EUROPEAN PV IN FOCUS

A special report on a pivotal year for Europe's solar sector, p.16

SYSTEM INTEGRATION
Structural reliability of PV power plants, p.56

PLANT PERFORMANCE
Why PV modules are getting weaker, p.72

DESIGN & BUILD
Improved albedo measurements for bifacial PV, p.86

STORAGE & SMART POWER
The key role of grid-forming inverters, p.104

In association with Energy Storage News
Tongwei Gene Repower

Intersolar A2-550 & 650

- **TNC-G12R 48**
  - Maximum Power: 455W+
  - Maximum Efficiency: 22.8%

- **TNC-G12R 66**
  - Maximum Power: 625W+
  - Maximum Efficiency: 23.1%

- **TNC-G12 66**
  - Maximum Power: 720W+
  - Maximum Efficiency: 23.2%
As has become a tradition in PV Tech Power’s annual publishing cycle, this edition typically features a report on the latest developments in Europe’s solar sector. This year, we felt the topic deserved a deeper dive than usual, as 2024 has all the signs of being a pivotal year for the European PV industry.

On one level, things have never looked better. The multiple policy measures taken in response to Russia’s invasion of Ukraine and the ensuing energy crisis prompted three years of rapid growth, with new PV capacity additions in 2023 hitting an all-time high of 56GW.

But as the immediate risk of energy shortfalls subsides and prices decrease, the sense of urgency that has driven European solar to its recent heights is also abating, posing a risk to future momentum. On top of that, the prospect of changing political winds following June’s EU elections in Europe adds a further layer of uncertainty, as does the question of whether planned investment in upgrading critical power infrastructure is enough to keep up with the demands of a fast-changing energy mix.

These and other dynamics are explored in detail in our special report. On pages 21 to 35, we profile each of Europe’s four main subregions and the key market trends shaping them. We also look at the critical issue of grid development, one of the key potential bottlenecks in Europe’s energy transition (p.42). The question of how Europe can maintain its investor-friendliness also comes under scrutiny (p.40), as do the prospects of a resurgence in European PV manufacturing, seen as critical to supporting the continent’s deployment ambitions (p.38).

Elsewhere in this edition, Colin Sillerud of CFV Labs offers a fascinating account of an emerging issue for the industry, namely that PV modules are getting weaker as they’re getting larger (p.72). Sillerud’s extensive testing activities have revealed that a corollary to the growth in module size seen over the past few years is a greater propensity to mechanical failure. What should be done about it is a question he says the industry needs to answer.

Another weighty concern for the industry is highlighted in a piece from kWh Analytics in the US, which analyses shortcomings in the “availability” metric used by the industry as the standard basis for PV system modelling (p.76). According to author Hannah Rasmussen, the assumption that PV power plants operate at 99% availability is overly optimistic, meaning that yield forecasts are similarly so. She argues a more realistic 97% availability value would improve the accuracy of energy projections and, therefore, of financial modelling, creating a virtuous circle for PV’s wider investment case.

To round off the journal, our regular Storage & Smart Power section leads with a piece from German inverter specialist SMA exploring the role of grid-forming technology in ensuring energy system stability (p.104). Aaron Philipp Gerdemann of German inverter specialist SMA looks at how advanced inverter and control technologies represent a pivotal advancement in ensuring the stability and resilience of energy systems, particularly as the integration of volatile generation sources such as PV wind gathers pace.

As ever, we hope this edition provides you with valuable information and insight. Some of the team and I will be at Intersolar Europe in Munich in June and look forward to meeting you there.

Ben Willis
Editor
PV Tech Power
Contents

10-14 NEWS
Round-up of the biggest stories in PV from around the world.

16-45 COVER STORY
16-20 Is Europe no longer stepping on the gas?
Why 2024 could be a pivotal year for European solar
16-20 Political clouds cast shadows over Western Europe’s burgeoning solar sector
Elections past and future are making waves in Western Europe’s solar markets
24-28 Solar targets up across the piece
A mixed picture for the Nordics and Baltics
29-32 Low electricity prices in Iberia and curtailments in Greece, Southern Europe sees red
The pricing headache that could soon become an EU-wide issue
33-35 Welcome to the gigawatt club
The Eastern European solar markets joining the top table
38-39 European PV Manufacturing: where is it and what might it become?
Why a revival in European PV manufacturing is key to future deployment
40-41 Keeping the taps on
The challenge of maintaining European solar’s investor-friendliness
42-45 Future-proofing Europe’s energy network
Ember on the European grid development challenge

46-55 MARKET WATCH
46-47 China’s distributed PV surges yet constraints loom
Inside China’s accelerating distributed segment
49-52 India marches on towards 2032 solar goals
PV targets on track despite lacklustre 2023
53-55 A global election year: what does this mean for solar?
The elections that will shape solar’s fortunes

56-65 SYSTEM INTEGRATION
56-59 The key to structural reliability of power plants for high long-term asset performance
Nextracker on the hardware challenges for maintaining system integrity
62-65 Taking floating offshore solar from proven concept to commercial reality
DNV on the challenge of commercialising offshore PV
Making the Most of Every Ray

Utility-Scale Smart PV & ESS

Commercial & Industrial Smart PV & ESS

Residential Smart PV & ESS

All-Scenario, Grid-Forming Solutions

Intersolar Europe
June 19-21, 2024 | Messe München, Munich, Germany
Booth No.: C1 Hall
72-84 PLANT PERFORMANCE
72-75 PV modules are getting weaker – how should the industry respond?
    CFV Labs on why PV modules are getting weaker as they get bigger
76-80 Bringing solar availability assumptions back down to earth: the case for adjusting to 97% kWh analytics on a more realistic modelling basis for PV forecasting
82-84 How digital twins are revolutionising solar operations
    SmartHelio and Sitemark profile a key tool in solar digitalisation

86-88 DESIGN & BUILD
86-88 Enhancing reliability in bifacial PV modules: a novel approach to albedo estimation
    Enertis Applus+ on a new method for improving bifacial albedo measurement

90-99 FINANCIAL, LEGAL, PROFESSIONAL
90-94 Closed loop PV recycling still elusive but global efforts gathering pace
    The state of PV recycling worldwide
96-99 Agrivoltaics: Innovative business models may unlock new opportunities
    How agriPV can be helped to flourish

104-116 STORAGE & SMART POWER
104-108 Grid-forming technology and its role in the energy transition
    SMA’s Aaron Philipp Gerdemann on the quest to maintain grid stability
110-111 The benefits of longer-duration storage and energy project co-location
    Ireland’s first 4-hour duration battery storage project
112-116 The evolving landscape of international BESS transportation
    TROES on the role of shipping in BESS project logistics and economics

REGULARS
03 Introduction
66 Products
118 Advertisers index
HJT CHOOSE RISEN ENERGY
Higher Return, Lower Carbon Emission
CFP < 376.5kg eq CO₂/kWc
InterSolar Europe
Booth No.: A1.250

www.risenenergy.com
The adoption of N-type modules around the world continues apace, with technologies including TOPCon, HJT and BC rapidly taking a dominant position due to the multiple and significant advantages of high conversion efficiency, high bifaciality, low temperature coefficients and lower LCOE.

Tongwei has been a recognised leader in global cell shipments for a number of years – as of the end of 2023, global shipments of the company’s high-efficiency cells had exceeded 200GW – and is at the forefront of the current wave of N-type deployment, achieving breakthroughs in the increase of module capacity culminating in the rollout in April of its TNC-G12 large rectangular module with a power output of 700W+.

The company’s range of rectangular modules can reach a power output of 625W in the case of the TNC-G12R 66 module, an increase of more than 40W combined with an efficiency increase of up to 0.5% compared to the standard TNC-M10 72 module. On the technical side, the TNC-G12R 66 is based on Tongwei’s self-developed TNC high-efficiency cells, combined with a Super Multi-Bus Bar (SMBB) design, together with technologies including non-destructive slicing, reflective strips and high-density packaging. These innovations minimise efficiency loss, optimise the utilisation rate of optics and enhance module output within the same area.

Both TNC-G12R/G12 modules come from the company’s intelligent production base, the entire production process “visualised” to make it more efficient and safer. Tongwei’s products have been endorsed with certifications from TÜV NORD, China Quality Certification Center (CQC), MCS in the UK and the Italian fire resistance association, among others.

With the concept of ESG having become a consensus for the green transformation and sustainable development of the global economy, including the solar industry, Tongwei has also taken a leadership role in the integration of ESG initiatives into its corporate operations, implementing the concept of green and low-carbon development throughout every link of its industrial chain, underlining a forward-looking vision for the development of the global renewable industry as a whole.

As early as 2018, Tongwei had initiated R&D into its proprietary THC technology, providing technical and cost analysis support for large-scale production and, in the HJT cell area, conducting research into efficiency
enhancement and cost-reduction technologies including silver-free, low-indium and thin-slicing processing.

On 20 April 2024, Tongwei announced that the high-efficiency HJT module independently developed by Tongwei was tested by the authoritative third-party testing organisation TÜV SÜD, and the highest output power of the module reached 762.79W under the standard size of 2384*1303mm, with the photovoltaic conversion efficiency reaching 24.56%, which is a new record for the power of HJT module again.

Since 2023, Tongwei has set a new world record for HJT module power seven times. The module power record is due to Tongwei’s advanced HJT cell and module manufacturing process. The cell side takes double-sided microcrystalline cell technology as its core, further optimising metallisation contact and optical performance, while the module side adopts Tongwei’s self-developed 0BB interconnection technology, superimposed with ultra-low transmission loss and high-density encapsulation and other advanced technologies, to maximise the reduction of optical and electrical losses in the power generation device, and significantly increase the power of the module. The high-frequency refreshing of the power record of Tongwei’s HJT modules verifies the great potential of the power of Tongwei’s HJT modules.

In terms of innovation and R&D, Tongwei has continued to increase its investment in infrastructure and explore the value of HJT cell and module technology. on April 26th, the first batch of process equipments of Tongwei Global Innovation R&D Center, which takes HJT as one of the main directions of R&D, entered into the field, and as an important engine to cultivate the new productivity of photovoltaic, the establishment of the Global Innovation R&D Center signifies that Tongwei will continue to lead the development of cutting-edge technology of the photovoltaic industry.

