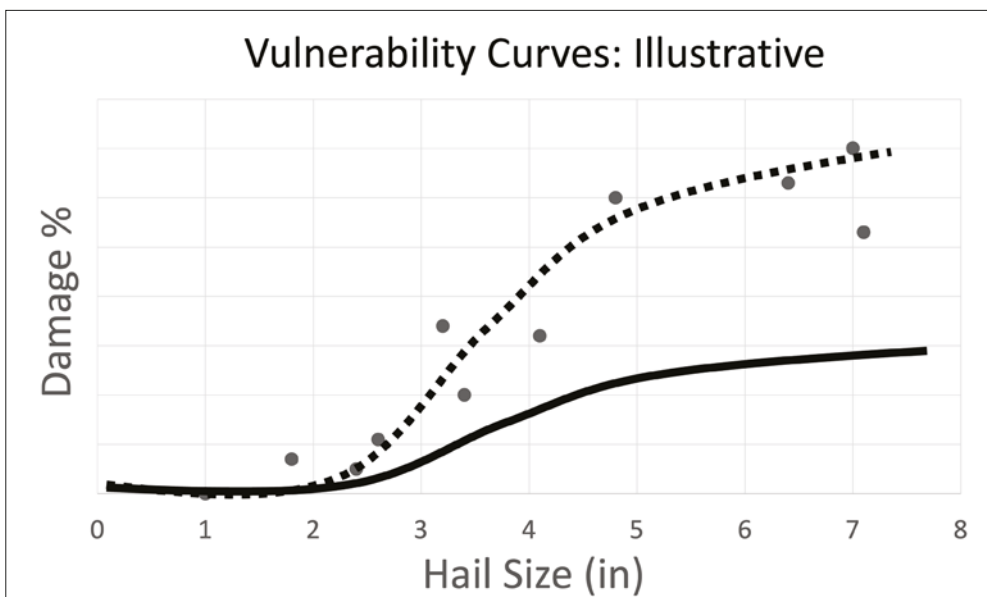
**Resiliency Measures:** Assets designed for regional perils will fare better in these extreme weather events. Sites in the central US which employ panels with thicker, tempered glass and utilise a robust hail stow program may have a significantly lower AAL (Average Annual Loss) than those without. While sites in California don't need to consider hail, maintaining a low fire fuel load via vegetation management becomes more important. Likewise, while building in or near a flood zone, height of panels and equipment pads become a main driver of losses. The risk of a PV site raising panels and electrical equipment up to the 500 year flood elevation should be evaluated differently than PV built at a lower height.

industry by evaluating the performance of a site for financing purposes. These engineers use various models to estimate the energy production potential of a site, taking into account factors such as location, climate, topography, and equipment. By providing accurate production estimations, independent engineers help to ensure that renewable energy projects are financially

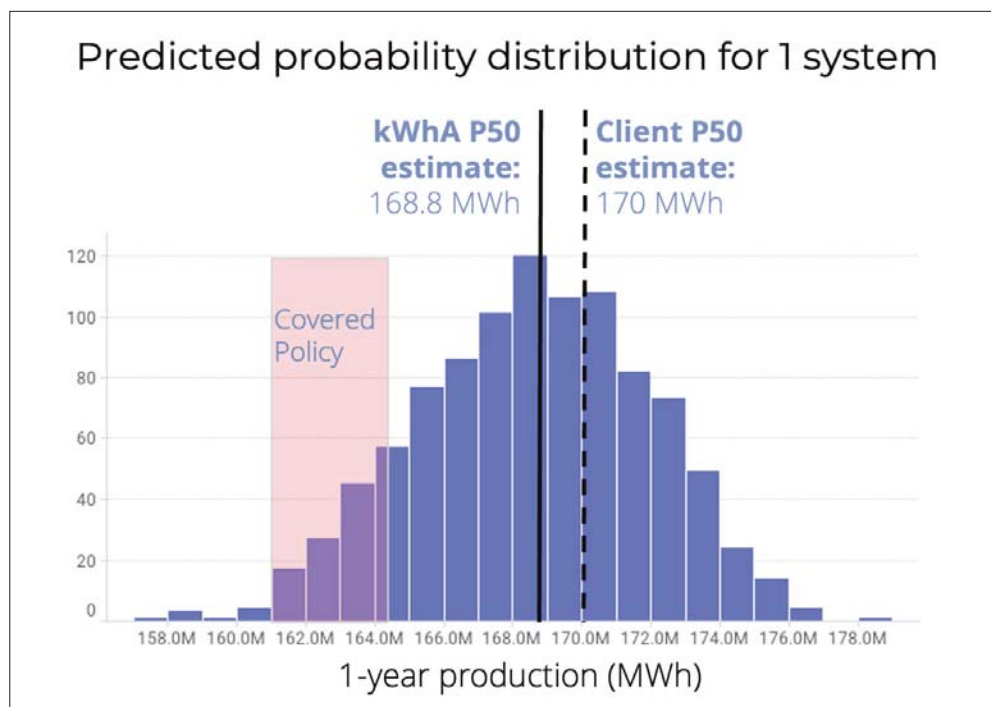
viable and that energy providers can meet the demands of their customers.

However, recent research from the 2022 Solar Risk Assessment has shown that production estimations provided by independent engineers have been nearly 8% over actual production. This discrepancy is due to a number of factors, including the fact that the models used by independent engineers do not always accurately account for the variability of renewable energy resources. In addition, unexpected changes in weather patterns and equipment performance can also contribute to discrepancies between estimated and actual energy production.

To address this issue, kWh Analytics is using more sophisticated modelling techniques that take into account a wider range of variables and provide more accurate predictions of energy production. Utilising data, companies like kWh Analytics have constructed a data-driven probability distribution that combines all of the disparate risk factors of a solar PV project into a single insured production figure, and are able to price this risk and move production volatility into the insurance markets. This lowers the risk on the cash flow streams for lenders and investors, making it a more appealing investment opportunity and improving financing terms.



A vulnerability curve, also known as a damage ratio curve, describes the amount of expected damage given an intensity of an event (e.g. hail size). The REAL model leverages a dataset of loss events specific to solar to fit a curve (represented by the dotted line), which yields higher expected damages than the traditionally used curve, represented here by a solid line. This figure is illustrative only, with no real data included.



This histogram is an illustrative example of the predicted probability distribution for 1 system. The client's P50 energy expectation is represented as a dashed line at 170 MWh, whereas kWh Analytics' estimate is represented by the solid line at 168.8 MWh, and is the median of the distribution. Overlayed on this histogram in red shows the typical coverage range for downside production scenarios.

From a sponsor's perspective, protecting downside risk on renewable energy investments is pivotal. When an energy project underperforms, this has direct impacts on expected revenue, leading to potential losses. Therefore, it is important to have a holistic understanding of production risk and the included factors.

One of the primary drivers of plant underperformance is unscheduled equipment maintenance and failures. This can result in significant downtime and lost energy production, leading to lower overall project returns. In a recent analysis completed on behalf of the US Department of Energy, data modelling found that 80% of energy losses come from just 10% of maintenance tickets. When looking at the breakdown of culprit equipment, inverters cause 46% of energy losses, higher than all other components.

Trackers, transformers, and downtime related to replacing and servicing modules are also common causes of underperformance. These issues can be mitigated through proper maintenance and monitoring, but unexpected failures can still occur. Advances in data modelling find that layering probabilistic modelling on top of standard deterministic modelling allows actuaries to evaluate uncertainties not well defined with deterministic modelling alone.

**Deterministic modelling:** Using system design specifications to estimate the output of the system under ideal conditions.

**Probabilistic modelling:** Using data,

such as historical weather data and insights from published studies, to estimate the uncertainty on the deterministic modeling, such as the occurrence of rare but impactful events.

In studies using actual client data, the kWh Analytics P50 forecast, while lower than a client's estimations, has proven to conform more closely with actual production curves.

### Carriers as Catalysts

With the rise of solar energy, the insurance industry has had to adapt to the unique risks and challenges that come with insuring solar sites. Modelling agencies have broadened their view to include more accurate construction and occupancy classes specific to solar sites and the advent of big data and machine learning algorithms has greatly aided in this process.

Machine learning algorithms can identify trends and anomalies in data that would be difficult or impossible for humans to detect, enabling actuaries to analyse vast amounts of data to identify patterns and make more informed decisions leading to more accurate predictions and better risk management.

As a result, models have been adapted to include solar-specific secondary modifiers to appropriately tune results based on site characteristics. With these advancements, insurers can more effectively underwrite solar sites and provide better coverage to their clients.

The growth of the sector and rapid technology improvements have led to a vastly different insurance landscape than just a few years ago. In the past, insuring renewable energy assets was uncharted territory, with few insurers having the expertise to underwrite this asset class. As databases expand and models improve to better simulate and understand risk, the industry continues to mature.

Carriers have a unique role to play, not only in the growth of renewable energy, but in the resilience of the assets. With their comprehensive understanding of property, performance, and natural catastrophe risk, carriers – and the underwriters they employ or support – can encourage resilient design, construction, and management of sites. Improved technology, such as stow capable trackers, storm detection systems, and smart cleaning systems, have made way for new and better ways to protect assets, and carriers can be at the forefront of this revolution by incentivising insureds to take advantage of these advancements. By sharing their expertise and data with their clients, insurers can help insureds to take measures that reduce the risks of natural catastrophes and other hazards, ultimately contributing to the sustainable growth of the renewable energy sector.

The renewable insurance industry has changed drastically and rapidly. Though the market has faced a recent hardening, updates to technology, data collection, and resiliency provide hope for a future where extreme weather risk is better mitigated, and overall asset risk is shared appropriately. By sharing information and incentivising asset resiliency, renewable energy asset owners and insurers can work together to create a more sustainable future for all.

### Author

Jason Kaminsky is the CEO and co-founder of kWh Analytics, a provider of Climate Insurance for renewable energy assets. He is passionate about activating insurance capital into climate-forward opportunities and has helped grow the company from its creation. Prior to joining kWh Analytics, Jason spent over three years as a Vice President of Environmental Finance at Wells Fargo Bank, where he originated and financed tax-equity investments. kWh Analytics specialises in unique risk transfer products using real-world project performance data and decades of expertise, such as the Solar Revenue Put production insurance and kWh Property Insurance. The company has insured over US\$4 billion of assets to date.



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# How will the UK CfD scheme fare against the rising cost of capital?

**Renewables support** | Lena Dias Martins explores the UK government's Contracts for Difference scheme which supports the country's move to a zero-carbon economy.

**T**he Contracts for Difference (CfD) scheme is one of the UK government's chief mechanisms for supporting low-carbon electricity generating projects.

Alongside FIDER (an early form of the scheme) the CfD scheme has supported a total of 26GW of renewable generation capacity across the UK since its first allocation round (AR1) which ran from October 2014 to March 2015.

This includes bolstering the UK's solar generation capacity to 15GW, according to Chris Hewett, chief executive of Solar Energy UK.

Earlier this year however, market research company Cornwall Insight warned that the support offered by the CfD scheme to solar and other renewable generations projects is threatened by inflation and the consequent rising cost of capital.

*PV Tech Power* looks at the UK's CfD scheme's success to date and explores what threats it faces.

## The 'undeniable' success of the UK CfD scheme so far

A CfD is a private law contract that is awarded through private auction. Once agreed, the counterparty (which in the UK is the government) will pay the difference between the strike price agreed at auction and the renewable generator's revenue.

This offers investment security by allowing renewable generators to bid for a guaranteed revenue stream for the duration of the contract; thus, encouraging investments in renewables.

"The CfD scheme has been undeniably successful, I would say. It gives renewable projects the stability they need by providing secure revenues, leading to investor confidence and increased viability, especially when they're in those early stages of development," Jamie Maule, research analyst at Cornwall Insight, told *PV Tech Power*.



Credit: Sebastian Gamso, Pixabay

"It's a really good mechanism to allow these projects to become more viable and eventually, perhaps even open up other routes to market. What we've seen alongside increasing investor confidence, is that learning rates become more favourable; so as the technologies have developed and been produced, the cost of development has come down quite significantly."

In February 2022 the government announced that the CfD auctions were to run annually, rather than every two years to accelerate the domestic production of renewable electricity.

The first of these annual allocation rounds was allocation round four (AR4) which ran from December 2021 to July 2022. AR4 was the biggest round to date, with contracts awarded to almost 11GW of renewable generation capacity in total.

AR4 was also the first allocation round in which solar was allowed to participate since the first allocation round in 2015. Alongside wind, solar was able to apply for a share in the £10 million allocated budget from a total of £285 million.

In total, 66 ground-mounted solar

projects were awarded CfDs in AR4 with a combined total of 2.2GW.

Solar generation projects will also be able to bid in the current AR5 which opened on 30 March 2023.

This year solar photovoltaic (PV) has been allocated into 'Pot 1' dedicated to established technologies and will be able to bid for a share of £170 million budget for projects greater than 5MW.

Other technologies in Pot 1 include hydro and remote island wind.

"It can only be a good thing for the solar sector that it is included in the allocation rounds," said Mark Williams, senior analyst at Energy UK, the trade association for the UK's energy industry.

"If you can get a project over the line within the next year, the chances are you'd benefit from prices in the hundreds-per-megawatt-hour for next year, so there's that trade-off between CfDs and other routes to market.

"It's broadly going to be a positive thing. We saw 2GW come through for AR4 but for AR5 I suspect will be somewhat less than that. Who knows what future allocation

rounds hold but we need tens of gigawatts over the next decade, so [re-introducing solar into CfD allocation rounds] is going to be important.”

### The threat of the rising cost of capital

The current volatile macroeconomic and geopolitical climate has caused inflation and interest rates to soar.

These circumstances are exacerbated by the ongoing energy crisis, supply chain issues and labour shortages, ultimately driving renewable projects’ capital expenditure higher and higher.

The CfD scheme indexes the strike price to the Consumer Price Index (CPI) to account for price fluctuations to help protect generators from inflation; however, unprecedented rises in supply chain costs are putting additional strain on renewable energy developers and is affecting the CfD scheme’s ability to guarantee expected returns as much as possible and, by extension, generating investor confidence.