The company currently operates six national green factories, four national green supply chain organisations, three national green design products and has been the recipient of no less than 33 domestic and foreign carbon footprint certificates.

Tongwei has additionally built a green supply chain for its PV cells, continuously upgrading its intelligent manufacturing to improve production efficiency and reduce energy consumption. In terms of environmental protection, the company has been a pioneer in developing a “Fishery-PV integration” model, 54 such plants already operational across China, with a cumulative installed capacity of 4.07GW eliminating an annual 5.3 million tons of carbon emissions.

In 2021, the company officially joined the United Nations Global Compact and China Enterprise Climate Action, fulfilling its commitment to social responsibility and promoting global sustainable development.

During the first quarter of 2024, Tongwei has become part of a number of international initiatives and alliances, joining the SEMI SCC & ECOPV Cooperation Alliance to jointly promote the green and sustainable development of the PV industry, also joining the RE100 global initiative as a gold member, committing to its goal of using 100% renewable energy by 2030, going on to officially sign up to the United Nations Women’s Empowerment Principles (WEPs), promoting gender equality and the empowerment of women in the workplace.

More information: en.tongwei.com.cn
Europe

China’s Hunan Rich signs MOU for 1GW PV module factory in Serbia

The government of Serbia has signed a memorandum of understanding (MOU) with Chinese firm Hunan Rich Photovoltaic Science and Technology to build a 1GW solar module production facility in Serbia. Serbian minister of mining and energy, Dubravka Đedović Handanović, signed the deal last week, which will see the Chinese company invest €30 million (US$32 million) over three years to establish the plant. The site will be in the central Serbian town of Paraćin. Hunan Rich will invest a further €280 million (US$301 million) to build a 200MW solar PV project in Serbia, the location of which was not disclosed. Handanović said that she wants Serbia to become a “significant actor” in solar module and hydrogen production. On the same day, the government also signed a framework agreement with the China Energy International Group to build a plant to process oil and oil derivatives in the northern city of Smederevo. The two deals were signed on the back of Chinese president Xi Jinping’s visit to Serbia on his recent tour of Europe.

Solar module demand growth slowing in Europe as prices keep falling, says sun.store

Demand for solar modules has dipped in Europe since February, and both installation rates and prices have fallen, according to data from solar trading platform sun.store. In its pv.index report, sun.store said that its buyers had reported “small but steady declines since February,” which represents a decline in forecast demand. The company uses its PV Purchasing Managers’ Index (PMI) points to track demand based on over 300 PV buyers, with numbers above 50 representing projected growth, 50 showing steady growth and below 50 showing a projected decline. The latest figures showed a decline from 73 points in February 2024 to 71 in March and 68 in April. The index also gauged buyers’ intentions for the next month. Consistently, over 50% of buyers said that they planned to buy more PV products in the coming month. Yet on the whole, the market is still growing, as sun.store pointed out: “Overall, April’s PV PMI reading would be considered strong in any other industry, as half of the respondents plan to increase their purchases in May compared to April.”

Italy bans solar on agricultural land

The Italian government has banned solar PV installations on agricultural land, in a move that the nation’s solar trade association said would cost Italy €60 billion (US$64.5 billion). The government rules constitute a complete ban on ground-mounted solar PV projects on land classed as agricultural. The policy is intended to preserve Italy’s productive agricultural land and “put an end to the wild installation of ground-mounted photovoltaics,” according to agriculture minister Francesco Lollobrigida. The government confirmed that projects already undergoing approvals will be protected from the new ban. The new laws are subject to approval from both Italian houses of parliament, which can amend the decision, but the decision has already drawn criticism from the Italian solar sector. Italia Solare, the national trade body for the solar industry, called the decision “a serious mistake” and said that it would cost Italy approximately €60 billion (US$64.6 billion) in lost private investment and tax revenues.

Americas

Biden to increase Section 301 tariffs on solar cells to 50%

US President Joe Biden has announced a series of tariffs directed towards Chinese goods, including solar cells. Under Section 301 of the Trade Act of 1974, solar cells – whether assembled
LBNL: residential solar PV installations remain flat since NEM 3.0 in California
Residential solar PV installations in California since the introduction of the NEM 3.0 – a billing structure of California’s rooftop solar net metering scheme – have been roughly equal to the amount in the prior year, with more customers installing battery energy storage systems (BESS), according to a study conducted by Lawrence Berkeley National Lab (LBNL). The study, "One Year In: Tracking the Impacts of NEM 3.0 on California’s Residential Solar Market", said the passage of NEM 3.0 in December 2022 had set off a surge of applications seeking to qualify under the previous net metering tariffs (NEM 2.0) before its close in April 2023. The increase in applications led to a subsequent spike in net energy metering measures during the summer of 2023, and after that, the number of installations began a steady decline. Installations under NEM 3.0 have started to increase since the second half of 2023. On average, approximately 8,000 installations took place per month in Q1 2024.

ACP: US adds 4.6GW of solar in Q1 2024, total installed capacity reaches 100GW
The US added 4,557MW of solar capacity in the first quarter of 2024, bringing the total installed capacity to over 100GW, according to the American Clean Power Association (ACP). In its quarterly report for the US market, the ACP said project developers in the US commissioned 111 utility-scale solar, battery energy storage system (BESS) and wind projects in Q1, adding 5,585MW of clean power capacity to the grid. This represented a 28% increase compared to the same quarter in 2023. Of the new renewables additions, solar (4,557MW) accounted for 81.6% in Q1, followed by onshore wind (449MW), BESS (447MW) and offshore wind projects (132MW). Solar additions in Q1 increased by 83% compared to Q1 2023, but dropped by 63% quarter-on-quarter. Cumulatively, the US had 269.9GW of renewables capacity as of the end of Q1 2024. Wind accounted for 56.1% of the total capacity (151.3GW), while the solar sector (11.5GW) made up 37.3%. BESS accounted for only 6.6% (17.8GW/47,543MWh) of the operating renewables capacity.

FTC Solar meets revenue forecasts in Q1 2024, predicts stable revenue in Q2
US tracker company FTC Solar has announced its financial results for the first quarter of 2024, which include revenue of US$12.6 million, and a net loss of US$8.8 million. While this revenue figure for the quarter ended on 31 March is lower than the US$23.2 million posted by the company in Q4 2024, this falls within the US$10-15 million forecast made by FTC Solar in 2023. In addition, the company’s net loss is smaller than the US$11.2 million net loss endured in Q4 2023 and means that the company’s losses have more than halved since Q4 2022. FTC Solar’s financial performance also met the upper end of its forecasts in this quarter. The company posted non-GAAP gross losses of US$1.7 million, in excess of its forecast of US$1.8-3.8 million, and posted a non-GAAP gross margin of -13.7%, compared to its forecast of a margin of -12 to -38%. “The company’s first-quarter results were in line with our targets,” said Shaker Sadavisam, chairman of the board of FTC Solar.

US adds 100,000 clean energy manufacturing jobs since IRA, over one quarter solar
US companies have announced more than 100,000 jobs in clean energy manufacturing since the passage of the Inflation Reduction Act (IRA), according to figures from non-profit group E2. Since the act’s signing in August 2023, US companies have announced 69 new projects in the solar sector, adding 25,157 jobs to the US economy, second behind only electric vehicles (EVs). The solar sector has also attracted the third-most investment among the sectors studied, receiving US$13.8 billion, behind EVs and energy storage, respectively. The manufacturing sector has been a particular beneficiary of the IRA, with E2 reporting that 47 new projects in the solar manufacturing space have been launched since the act’s passage, which account for 18.5% of all new manufacturing jobs, behind only the clean vehicles sector, which accounts for more than half.
AMEA Power starts construction on 120MW solar PV plant in Tunisia

UAE-based renewables developer AMEA Power has started constructing a 120MW solar PV project in Tunisia. The developer secured US$86 million in financing in September 2023 through the International Finance Corporation – a member of the World Bank – and the African Development Bank. AMEA Power expects to commission the Kairouan Solar PV plant in the fourth quarter of 2025. The company secured the construction of the project through an international tender programme launched by Tunisia’s Ministry of Industry and SMEs and is the first to reach financial close. A 20-year power purchase agreement for the plant has already been signed with state-owned utility the Société Tunisienne de l’Electricité et du Gaz (STEG).

AMEA Power has secured finance to begin building a 120MW PV power plant in Tunisia

GEI launches solar-plus-storage project in Zambia

Zambian developer GEI Power and Turkish energy technology firm YEO are planning a 60MWp/20MWh solar-plus-storage project in Zambia, expected online by September 2025. The project will be built in the southern Zambian district of Choma and executed through a special-purpose vehicle, Cooma Solar Power Plant Limited. The Ministry of Energy said the project will require US$65 million of investment and will assist in mitigating power shortages in the country. Preliminary activities, including a feasibility study, environmental impact assessment (EIA) and grid impact study, have been conducted to start the project.

South Africa: First projects from REIPPPP round 6 reach commercial close

The first two solar PV projects from the sixth round of South Africa’s state renewable energy tender – representing 360MW capacity – have been approved and reached commercial close. In a public statement, the Department of Mineral Resources and Energy said that the Virginia and Doornhoek solar projects had signed project agreements and reached commercial close as of 30 April. The 120MW Doornhoek project is being developed by Emirati renewable energy developer AMEA Power, alongside local South African energy companies Ziyanda Energy and Dzimuzwo Energy. The other project that reached commercial close was the 275MWp Virginia Solar Park, owned and developed by South African independent power producer (IPP) Red Rocket. 240MW of the site’s capacity is contracted under REIPPPP. These projects are included under the sixth round of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), which was launched in April 2022.

Gamechange solar to supply 500MW trackers to southern Africa

Solar tracker provider Gamechange Solar has secured a deal to supply 500MW of trackers to a group of solar PV projects in southern Africa. The 500MW capacity is split across four projects: three in South Africa and one in Zimbabwe. Gamechange will supply its Genius Tracker products to the sites. The Zimbabwe project is the first phase of the 185MW Zimplats project in Mashonaland West, which is expected to begin production by the end of 2024 and support a platinum mining operation. Gamechange did not specify the location or capacity of the three projects in South Africa, but did say that one of them is a government-backed Risk Mitigation Independent Power Producer Programme (RMIIPP) project located in the Northern Cape. The other two projects are private-sector undertakings to supply electricity to mining operations in the Northern Cape and Limpopo regions.