Concerns over the hindering effect this could have on the decarbonisation of the UK’s energy system have been raised by a number of industry players.

According to Cornwall Insight the current climate has increased the weighted average cost of capital (WACC) of renewable projects by 4% in comparison to early 2021.

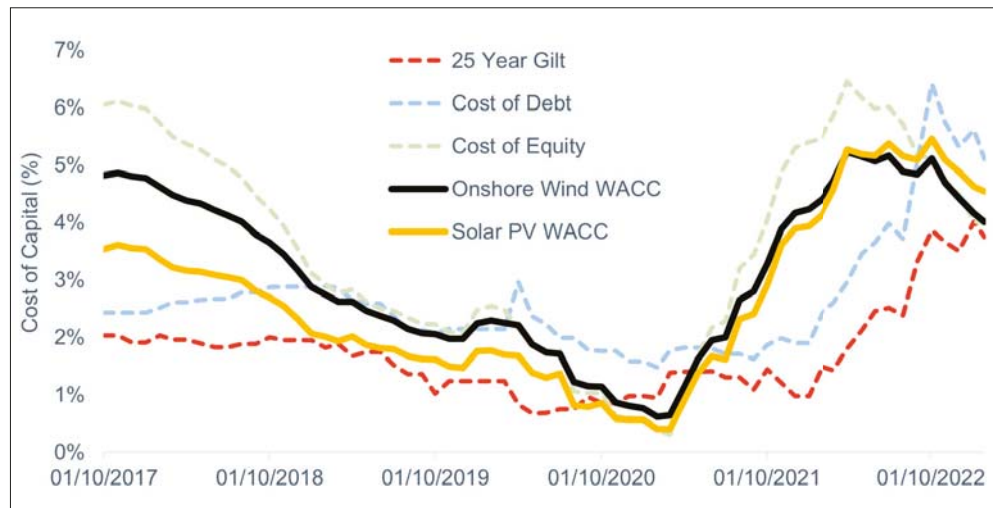
Maule explained the effect of the rising cost of capital on renewable projects: “To boil it down, it means that the required rate of return (RRR) to make a project financially viable and secure capital investment is rising – this comprises both debt and equity.

“On the one hand, rising interest rates are raising the ‘cost’ of incurring debt while unfavourable macroeconomic conditions – including an insufficient market risk premium – are causing equity investors to demand higher rates of return.

“So, while projects are subject to inflationary pressures, they are also having to generate higher returns if they want to remain viable and go to market.” Energy UK warned that the rising cost of capital alongside the Electricity Generator Levy – which imposes a windfall tax of 45% on electricity generators for “extraordinary returns” – has increased the cost of developing low carbon generation projects by 20% to 30%, increasing to as much as 50% for specific projects.

“We are seeing capital costs increasing and this will make it harder to make investment decisions for renewable projects,

**Weighted average cost of capital for onshore wind and solar PV projects between 2017 and 2023, with a dashed vertical line marking the application window for Allocation Round 4 of the CfD scheme**



Graph: Cornwall Insight

especially solar,” added Williams from Energy UK.

Investment uncertainty is now a considerable threat for renewable energy projects and the recent budget announced for AR5 has caused some concern within the UK energy sector.

In March 2023, the UK government confirmed the CfD budget for AR5 to be £205 million (including £170 million for established technologies such as solar) – down from £265 million for AR4.

RenewableUK warned that the budget sent “the wrong investment signals”.

“Unfortunately, in the light of global inflationary pressures, the budget and parameters set for this year’s CfD auction are currently too low and too tight to unlock all the potential investment in wind, solar and tidal stream projects which the industry could deliver,” added RenewableUK’s economics and markets manager Michael Chesser.

A lower budget means that the strike prices offered by CfDs – especially for solar – could threaten the effectiveness of the scheme.

As recorded in the UK government’s *Contracts for Difference Allocation Round 5 Allocation Framework, 2023*, the Administrative Strike Price (ASP) for solar PV in AR5 for projects with delivery years from 2025 to 2028 is £47/MWh (in 2012 prices).

The ASP is the highest strike price limit per MWh of electricity generated that a project of a particular technology can achieve, even if a project clears at auction at a higher price.

In comparison, the Reference Price (the price compared to the strike price in the auction to calculate how much the contracts cost) for AR5 is £48.99/MWh (in 2012 prices).

“It appears that the parameters of the allocation rounds are arbitrarily harsh and I think that’s really worrying,” continued Williams.

“If you look at the fifth allocation round coming up, we are really worried about that, because the budget is much lower.”

Williams warned that current strike prices are “unrealistically low” and that Energy UK is expecting CfD Reference Prices to be much less than wholesale electricity prices to be out to the end of the decade.

Stagnant strike prices that fail to keep up with wholesale energy prices make it more difficult for renewable projects to generate revenue, thus making them less sustainable.

“For projects on a CfD, and thus fixed strike prices (revenues), it may well be that your project is less viable and investable at this point because with everything getting more expensive, you are stuck with

**The government’s capped administrative strike prices (£/MWh) and delivery years for different technologies from AR1 to AR5**

	AR1	AR2	AR3	AR4	AR5
Solar PV	120, 2014-15				
	120, 2015-16				
	115, 2016-17	-	-	47, 2023-24	47, 2025-26
	110, 2017-18			47, 2024-25	47, 2026-27
	110, 2018-19				47, 2027-28

Table: Cornwall Insight

stagnant revenues, unable to access the wholesale market, and less able to generate profits," said Maule.

These effects are already being seen for projects that won CfDs in AR4.

"We've already seen some media reports from developers who secured projects during AR4 calling on the government for further support. Some of these projects under AR4 do have the ability to generate higher revenues through the merchant nose prior to their CfD start date but that could be limited by the Electricity Generator Levy," added Maule.

"For many of these projects, the changing and unforeseen macroeconomic conditions have resulted in an inability to generate the sort of profits that they were expecting. The strike prices they previously agreed were viable at the time but now they are proving to be too low."

Another factor curbing the success of the CfD scheme is the now limited option for renewable projects to enter the merchant market before the start of their contract.

"The Low Carbon Contract Company now has more power to enforce CfD start dates within the delivery year when projects are seen to have begun commercial operations," continued Maule.

"Prior to these changes, generators could enjoy greater access to wholesale markets before their CfD start date, allowing for a period of higher revenues that allowed them to generate a faster return on investment and insulate themselves from unforeseen rises in supply chain and/or commodity costs."

### AR5 to provide useful insight

The UK government has indicated that the outcome of AR5 will provide a useful insight into the current costs of technologies that can be used to inform future allocation rounds.

"Our flagship renewable energy auctions are hugely successful in strengthening Britain's energy security, securing last year a record capacity of reliable, affordable and clean energy – enough to power around 12 million homes," commented a government spokesperson.

"The Contracts for Difference scheme also plays a critical role in attracting large scale solar projects and investments to the UK. Solar energy will be key as we go further and faster to power Britain from Britain and increasing our solar capacity five-fold by 2035."

The UK's renewables landscape has seen

promising growth making the nation one of the prominent players in the European market, and the CfD scheme has been a significant constituent in this success.

To continue this upward trajectory, the UK will need to keep building on the CfD scheme to ensure it remains relevant to the current volatile market.

In April this year, the UK's Department for Energy Security and Net Zero (DESNZ) said it would consider a "major reform" to the CfD scheme by allowing applicants to be awarded wider benefits offered by their projects.

These 'non-price factors' include: addressing skills gaps; supply chain sustainability; helping drive sector investment; and supporting the UK's energy security.

Responding to the announcement Ana Musat, RenewableUK's executive director of policy, commented:

"Designing the right framework for Contracts for Difference is absolutely crucial if we're to attract the billions of pounds of private investment we need to build more clean energy projects faster – at the very time when international competition for capital and expertise has never been more intense.

"Going forward, it's clear that awarding CfDs shouldn't just be based on a race to the bottom on prices, but it should also take account of the wider economic and environmental benefits which this industry can deliver."

In light of the current volatile macro-economic environment, re-assuring and re-engaging renewable investors is paramount to continue the growth of UK solar power.

"One thing that the energy market absolutely hates is uncertainty – it provides a really difficult investment landscape," said Tom Faulkner, head of asset & infrastructure and networks at Cornwall Insight.

"The CfD scheme and the renewables landscape in general in GB has been very successful in terms of getting up the curve. The next step will be ensuring certainty for investors, ensuring that people are able to access the revenues they want."

One route to investor confidence is to increase the CfD budget to provide a more attractive alternative to the merchant market.

"A higher CfD budget would certainly help," said Williams from Energy UK.

"This is because if, through the Electricity Generators Levy, you are taking away those more merchant routes to market,

which is what we're expecting to see, unless those projects can go through the CfD route instead, what you're going to have is projects not progressing. That's not what we want, and higher budgets are an important part of that."

Further updates to the CfD scheme are also in the pipeline as the UK government continues its Review of Electricity Market Arrangements (REMA).

Launched in July 2022, REMA seeks to explore changes in the UK's wholesale electricity market to help protect against volatile gas prices and bolster the nation's energy security.

The first part of the review constituted an initial REMA consultation, with the majority of respondents being generators and developers, to establish a holistic vision and a set of objectives for the UK electricity market.

A summary of the consultation responses was released in March 2023. It found that 67% of respondents felt that the current form of the CfD discourages provision of ancillary services.

Some respondents suggested additional options to reform the CfD, including extending contract lengths, auction process reform and allowing existing generators to bid for CfDs.

With the first step of the review now completed, REMA will collate both professional and consumer inputs in order to make an informed decision on the future of the UK energy market, including deciding what the future CfD scheme will look like.

"We're in a very different world now, where gas prices are going to be structurally higher as we shift to more energy coming from liquified natural gas (LNG) across Europe. We should try to deliver all possible renewable projects where the CfD strike price is lower than the expected price of gas, and that is not what upcoming allocation rounds are currently set up to deliver," summarised Williams.

"The best thing for consumers, the thing that will bring down bills, reduce carbon emissions and help energy security, is to have as much capacity as possible come forward. And I don't think that's currently what the main motivating factor behind the CfD scheme is. It's still about driving down those prices.

"We're probably now in a world where we've driven down prices to almost as low as they will go and it's now about sustainably delivering capacity; that requires a slight change in thinking that I don't think we're quite seeing yet."

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# Introduction



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

It's been an interesting three months since the last time I wrote one of these editor's intros. As 2022 drew to a close, it felt like a new era was beginning for energy storage. The Inflation Reduction Act would change forever a market landscape in the US that was already evolving quickly and Europe's policymakers had finally come to the realisation that storage is vital to an energy independent and low carbon future.

Positive policy developments elsewhere, from Australia to India, the Philippines, Turkey and Japan, left many of us aware that we were looking at an industry growing so fast that it might be unrecognisable within a few years.

The market isn't just growing, it's maturing. That's a phrase that's often thrown around too easily, but it's accurate in this case. Many of the issues impacting energy storage, like supply chain bottlenecks or long grid interconnection queues, to some extent make the industry a victim of its own success. Meanwhile much of what drives it forward is down to the years of hard work put in by its pioneers, early adopters and early movers.

This year, we're even holding our first-ever awards, after eight great years of Energy-Storage.news and Energy Storage Summit events around the world. The Energy Storage Awards will this year focus on European activities, with a ceremony to be held in London in September.

In the next edition of this journal, we'll take a look at the Inflation Reduction Act and the North American market more broadly; early signs are that many in the industry are still getting their heads around some of its more complex provisions.

This time out, and coinciding with the launch of Energy-Storage.news Premium, our new subscription service, we offer you perhaps the most eclectic edition of Storage & Smart Power to date – with five feature articles, it's certainly the biggest.

With duration of storage assets seen to increase as markets mature, Long Duration Energy Storage Council (LDES Council) executive director Julia Souder's excellent overview of the technologies, market opportunities and challenges for LDES is very timely indeed.

For now lithium-ion remains very much the mainstream technology of choice, and Alex Thornton from developer-investor Harmony Energy offers a case study on how the 196MWh Pillswood Li-ion BESS project in England was delivered.

Elsewhere, Energy-Storage.news reporter Cameron Murray and I take a look at two markets that could be poised to join the 'maturing market' conversation in the next few years: Italy and Canada. Plenty more to come on those topics for Premium subscribers on the site, too.

Last, but not least, we've somehow persuaded friendly rivals ACCURE and TWAICE from the world of cloud-based battery analytics to discuss why the industry needs to mature and rethink the commissioning process.

We're very fortunate to have so many great industry participants and experts working with us, and we owe every success to you, the readers, and the industry. Thanks for subscribing and reading.

**Andy Colthorpe**

Editor

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## US grid-scale BESS capacity reached 9GW/25GWh in 'record-breaking' 2022

The US utility-scale battery storage sector achieved its highest-ever annual deployments in 2022. According to trade group American Clean Power Association, 4,027MW and 12,155MWh of large-scale battery energy storage was deployed in the country last year. That exceeded the previous record, set just a year before in 2021, when 3GW/9.5GWh was commissioned. That amounted to an increase in cumulative operating battery storage of 80% in megawatt terms, bringing it to a total of 9,054MW, and a total 25,185MWh of energy storage capacity – an increase of 93% in megawatt-hours. During the fourth quarter, 850MW/2,375MWh of battery storage was commissioned. That was an increase of 31% year-on-year.

## UK FFR prices fall to three-year low

Firm Frequency Response (FFR) auction prices in the UK have hit their lowest level since 2019 as market saturation begins to take effect, market analytics platform Modo Energy said recently. The firm said the auction during April saw a drop in volume requirements leading to 86% of all bidded volumes, totalling 1.59GW, being rejected in each EFA block (Electricity Forward Agreement) for May delivery. Perhaps more significantly, the reference price for this month's tender round is just £5.69 (US\$7.13)/MW/hour, a 16% fall on April and the lowest price since Modo started collecting the data back in January 2020. Prices were above £20/MW/hour from September to November 2022.

## Europe's 'first' LFP gigafactory opens in Serbia

ElevenEs has opened a lithium iron phosphate (LFP) gigafactory in Serbia, which it claimed is the first in Europe. The facility in Subotica has opened with the aim of reaching 500MWh of annual production capacity in 2024. The firm, which was spun out of aluminium processing company Al Pack Group, is aiming to reach 48GWh of production capacity in five years' time across two gigafactories. The LFP gigafactory will produce prismatic cells for the electric vehicle (EV) and stationary energy storage system (ESS) markets.

## California utility signs PPA with NextEra for eight-hour project

California utility Clean Power Alliance has inked a 15-year PPA with NextEra Energy Resources for an eight-hour duration energy storage project. Clean Power Alliance (CPA) announced the long-term power purchase agreement (PPA) with energy giant NextEra Energy's clean power arm last week (7 April). The PPA secures the offtake from NextEra's 75MW, long-duration Desert Sands Energy Storage facility in Riverside County, California, starting in June 2026. CPA is one of California's many CCAs, smaller community-owned utilities which provide local communities an alternative to the state's big three investor-owned utilities PG&E, SDG&E and SCE. This is its fourth battery energy storage system (BESS) PPA deal.

## LG Energy Solution building US factory with 16GWh dedicated to battery storage

LG Energy Solution will build a new battery cell factory in the US with 43GWh annual manufacturing capacity, including 16GWh dedicated to the stationary energy storage market. The company will invest KRW7.2 trillion (US\$5.5 billion) into the production plant in Queen Creek, Arizona. Scheduled to break ground this year, the complex will feature twin production facilities, one for cylindrical 2170 battery cells targeting the EV sector with 27GWh annual

production capacity, the other making LFP pouch cells for energy storage systems. According to LG Energy Solution (LG ES), the LFP production line would be the "first ESS-exclusive battery production facility in the world" and is expected to begin production in 2026.

## Planning approval for 'Super Battery' to replace coal power plant

Planning approval was given in February for the Waratah Super Battery by the government of New South Wales, Australia. The project will help the state overcome the 2025 decommissioning of Eraring, a 2,880MW coal power plant. Scheduled to come online that same year, the NSW government has awarded the project the status of Critically Significant Infrastructure, fast-tracking its development. The battery storage project has a contract in place to deliver System Integrity Protection Services (SIPS) with developer Akaysha Power – owned by Blackrock – handed a SIPS contract to guarantee at least 700MW/1,400MWh to secure the stability of the network and reliability of electricity supply. Akaysha Power has contracted Powin Energy to deliver the BESS.



Credit: Energy Corporation of NSW

Waratah Super Battery will help replace Eraring coal power plant, due for decommissioning in 2025.

## SRP and Plus Power constructing 1GWh BESS project in Arizona

A 250MW/1,000MWh BESS project in Arizona broke ground in April, through utility Salt River Project (SRP) and developer Plus Power. The Sierra Estrella project will serve SRP customers during times of peak demand on the grid and will help the utility integrate more renewable generation into the mix. The four-hour lithium-ion BESS is expected to come online in summer of 2024. It is one of two large-scale projects the utility has contracted for which will help it achieve a doubling of its 400MW BESS capacity target by summer 2024, along with the 90MW/360MWh Superstition project, also from Plus Power. Plus Power will design, build, and operate the Sierra project with batteries "assembled in the US".

## Europe reached 4.5GW of battery storage installed in 2022

Europe reached 4.5GW of cumulative installed battery storage capacity last year, and could hit 95GW by 2050, according to LCP Delta and Aurora Energy Research respectively. Some 1.9GW of grid-scale battery storage was installed across the continent including the UK in 2022 and at least another 6GW is expected in 2023, according to LCP Delta's quarterly European Market Monitor on Energy Storage, published with the European Association for Storage of Energy (EASE). By 2050, Europe is expected to install at least 95GW of grid-scale battery storage systems, according to separate figures from Aurora Energy Research, which itself found 5GW of grid-scale storage is online today.

# Net Zero's Missing Link: Long Duration Energy Storage

**LDES** | Julia Souder, CEO of the Long Duration Energy Storage Council, explores energy storage as the cornerstone of power grids of the future.

Changing times are calling for stronger policies as governments around the world continue to increase their renewable energy ambitions, including at the G7 Summit in Japan, where member countries pledged to increase capacity of offshore wind by 150 gigawatts and elevate solar capacity to 1 terawatt by 2030. As the world accelerates the transition to more sustainable energy sources, the need for flexible energy storage solutions is critical.

At present, short duration energy storage technologies are added to many electric grids and infrastructure across the globe, but have limitations on safety, how long energy can be stored, and expected lifetime value.

Long duration energy storage (LDES) can help solve these challenges while providing an array of benefits to diverse industries and communities. LDES technologies can store power for extended periods of time – from multiple hours, days, weeks, months to seasonal – storing energy from wind, solar and other clean sources in an affordable, flexible, reliable, and sustainable way. Many LDES technologies are already commercially available today, but to scale to the level needed to reach the world's decarbonisation goals, the potential for LDES needs to be fully realised with supportive policies that support an accelerated clean energy transition.

LDES provides multiple benefits across the energy and heat sector, making it a critically important component of any sustainability initiative. For one, LDES makes wind and solar dispatchable every hour and seasonally as it balances the variability of renewable energy sources to match load and demand. LDES enables the provision of reliable and continuous power, even during periods of high demand by providing energy shifting services reducing the need for fossil fuel power plants, further contributing to a low carbon energy system.

Working to decarbonise global communities is why LDES is an essential technology that will underpin the transition

towards a cleaner and more sustainable future, while being a strong economical investment.

## Enabling Europe's Renewable Future

The European Union is currently investing significant resources into the clean energy transition, motivated by the need to meet net zero emission goals and to ensure energy security following Russia's invasion of Ukraine. While Europe successfully navigated its first winter without Russian imports, Kadri Simson, the European Commissioner for Energy, has stressed that there is more work to do to reduce the dependence of electricity bills from the price of gas and to stop overlooking the critical role of storage.

The European Council recently raised its renewable target for 2030 to a minimum of 42.5%, which doubles the existing share of renewable energy in the EU, and countries such as Spain can lead the way in surpassing this as Spain recently reached 56% solar generation on the electric grid. At a time when Europe is facing electricity and natural gas prices that are over ten times higher than historical averages, LDES is essential to creating affordable, reliable, clean energy systems, by decreasing the amount of renewable energy curtailed and saving billions of euros whilst also boosting energy security.

The European Commission's REPowerEU plan aims to safeguard Europe's energy security by increasing the rollout of renewables, diversifying energy supplies and speeding up the deployment of clean

technologies. Under the current plan, 1.2TW of renewables capacity will need to be installed by 2030, however this must be combined with significant increases to energy storage to ensure European energy systems can perform effectively. To meet that significant increase in renewables, the LDES Council has estimated Europe will require over 200GW of energy storage by 2030.

Whilst REPowerEU specifically includes a focus on the use of photovoltaic, hydrogen, and heat pumps, and set targets for their deployment, it fails to do the same for LDES. EU policies must incentivise a diverse range of LDES technologies that address the range of intra-day, multi-day, and seasonal storage needs that will provide the flexibility the EU needs to meet its diverse system needs. Only through these important changes for clean energy will there be successful transition towards a net zero future.

## LDES: The Power of Diverse Technologies

Since 2019, over US\$58 billion in commitments have been made by governments and companies to LDES, which shows the significant progress of the market in recent years.

However, this only represents a small slice of the true potential of this technology. Research conducted by the LDES Council shows that the market has a potential to reach US\$4 trillion through deploying 8TW of LDES by 2040, resulting in delivering US\$540 billion in cost savings.

There is a tremendous amount of



### Intraday flexibility

Flexibility that allows daily variations in supply and demand to be smoothed out (such as peak energy demand in the evening)



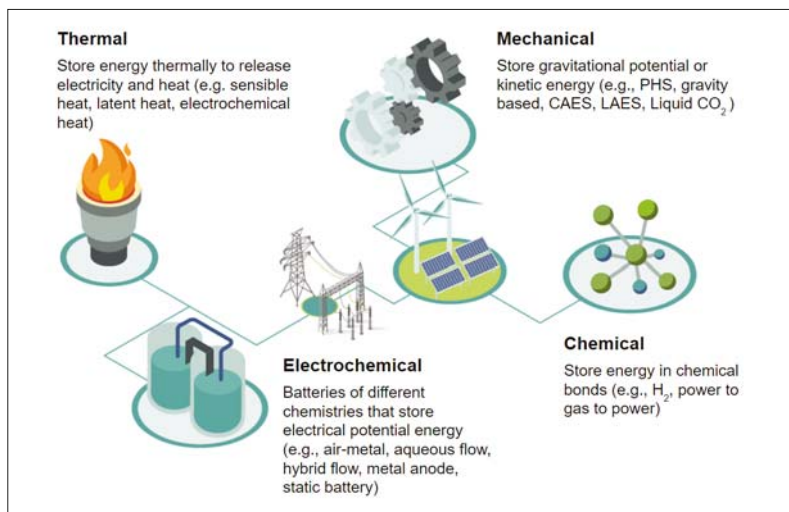
### Multiday and multiweek flexibility

Flexibility that allows day to week long fluctuations in supply and demand to be balanced (such as taking into account weather anomalies)



### Multi-month flexibility

Flexibility that allows seasonal mismatches in supply and demand to be managed (such as energy demand peaks in winter)



innovation and diversity in LDES, represented by four main LDES technology types (mechanical, electrochemical, chemical, and thermal), and a myriad of sub-types. This makes LDES suitable for many different applications, and regions, whether urban, rural, or remote systems, as well as industrial and island energy grids and various types of infrastructure.

The below guide reviews the four main types of LDES technology, each offering unique characteristics and parameters. With the right level of investment, they could be delivered at speed and scale to unlock tremendous environmental and economic benefits.

### Mechanical energy storage

Mechanical energy storage is often referred to as the experienced guide of LDES. The most well-known and widely recognised form is pumped hydro-storage (PHS), which is widely used for load balancing around the world by grid operators, and can also provide an array of ancillary services. It was first deployed in 1907 and provided 160 GW of global storage power in 2019 – over 90% of the global energy storage total.

The majority of mechanical energy storage technologies work by storing kinetic energy through a series of complex systems that use heat, water or air with compressors, turbines and other machinery. As a spring becomes compressed or stretched, it stores the potential energy which can be utilised by releasing the spring back to its original shape. Other popular forms of mechanical energy storage that are available today include compressed air energy storage (CAES), where air is compressed and stored within underground reservoirs, and liquid air energy storage (LAES) which works by cooling air to its liquid state and storing it within insulated containers. More recently,

new gravity-based energy storage systems are in the early stage of commercial development, which function by storing energy by lifting mass that is then released when the energy is needed.

### Electrochemical energy storage

Currently, electrochemical energy storage (which involves many elements in the periodic table) is amongst the most widely recognised forms of energy storage (batteries), as it is a category which includes lithium-ion. However LDES forms of electrochemical energy storage can provide 6 to 12+ hours, and multi-day solutions to support renewable energy fluctuations, have no fire risk, and are more stable.

Electrochemical energy storage works by converting the chemical energy contained in its active materials into electric energy through an electrochemical oxidation-reduction reverse reaction. These batteries can be divided into the following basic groups: standard batteries, modern, special batteries, flow batteries, and high temperature batteries.

These solutions operate over six hours and have a wide range of advantages as they are safer to deploy, easily scalable, have no detrimental effects from deep discharge, have minimal self-discharge as well as lower levelised costs of storage and long-life cycles – many over 20 years. In sum, electrochemical batteries hold great promise and are already being widely deployed across the globe in a variety of different environments. Electrochemical batteries are rapidly scalable, which significantly reduces the overall costs of these technologies and helps to realise their vast potential.

### Chemical energy storage

Chemical energy storage refers to the process of storing energy in the form of

chemical bonds in materials, such as hydrogen or ammonia. They can be produced from a variety of different energy sources, including renewable energy, nuclear power and fossil fuels and produce high energy density fuels. Hydrogen for example can be stored as a compressed gas, in liquid form or bonded to other substances. After conversion, chemical storage is particularly flexible, as it can feed power directly into energy grids, or be stored for later use during peak periods or seasons. The chemicals produced can also be sold into the industrial or transportation sectors, providing alternative revenue streams from their production and avoiding waste.

### Thermal energy storage (TES)

There is an urgent need to decarbonise the heat sector to achieve net zero, as it represents 45% of energy related emissions and TES can play a critical role in this.

There are three main types of TES systems: sensible heat which includes molten salts, rock material, thermophotovoltaic (TPV), and concrete, latent heat, and thermochemical. The materials used in these types of systems are often cheap and abundant, which is a particular strength of TES.

The technology behind the systems involves converting electric energy from the grid into thermal energy that is then stored as thermal potential. When running at full capacity, the systems store energy in tanks, rocks, cement, salts, and low cost mediums from hours to weeks, or months before converting it back to electrical energy when needed. This can then provide upwards of 10 hours of electricity and capacity can be increased by increasing the total volume of the storage tanks, cylinders, etc.

TES when combined with renewable energy sources, waste heat, or surplus energy production, accelerates the replacement of heat or cold generation from fossil fuels. In Europe alone, the International Energy Agency has estimated that 1.4 million GWh of power per year could be saved through the use of heat and cold storage. This would avoid 400 million tonnes of CO<sub>2</sub> in the building and industrial sectors, which are amongst the hardest to decarbonise. According to the Australian Solar Thermal Research Institute (ASTRI), concentrated solar thermal power for utility-scale power generation will be the lowest-cost technology for eight-hour storage in 2050, at just over A\$100/MWh, compared with lithium-ion battery at



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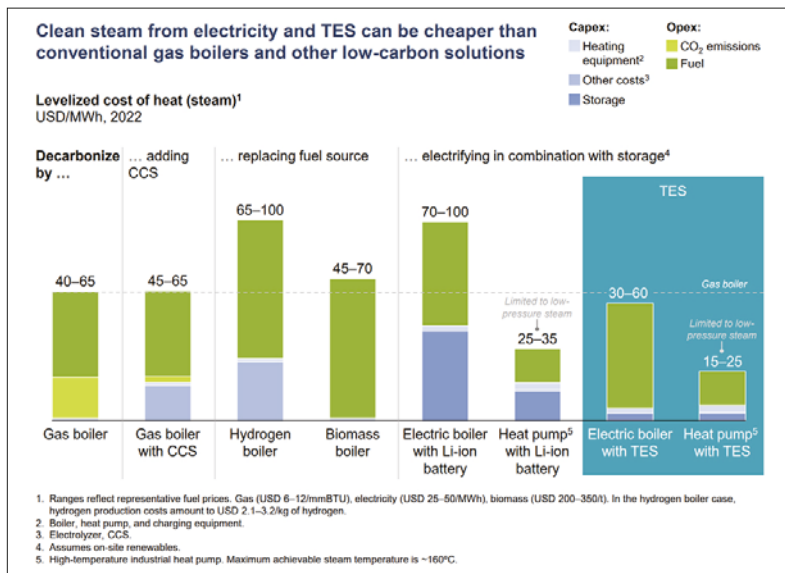
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A\$140/MWh and pumped hydro at around A\$155/MWh.