EDF Renewables and KOWEPO to develop EWEC’s 1.5GW Al Ajban solar plant

The Emirates Water and Electricity Company (EWEC) has awarded development rights for the 1.5GW Al Ajban solar project in the UAE to a consortium comprised of French firm EDF Renewables and the Korean Western Power Company (KOWEPO). Under the terms of the agreement, the consortium will be responsible for building and managing the project, and will sign a long-term power purchase agreement (PPA) to sell net electricity produced by the project to EWEC, once the project reaches commercial operation in the third quarter of 2026. Emirati state-owned renewables company Masdar is also the primary shareholder of the project.

EWEC launches RFPs for 1.5GW solar PV project in Abu Dhabi

Abu Dhabi’s Emirates Water and Electricity Company (EWEC) has issued a request for proposals (RFPs) for a 1.5GW solar PV plant in Abu Dhabi. The RFPs were issued to 19 developers and consortia, from a pool of 27 companies and consortia that submitted expressions of interest (EOI) for the Khazna project in September 2023. Successful bids will involve the companies in the development, financing, construction, operation, maintenance and ownership of the plant and associated infrastructure, which is set to be built in the Al Khazna area of Abu Dhabi. EWEC will receive responses to the RFP until the third quarter of 2024. The successful developer or developer consortium will own up to 40% of the entity, while the remaining equity will be held indirectly by the Abu Dhabi Government. Moreover, the developer of the project will enter into a long-term power purchase agreement (PPA) with EWEC. The PPA will be structured as an energy purchase agreement, as EWEC will only pay for the net electrical energy supplied by the plant.
SMALLER SIZE
HIGHER EFFICIENCY

Rectangle
TOPCon
Series

◆ LOCAL LOGISTICS
◆ RAPID RESPONSE
◆ QUALITY ASSURANCE
◆ GLOBAL SERVICE

www.sunpropower.com
Credit: SolarDuck

**SolarDuck, Tokyu Land build Japan's first offshore floating PV project**

Dutch-Norwegian floating solar company SolarDuck and real estate firm Tokyu Land have completed an offshore floating solar PV project in Japan. Located in the Tokyo Bay Area, the Tokyo Bay eSG Project, with a capacity of 80-100kWp – is a demonstration project for the Tokyo Metropolitan Government’s policy planning bureau. The capacity generated by the floating plant – which is stored in nearby battery energy storage systems with a 60kWh capacity – will power Open Street Corporation’s electric fleet, including the navigation of an electric boat. The company also plans to use the power for future events in the Takeshiba area in Tokyo Bay. SolarDuck, along with Everblue Technologies – a Japanese manufacturer of automated control technologies – were selected for the project in November 2022.

---

**Australia approves 800MW solar-plus-storage project in Queensland**

The Australian government has approved an 800MW solar-plus-storage project in Southern Queensland. Located near the city of Toowoomba, the Punchs Creek Solar Farm, developed by SkyLab, will include the installation of 1.7 million solar panels on previously cleared agricultural land. A timeline for the construction of the project and its expected commercial operation date was not disclosed by the Australian government. The solar park will be paired with a 250MW battery energy storage system (BESS). Although stated as having a 250MW output by the Australian government, the BESS unit could have an output of 200MW and a capacity of 250MWh. The government of Queensland recently published a roadmap for its 12 Renewable Energy Zones of which Toowoomba is part of the South Queensland region and is expected to host between 1.8-2.4GW of renewables.

**ReNew inks 800MW of solar PV PPAs in India**

Indian independent power producer (IPP) ReNew has signed 800MW of solar PV power purchase agreements (PPAs) in India. Comprising three separate solar PV PPAs, the company secured offtake agreements with utilities NTPC, Damodar Valley Corporation and Solar Energy Corporation of India at an average tariff of INR 2.59/kWh (US$0.03/kWh). The Indian IPP also secured a 1GW PPA of firm and dispatchable renewable energy with SJVN at 4.39kWh and a 438MW PPA with an undisclosed commercial and industrial (C&I) company. Overall, the PPAs will involve the development of 1.5GW of solar PV which is expected to be commissioned over the next 24 months. The location of where the solar PV capacity will be built was not disclosed. These latest PPAs will contribute to expanding ReNew’s operational renewables portfolio which sits at nearly 9.5GW, as the company continues to expand its portfolio.

**Trina Solar module shipments exceed 65GW in 2023**

Major Chinese module manufacturer Trina Solar shipped more than 65GW of modules in 2023, growing its revenue by over 27% compared to 2022. The company shipped 65.21GW of modules last year, up from 43.1GW in 2022, representing a 51.3% year-on-year growth. As of the end of the first quarter of 2024, Trina Solar had shipped over 205GW of modules. The company’s cumulative shipments of 210mm modules exceeded 120GW as of Q1 2024. Aside from modules, Trina Solar’s tracker manufacturing unit TrinaTracker has delivered over 20GW of trackers worldwide as of Q1 2024, with the company’s global tracker production capacity standing at more than 10GW. Additionally, by the end of last year, Trina Solar’s shipments in DC container and battery energy storage systems (BESS) totalled 5GW.

**China restricts offshore solar PV projects to specific sea areas**

China’s Ministry of Natural Resources has issued a document for solar offshore PV, stating that only four types of sea areas can accommodate offshore solar PV projects. According to the document, offshore solar PV projects can only be built two kilometres offshore on four types of sea areas: nuclear power plants’ thermal discharge areas, salt ponds and salt fields, sea aquaculture areas and offshore wind-solar sites. Currently, most of the approved offshore PV projects fail to meet the requirements, which means they can only be carried out on a demonstrative basis in these four types of sea areas. The document adds that offshore solar PV projects can only be developed on a larger scale after demonstrating their impacts, including on the local marine environment.

**Philippines to add 2GW of installed solar capacity in 2024**

The Philippines is expected to add approximately 1.99GW of solar capacity in 2024, according to the Philippines’ Department of Energy (DOE). The DOE announced that at least 4.16GW of power projects will come online this year from a mix of renewable and conventional sources. Of this total capacity, 1.99GW will be from solar projects. The DOE said about 966.3MW will be operational by June, while about 494.9MW are under testing and commissioning and can already inject energy into the grid. Meanwhile, at least 590MW of battery energy storage systems (BESS) will come online this year, with 32.42MW already operational. The Philippines had about 2.36GW of operating solar capacity as of the end of 2023. It has drawn considerable interest from the solar sector, notably floating solar developers. Recent figures estimate the country has the capacity for an additional 36.6GW of PV.
AxoneDuo Infinity redefines solar power generation. Its innovative technology offers unprecedented adaptability and reliability, accommodating a variety of configurations to meet the specific requirements of any site. With state-of-the-art defense mechanisms against adverse weather conditions, AxoneDuo Infinity maximizes the potential of PV modules while minimizing costs and environmental impact.

- **Delivered Pre Assembled**
- **Allows Multiple Configurations.** Linked or Unlinked Rows, 2, 3 or 4 Strings Per Row
- **Minimum Number of Man Hours on Site**
- **Lowest Number of Motors and Controllers Per String in the Market**
- **Improved Terrain Adaptability**
- **75° Hail Option**

As featured in

**inter solar**
connecting solar business | EUROPE

**BOOTH #A6.380**
Is Europe no longer stepping on the gas?

Looking at the numbers from 2023, it would be hard not to conclude that European solar has never been in better shape. Last year marked another year of record for solar PV in installed capacity, with 55.9GW across the 27 Member States, a 40% growth from the previous year, according to trade association SolarPower Europe’s report, “EU Market Outlook for Solar Power 2023-2027”. This is the third year in a row with growth of 40% or above for the region.

And yet 2024 has started on a much more worrisome note, especially for the European solar manufacturing industry, which saw Swiss manufacturer Meyer Burger close a module plant in Germany and Solarwatt announcing plans to shut its 300MW production plant in the coming months. In terms of capacity growth for solar PV in 2024, SolarPower Europe also expects much slower growth than in previous years as the urgency to deploy renewables during the energy crisis fades.

Dries Acke, deputy CEO at SolarPower Europe, says the double-digit growth of added PV might even end this year, with still a record year in 2024 but at a much slower pace. “We don’t project more than a 10% increase. And actually, the latest numbers are saying that it may be slightly below the 10% [mark]. This will be the first time that the market grows only with single-digit numbers, or at least that is what we are foreseeing.”

Acke says that one reason for that slower pace is a lack of political signal and a sense of urgency that is no longer present. The added capacity record years in the past two to three years were closely linked to the energy crisis in Europe, which stimulated the growth of renewables.

On top of that, interest rates continue to remain at a high level, coupled with electricity prices reverting to levels seen before Ukraine’s invasion. “The combination of the two is, of course, problematic as it squeezes the business case for solar investors,” explains Acke.

Before looking in closer detail at some of the specific topics shaping Europe’s solar sector and the trends at play in the continent’s four sub-regions, this article will explore the bigger picture for Europe, including some of the achievements made more recently (capacity and policy-wise), and what awaits solar PV in 2024 and in the coming years.

14 EU markets added over 1GW in 2023

Once again, solar PV had a record year in 2023 with 56GW of grid capacity installed – the third year in a row with a more than 40% increase from the previous year. The total installed capacity for solar PV across the European Union (EU) reached 263GW at the end of 2023, more than a third of the way towards the EU’s 740GWdc solar PV target by 2030.

In its market outlook report for 2023, SolarPower Europe highlighted that 20 of the 27 member states had their best year in 2023, while 25 installed more capacity in 2023 than they did in 2022. As solar continued to accelerate its growth, 14 markets managed to add over 1GW of capacity last year, four more than in 2022.

Dethroned by Spain in 2022, Germany regained the first position last year with
14.1GW of solar PV added. “Germany is again number one, and it’s really a consequence of good ambition and good planning. Their auction system is working, and their scheduling is working,” says Acke.