The LDES Council's recent report on net-zero heat points to the power of TES in helping to abate industrial needs such as mining, refining, agriculture, and aluminium. TES for high-pressure steam production can generate up to 16% IRR, and TES with co-generation in an off-grid setting can generate up to 22% IRR, regardless of the additional value of flexibility.

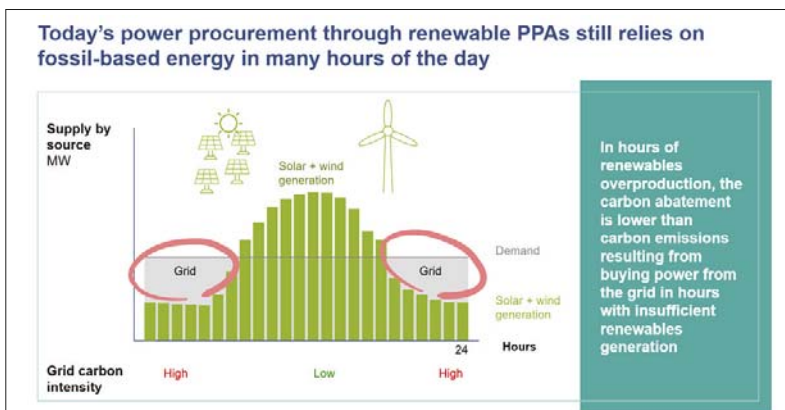
By nurturing a supportive ecosystem between business leaders, policymakers and investors, the potential of TES technologies, which are commercially available and ready to be deployed, can be harnessed to tackle this crucial sector. And most importantly, reaching that 8TW goal will see a cost savings of US\$540 billion annually.

### The Future of LDES: Challenges, Barriers, and Market Opportunities to Scale LDES Globally

While there are many positives to LDES, there are still barriers to overcome to create a new economy and ecosystem based on climate dependent generation.

As there is a rise of renewable energy integrated in power and heat systems around the world, LDES will need to be deployed faster to provide system flexibility, reliability and stability. Three key challenges are: rising power supply and demand imbalances, an increase in transmission congestion, and a decrease of system inertia. These can all be solved by introducing LDES technologies to provide flexibility into the power and heat sector across different time spans, allowing renewables to meet constant demand. The ups and downs of variable generation are flattened out to a continual source, allowing clean energy to be stored via LDES at times when supply exceeds demand and released at times when demand exceeds supply.

Current transmission and distribution planning does not incorporate the multiple value-adds of LDES including an array of ancillary services (blackstart, load following, synchronous inertia, frequency response) that provide additional reliability and flexibility, and models must be updated to reflect the multiple benefits to the system and markets.



A crucial barrier to LDES adoption is the need for new policy and regulation. For LDES to be available to support the decarbonisation of energy systems in 2026 and beyond, signals need to be created today to spur scale-up, investment, and adoption.

Most climate targets and current policies aim at 2030, which is less than seven years away. To truly decarbonise economies and reduce emissions, policies must change today to address tomorrow's needs. Scaling up the LDES value and supply chain must start now to provide the savings tomorrow.

There are three types of policy support which can drive action towards net zero: long-term market signals, revenue mechanisms and direct technology support.

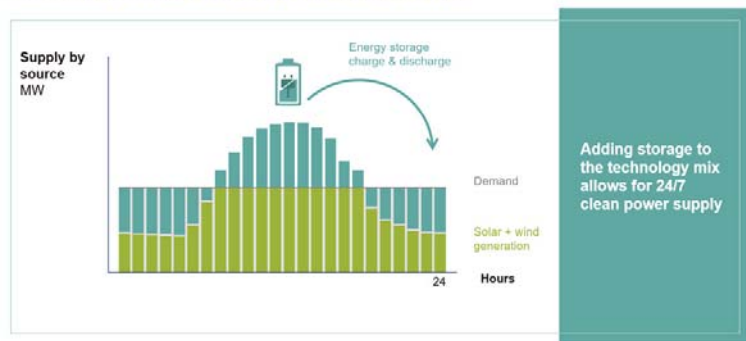
**Long-term market signals** critically provide a more secure investment case for LDES as they provide certainty and transparency, while more strategic planning for storage capacity targets, and clearer procurement targets will aid the incorporation of LDES into inclusive grid planning, ensuring climate needs are met with LDES flexible solutions. Carbon pricing and the removal of fossil fuel subsidies also helps to level the playing field in the coming decades.

**Revenue mechanisms** will be necessary for improving project financial viability for both customers and investors, and Contracts for Difference, Caps & Floors and 24/7 Purchase Power Agreements (PPAs) can all also be leveraged to achieve this. These tools provide mechanisms for ensuring the multiple value streams LDES provides are compensated and provide financial certainty.

Another tool gaining global attraction is hourly accounting for renewables, and LDES can provide this flexibility, security and reliability. Today's pay-as-produced renewable PPAs, which account for supply and demand on an annual basis, only achieve 40-70% decarbonisation of the off-taker's actual electricity consumption, while exposing off-takers to market price risks stemming from the variability of renewables. Instead, 24/7 clean PPAs offer a more precise means of matching supply and demand as renewables contribute an increasing share of global generation capacity.

Finally, **direct technology support** is needed to fast-track significant growth in public-private partnerships, provide investments from governments, and to amplify the need and targeted tenders to accelerate innovation and delivery. This is critical to validate need and ensure innovations and

To fully decarbonize the power consumption, matching of supply and demand is needed for every hour of the day...



existing technologies can scale to meet the growing demand and need to decarbonise all economies.

By leveraging these mechanisms through supported policies, a marketplace can be created that can retrieve benefits from LDES and ensure support to scale to the large needs which are already widely supported through global renewable energy targets and goals.

#### How LDES can lead the energy transition

As the world increasingly transitions towards renewable energy sources, the importance of LDES cannot be overstated –

there is no way to reach renewable targets without these essential technologies. The diversity of LDES can also meet global regional demands and provide options for different geographies and community needs.

LDES provides affordable and reliable storage solutions that can help balance the variability of renewable energy sources by providing flexibility, reducing fossil fuels dependency, and contributing to a more equitable, sustainable, and clean energy system.

Regulators and policymakers can take immediate action to support the clean energy transition. By building on existing

policies and targets and adding specific LDES goals, strong policies can be developed that support the procurement and scale up of long duration energy storage technologies. By reaching these goals and with proper investment, policy support and incentivisation, LDES is a commercially available solution available today that has tremendous environmental and economic benefits, creating a cost-optimal net-zero energy system that benefits communities around the world.

It's very simple. By developing clear LDES targets across all regions to support the rapid growth of renewable energy, providing market mechanisms that drive investment and unlock opportunities for LDES to work within the existing marketplace, and creating an environment that supports 24/7 clean power purchase agreements (PPAs), policymakers can ensure wind and solar resources are not wasted, while supporting the US\$4 trillion market opportunity of LDES and US\$540 billion in cost savings once 8TW of LDES is implemented worldwide. The time to act is now, and there is no way to reach global clean energy goals without LDES as a critical component in the energy transition. ■

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# How we delivered the 98MW/196MWh Pillswood BESS Project

**Case Study |** Alex Thornton, operations director at Harmony Energy, gives us a deep dive into the biggest battery storage project in Europe, including the bold decision to be an early-mover into 2-hour lithium-ion BESS, in a market of much shorter duration assets.



Credit: Harmony Energy

## FACT SHEET:

**Project name:** Pillswood BESS  
**Location:** Hull, UK  
**Capacity:** 98MW (196MWh Lithium-ion)  
**Energisation date:** November 2022  
**Developer/asset owner:** Harmony Energy, **Harmony Energy Income Trust (HEIT)**  
**Battery technology providers:** Tesla  
**Distribution network operator:** Northern Powergrid

## TIMELINE:

- **2016:** Planning and preparation begins
  - o a) Technical analysis of the distribution network
  - o b) Negotiations with landowners
  - o c) Design phase
- **2017:** First planning application submitted
- **December 2020:** Planning rights secured
- **April 2021:** Contract with Tesla signed
- **November 2021:** HEIT lists on the London Stock Exchange

- **November 2021:** Construction begins
- **November 2022:** System is energised
- **January 2023:** Phase 2 fully operational
- **March 2023:** Official launch and site opening

## PROJECT OVERVIEW:

The Pillswood Battery Energy Storage System (BESS) near Hull in northern England was officially opened by Harmony Energy and its investment company, Harmony Energy Income Trust, in March 2023.

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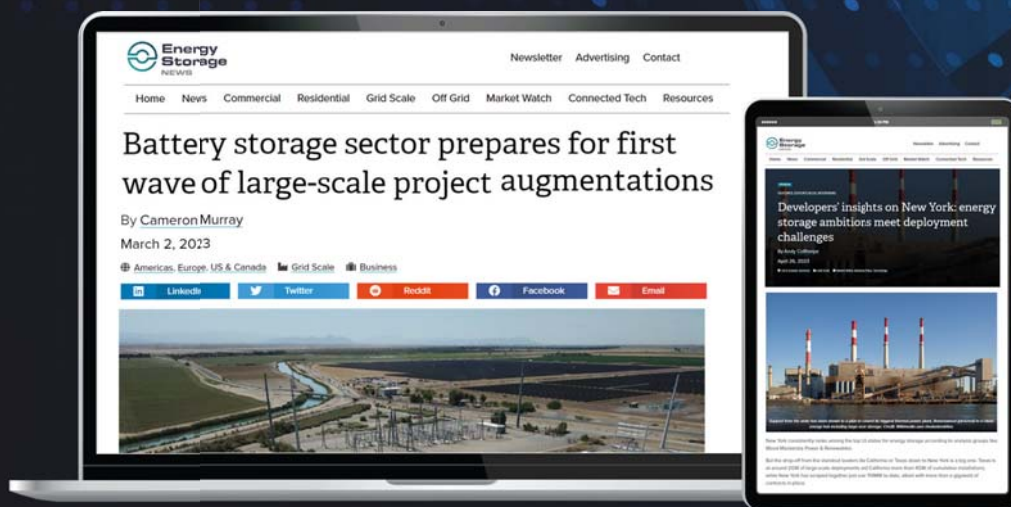
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SCAN ME

This 98MW/196 MWh scheme is Europe's largest by capacity, using a Tesla 2-hour Megapack technology system.

The site is located next to National Grid's Creyke Beck electricity substation. The world's largest offshore wind farm, Dogger Bank, also feeds into the same substation, planned to be the connection point for the first two phases of Dogger Bank.

### Investigating the potential for energy storage in the UK

The project was conceived in early 2016, when Harmony Energy made a leap of faith into the energy storage sector. As a company, we had a strong belief that the energy storage market in the UK was fundamental to the country's ambitions to decarbonise. The UK's target at the time was a commitment to an 80% reduction of greenhouse gas emissions by 2050.

European and UK government policies were driving a reduction in emissions and, in the UK, we were also seeing a reduction in the reliance on centralised coal-fired power stations. With the resulting movement towards wind and solar, we firmly believed that BESS had an increasing role to play in the energy supply of the future.

In 2016, we had already started conversations with Tesla about the potential for 2-hour lithium-ion batteries. Where other UK developers were only speaking about 30 minute or 1-hour duration batteries, we identified that the UK energy system would need longer duration storage as we continued to decarbonise and decentralise generation.

Harmony's mission statement was clear: develop, build, own and operate energy storage projects at utility-scale with lithium-ion batteries being the product of choice.

### The Pillswood project is born

Following the review of the Electricity Distribution Network data, we identified Creyke Beck substation, at Cottingham near Hull, as a potential viable grid connection point for a large-scale BESS. This initial technical analysis including a desktop appraisal of the site, led us to confirm that there was sufficient capacity at this substation to connect a project of this size.

Local Distribution Network Operator (DNO) Northern Powergrid confirmed that there was sufficient capacity and reinforcement on the network for batteries with a combined grid connection of 98MW. The

concept of Pillswood was born.

The next stage involved pre-planning consultations with the local planning authority. During this stage, we identified key risks to the project. The main risk being the site's status as a flood sacrifice zone, used as a floodplain to prevent people's houses flooding in the event of an extreme weather event. This would necessitate an elevation of the batteries and formed a founding principle of the layout of the project.

### Securing property rights

Harmony Energy then entered into negotiations with landowners and adjacent landowners with a view to obtaining a long-term lease for the project build.

Initially, it was planned for the site access to utilise existing level crossings. Although we received initial consent for this, following further discussions with Network Rail, it became clear that this would be too complicated due to local site constraints. Further solutions were put into consideration, including the option of building a new bridge across the railway. However, this option proved challenging technically and financially so was deemed unsuitable.

The remaining option was to build a new access road from the west, and we subsequently began discussing terms for that option. Negotiations began in pursuit of extremely complex agreements with three separate landowners who could grant alternative access across their land.

During the four-year development period of this project, we encountered fundamental challenges which led to us changing our plans multiple times and the access track is just one example of this.

Securing the land rights with four different landowners was one of the largest pieces of work during the entire project, with in-house staff and lawyers from all stakeholders involved in negotiating, drafting and executing the land agreements.