If Germany continues to light the way for solar PV across European countries, others are also making progress. Acke highlights several countries in Central and Eastern Europe, such as Bulgaria, Romania and Lithuania, where solar PV penetration is increasing. Both Bulgaria and Romania reached a gigawatt-plus of new additions in a single year in 2023, a first for Bulgaria and, in Romania’s case, the first time for over a decade. The shift towards renewable energy in some of these countries was made as a reaction to the energy security plans which are intricately connected to gas, explains Acke, adding: “The mentality of the energy security crisis has been shifting in favour of renewables with some auctions and some support schemes being put in place.”

Once a leader in solar PV at the beginning of the 2010s, Italy seems to have made a comeback with more than 5GW of installed capacity in 2023, more than doubling the already improved numbers in 2022 and after nearly a decade of installing less than 1GW of capacity.

The distributed generation market carried the growth in the country with residential solar still boosted by the “110% Superbonus” scheme in the first half of the year before ending in February 2023. With that scheme ending, the commercial and industrial (C&I) solar carried the rest of the weight, and with more installers available to install more C&I projects, according to Paolo Viscontini, president of trade association Italia Solare.

**Solar PV is no longer just about Germany or Spain**

Last year also marked the second time EU governments had to submit their national energy and climate plans (NECPs), which were adopted in 2019. These national plans outline how each member state intends to address several dimensions of the energy union goals, including energy efficiency, energy security and an internal energy market. Each country needs to supply targets for various technologies—solar PV included—by 2030 and beyond.

All but Austria have submitted their updated draft and only the Netherlands reduced its target for 2030 from 27GW to 25.7GW.

“Solar ambition [has increased] by 87%, which is almost a doubling [of the previous target]. And close to 600GW by 2030, which is close to our 700GW ambition,” says Acke.

In terms of absolute numbers, Germany (21.5GW), Italy (80GW) and Spain (76GW) lead the way for solar PV’s installed capacity but are no longer the only countries where PV will play an important role. “It’s proliferating across Europe, and it’s not just the story of Germany, Spain or Italy anymore,” explains Acke, adding that countries such as Lithuania (5.1GW), Ireland (8GW) or Poland (29.3GW) have multiplied their targets by a factor of five, 10 or three, respectively.

**205GW of solar PV held up by grids**

However, these increased targets for solar PV and other renewables across member states could yet be thwarted by what is emerging as a major stumbling block for Europe’s energy plans – namely its grid infrastructure.

In March 2024, think tank Ember published a report looking at the transmission networks across Europe and their development plans over the coming years. Out of 23 countries it analysed, 19 had underestimated the deployment of solar PV by 205GW by 2030.

For Gaëtan Masson, founder and CEO of Becquerel Institute, the grid discussion should be handled at different levels, including transmission system operators (TSOs), distribution system operators (DSOs), and even cross-border interconnection.

“It’s clear that not all DSOs are able to manage high shares of decentralised PV. And very often, it’s coming from the fact that they are too small in size. If you’re taking Germany, where you have 900 DSOs, and you compare with France, where we have one,” explains Masson.

Considering how long building new transmission lines and expanding the grid takes, investing in it is of the essence in order to avoid a slowdown of renewables in the coming years and also to avoid increased curtailment issues. “There is a big topic linked to investments in the grid,” says Naomi Chevillard, head of regulatory affairs at SolarPower Europe.

“There’s a big priority for the modernisation and digitalisation of networks. What we mean by that is being able to operate the grid closer to real-time capacities by having sensors on the cables to understand what are the real-time limits,” adds Chevillard.

**Flexibility to combat price cannibalisation**

One ongoing trend that has slowly increased in importance since the beginning of the year has been the electricity price decrease in many European countries, particularly Portugal and Spain. This topic will be covered more extensively on p.28. But in general, the price decrease has affected most of the continent, and if it continues, it will increasingly become an issue for solar developers.

“It’s one of the priorities for the solar sector and the renewable sector in general for the next year,” says Acke, adding that what is currently happening in Spain will eventually happen to all of Europe and should be looked at closely. “It’s a good wake-up call to really work on flexibility resolution. And it’s both on transmission and distribution levels.”

Both Chevillard and Acke highlight the importance of flexibility to help with grid congestion. With 27 member states, cross-border transmission lines could play an important role in delivering that flexibility. “It has the possibility of importing electricity from another country if there is a need,” explains Chevillard. Similarly, Acke calls for a “flexibility revolution.”

**EU policies ahead of the election**

At the time of writing, the European Union has either made progress or adopted several key policies in 2024 on the road towards the European Parliament’s upcoming election. The latest ones are the Net Zero Industry Act (NZIA) and the Solar Charter. “The progress has been immense and very important for the solar sector,” says Acke.

Going back to the beginning of this feature and the dire situation of the European solar manufacturing industry, the NZIA aims to back domestic production by 40% target of its annual deployment by 2030.

Not only has the EU set a target for domestic production by 2030, but it has also implemented rules to be applied in public procurement tenders where 30% of all tenders above 10MW would be required to meet these criteria in each member state. The next step for the NZIA is to be formally adopted by the European Council to become law which should be completed by June 2024.

“It’s not going to help existing companies right now, because it will take some months to be put in place. But we can
As the n-type technology landscape undergoes a significant transformation within the solar industry, heterojunction (HJT) technology stands out by showcasing remarkable advancements in the last couple of years. Recent data projections indicate that over 60GW of HJT production capacity will be operational by 2024. With improved efficiency, consistent power generation performance, and heightened reliability, HJT modules are increasingly catching the attention of Chinese state-owned enterprises, international investors and project developers, fuelling anticipation for a surge in global demand for HJT modules.

In this dynamic environment, Huasun Energy, the world’s largest HJT product manufacturer, has unveiled its latest innovation in high-efficiency modules, featuring groundbreaking zero busbar (0BB) technology. This cutting-edge advancement has been seamlessly integrated into Huasun’s mass-production lines, including the Himalaya G12 Series and Everest G12R Rectangular Series of large-format modules. Leveraging innovative improvements in the printing process, welding before lamination, fine solar ribbons, ultra-thin silicon wafers, encapsulation and sealing technologies, Huasun has significantly elevated the electrical, optical and temperature coefficient performance of HJT modules, enhancing the market competitiveness of its product lineup.

As a front-runner in HJT mass production, Huasun continues to lead the PV industry by harnessing the latest 0BB technology. This breakthrough enables higher conversion efficiency, enhanced reliability and lower levelised cost of electricity (LCOE) for PV projects worldwide, further solidifying Huasun’s position as an innovator in HJT technology R&D and industrialisation.

While 0BB technology is advancing towards industrialisation, variations exist among companies regarding specific implementation methods. Huasun’s approach primarily involves welding and dispensing, incorporating advantages such as stronger adhesion, improved resistance to hot spots and elimination of load-bearing film.

Specifically, regarding the manufacturing process of 0BB cells, Huasun adopts a simpler two-step single printing technology to deliver superior product quality and enhanced electrical and cell-to-module performance, demonstrating significant advantages over super multi-busbar products in terms of open-circuit voltage, conversion efficiency and module power output.

“Huasun’s 0BB modules employ welding before lamination, which offers benefits including reliable soldering, reduced contact resistance, enhanced resistance to hot spots, lower hot-spot temperature and higher module reliability. Additionally, the design reduces metal shadowing area on the rear side, expanding the light-receiving area and achieving bifaciality of up to 90%,” says Christian Comes, Huasun’s BD Director Europe.

Thanks to the implementation of 0BB technology and other advancements such as texturing processes, bifacial microcrystalline technology and cost-effective silver-coated copper paste, Huasun has recently achieved a remarkable champion efficiency of 26.5% in mass production for its Himalaya Series G12 HJT solar cells, with an average efficiency level reaching 26.15%. For its Everest Series G12R rectangular HJT cells, the champion efficiency stands at 26.41%, with an average efficiency of 26.01%. This breakthrough signifies the full-fledged arrival of Huasun’s state-of-the-art HJT cells into a new high, surpassing the “26%+” efficiency mark.

The 0BB technology supports the trend towards thinner silicon wafers by providing higher reliability with no main grid, thinner ribbons, minimal stress and lower fragmentation rates. By leveraging the downshifting light conversion encapsulation and PIB edge sealing technology, Huasun’s HJT 0BB modules deliver a substantial increase in power generation capacity. This advancement translates into more dependable products for owners of photovoltaic projects across utility, commercial & industrial, and residential rooftops.

The successful mass production of “G12+0BB” and “G12+R+0BB” HJT products signifies another milestone for Huasun in its quest for efficiency and power enhancement. Committed to advancing the industrialization of HJT technology, Huasun continues to promote the widespread adoption of 0BB high-efficiency modules, contributing to the global development of clean energy.

Huasun Energy Contact
Website: www.huasunsolar.com
Email: sales@huasunsolar.com
LinkedIn: “Huasun HJT”
No.1 in Heterojunction

Capacity
20GW+

Shipment
5GW+

Certified by TÜV SÜD
Source: TaiyangNews Top Modules

www.huasunsolar.com  sales@huasunsolar.com  Follow us on
Progress in permitting

One recurring issue for solar developers relates to project permitting and, depending on the country, how intricate this process can be. Although it is a case-by-case situation, Chevillard says improvements have been made in the past years. “Overall, we’ve seen things improve in the last few years, [helped by] the commission publishing an emergency regulation on permitting,” says Chevillard, referencing a regulation implemented in 2022 as a response to Russia’s war against Ukraine and which EU energy ministers extended last year until the end of June 2025. The faster permitting process implemented in that emergency regulation ended up being included in last year’s Renewables Energy Directive.

The new regulation set a two-year limit for projects to get greenlit, or one year for projects located in designated “renewables acceleration areas”, also called “go-to areas” set by each EU member state.

Chevillard adds having permitting and emergency written next to each other made countries more conscious of accelerating the permitting process to deploy renewables faster. Even though the issue of permitting might be more on a national scale, the EU’s involvement helps give investors a minimum legal certainty on how long a project will take before construction begins.

“I investors, when they invest in a country, look at Europe as a whole. The same thing as when they look at India, the US and Canada. They need to know more or less how much time permitting will take. That’s where the EU is super powerful because they say permitting should take two years and one year under certain conditions,” explains Chevillard.

Masson believes that the permitting issue is first a political question. Regarding the cost associated with permitting, Masson gives the examples of France and Germany’s tenders, which are priced differently despite similar cost of capital. “On one side, we went recently to around €45 to €50/MWh in Germany, and in France, we are more in the range of €75 to €80/MWh – even more,” explains Masson, adding that the difference is mostly about grid cost.

“The choice, which has been made in France and no one recognises it, is that the developers should bear the cost. Hence, PV remains extremely uncompeti-
Political clouds cast shadows over Western Europe’s burgeoning solar sector

Western Europe | JP Casey reports on recent developments in Western Europe, where past and future elections are creating waves

Germany
Western Europe is home to a number of leaders in the continent’s solar sector. According to trade body SolarPower Europe’s latest EU Market Outlook report, covering the period 2023 to 2027, Western Europe is home to five of Europe’s 14 gigawatt-scale markets – Germany, the Netherlands, France, Austria and Belgium – and none is larger than Germany, with a total installed capacity of 81.7GW at the end of 2023.

“Solar energy has been the most popular form of energy in Germany for many years,” Carsten Köning, managing director at the Bundesverband Solarwirtschaft (BSW-Solar), Germany’s national solar association, tells PV Tech Power. “At 15GW, the newly installed solar power capacity in 2023 has almost doubled compared to the previous year.”

Köning notes that, from 2026, the government is aiming to install 22GW of new capacity per year, which would push Germany’s total installed solar capacity to 215GW by 2030, and 400GW by 2040. Crucially, these targets align with those submitted to the EU by the government as part of Germany’s updated National Energy and Climate Plan (NECP), with the German target of 215GW of solar by far the most in all of Europe, more than double Italy’s target of installing 80GW of solar PV, the second-most ambitious goal.

Strong government support for solar has been a hallmark of the German solar expansion, and was buoyed further by the passage of the Solarpaket I tranche of legislation in April this year. This framework makes a number of changes to German solar legislation, including the raising of feed-in tariffs for commercial and industrial (C&I) solar projects by €0.015 (US$0.016) per kWh, a move intended to make distributed solar more commercially viable and thus more attractive to potential investors.

“This will make it easier for property owners, tenants, farmers and other professional investors to access inexpensive solar power,” says Köning of the new legislation. “According to the draft law, barriers to accessing solar power generated close to the public, to the electricity grid and to suitable locations for larger solar power plants are to be removed.”

However, as is always the case with a market that has benefitted from government support, impending elections in Germany cast doubts over the long-term future of the solar sector. Germany is slated to have federal elections in 2025 and radical changes to the political status quo could derail this progress.

Yet Köning is optimistic that Germany’s strong solar sector will endure any such changes, most notably because the sector is, for the most part, an attractive investment destination. The SolarPower Europe report notes that, in March 2023, Germany’s auction for
ground-mounted solar power was oversubscribed by 186%, while tenders for rooftop solar launched in June and October were oversubscribed by 75%, showing very strong interest in funding new German solar projects.

"Of course, legal regulations also help to increase the attractiveness of solar energy, as do tax breaks, such as the VAT exemption on the purchase of PV systems and electricity storage systems that has been in force since the beginning of 2023," says Köning.

The Netherlands
The Dutch solar sector has also benefited from a growing distributed sector. The rooftop solar sector alone added 1.8GW of new capacity in 2022, accounting for 46% of new capacity additions that year, helping the total installed capacity of the Dutch solar sector exceed that of France by the end of 2023.

SolarPower Europe expects this growth to remain steady in the coming years, forecasting growth of 1.6GW in the rooftop sector in 2023 and 1.8GW in 2024. As is the case in Germany, this sector has also benefited from supportive legislation, such as the Investment Subsidy for Sustainable Energy and Energy Savings (ISDE), which saw its funding increase to €600 million this year to subsidise the cost of devices such as heat pumps and solar panels.

Crucially, SolarPower Europe reports that, in 2023, the sector achieved “average negative subsidy levels”, meaning that the government is no longer making a loss on financially supporting new solar installations, a state of affairs that could encourage more government support for solar. Similarly, the senate rejected a proposed bill to phase out the net metering scheme in February 2024, a move that Juan Monge, principal analyst for distributed solar in Germany, has said will not take the office of prime minister, as his party tries to form a ruling coalition government with several other parties, the Party for Freedom voted against the creation of a €35 billion fund to aid in the renewable transition last year. The prospect of a party sceptical of the need to decarbonise the country’s energy mix holding significant power in the German government casts a doubt over the long-term health of the country’s solar sector.

France
France is Western Europe’s third-largest solar market, with around 20GW of capacity in operation, and 3.1GW of new capacity added in 2023. This was a record high for the country, exceeding the previous annual installation record of 2.8GW, set in 2021, and roughly tripling the annual installation totals of 2012-2019, which never exceeded 1.02GW during this period.

The French Renewable Association also has a number of ambitious targets for the solar sector, aiming to install 65GW of operating solar capacity by 2030 and 115GW by 2035, figures that are more ambitious than the NECPs submitted to the EU, and could help France reclaim its top-two spot among Western European countries.

Making solar an attractive investment destination has been a priority for the government, which hopes to encourage private investment into the sector to meet some of these targets. The government plans to offer tenders for 3.2GW of new solar projects each year, and while these tenders have been historically undersubscribed, the government granted tenders to 129 projects, with a combined capacity of 1.5GW, in September 2023, a record tendered capacity.

“The French solar sector is attractive to investors due to robust government support and clear regulatory frameworks,” explains Alejandra Pérez-Pla, regional manager of the Mediterranean at financial adviser Global Capital Finance, and maintaining this state of investor-friendly affairs could be vital if France is to meet some of these more ambitious targets.

“Opportunities for public-private partnerships and financial instruments like green bonds provide secure and targeted investment channels, making France a prime market for solar investment,” adds Pérez-Pla. Other government initiatives include...
the deployment of agrivoltaics projects in France is seen as key to scaling up the country’s solar capacity

The strategy to achieve 100GW of solar capacity by 2050 involves more than substantial investment in rooftop solar; it includes balancing utility-scale and rooftop solar installations. Innovations like floating solar panels and integrating solar infrastructure are considered to help mitigate land use issues, says Pérez-Pla, highlighting the range of investments needed to meet these ambitious targets.

"Innovations like agrivoltaics and the use of non-conventional sites are crucial for scaling up France’s solar capacity," adds Pérez-Pla, who is supportive of the potential of agrivoltaics to overcome this land-use challenge. "Community engagement and modernised infrastructure also play key roles in supporting the expansion of solar installations."

However, Pérez-Pla concedes that the availability of connections to France’s energy grid poses a challenge for new solar deployments. As is the case in much of Western Europe, the speed with which new solar projects are being commissioned is faster than the pace at which the grid can be expanded and these projects connected to the grid, creating a frustrating wait for grid connections and preventing countries from meeting the targets they have set.

"The success of expanding solar capacity will also depend on simplifying regulatory processes and enhancing energy storage technologies to manage solar energy’s intermittent nature," says Pérez-Pla, suggesting that parallel reforms of regulation and investment into technologies such as storage will be needed to modernise the French energy grid to facilitate the connection of new solar capacity.

"Overcoming these obstacles will require concerted efforts from the government, the private sector and local communities."

Less mature markets

Beyond the big three in Western Europe, there has also been considerable growth in smaller solar markets, led by Austria, which crossed the 1GW threshold for the first time in 2022. The country expanded its total installed solar capacity to 6.2GW in 2023 and plans to reach 41GW of cumulative installed capacity by 2040.

The country’s Renewable Energy Expansion Act, passed in 2021, obligates Austria to meet 100% of its electricity consumption by 2030, and the act targets a renewable power output of 277TWh by this date, of which 117TWh will have to be produced by solar sources. To meet these targets, the national government has increased its PV subsidies considerably, almost sextupling financial support from around €110 million (US$118.5 million) in 2021 to €600 million (US$651 million) in 2023. The government also supports 700MW of new capacity installations per year through a contracts-for-difference scheme.

However, this raises questions about the long-term viability of large-scale solar in Austria. A common feature of the more mature solar markets in Germany, the Netherlands and France is that solar projects are often lucrative investments for potential investors. These projects can generate a profit without relying exclusively on generous government subsidies, and the Austrian solar sector will also likely have to attract greater private interest to scale up its solar deployment in the coming decades.

"Look at the track record in countries where you don’t have a very developed permitting or even auction system, like in the east of Europe," explains Naomi Chevillard, head of regulatory affairs at SolarPower Europe, who suggests that private interest is a necessary component to solar expansion.

"You have a lot of interest for power purchase agreements, completely private contracts between a buyer and a seller. That really shows the interest there is from the market to invest in solar."

Belgium, meanwhile, added less new capacity in 2023 than Austria, commissioning 1.8GW of new projects, but its solar sector is much larger on the whole, with 9.9GW of capacity in operation. This is already in excess of the 8.9GW target in place in its latest NECP and, as has happened in Austria, this growth owes much to supportive government policies.

Between 2021 and 2022, the government implemented a “social tariff” to cover some of the energy costs for Belgium’s poorest citizens, which amounted to the government committing €600 million (US$651 million) to help grant energy access to those who would otherwise struggle to meet their energy needs.

The government has also deployed the Energy Effective Retrofit (ASTER) programme in Flanders, the Belgian region that accounted for 1.4GW of new capacity additions in 2023, that will see local social housing companies invest around €155 million (US$168.2 million) into a rooftop solar installation scheme, where local people will be charged just €0.2 (US$0.22)/kWh for electricity consumed.

However, the long-term viability of many of these projects is unclear, considering Belgium is one of many European countries set to hold elections over the summer. In March, far-right party Vlaams Belang held a lead in the Flemish polls, with 27.8% of the vote, and the party’s members have already made their scepticism of renewables clear, calling for an abolishment of the Green New Deal in the European Parliament.