### Entering the design phase

Once the grid connection was confirmed at 98MW, Harmony Energy could begin the design phase within the space available. The design had two elements to it: the new DNO 132/33kV substation; and our battery system. There were around four or five different iterations over the process. We worked in close partnership and collaboration with Tesla in order to adapt the design to make sure we were creating the best solution whilst trying to value engineer within the specific site constraints.

Due to the designation of the site, we were faced with the task of designing the first ever project of this scale to be elevated on a steel platform. As the site is located in a flood sacrifice zone, our design needed to incorporate the elevation of equipment which would raise the batteries from the ground without impacting on the volume of water that the site could accommodate in a flood event. This brought many challenges as the design needed to



Credit: Harmony Energy.



Credit: Harmony Energy

solve three singular needs: to guarantee that the platform was structurally sound on engineering terms; to ensure that the project could operate safely even in a once-in-a-century-flood event (combined with the added likelihood of the access being inaccessible during such a flood); and to maintain the cost-effectiveness of the solution.

This made the design totally unique, with all the electrical equipment designed to sit approximately 1.8 metres above ground level. The height calculations were made in consultation with the environment agency and local planning authority according to both detailed engineering design data and thorough risk assessments which took historical data, flood modelling and additional safety factors into account.

In light of these discoveries, we consulted a structural engineering company to carry out some preliminary structural design work to determine the feasibility of this elevated platform even before negotiations with Tesla on contracts had taken place.

The final proposed design incorporated the construction of four large steel platforms. This had the added advantage of the fact that all electrical cables were run above ground, reducing the amount of cable trenching and civil works on site.

#### The final site design incorporated:

- 78 individual mega pack battery units, manufactured in the United States
- 40 MV/LV transformers, manufactured

locally by Wilson Power Solutions in Leeds

- Two 33kV customer switch rooms supplied by CRT in Italy
- One 1.4km access track
- Over 20,000 m<sup>2</sup> site – the size of three football pitches side by side
- A new 132/33kV substation constructed by Northern Powergrid

#### Getting the project shovel-ready

During the development phases, Harmony Energy submitted numerous planning applications, all taking into account the latest developments in lithium battery technology. After 17 revisions, we submitted our final 98MW grid connection planning application to the local planning authority.

Due to the sustainable credentials of the batteries which do not produce emissions, the council took the view that the construction of the battery energy storage site would be a necessary development. Our plan also proposed landscaping to create biodiversity gains, including trees and over 1km of hedge planting on the site and along the 1.4km access track. All of this results in a minimal impact on the landscape.

By the end of 2020, we had secured grid capacity, planning and land rights which meant we were ready to move on to the next stage.

#### HEIT acquires and funds the project

In November 2021, Harmony Energy successfully floated its investment arm,

Harmony Energy Income Trust Plc (HEIT), on the London Stock Exchange, raising £210 million. HEIT has preferential rights to acquire and build out the next 1GW of Harmony Energy's development pipeline into the future which provides investors with an opportunity to participate in the construction and growth of the battery energy storage and renewable energy market in the UK.

HEIT acquired and funded the project for Pillswood at the construction-ready stage – once planning, grid connection, construction and battery supply contracts and the lease option over the land had been secured. As a result, investors were protected against the usual development risks inherent in a project like this, while benefitting from value uplift as the project went from construction to operation.

One of the most remarkable aspects of battery energy storage schemes like Pillswood is that they are constructed without depending on government subsidy which is a significant benefit to taxpayers and consumers in the UK. Historically, new renewable energy infrastructure has always required subsidy to make them financially viable.

#### Forging ahead with construction despite supply chain challenges

Work began in autumn 2021 with the construction of a 1.4km access track, complete with two bridges and two culverts. The track runs across agricultural fields so in order to prepare the ground for the build, the topsoil needed to be stripped, the soil stabilised through the injection of lime to form a hard formation, and then compacted stone was added on top.

In January 2022, we began to prepare the battery site itself, which involved the installation of 478 individual piles, each to a depth of around 15m. These were installed to support the steel frame elevating all of the electrical equipment approximately 1.8m off the ground. Ground beams were inserted to connect the piles, before our specialist construction team began building up the legs of the platforms on which the batteries would sit.

Constructing the scheme to a tight timescale in a challenging geopolitical and global supply chain environment was no mean feat. International shipping issues were affecting lead times, particularly on the electrical equipment which we were reliant on. To reduce the risk of delays on components, we spoke directly with



manufacturers and suppliers, often spending days negotiating a multitude of assets, from steel beams to cranes, trucks and staff. The global supply chain was experiencing significant strain as we came out of Covid-19 lockdowns but through effective communication we were able to maintain and develop strong relationships with the supply chain, allowing us to mitigate much of the impact.

During the access track construction, we also encountered a number of underground utilities. Safe working practices and bespoke construction strategies were deployed to protect and mitigate any immediate or future impact on the in-situ utilities.

### Rapid construction of the new substation

Simultaneously to this, Northern Powergrid was working hard on the construction of the new distribution substation adjacent to our site. Northern Powergrid had a large scope of work to complete to connect our project which included refurbishment of a 132kV circuit breaker, installation of 132kV cable and building a new 132/33kV substation with 33kV switchboard. Again, due to the nature of the site, Northern Powergrid's new assets were built on a raised platform so that the equipment could be lifted out of the flood zone. Due to the scale, complexity and timescales of the project, Northern Powergrid worked at an incredible speed, safely delivering the build of their works in record time.

During this phase, the Harmony Energy team coordinated the three parties: Northern Powergrid, the distribution network operator providing grid connection; Tesla, providing the Megapack batteries; and G2, the subcontractor responsible for plant construction including civil work, the access track, and facilitating connections between transformers and megapacks.

### Successful energisation of the project

As the construction phase begins to finish, thoughts turn to energisation. Before we could energise the site, all parties have to ensure that the new system is safe and ready to be switched on. We engaged with the control centre for Northern Powergrid to run through a sequence of safety checks and tests in order to make sure that the site would not impact the network. Numerous cold commissioning checks were done on all the equipment including cable pressure, sheath tests, communications tests and emergency stop buttons.

The moment then came for Northern Powergrid to close their 132kV circuit breaker and energise the transformer. There were no loud noises, lights or surprises which was exactly what everyone was hoping for. Despite knowing that the works were completed by professionals, there was a sense of relief from the Harmony team as we left site at 11pm on a Friday night knowing that the Northern Powergrid transformer was energised.

Following the first stage of energisation, Northern Powergrid was able to energise their 33kV switchboard. Shortly after that, the project was energised as Northern Powergrid closed the metering circuit breakers. Once again, the teams and Senior Authorised Persons (SAP) from Northern Powergrid, Tesla and G2 worked as a single unit to ensure that the system was energised in a safe and controlled manner. With the energisation documentation issued, Northern Powergrid left the project team to conclude the on-site activities.

### Rigorous testing before the project officially goes live

Each 33kV circuit was energised under a controlled routine and the MV/LV transformers were energised and left to 'soak' overnight. Further safety checks followed, along with control procedures, and breaker tests. Tesla then conducted their own tests where they moved energy around within the batteries.

Finally, we moved into the live commissioning tests where all of our previous hard work is put under scrutiny. Firstly, commissioning tests are carried out at 20% as part of the G99 procedures. Once passed, these restrictions are lifted to enable the system to be tested at 100% power. Alongside these G99 commissioning tests the project team also conducted

performance tests, to make sure that the batteries were performing as they should do.

After an intensive period of testing and control procedures, the Pillswood scheme was fully energised a month ahead of schedule and in time to support National Grid in providing stable, secure power to the network over the challenging winter period.

The project will continue to be operated through Autobidder, Tesla's algorithmic trading platform. Autobidder has demonstrated a strong track record over the past two years in managing both the Holes Bay and Contego BESS projects. These are two existing battery storage projects also developed by Harmony Energy Limited in conjunction with FRV.

### An exciting future ahead for BESS projects

Looking to the future, the whole globe needs to come together collectively to support developments like these if we want to enable clean energy generation and to protect the future of our planet. The Pillswood BESS project is the first of eight similar battery energy storage schemes scheduled for delivery by HEIT in the coming year. Harmony also has plans to replicate its UK success in continental Europe to address the urgent need to deploy significant volumes of BESS to support the deployment of intermittent renewable energy generation.

In the medium to long-term, we see the technology moving towards longer duration batteries. With the growth of solar and wind, battery energy storage sites will be even more important for a sustainable future. ■

#### Author

Alex Thornton has over 15 years' experience building and managing fast-growing businesses in the renewables energy sector. As operations director at Harmony Energy, a developer, owner and operator of utility-scale battery storage projects, Thornton manages and supports its project development, delivery and asset management teams. He also oversees the build-out of Harmony's battery energy storage systems. He works closely with Tesla, Balance of Plant contractors, DNOs and local stakeholders at all stages of project delivery. Harmony Energy is currently focused on developing projects in the UK, France and New Zealand.



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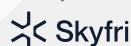
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# Cloud-based analytics for de-risking BESS deployment and operation

**BESS analytics** | Energy storage assets are versatile, profitable low carbon resources that need the right conditions and guidance to deliver value from the very start of operation. How we look at commissioning can determine the outlook for the asset for a lifetime, write Dr Stephan Rohr, Sebastian Becker and Dr Mathias Simolka from TWAICE.

## Introduction

More than 1,600 battery energy storage projects with a total capacity of 386GWh have been announced for 2023-2025 around the world, according to market research group Rho Motion. One visible trend is an increase in the average size of storage systems. The average storage size planned to be deployed in 2023 is 170MWh, this will increase to 230MWh in 2024, and is likely to reach 600MWh in 2025.

Another trend that has been shaping the energy storage market over the past years is, however, coming to an end. Companies were enjoying favourable battery and project costs, but due to recent developments, project costs can exceed US\$1 million per installed MWh. The increasing prices have led to an adoption of lithium iron phosphate (LFP) cells in the battery energy storage system (BESS) industry, but whilst these come with a cost advantage, they come with a disadvantage – accuracy in controlling the BESS.

BESS projects do not only come with high costs, but also with high risks of failure or unplanned downtime. Between 2015 and 2022, 58% of energy storage system failures happened in the first two years of operation. Two thirds of the incidents occurred in the first year, shortly after the storages were deployed.

These incidents have many different causes, from cell and fan issues, cooling system errors, inverter breaks, battery management system (BMS) malfunctions, and more. Figure 1 below illustrates this point with data taken from the EPRI BESS Failure Event Database.

Energy storage system failures do not only pose safety risks, but they also cause storage downtime. Availability rate is a crucial part of the equation to ensure a profitable business case for the energy storage project. Fixing malfunctions and repairing defects lead to temporary

downtime of the system, hence, negatively affecting the business case of asset owners. Whilst downtime for BESS maintenance can be scheduled to keep revenue loss to a minimum, unplanned downtime cannot be accounted for in daily operation.

In a worst-case scenario, asset owners miss out on significant revenue because their energy storage system is out of operation during a spike in energy prices, as seen in the Texas power crisis in 2021.

Not all detectable errors will immediately lead to BESS failure. Some issues appear less serious as they do not pose an immediate safety risk but can have considerable financial consequences. For example, a poorly configured cooling system (e.g. the cooling swirls are not ideally positioned in the container) can cause inhomogeneous aging, therefore leading to a shorter battery lifetime, in which case the overall return on investment is lower.

Despite these challenges, storage projects can be extremely profitable when you have an ecosystem of partners and tools in place to help you prevent costly failures and ensure availability.

## Get what you pay for (since you are paying a lot!)

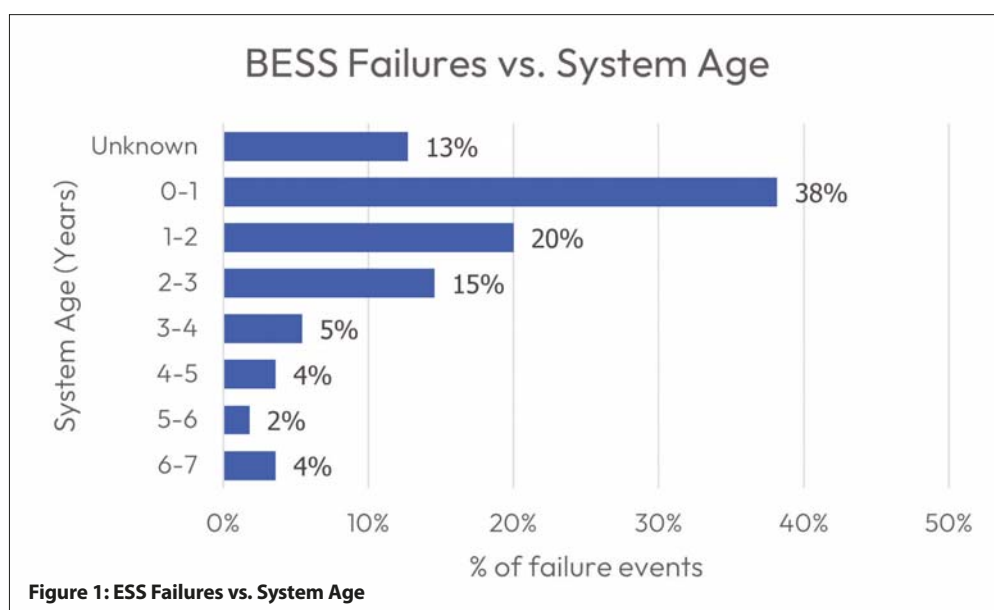
### Commissioning

Before deploying an energy storage system, a process generally referred to as “commissioning” takes place to test and verify that the storage system and its components are installed and configured correctly.

Commissioning is performed once the project is handed over from the EPC to the owner. The aim is also to test the operability of the storage at its initial state in terms of performance, reliability and safety. To put it simply, not only are the keys handed over, but also the responsibilities and risks regarding the asset.

The results of this process are provided in a commissioning report that provides detailed information about the system's set-up and performance, which can be used to identify and resolve manufacturing issues, underperforming components and to ensure compliance with regulations.