Should the party’s popularity continue, the shape of Belgian politics could come to resemble that of the Netherlands, raising many of the same questions that the Dutch solar sector will have to address, if it is to meet its targets. With such uncertainty in place, there is more emphasis than ever on answering the question that is asked of many smaller solar sectors, namely how can solar projects be made attractive for private investors, so money will continue to flow into the sector even as government support falters.

www.pv-tech.org | May 2024 | 23
Solar targets up across the piece

Northern Europe | George Heynes charts the key market developments in the EU countries of Northern Europe, as well as non-EU members, Norway and the United Kingdom.

The Republic of Ireland was one of seven EU-27 countries with an operating solar capacity below 1GW as of the end of 2023, with 0.9GW installed in total, though it is worth noting that in February 2024, ESB Networks, which builds and maintains Ireland’s electricity transmission system, confirmed the 1GW mark had been reached. Despite this, the country has already achieved its original national energy and climate plan (NECP) target of having 0.4GW of installed solar capacity by 2030, which led to an increase in its target to 8GW last year. This was introduced as part of its Climate Action Plan 2030. There has been a rapid increase in recent years, with the country having a cumulative installed capacity of 170MW at the end of 2022, meaning 730MW was added throughout 2023.

According to the Sustainable Energy Authority of Ireland (SEAI), in 2022, the country had 0MW of solar installed. With over 1GW installed now, ESB has dubbed solar the “fastest growing renewable power source in Ireland.” This has been unlocked via two changes: removing barriers for rooftop solar and showcasing a route to market for emerging utility-scale ground-mount solar.

Nordics
Despite being regarded as one of the coldest regions in Europe and with fewer hours of sunlight than other areas, the Nordics region continues to pave the way forward not only for solar but renewable generation in general, owing to its vast natural resources.

Denmark had a somewhat disappointing year. The Nordic country saw a 57% drop in new capacity additions to 0.7GW in 2023, meaning its capacity only increased to 4.9GW, securing the 11th spot. Despite this, it is worth noting that Denmark ranks third for installed solar power per capita with 832W/c—a 17% increase from 713W/c in 2022.

SPE’s report also mentions that “clouds are on the horizon” in terms of political support for solar in Denmark. According

With an installed capacity of around 1GW and Norway, with around 0.6GW at the end of the year.

Although trade body SolarPower Europe (SPE) detailed in its 2023 EU Market Outlook report that Sweden and Denmark were both anticipated to be among the top 10 markets for solar in Europe in 2023, stuttering capacity additions that year meant that both missed out. Denmark, which was ranked in the top 10 for additions in 2022, was replaced in 2023 by Austria and Belgium.

Denmark
Denmark had a somewhat disappointing year. The Nordic country saw a 57% drop in new capacity additions to 0.7GW in 2023, meaning its capacity only increased to 4.9GW, securing the 11th spot. Despite this, it is worth noting that Denmark ranks third for installed solar power per capita with 832W/c—a 17% increase from 713W/c in 2022.

SPE’s report also mentions that “clouds are on the horizon” in terms of political support for solar in Denmark. According
to the report, Denmark’s solar boom has heavily depended on utility-scale, subsidy-free projects. However, introducing higher grid connection fees in January 2023 caused a notable slowdown in this segment. As a result, there was a significant market decline in 2023, which is expected to continue into 2024. Although SPE anticipates that the issue will be resolved, its report said this may take a couple of years for the market to recover to its previous levels.

Denmark is also making good strides towards achieving its NECP targets, which the country updated in 2023. Under this target, the country aims to have 11.7GW of solar capacity installed by 2030.

Sweden
For Sweden, 2023 marked a strong year. After finishing 2022 with 960MW of new installed capacity, 2023 saw installations pick up to 1.6GW. This brought Sweden to a total cumulative installed capacity of close to 4.5GW at the end of 2023.

The solar power market in Sweden has experienced steady growth over the years. Although it started from a low level in the first half of the last decade, it reached an annual capacity of over 100MW for the first time in 2017.

As of the end of 2022, the total installed capacity was approximately 2.8GW. However, despite this growth, solar power still accounts for a very small percentage of the country’s overall electricity mix, and it’s expected to reach only 2% by 2023.

According to the SPE report, there is a case to be positive for solar in Sweden with the local population being “more optimistic” about solar power compared to other energy sources. The report stated that “80% of the Swedes want more investments in solar”, and politicians at the local level are just as positive about solar.

The demand for solar and batteries increased significantly in 2022 and the beginning of 2023 due to the energy crisis in Europe and Russia’s invasion of Ukraine. However, the market has slightly decreased during the second half of 2023 and is now at the same level as it was at the beginning of 2022.

Although the market growth has slowed, it is still at a historically high level. In Sweden, the solar market is primarily driven by the residential sector, which accounts for approximately 57% of the total capacity by the end of 2022. The commercial and industrial (C&I) segment follows closely with about 37%, while the utility-scale market represents only 6% of the cumulative capacity.

Finland and Norway
Turning our attention to the rest of the Nordics through Norway and Finland, both of these markets saw growth throughout 2023 and continue to support the rollout of renewables despite geographical limitations.

Finland reached a key milestone—having a cumulative installed solar capacity of 1GW. In 2023, it joined several other EU member states, including Slovenia, Lithuania and Estonia, in having achieved this. As such, the country added a total of 400MW across 2023.

Finland also has an NECP target of 2.8GW for 2030, which was updated in 2023 from the pre-established target of 1.2GW, a near doubling of the original target. However, it is worth noting that this is low in terms of W/capita, with 503W per person, significantly below the EU average.

Norway, meanwhile, added 300MW of new capacity in 2023 and ended the year with 597MW of cumulative capacity installed. This is substantially more than in 2022 when the nation installed 152.7MW.

About half of the 0.6MW capacity is installed in households; the rest is for industrial and commercial purposes, with only very limited utility-scale capacity.

Norway’s 2030 target is to produce 8TWh of solar energy annually, with an overall renewables target of 40TWh.

Baltics
In the northeast of Europe, the Baltic states saw growth throughout 2023, with several key milestones reached.

Of the three countries in the Baltics, Lithuania and Estonia both now have a cumulative installed capacity exceeding 1GW (1.1GW each), whereas Latvia had an installed capacity of 300MW at the end of 2023. Latvia is also the only Baltic state not to have an NECP target for solar but has set a contribution to the EU renewable energy target of at least 45% in the gross final consumption of energy for 2030.

In terms of NECPs, Lithuania raised its initial target of 0.8GW of solar to 5.1GW in 2023, a five-fold increase, whilst Estonia raised it from 0.4GW to 1.2GW.

As such, Lithuania is aiming to have the most installed solar capacity by 2030 in the Baltic region. Under the current target, SolarPower Europe expects Estonia to achieve its NECP target in 2024. Lithuania, on the other hand, is expected to reach its ambitious target after 2027.

Lithuania
Lithuania is expected to reach 55% renewable energy by 2030. The electricity sector is anticipated to see a much more substantial increase, with the country expected to reach 100% electricity from renewable energy sources (RES-E) by 2030.

Interestingly, the country is anticipating installing the “lion’s share” of new solar PV capacity between 2023 and 2025, with this expected to amount to around 3.6GW. Although it has a target to deploy 5.4GW of solar by 2030, there has not been a breakdown of what will be rooftop and ground-mount PV. According to the International Renewable Energy Agency (IRENA), the country added 568MW of new solar capacity in 2023.

It is worth mentioning that Lithuania has several support schemes that have been introduced and are actively enabling the rollout of solar. The country’s renewable plan details information on a tender for renewables in marine areas of the Baltic Sea, with the first expected delivery of electricity by 2028. The plan also detailed support schemes for the commercial and industrial sectors, as well as for the public sector, with the planned intervention of EU funding. However, this financial package does not determine how much will be allocated to ground-mount PV.

As utility-scale solar farms begin to ramp up in Lithuania, there will be a major

Sweden saw new capacity additions almost double between 2022 and 2023
Jinko will be presenting its new SunTera 5 MWh energy storage system at Intersolar in Munich. The head of the company’s ESS team for Europe, Roberto Murgioni, answers some questions on the new system and the benefits it offers for customers.

How has the new SunTera 5 MWh been developed with customers’ needs in mind? What are you hearing from developers or investors in storage that they are looking for in their battery energy storage system (BESS)?

Our new SunTera 5 MWh features increased energy density, which allows for more energy storage within the same physical footprint, thereby maximising space utilisation. Additionally, the increased roundtrip efficiency ensures that more of the stored energy can be effectively used without significant losses during the charging and discharging process. Our modular design also facilitates ease of customisation, allowing customers to tailor the system to their specific project requirements, whether it’s for utility-scale or industrial-scale use.

You stated that the SunTera 5 MWh comes with increased energy density, increased roundtrip efficiency and modular design for ease of customisation. What are some of the benefits that these improvements bring to BESS projects?

Firstly, the increased energy density means that more energy can be stored within a smaller footprint, thereby reducing the overall space requirements for the project. This can be particularly advantageous in areas where space is limited or where land costs are high. Secondly, the increased roundtrip efficiency ensures that more of the stored energy can be effectively utilised, maximising the economic value of the system. Lastly, the modular design allows for ease of customisation, enabling customers to scale their projects according to their specific energy storage needs, whether it’s for peak shaving, load shifting, or renewable energy integration.

Safety is clearly the most important thing for any energy technology, even above performance or efficiency. What product design strategies has Jinko Solar brought to SunTera 5 MWh around safety?

Safety is indeed paramount, and Jinko has implemented various product design strategies in SunTera to prioritise safety. These strategies may include rigorous testing and certification processes to ensure compliance with industry standards and regulations, the use of redundant safety features to mitigate risks of thermal runaway or other potential hazards, and the incorporation of advanced monitoring and control systems to detect and respond to safety-related issues in real time.

SunTera’s expected lifetime is 8,000 cycles, above what we might typically have expected from BESS solutions until quite recently. Why is this important, and how was it achieved?

The expected lifetime of 8,000 cycles for the SunTera 5 MWh is significant as it surpasses what might typically be expected from BESS solutions until quite recently. This extended lifespan is important for several reasons. Firstly, it enhances the economic viability of the system by providing a longer operational lifespan. Secondly, it improves the overall sustainabil-
Meet the new SunTera 5 MWh

JinKo ESS's advanced Utility-Scale Energy Storage System, offering over 5 MWh capacity in a 20-foot container, with advanced safety features and flexible deployment options.

www.jinkosolar.eu/ess
opportunity for the co-location of battery energy storage systems (BESS) to facilitate this expansion of variable technologies. Lithuania’s NECP details plans to develop a capacity mechanism to support demand response and storage but does not provide any details on the support of demand response or the total expected battery capacity.

Estonia
Much like Lithuania, Estonia has a cumulative installed solar capacity of 1.1GW and now ranks fifth in Europe for solar capacity per capita in 2023, with 803W/c.

In terms of NECPs, it is worth mentioning that Estonia achieved its original solar target in 2022, alongside Ireland, Poland and Sweden. The result saw it increase its target to 1.2GW, with SolarPower Europe anticipating the country achieving this in 2024. Consultancy Black and Veatch indicated that the country had an installed capacity of 506MW in 2022, thus meaning 594MW was added in 2023.

Although Estonia has established a new NECP target to reach 65% renewable energy by 2030, higher than the previously established 42% the country foresees a total solar PV capacity of 1.2GW for 2030. As noted in the 2023 EU Market Outlook report, this target appears low, especially as many instantly point towards rooftop solar installations, the true potential for solar can be seen in utility-scale developments in the form of nationally significant infrastructure projects (NSIPs).

NSIPs are projects of national significance in England and Wales that bypass the usual local-level planning systems. For solar, any project with a generation capacity over 50MW can be deemed an NSIP.

By bypassing local-level planning, large-scale solar projects are able to be decided by the secretary of state with a development consent order (DCO) granted. The scheme has proven to be a success, with Project Fortress, more commonly known as the Cleve Hill Solar Farm, having entered construction in April 2023. Once completed, the solar farm will be by far the UK’s largest with a generation capacity of 373MW with battery storage to be co-located.

It is worth noting that Project Fortress was the first solar farm to gain a DCO in the UK, paving the way for other large-scale projects to progress. Since then, multiple developers have been looking to create utility solar projects. The biggest we have seen thus far is being explored by UK-based renewables developer Elements Green in Nottinghamshire. Dubbed the Great North Road Solar Park, the project could have a generation capacity of 70GW by 2035.

In 2023, 1.1GW of new capacity was added in the UK, taking its cumulative total to around 17GW, according to trade body Solar Energy UK. In addition, also by the end of 2023, a further 16GW of solar farm proposals had been granted planning permission and a grid connection, and another 9GW of projects were being considered for planning. The UK’s solar sector boasts 90GW of projects in its pipeline.

Growth is anticipated to continue through much of 2024 and throughout the rest of the decade, but the extent of this growth will likely be determined by the upcoming general elections.

Solar is a core pillar of the UK’s goal of achieving net zero emissions, but although many instantly point towards rooftop solar installations, the true potential for solar can be seen in utility-scale developments in the form of nationally significant infrastructure projects (NSIPs).

UK remains a key solar market within the European continental area. Last year saw some critical milestones achieved on the UK’s pathway to the government’s target of 70GW by 2035.

In 2023, 1.1GW of new capacity was added in the UK, taking its cumulative total to around 17GW, according to trade body Solar Energy UK. In addition, also by the end of 2023, a further 16GW of solar farm proposals had been granted planning permission and a grid connection, and another 9GW of projects were being considered for planning. The UK’s solar sector boasts 90GW of projects in its pipeline.

Growth is anticipated to continue through much of 2024 and throughout the rest of the decade, but the extent of this growth will likely be determined by the upcoming general elections.

Solar is a core pillar of the UK’s goal of achieving net zero emissions, but although many instantly point towards rooftop solar installations, the true potential for solar can be seen in utility-scale developments in the form of nationally significant infrastructure projects (NSIPs).

NSIPs are projects of national significance in England and Wales that bypass the usual local-level planning systems. For solar, any project with a generation capacity over 50MW can be deemed an NSIP.

By bypassing local-level planning, large-scale solar projects are able to be decided by the secretary of state with a development consent order (DCO) granted. The scheme has proven to be a success, with Project Fortress, more commonly known as the Cleve Hill Solar Farm, having entered construction in April 2023. Once completed, the solar farm will be by far the UK’s largest with a generation capacity of 373MW with battery storage to be co-located.

It is worth noting that Project Fortress was the first solar farm to gain a DCO in the UK, paving the way for other large-scale projects to progress. Since then, multiple developers have been looking to create utility solar projects. The biggest we have seen thus far is being explored by UK-based renewables developer Elements Green in Nottinghamshire. Dubbed the Great North Road Solar Park, the project could have a generation capacity of 70GW by 2035.

Alongside the NSIP scheme, another major opportunity can be found through the UK government’s Contracts for Difference (CFD) scheme. To incentivise further investment, in late 2023, the government increased the administrative strike price for AR6 to £61/MWh ($77.48) for solar – a 30% increase from AR5.
Low electricity prices in Iberia and curtailments in Greece, Southern Europe sees red

Southern Europe | Jonathan Tourino Jacobo looks at Southern Europe, where pricing, grid capacity and a recent prohibition of PV on farmland are causing headaches

This dedicated region instalment will look at Southern Europe: Portugal, Spain (referred to as Iberia), Italy, Greece, and the Balkans to a lesser extent. The region has seen many developments occur this year (mostly negatively affecting the solar industry), from low electricity prices in Portugal and Spain to record curtailments in Greece to the most recent ban on solar development on agricultural land in Italy.

Germany aside, Spain and Italy have the highest targets for solar PV by the end of the decade. In their respective updated national energy and climate plans (NECPs), the two countries aim to install 76GW and 80GW of solar PV by 2030 respectively, up from 39.1GW and 52GW in the first plan submitted in 2019.

Portugal and Greece have also both increased their PV targets. Portugal more than doubled its previous one, set at 9GW, and now expects to reach 20GW. Similarly, Greece nearly doubled its target, going from 7.7GW to 13.4GW.

For all these markets, solar PV is expected to play an important role in the renewables transition, although some shadows are looming on the horizon.

Iberia sees red
Since the beginning of February, Spain and Portugal have, more often than not, set the lowest price in the EU. At the end of February and the beginning of March, both countries even spent ten days without crossing the €10/MWh (US$10.82) average price for the day-ahead spot price. It is no longer an anomaly to witness the two Iberian countries having whole days with an average price of nearly €0/MWh.

Speaking about price cannibalisation and, more specifically, Spain and Portugal’s case – which have witnessed negative prices – Dries Acke, deputy CEO at SolarPower Europe, says it is one of the most pressing issues for the solar industry in Europe. “It’s one of the priorities for the solar sector and the renewable sector in general for the next year,” explains Acke, adding that the current price issue in Iberia will happen to the rest of Europe sooner or later.

“It’s a good wake-up call to really work on flexibility resolution, and it’s both on transmission and distribution levels.” Acke adds that the issue for Iberia is that the two countries are currently operating as an energy island, with very little interconnection with the rest of Europe.

Price cannibalisation has become a big issue for solar in Portugal and Spain

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity added in 2023 (GW)</th>
<th>Total installed capacity as of end of 2023 (GW)</th>
<th>2030 NECP solar target, 2023 update (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>1.22GW</td>
<td>35.6GW</td>
<td>5.23GW</td>
</tr>
<tr>
<td>Spain</td>
<td>7.3GW</td>
<td>7.26GW</td>
<td>29.5GW</td>
</tr>
<tr>
<td>Italy</td>
<td>0.5GW</td>
<td>1.3GW</td>
<td>1.3GW</td>
</tr>
<tr>
<td>Greece</td>
<td>0.3GW</td>
<td>0.9GW</td>
<td>0.6GW</td>
</tr>
<tr>
<td>Malta</td>
<td>0.3*GW</td>
<td>1.3GW</td>
<td>0.3GW</td>
</tr>
<tr>
<td>Cyprus</td>
<td></td>
<td>0.6GW</td>
<td>0.6GW</td>
</tr>
</tbody>
</table>

*No solar target given in 2023 NECP update

Credit: Mariana Proença/Unsplash
France’s insistence on slowing down a proper cross-border transmission line between Spain and the rest of Europe could be remedied by bypassing the neighbouring country and building a connection with Italy. “I would bypass France and go to Italy. For Italy, it would make a lot of sense. If you look at the electricity prices in recent months, Italy is one of the few countries where they remain quite high while they went extremely low in Spain and Portugal,” explains Gaëtan Masson, founder and CEO of Becquerel Institute.

This would not only open the doors for Spain and Portugal to export their capacity to Italy but also to the rest of Southern Europe: from Italy to Greece and from there to the Balkans and Cyprus, says Masson, adding: “There is a possibility to do something quite impressive in terms of high voltage transmission lines.”

Obviously, this would be a more long-term solution, given how long (and costly) it would be to build even a single transmission line between Spain and Italy.

Unfortunately, the challenges this is Spain currently faces are twofold. On one side there’s the nearly 25GW of solar PV projects that received environmental approvals and were granted grid access in 2023 but have yet to be built. And that’s only the tip of the iceberg, with over 100GW of capacity in the country’s pipeline, according to Masson.

With such a high pipeline of solar PV capacity to be built in the coming years, Masson explains that two technologies adjacent to solar are expected to see an increase in development too: storage and green hydrogen.

“You cannot have 100 gigawatts of PV installed in Spain when you have a peak power of around 40-45GW,” adds Masson.

On the other hand, there is the issue of finding enough skilled workers to build all this capacity, even though not all projects will end up being built. With so many projects being greenlit at the same time, Spain has experienced a bottleneck in engineering, procurement, and construction (EPC) capacity, Masson adds: “The salary level for engineers specialised in EPC has doubled in the last few years, in some Southern European countries. It starts to be unsustainable.”

The pace of growth for solar PV in the country stagnated in 2023 with over 7.3GW of installed capacity, combining ground-mounted and self-consumption, compared to the 7.5GW of added solar in 2022.