Energy storage commissioning is not a standardised process and includes different aspects depending on what has



been agreed between the different parties. So it is not only about testing all physical components and electrical connections for functionality. As the BESS also needs to be compliant with local and national safety regulations, the report usually also includes details on safety features of the system and the fire protection concept. The report provides evidence that the system has been configured correctly (particularly software), to ensure that operation within the specified parameters.

Industry standards for commissioning reports have not yet been developed, but more and more common practices are emerging.

### Importance of the battery in the commissioning process

The battery is the most expensive part of energy storage projects (making up 40-50% of the cost) and the most complex, for number of different reasons. Let's focus on why that is from a commissioning perspective.

- Unlike most other components, the battery is not either working or not working – there are many shades of grey when assessing a battery's performance. What is the system's state of health? To what degree is the promised round-trip efficiency achieved?
- The commissioning process is usually carried out at system level, thus providing system-level KPIs. This only tells half the truth about what is really going on within a battery energy storage system, as it does not provide the vital information about issues on cell or module levels. What is the state of health of each module? Is the HVAC system capable of controlling the temperature homogeneously within the entire container? What is the initial energy spread of the single strings?

### What commissioning typically includes

The part of the commissioning covering the battery typically includes information such as the system's capacity, efficiency, and power output. It also includes details on issues that were identified during the commissioning process and the steps taken to resolve them. Additionally, the report will serve as the foundation in case of warranty claims or disputes about the asset's status.

### What commissioning does not typically include

However, conventional storage commissioning comes with drawbacks.

Incident	Action
Weak cells are identified due to observations in various KPIs	Modules with self-discharge issues should be replaced
System design failure diagnosis based on temperature analyses	Cooling system should be redesigned
Strings and Modules should showcase data sheet based behaviour	Modules with identifiable outlier for relevant KPIs which represent manufacturing issues and defects should be replaced

One of the significant drawbacks of commissioning reports for batteries is that they often focus on the system level, which is not where most issues are happening. Most problems occur at the sub-component level, such as individual cells, modules or strings.

Therefore, a commissioning report that only analyses the system level may miss crucial information about underperforming sub-components, leading to decreased efficiency and potential system failure. For example, if one cell is not functioning correctly, it may not be detected by the process if the other cells in the module are compensating for its lack of performance. This can lead to continued use of an underperforming cell, ultimately affecting the overall efficiency of the system.

The overall system performance is determined by the weakest sub-component; hence it is essential to identify underperforming and high-risk strings and modules as early as possible. Identifying and replacing these underperforming sub-components can significantly improve the efficiency and lifespan of the system. However, commissioning reports that only

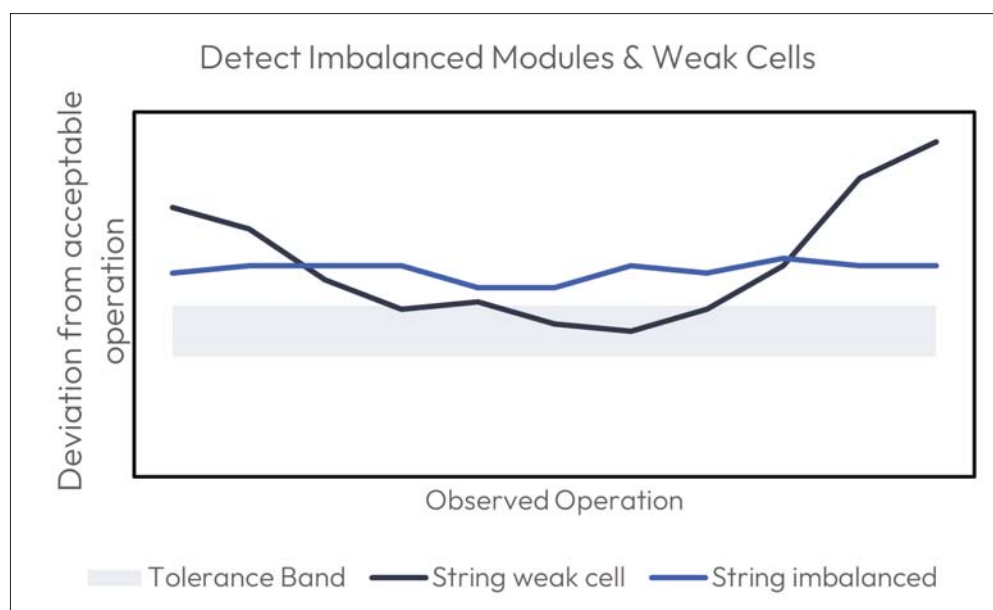
focus on the system level may not provide this level of detail, leading to continued use of underperforming sub-components and decreased efficiency.

Commissioning reports require a lot of work and time onsite, which can prolong the construction timeline and push the start of revenue generation further into the future. It is essential to invest the necessary time and resources to ensure that the battery system is functioning optimally, but efficiency should be the key.

Lastly, if the commissioning report is carried out by the EPC contractor, there may be no neutral party involved, meaning that incentives for detailed checks might be limited. While neutrality is difficult to define, conflicts of interest could arise when multiple projects need to be commissioned within a tight timeline. Thus, having a neutral party involved in the commissioning process is essential to ensure that the report is unbiased and thorough.

### The benefits of more insights

Deeper insights than can be provided with onsite commissioning are crucial to get



**Figure 2: All strings are tested in the observed operation range, leveraging different methods. The deviation from the acceptable operations can be observed and underlying issues can be identified, which are in these cases weak cells within the string and imbalances**



an overall picture of the asset and uncover more manufacturing failures, system design failures or other issues.

Let's look into the inside of a storage system and at three common findings that could be fixed with additional KPIs.

### You got off to a great start – now keep up the good work!

Successful commissioning and the detection of potential anomalies in the early phase of storage life is only the first step to profitable and reliable energy storage operations. After deployment, in-life monitoring and analytics is essential to ensure high availability and avoid safety-critical incidents.

### In-life analytics for a safe and healthy operation

Using safety analytics, possible safety incidents can not only be identified, but grouped into meaningful technical units so that trends can be detected, and Operation & Maintenance (O&M) teams can plan and act accordingly.

One temperature or voltage value outside the boundaries is not necessarily a cause for immediate concern, but an accumulation could be a long-term risk. Values occurring outside safety-critical thresholds must be interpreted correctly and considered in the context of other KPIs. Notifications can be helpful in finding out when an unsafe level has been reached. This is where battery analytics is the ideal solution.

To make it more concrete, a vital component of battery safety involves detecting anomalies and trends outside the norm. Deviations from the average distribution in resistance and temperature, for example, could indicate side reactions within battery cells. These are the incidents you want to know about and fix as quickly as possible. Having enough time to fix such anomalies before they escalate will help to keep storage availability high.

Energy storage management systems (ESMS) usually do not provide sufficient information to ensure health and safety of energy storage systems. Such systems do not provide an analysis of historical data and hence do not supply the necessary data to detect long term trends or anomalies.

### Conclusion

Battery energy storage systems are valuable assets. As much as BESS are advantageous in storing and trading energy, reliable insights are essential to ensure continuous operation and optimal performance of the batteries. At the beginning of the storage life, the storage needs to be commissioned. However, the main concern with conventional commissioning is that it often lacks detailed insights into the batteries. Digital commissioning can provide the necessary insights to ensure problems can be solved before deployment. This lays the foundation for

**Figure 3: Screen from TWAICE Safety Solution**

a safe and long lifetime as well as high availability.

Digital commissioning is one option to deal with these challenges. Once digital commissioning has been carried out on an asset, the data connection is established and in-life analytics can finish what digital commissioning has started.

### Authors

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Dr. Matthias Simolka: Matthias Simolka is part of Technical Solution Engineering at TWAICE. In this capacity, Matthias bridges the gap between Sales, Product and Tech, working with all teams to ensure maximum value and the optimal solution is delivered to battery customers.



# Using battery analytics to support BESS commissioning: A technical deep dive

By Dr. Kai-Philipp Kairies, ACCURE Battery Intelligence

The BESS commissioning phase is the first and crucial operational step for companies to become profitable with big batteries. Dr Kai-Philipp Kairies of ACCURE provides insights into typical technical commissioning challenges and how advanced battery analytics can support owners and operators.

In this article we examine **four typical technical challenges** BESS assets face at the beginning of their lifecycle and how battery analytics can help to overcome them. All are based on real-life BESS projects with sizes between 20MW and 200MWh, informed by ACCURE's experience with over 2.5GWh of connected battery assets. Insights are anonymised and modified to respect the confidentiality of ACCURE's customers.

## 1. Battery cell quality

Battery cells are the heart of a BESS; their quality makes or breaks a system's ability to provide value. But high battery quality is not a given. Even the best cell manufacturing lines have significant scrap rates and produce batteries of varying qualities. New cell chemistries, exponential growth, accelerating product development cycles, and the advent of new suppliers hyper-scaling into the market have not improved this situation.

In the last three years, manufacturers of battery cells for stationary applications almost completely reinvented their commercial products: Cathode material changed from nickel-manganese-cobalt (NMC) to iron-phosphate (LFP). Form factor transitioned from pouch or cylindrical to prismatic. And the capacity per cell increased from 'small' (3-50Ah) to 'huge' (270-500 Ah). Challenges in terms of production quality and consistency come naturally with this level of transition, especially given the short timeframe.

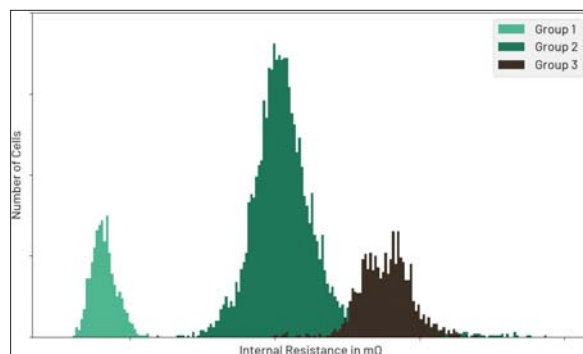


Figure 1: Distribution of internal resistances of a BESS

Importantly, cell production quality and consistency are essential for optimal BESS performance. Like a chain, the performance of a battery system is defined by its weakest link. Single-cell failures in battery racks can lead to accelerated ageing, system imbalance, or even catastrophic events such as fires and explosions. As the numbers of cells deployed grow exponentially, the risk of unplanned incidents also increases. This represents massive challenges for asset managers who are responsible for companies' growing fleets and the associated operational complexity.

Today, the industry typically uses end-of-line (EOL) testing and sorting at the factory to ensure a minimum cell quality and to deal with the inevitable spread in cell properties during battery production. One typical test is to use an AC power source providing a current pulse at 1,000 Hz to measure the internal resistance of the cells. Cells with similar properties are grouped, and outliers go straight to recycling. Internal resistance is not typically evaluated during commissioning and operation, but it should be. Today, internal resistance can be tracked by combining battery management system (BMS) readings and advanced cloud computing capabilities.

In Figure 1, ACCURE's advanced cloud analytics platform depicts the distribu-

tions of internal resistances in a BESS shortly after its commissioning. The batteries fall into distinct groups:

(a) The left-most group shows highly desirable properties: The distribution of internal resistances is centred around a low value and has a small standard deviation. The EOL testing and sorting at the factory clearly worked here.

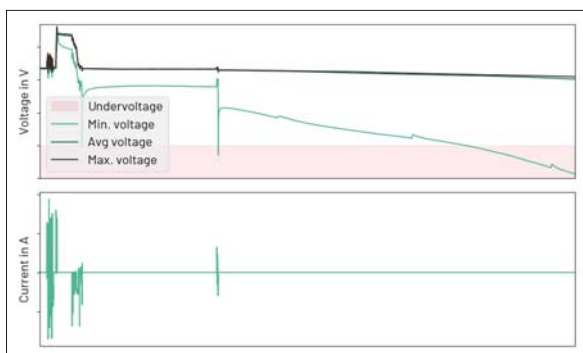
(b) The middle and right group show the opposite: The distributions are centred around higher values, with higher standard deviations. In layman's terms: The cells in the middle are B stock, the cells on the right are trash.

A deeper look into the electric and electrochemical properties suggests that the cells came from different production batches and probably used different components (e.g., a different electrolyte or separator). It was also clear that the right group did not fulfill the quality criteria promised to the client. These battery cells were liabilities. Based on the performed cloud analytics and a summarising report created by ACCURE, a pragmatic solution was found between the involved parties.

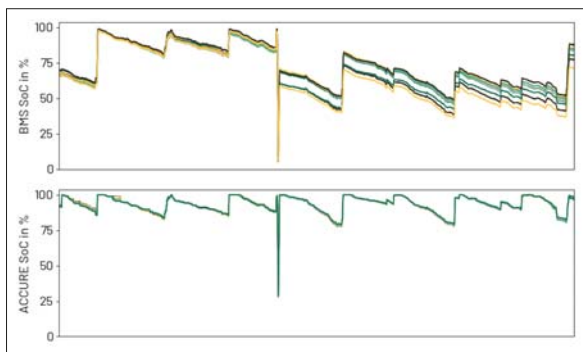
## 2. Battery Management System (BMS) failures

The BMS is the brain of a battery. It ensures the battery is not operated outside of its specifications and provides abstract values like state of charge (SOC) to the overlying energy management system. To operate, it continuously tracks the voltage, current, and temperature of all battery modules. If a sensor fails or the BMS logic is corrupted, potentially dangerous situations can arise:

- Unexpected shutdown of a battery rack because the BMS (falsely) believes a battery has reached its operational limits
- Erroneous SOC calculation, leading to an underutilisation of the asset and increasing system imbalance



**Figure 2: Deep discharging of a battery during commissioning**



**Figure 3: SOC of a BESS during late stages of commissioning**

- Deep discharging, leading to the dissolution of copper from the anode tab and the risk of internal short circuits
- Overcharging, leading to a thermal runaway event

These issues are not academic theories of ‘what could go wrong’ but a collection of actual events that ACCURE observed in real-life BESS. The observed incidents were also not minor: Going 50mV above the upper voltage limit for a few minutes is hardly an ‘overcharging’ problem; pushing an already instable NMC battery to more than 4.35 V regularly is.

Figure 2 shows a case of deep discharging that happened during commissioning. During commissioning, deep discharges can easily occur by accident – through parasitic loads or faulty active balancing. If a battery is deep discharged beyond a certain depth and duration, its warranty can be voided, and it can no longer be considered safe. The dissolution of copper can lead to internal short circuits weeks for months later. Such a battery needs to be taken out of operation. Digital monitoring can inform these discussions.

### 3 SOC errors and imbalanced racks

Since 2020, most new BESS use lithium-ion LFP batteries rather than NMC. These

batteries generally have a higher raw material availability, lower costs per kWh, and a lower energy density. This lends itself well to stationary applications. However, one major challenge when working with LFP batteries is SOC estimation. While the SOC estimation for NMC batteries typically is less than 5 percentage points (pp), it can be 10-25pp for LFP. Such deviations dramatically reduce the value of an asset, as it will not be optimally traded. Additionally, as the inverters distribute the power according to the containers’ SOC, an inaccurate SOC estimation can create balancing problems.

Figure 3 shows the SOC of a BESS during a late part of the commissioning phase. The greater than 30pp SOC difference between the racks is striking – and in this case incorrect. Using cloud-based algorithms, it was shown that the actual spread at the time was significantly smaller and that some of the initiated balancing activities actually increased the problem. In the given example, the error was pinpointed using ACCURE’s cloud-based analytics, and the issue was quickly addressed through recalibration. Without battery analytics, the site would have gone online significantly later or in a low-performing way.

### 4 Water leakage and heat damage

Problems with water have been a repeated source of worry for BESS. Failures of the cooling or fire suppression system started several high-profile fires over the past few years. But not every water issue automatically leads to

a fire. And if the water did no apparent damage, a contractor might be incentivised to find pragmatic ways to deal with seemingly minor incidents.

One example of such a pragmatic solution was found by ACCURE when analysing the temperatures of battery containers during the commissioning phases. In Figure 4 the current and temperature profile of one of the containers is depicted. Although the system is inactive, the temperature steadily rises over several days.

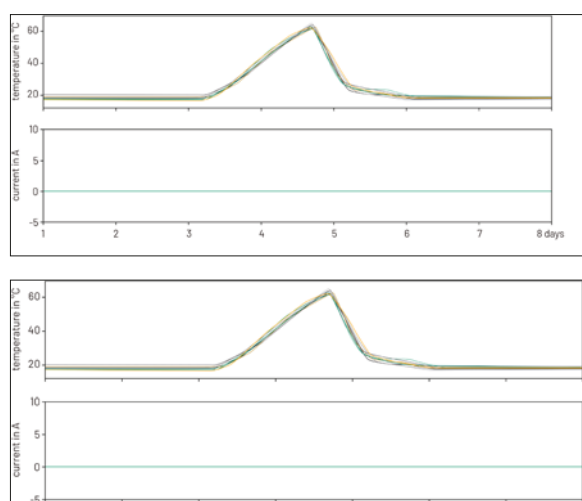
A simple failure of the HVAC system does not explain the observed thermal behaviour. If the sun heated the container, temperature dips should occur at night. But the temperature rises steadily over days, reaching more than 60°C at its highest, then falling back to the base value of around 20°C. All other containers showed normal behaviour during this phase, with temperatures around 20°C. One plausible solution to this riddle is using a dehumidifier after water damage. It was probably well-intended. However, it had violated the battery’s warranty conditions.

### Summary

The commissioning phase of BESS is essential for its performance but also a source of delays, conflict, and potential future underperformance. Owners and operators that leverage their (already existing) battery data can avoid delayed delivery, underperformance, and lengthy discussions with their contractors about potential claims. Leaning on highly specialised battery experts, a complete evaluation of the batteries can be done concurrently with commissioning. After site acceptance, continuous battery monitoring de-risks the operation and ensures asset performance every day of the year.

### Authors

Dr. Kai-Philipp Kairies is a scientist and entrepreneur focusing on innovative battery energy storage solutions. He worked as a battery researcher and consultant in Germany, Singapore, and California. Since 2020, he is CEO of ACCURE Battery Intelligence, a battery analytics solution provider that supports companies in understanding and improving their batteries’ safety and longevity to reduce risk and increase value and sustainability.



**Figure 4: Current and temperature profile of one container in a BESS.**

# Canada's energy storage leaders have valuable lessons to teach

**Lessons for BESS** | Ontario and Alberta account for the bulk of Canada's installed, planned and proposed large-scale energy storage today. The rest of the country can lean on the experiences and lessons learned. Andy Colthorpe hears from developers and expert voices.

Canada could be reasonably expected to reach at least 5,000MW of cumulative battery energy storage systems (BESS) by 2030 across all provinces and territories. According to consultant Patrick Bateman, that figure comes from adding up the few hundred megawatts already installed to major announced developments like the 250MW/1,000MWh Oneida project in Ontario, that province's 2,500MW procurement, a big pipeline of standalone and hybrid storage projects in Alberta and smaller developments in other provinces.

In fact, much more is likely to come by then, says Bateman, who has been retained by Energy Storage Canada for market development activities in Atlantic Canada. The Atlantic Canadian province of Nova Scotia, for example, has an integrated resource plan (IRP) that calls for 200MW of storage by 2030, but the IRP is undergoing revisions and "could

take a few steps up gradually", and New Brunswick's government-owned utility NB Power is currently seeking bids for 50MW.

However, Canada's different provinces represent a "patchwork" of different electricity markets, with different structures, rules and regulations, and activity so far is largely concentrated in Ontario and Alberta – around 94% of the entire projection, according to Bateman.

Both those provinces have a pretty strong head start; Ontario has about 225MW of large-scale behind-the-meter energy storage resources installed at industrial facilities to mitigate Ontario's unique Global Adjustment Charge peak pricing tariffs, while Alberta has about 100MW of battery assets providing operating reserves to the grid.

Bateman points out that there are fundamental market drivers as well as interesting projects in all of Canada's 10 provinces and three territories. These

should perhaps be considered analogous to how we generally look at the US as comprising many different state, transmission, or wholesale market constructs. There is less coordination at sub-national level in Canada, however, he says.

## LT1 procurement

Ontario's LT1 procurement, through which around 2,500MW of energy storage will be contracted for through competitive solicitation, along with a similar amount of new gas resources, is serving a primary function of contributing to resource adequacy.

"We've got nuclear retirements and refurbishments taking some capacity offline. We've got load growth, not only from electrification, but also some very significant electrification projects and sectors, greenhouses are really increasing in southwestern Ontario, and then there's some steel and aluminium plants that are switching over to electric arc furnaces," all contributing to significant load growth, Patrick Bateman says.

While adding much-needed dispatchable firm capacity, new resources contracted for will be able to participate in ancillary services markets. It seems likely Ontario will see other energy storage added too, including non-wires alternatives (NWA) projects at the distribution level, and more commercial and industrial (C&I) projects.

Alberta on the other hand has just 100MW of operating reserves today. Yet as a rapid adopter of renewable energy as well as a traditional home of carbon-intensive energy industry activity, there is a fundamental need for clean energy resources.

Of around 2,500MW of energy storage project applications waiting for grid connections in the Alberta Independent Electricity System Operator (AESO) queue, about two-thirds are standalone



Credit: Northland Power Inc.

Rendering of the 250MW/1,000MWh Oneida project, from NRStor with partners including IPP Northland Power and technology providers Aecon and Tesla.



Credit: Hydrostor.

NRSTor and technology provider Hydrostor completed the world's first advanced compressed air energy storage plant (pictured) in 2019.

energy storage and the remaining third hybrid renewables-plus-storage or thermal generation-plus-storage.

"A lot of these projects have posted in-service dates of 2023-2024, and it's probable that some of them will be pushed back to the 2025 to 2030 timeline, but there's really a very substantial amount of projects proposed already," Bateman says.

Ontario phased out its use of coal power generation a few years ago, in what was then the single biggest carbon emissions reduction measure in North America, while Alberta has just achieved that goal, seven years ahead of a 2030 target. That's great, says Bateman, but in Ontario much of that capacity was replaced by cleaner-but-still polluting gas plants ("taking two steps forward and one step back") while Alberta currently mulls that decision-making process.

It is an often-encountered trend when looking at the energy storage industry: the technologies involved are far newer than the market and regulatory constructs they have to abide by. One challenge both provinces face – and that the other provinces will no doubt wrestle with too – is that market participation is limited by those structures today.

### Alberta storage tariffs in transition

The 100MW of BESS installed in Alberta today, for example, provide operating reserves, "and some initial exploration of providing primary frequency response as well", Bateman says. However, work to

Canada's different provinces represent a patchwork of different electricity markets, with different structures, rules and regulations, and activity so far is largely concentrated in Ontario and Alberta

develop an appropriate storage tariff has not been completed despite an ongoing modernisation process.

"The AESO has initiated a new process with a view to having the storage tariff modernised by the middle of next year. So if that goes through, and if it's favourable, a lot of these projects in the connection queue might move forward more quickly," the consultant says.

One company with projects in that interconnection queue is Westbridge Renewable Energy. Founded just a couple of years ago, Westbridge is developing five large-scale solar-plus-storage projects in Alberta.

Each of those is planned with 2-hour duration BESS in the 100MW range, paired with around 300MWp of PV per site. While Westbridge also develops standalone storage projects in other territories, in Alberta, co-location with renewables offers the quickest path to grid connection, Westbridge special advisor and technical expert Alex Dickinson says.

Francesco Cardi, VP of development of Westbridge, adds that Alberta is a "great place for solar development," which he says is well-planned and straightforward, with clear requirements for developers.

It also helps that it isn't yet saturated or becoming saturated in the way that other leading solar market hotspots like California are, and there are "a lot of planned transmission lines as well" in the province, as well as existing transmission lines, connecting energy production to demand centres in the cities, perhaps an unintended upside of its history as a fossil fuel intensive economy.

The Alberta market's likely evolution is impossible to predict, Cardi says. The

fundamental drivers for energy storage are there, as variable renewable energy sources represent a growing share of the energy mix, but as a developer the key characteristics of its planned projects are flexibility and optimisation to adapt to changing conditions.

"We're looking at fast response systems so that we can adapt as the market evolves. Our revenue streams in two years' time, we would imagine would be totally different to revenue streams in six years' time. But what that difference is, we can't say."

Westbridge, as a pure play developer, is looking to get its projects to late stage development and sell them on. That includes the flagship Georgetown (278MWp PV, 100MW/200MWh BESS) and Sunnynook (330MWp PV, 100MW/200MWh BESS) projects that it hopes will be ready to begin construction this year, with the rest to follow over the next two to four years.

#### 'Absolute necessity' to adopt storage

Another developer active in Canada, NRStor, can reasonably be described as one of the country's pioneers of energy storage. In business for over a decade, largely focused on Ontario, the company has worked on a broad range of different projects and technology types: it owns and operates an advanced compressed-air energy storage (A-CAES) system and a flywheel-based system, in addition to working on everything from residential

and C&I BESS, to the 250MW, 4-hour duration Oneida project.

Oneida has been five years in development already and represents just another deal NRStor has brokered with Ontario's Independent Electricity System Operator (IESO), albeit one on an unprecedented scale.

"Many different kinds of service agreements" between NRStor and the IESO have helped lay the foundation for large-scale storage development in Ontario, claims Jason Rioux, the company's chief development officer.

Ditto the different technology types NRStor has explored, which Rioux says were representative of Ontario's early adopter status of energy storage technologies at single-digit megawatt-scale over the past decade or so.

A flywheel from now-defunct technology company Temporal Power was NRStor's first-ever project, and it is still providing frequency regulation to the Ontario grid today. The company still adjusts how that facility operates to provide new services to the market.

Meanwhile the A-CAES project is the world's first compressed air plant to run without thermal generation, using technology from Ontario-headquartered Hydrostor.

"When these first projects get through all of the heavy lifting, it sets the stage for compressed air energy storage projects of the future to be able to move ahead without similar roadblocks," Rioux says.

**Alberta's first large-scale BESS, Windcharger, went online in 2020.**

While both Westbridge and NRStor see the immediate future of energy storage largely comprising fast-responding lithium-ion BESS assets, there's room for other technologies, especially as the need for duration increases.

#### Transferable lessons and provincial competitiveness

What is important is that lessons learned in Ontario particularly, as well as in Alberta, can be applied to the rest

*Especially with several provinces still reliant on coal, cleaning up the grid and using the grid more efficiently, experiences from Ontario – mistakes as well as successes – can be an important springboard*

of Canada too. Patrick Bateman says that although the market structures and regulations need to be tailored, the technology lessons are almost all transferable.

Jason Rioux agrees, adding that Canada's other provinces don't now need years of pilot projects proving out what's already been proven elsewhere. Ontario's 2,500MW RFP, for instance, shows that scaling up energy storage is "not a crazy idea", but that it is in fact "an absolute necessity to adopt storage in smart and scalable and quick ways for each of these provinces, especially the ones that are looking to decarbonise their power grids", Rioux says.

Especially with several provinces still reliant on coal, cleaning up the grid and using the grid more efficiently, experiences from Ontario – mistakes as well as successes – can be an important springboard, Rioux claims.

"It's becoming a little bit clearer now as well that the jurisdiction of the province with the most energy storage wins, in respect to how you trade energy with your neighbours, and managing clean energy supplies for your jurisdiction's benefit. Those that are further behind are going to suffer in their energy management and operations and in the commercial aspects of delivering low cost energy to their customers."



Credit: TransAlta via Twitter

# Italy's grid-scale energy storage market: a sleeping dragon

**Grid-scale battery storage** | Cameron Murray writes about the nascent market for large-scale battery storage in Italy, which could see a massive expansion in the short term.

The Italian grid-scale energy storage market is set to become one of the most active in Europe in the next few years, having been close to non-existent until now. While the residential sector has boomed thanks to home storage's inclusion in the 'superbonus' energy-efficiency renovation tax credit, the front-of-meter grid-scale is only just picking up pace.

In this piece, we interview executives from three developers looking to gain a foothold in the market: Aquila Capital, Field Energy and Innovo Group.

Research firm LCP Delta recently forecast that after annual grid-scale deployments of just 20MW in the last few years, Italy would deploy 800-900MW in both 2023 and 2024, second in scale only to the UK.

Conversations with the developers indicate that the figure is likely to be much lower in 2023 but potentially made up for in 2024, with 2023 being the year for "sorting out all the issues around storage" and 2024 seeing the "gigawatts of deployment", one says.

Ingeteam and Renantis look set to bring large systems online this year but most others appear to be targeting 2024. Utility Enel announced in early 2023 that construction would start in Q2 on 1.6GW of battery storage projects for a 2024 commercial operation date (COD).

Transmission system operator (TSO) Terna says that some 94GWh of new energy storage will be needed to integrate the country's renewable energy pipeline, although this may include some pumped hydro energy storage (PHES).

The 2030 target is around 15GW by power and 80GWh by capacity, according to Aquila and Innovo Group (respectively).

## "Mainstream, recognised and with more players coming in"

"In 2020, storage was not on the radar of many players but it is now moving mainstream in Italy as it has done in the



Credit: Innovo

UK, Germany and elsewhere, because of similar factors to those countries," says Kilian Leykam, Investment Manager Battery Storage for Aquila Capital which announced plans to develop battery storage projects in Italy in early 2022.

"There is a recognition that renewables need to be deployed a lot faster and that gas is a bad way to provide flexibility to the grid and manage peak demand."

With that came a policy recognition from Terna last year that it needed energy storage to achieve that. In February 2022, just before it handed out over 1GW of capacity market contracts to battery storage projects, the TSO called the technology the "indispensable new lungs of our electricity system".

UK battery storage developer Field has since announced plans to join Aquila in the market, with the setting up of an Italy office and the appointment of Emanuele Taibi as country manager.

Taibi, who joined after nine years at the International Renewable Energy Agency (IRENA), says: "The need for utility-scale storage was finally recognised

## Render of a co-located battery storage project in Italy from Innovo Group.

by Terna last year, first in their scenarios and now in their development plan as a system need. And that's why everyone is gearing up to provide this capacity, which is going to be a really significant amount between now and 2030."

Rodolfo Bigolin is CEO of Innovo Group, which last year formed a 50:50 JV – iCube Renewables – with Spanish utility Iberdrola to deploy solar, wind and also battery storage projects in Italy.

He says the recognition that storage is needed to integrate Italy's big renewables pipeline has combined with a capital market which is now more comfortable with and willing to invest in energy storage.

"In Italy, through our JV with Iberdrola we have an indicative target of 1GW for 6 hours (duration). We have nothing under construction yet, around 200MW under development with COD 2024-2025, while the remaining will likely be the end of 2025 and 2026."

Field says it is in the process of developing its pipeline in Italy and would only be able to share details later in 2023.

In January 2022, Aquila signed a new cooperation agreement with Soltec Power Holdings to co-develop 421MW of solar PV projects in Italy and an additional 90MW of energy storage. When asked for an update on its Italy storage pipeline, Aquila gives a similar end-point target to Innovo Group but did not provide any additional details:

"Given the attractiveness and size of the Italian market, we have the ambition to build up a portfolio beyond 1GW in BESS in Italy," a spokesperson says.

All three firms appear to be developing projects on a develop, build and operate model rather than flipping them.

"There is basically no operational grid-scale market at the moment," says Bigolin. "Enel is the only one with a sizeable portfolio in Italy, and there are now a few other players developing small-to-medium size projects."

### Auction wins in the medium-term and positive noises in the long-term

The grid-scale Italian energy storage market has been kickstarted from two different directions.

The first was big wins for battery storage projects in ancillary service and capacity market auctions by Terna, in 2020 and 2022, respectively.

The second is a policy recognition from Terna that energy storage will be needed to integrate the country's large renewable energy pipeline. Italy has a target to deploy 60G of renewables by 2030, and plans to turn off all coal plants by 2025.

"Last year was the first in a decade where we saw a real, multi-gigawatt renewable energy development market

take shape. The regulatory environment has been trending towards a really strong deployment of renewables, and then once you've got that of course you need storage," Bigolin says.

Field's Taibi dives into the specifics of the regulatory changes. The regulator's consultation 393 from 2022 outlines a specific mechanism dedicated to energy storage to be procured via auctions run by Terna, the TSO, he says.

The consultation by the Italian Regulatory Authority for Energy, Networks and Environment (ARERA) has closed in December and should be released as a new regulation in "a matter of weeks," Taibi says.

That will then go to Terna which will run a consultation with the industry, allowing stakeholders and operators to comment on the proposed new auction system. This timeline means the implementation of the new regulation – and the first energy storage auctions carried out by Terna under it – should take place in late 2023/early 2024, Taibi and Bigolin both say.

### Time-shifting and services

"This planned energy storage capacity will do multiple things. One is time-shifting of renewables, very relevant in Italy because of the large amount of solar here," Taibi adds.

"The other one is to provide grid services to Terna but it's a bit more controversial in terms of how it is going to look once it's finalised."

Essentially, the current proposal would see the auctions contracting the entire capacity of a battery storage asset, including the provision of grid services, whereas operators would prefer to have auctions covering energy, as in

time shifting, and leave the provision of services as merchant, to allow better "stacking" of revenues with different risk profiles and better asset optimisation.

The process does mean that Innovo's development strategy is something of a "moving target" at the moment, Bigolin says.

But in any case, the Italy market opportunity is much bigger than just ancillary services.

### The revenue opportunities

The market opportunity in Italy started similarly to the UK, as Aquila Capital's Leykam explains.

"The market started with the fast reserve auction which gave the initial impetus to start the battery business case, with fixed revenues for the first five years, similar to the first UK FFR auctions which also provided firm revenues over several years," he says.

The fast reserve auction in Italy took place in late 2020 and saw five-year contracts to provide the service awarded to 250MW of battery systems, for the years 2023-2027. The auction's biggest winners were Enel and France-headquartered utility Engie.

The first project to be brought online to provide this service was a standalone 9MW/8MWh project in Liguria, North Italy, in March 2023, commissioned by renewable energy developer Renantis, formerly Falck Renewables.

However, the fast reserve auction does not look set to be repeated, Leykam adds. Most future business cases for energy storage in Italy are now being structured around the capacity market plus energy arbitrage, unlike most of Europe where ancillary services are the main share.



Render of a co-located battery storage project in Italy from Innovo Group.

Credit: Innovo



Credit: Enel

An Enel wind farm in Italy. The utility is the first big player in Italy's grid-scale energy storage market.

Batteries won substantial contracts in the February 2022 capacity market auctions by Terna, which gave 15-year contracts for 2024 delivery year. Enel alone won over 1 GW of battery storage projects through this, 93% of the total storage capacity awarded, which it has started building in Q2 2023 as mentioned previously. Of the total, 500MW is in Sardinia.

Taibi says this quantity of battery storage winning capacity market contracts came as a bit of a surprise to everyone, and was driven by the impressive capex reduction the technology had achieved in the years leading up to it.

The almost immediate upturn in capex costs in the sector afterwards might have caused "a bit of an issue", he adds, although it did trigger a commitment to deploying a significant amount of energy storage in the country by government, regulator and the TSO.

Stefano Girolami, engineering director at Innovo Group, says the smaller ancillary services market to-date is partly due to Italy's frequency control and grid service needs already being relatively well-served by its hydropower portfolio.

### Geographical differences and 'skipping a step' in storage durations

All interviewed agreed that battery storage projects located in the South, where the bulk of Italy's solar PV pipeline is located, would focus on time shifting,

while the North might be more focused on grid services.

Bigolin says battery storage projects will have five or six different revenue streams and these will depend not only on the region, but the node at which the project is connected.

Alberto Arcioli, Director, Energy & Infrastructure, for Aquila Capital, says: "In Italy, you have the seven price zones which drive the economic profile of

"Most future business cases for energy storage in Italy are now being structured around the capacity market plus energy arbitrage, unlike most of Europe where ancillary services are the main share"

energy generation. Within those, you have sub-zonal aspects to the balancing market which bring Italy somehow closer to a nodal model. Here we have the same problem as the UK but in reverse – our renewable production is mainly in the South while demand is mainly in the North."

However, battery storage projects are nonetheless most likely going to be standalone or at most co-located, rather than hybridised with solar PV with a shared grid connection and the battery

charging from the solar, says Girolami.

"You'll have two separate lines of connection so that your battery can access the energy market," he says. "The TSO is not incentivising hybridisation yet but it could in future."

With a different revenue stack, Italy looks set to move to medium discharge durations of four-eight hours much faster than the UK or German markets did at a comparable point of development.

Terna is envisioning an average discharge duration for energy storage on the grid of eight hours by 2030, weighted between battery energy storage and pumped hydro.

Innovo Group's Bigolin says: "In Italy we plan to develop the most flexible assets possible, meaning that we can start by building a one-hour battery and then after the first years we can repower that to a four, six or eight-hour battery, whatever is needed at that point in time. But that's pretty complicated to implement."

He adds that the firm's ideal project size for a battery is 40-70MW, a so-called 'sweet spot' which mitigates the risk of revenues being cannibalised by a competitor's battery system.

Leykam from Aquila on the other hand reckons durations will be between two and four hours.

### The role of BESS providers, EPCs and optimisers

Despite the quicker move to medium or longer discharge durations all interview-

ees say that initial projects would use lithium-ion technology.

"ARERA is taking a technology neutral approach in its regulation but auctions obviously have to be designed to some extent with specific technologies in mind. There is a gap in the 8-12 hour space in terms of technologies today. We don't know yet which technology will fill that gap most competitively, but there's a lot of interesting development happening on long duration energy storage (LDES)," says Taibi.

Girolami highlighted Fluence, the largest battery storage system integrator in the world, as a potential big player in providing BESS technology for projects in Italy. The firm is deploying one of the projects which Enel will use to service its fast reserve auction wins. Girolami also highlighted the China-based BESS providers Sungrow, Huawei and CATL.

Last year, competitor Nidec ASI announced orders from Italy of 1.35GW/5.4GWh by an unnamed company. Interestingly, the details and timeline closely match up with the projects being deployed by Enel. Spain-based energy conversion equipment specialist Ingeteam is deploying a 70MW/340MWh project for, again, an unnamed company, set to come online in 2023.

The main existing engineering, procurement and construction (EPC) firms which are already active on the grid in Italy are those coming forward for potential projects, Girolami adds. One of these is SAET, part of Renantis Group which brought the first system for fast reserve online in March this year.

On the topic of optimisers, Field will be bringing its own energy trading platform Gaia to optimise its projects, while Aquila says it plans to use third-party optimisers to play its systems into markets.

"There are a few players in Italy doing this but it's somewhat lacking, and there's definitely room for more," Leykam says.

Fluence also provides its energy trading and optimisation services alongside its physical BESS product.

### Grid challenges

As in many other countries, delays in getting a grid connection are a challenge in Italy. Aquila's Arcioli says delays can be over six years in some places while elsewhere there is no delay at all and projects can connect immediately. And the general permitting framework may need to change too, he adds.

"If you have a solar plant and want to add a battery, municipal permitting

applications are fairly simple. The same is true for standalone projects below 10MW. However it still remains to be seen if the current permitting framework is adequate."

He adds there are around 300GW of projects in the interconnection queue, mostly wind and solar.

### Conclusion

It's an exciting time for those looking to gain exposure to Italy's grid-scale market which has, until now, been virtually non-existent as some interviewees say.

There is clearly a lot still to play for in providing the BESS technology, optimisation services and financing for the quantity of projects the country needs. Perhaps there is even room for more developers too.

Exactly when projects start to break ground from a multitude of developers outside of first-mover Enel will depend on what comes out of the policy implementation process outlined earlier.

Battery storage projects have a wealth of opportunities to target, from ancillary services to capacity markets to energy trading, and developers are now positioning projects to best take advantage of these.



Credit: Terna

**Terna is the transmission system operator (TSO) in Italy, and is central to regulatory change needed to help the grid-scale storage market kick on.**

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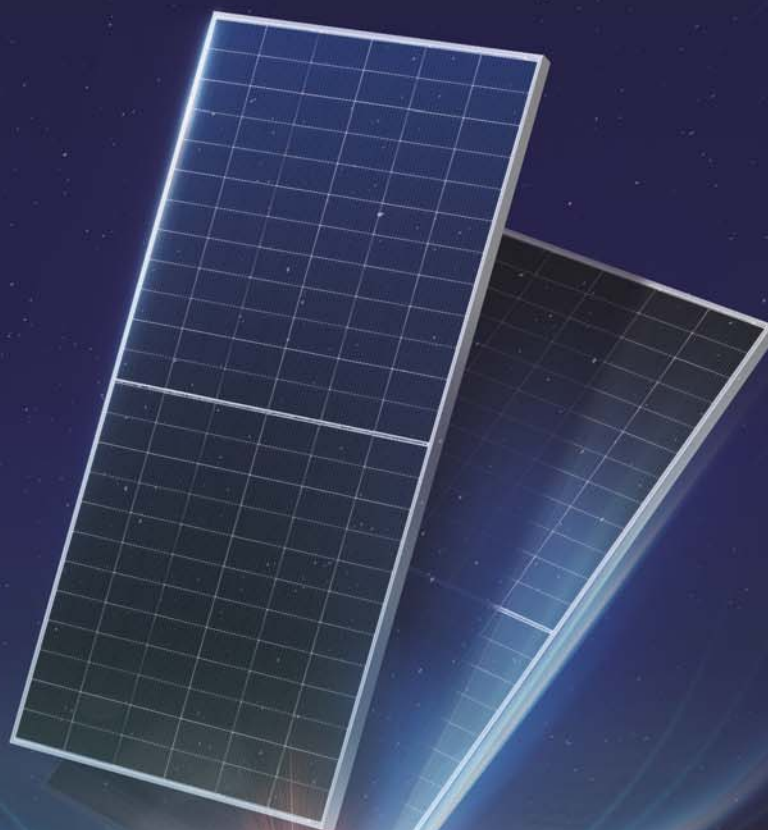
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