A recent report from energy think tank Ember on national grid development from European transmission system operators (TSOs) had Spain as the country with the second-highest difference of capacity forecast by TSOs grid plans and SolarPower Europe’s forecasts for the countries. Only Poland, with over 40GW, had a more underprepared grid than Spain (nearly 40GW) to allocate for new solar PV capacity.

However, on the bright side for Spain, it is the European country with the fastest grid expansion growth. Spain is expected to add a fifth of the 25,000 km of new transmission lines planned between now and 2026.

**Greece: low demand, high growth of renewables**

In the first four months of 2024, Greece has already surpassed the amount of renewables curtailed in the whole of 2023. This can be explained by the fact that electricity demand remains lower than it used to be before the COVID-19 pandemic, explains Panos Kefalas, research lead expert for Southeastern Europe at Aurora Energy Research. “Everyone thought that there would be a fast rebound. But it’s not the case yet, even now in 2024.”

“That is something that took some people by surprise. Because the renewables growth is pretty fast. And it did not slow down during this period. In fact, it grew even faster,” adds Kefalas.

With renewables being installed at a much faster pace than demand is growing, one main concern in Greece is how to solve this curtailment issue. This year, the country has even had similar price issues as Spain and Portugal, with negative or near-zero prices which could become more frequent in the future.

“Hydrogen should be the key factor that will increase demand, but it will take time. It will not be in the next three or four years. It will take a bit longer.”

**Implementing injection limits to solve the grid congestion**

Kefalas adds that in addition to the increased curtailment issue the country has been facing since the beginning of the year, the conversation about injection limits arose. This measure was implement-ed last year across technologies and caps the power capacity a project could provide to the grid.

The idea behind that temporary solution from Greece was to put a limit to virtually save grid space, while the network is being built to accommodate for more capacity, explains Kefalas.

Currently, that limit is set at up to 72% of a project’s installed capacity for solar PV. “On an annual level, this could drop your total generation by 2% to 4%,” says Kefalas, adding that this drop is not huge due to solar plants not ever reaching 100% load factor, yet still a non-deniable constraint.

However, Kefalas says that talks of reducing it even further to a 55% limit could potentially harm further the investment return of a solar plant. One solution to that problem will come through storage, and more particularly co-location of solar PV with battery energy storage systems (BESS).

Kefalas expects solar-plus-storage to become increasingly more important in Greece, where standalone solar projects will struggle to get grid connection.

“More and more we hear from players that they’re actually thinking of co-location as a standard way forward. They will now rarely consider now a standalone project.”

Upcoming auctions for co-location and securing a Contracts for Difference could help kickstart the market a bit faster, adds Kefalas.

Speaking of the role interconnectors could play in solving the curtailment issue and the low power demand Greece is facing, Kefalas said it could be a “game changer” in the long run, enabling countries in southern Europe to export their excess capacity to the north of the continent.

“The interconnectors could certainly play a huge role in combating this. But it’s quite complex in the sense that it’s not just the Greek market solving it. If you have an interconnector that passes through four or five countries, you need to have these countries cooperating and the TSOs agreeing in their investment plans to include parts of it,” explains Kefalas.

This would also apply to green hydrogen, adds Kefalas, as Spain and Greece are expected to have the lowest production costs for green hydrogen. However, this would depend on how easily green hydrogen can be transported throughout the continent.

“The growth of solar in Greece depends very heavily on the ambition and materialisation of hydrogen plants. Without these, the local demand is not enough to absorb a lot more [solar capacity],” concludes Kefalas.
18th (2025) International Photovoltaic Power Generation and Smart Energy Conference & Exhibition

June 8-12, 2025
National Exhibition and Convention Center
(333 Songze Avenue, Shanghai)

Exhibition: June 10-12, 2025
National Exhibition and Convention Center
(No. 333 Songze Avenue, Shanghai)

Conference: June 8-11, 2025
InterContinental Shanghai Hongqiao NECC
(No. 1700 Zhuguang Road, Shanghai)

9th (2024) International Energy Storage & Battery Technology and Equipment Conference & Exhibition
7th (2024) International Hydrogen and Fuel Cell Technology, Equipment and Application Conference & Exhibition

Sept. 24-27, 2024
Shanghai New Int’l Expo Center
(2345 Longyang Road, Pudong District, Shanghai)

Exhibition: September 25-27, 2024
Shanghai New Int’l Expo Center
(2345 Longyang Road, Pudong District, Shanghai)

Conference: September 24-26, 2024
Kerry Hotel Pudong, Shanghai
(1388 Huamu Road, Pudong District, Shanghai)

Hosted by: Shanghai New Energy Industry Association
Show Management: Follow Me Int’l Exhibition (Shanghai), Inc.
Add: Room 905-907, No. 425 Yishan Road, Xuhui District, Shanghai, China
For Exhibition: Tel: +86-21-64276991
E-mail: info@sneec.org.cn

For Conference: Tel: +86-21-33583167-809 / 810
E-mail: office@sneec.org.cn

International Agent: Follow Me Int’l Exhibition (USA), Inc.
Add: 2055 Junction Ave., Suite 225, San Jose, CA 95131
Tel: +1.408.386.3373
Italy bans solar on agricultural land

Probably the most impactful recent development has been the decision from the Italian government to ban the development of solar PV on agricultural land. Although ongoing projects waiting for approvals would not be affected by this newly implemented ban, it is a decision that could end up costing €60 billion to the solar industry, according to figures from trade association Italia Solare.

The government’s rule constitutes a complete ban on ground-mounted solar PV projects on land classed as agricultural. According to agriculture minister Francesco Lollobrigida, the policy is intended to preserve Italy’s productive agricultural land and “put an end to the wild installation of ground-mounted photovoltaics”.

In a letter to Italy’s President, Giorgia Meloni, Italia Solare argued that only 1% of the country’s non-used agricultural land could provide half of the 50GW still needed to reach the 80GW solar PV target set by 2030. The other half would be added through rooftop solar.

As mentioned earlier by Masson, Italy is one of the few European countries where electricity prices have still remained high and the ban could impede the construction of utility-scale solar capacity that could help lower prices, explained Italia Solare in its letter.

Italy is among the European countries with a high interest in agrivoltaics (agriPV), as shown by the Italian government’s decree deploying €1.7 billion toward the development of 1GW of agriPV in February of this year.

The confluence of agriculture and solar is an important topic for the solar industry, not just in Italy but across Europe in general. Acke argues that the Green Deal still needs to happen for the farmers. “Politically, it just is so important that we, as a solar sector, have a solution that is part of the puzzle of such a Green Deal,” explains Acke.

This comes after the country had its best year in nearly a decade with more than 5GW of solar PV installed in 2023. Numbers not seen since 2011, when it reached a record 9.5GW of added capacity.

Solar is yet to soar in other markets

Unfortunately, aside from Portugal, Spain, Italy and Greece, the south of Europe does not have a major market for solar PV. And even those countries outside the EU do not seem to show any promise.

Within the EU, Malta, Cyprus and Croatia have very low targets for renewables and are among the very few countries with less than 1GW of total installed solar capacity. None of these countries’ revised national energy and climate plans (NECPs) has a target higher than 1GW for solar PV by 2030. Only Croatia has a stark discrepancy between its target in the NECP and Solar-Power Europe’s estimates for the country.

The trade association expects the Adriatic country to reach 5.7GW of installed solar capacity by the end of the decade. This would make Croatia a much more interesting country to develop solar PV in the coming years.

At this moment, wind continues to be favoured in Croatia as tariffs for that technology are higher than solar PV, says Kefalas.

The Balkans do not seem any better than these three, with Masson quite sceptical about the role of solar PV in these countries. “I’m still unconvinced of the level of maturity of the political class to put in place the right regulations in any of them.”

“The challenges in the Western Balkans are not yet so specified, and so visible, because the market has not developed,” says Kefalas, adding that due to the Western Balkans’ still being in the infancy of a solar PV market, it is more about how to manage not having the same challenges than other Southern European markets.

It is worth highlighting a recent memorandum of understanding between the Serbian government and Chinese firm Hunan Rich Photovoltaic Science and Technology aims to build a 1GW solar module assembly plant in Serbia, along with the construction of a 200MW solar PV project. Both the module assembly plant and the 200MW solar PV project could be a big boost for the country to attract more interest in developing solar PV in Serbia.
Fourteen European countries installed 1GW or more of solar PV in 2023. Five of these were newcomers to the GW-scale club, and three of those five were in Eastern Europe.

Bulgaria, the Czech Republic and Romania all passed the 1GW mark in 2023, along with Poland which has been the leading light of Eastern European solar for some time.

There are some unifying factors across the region as we look out to 2030. Grids, unsurprisingly, feature heavily, as does distributed rooftop solar. The fairly universal increase in solar deployments following the outbreak of war in Ukraine has subsided in most of Eastern Europe as electricity prices have levelled off, so governments have had to become more proactive in encouraging uptake.

The biggest markets—Poland and Hungary—are undergoing changes and seeing their prosperous rooftop sectors begin to slow. In the former case, the utility-scale sector is poised to take over from distributed generation, whereas the latter is likely to see a quiet few years. Both the Czech Republic and Romania have booming distributed and sub-50MW sectors but face challenges at a larger scale.

**Poland**
The largest market in the region, Poland’s solar sector has been driven since 2016 by favourable conditions for distributed, residential and rooftop installations. Data from the Energy Market Agency shows that Poland had over 1.3 million micro-PV installations—those under 50kW—as of the end of September 2023. These alone represent over 10GW of grid-connected PV capacity.

This massive uptake was driven by two things: a net metering scheme which gave favourable returns to prosumers exporting power to the grid, and the war in Ukraine. However, the proliferation of residential systems put strain on the distribution grid, which led the government to replace net metering with a less attractive net billing system.

This legislative change has seen interest in residential systems decrease. Trade body SolarPower Europe (SEP) said the share of new residential solar installations decreased from 71% in 2021 to 60% in 2022 and to around 30% in 2023.

As one star wanes, another begins to wax. The utility-scale sector in Poland has been growing as government auctions and a taste for corporate power purchase agreements (PPA) drive figures forward. Dariusz Mańka, director of legal and regulatory affairs at Poland’s solar association Polskie Stowarzyszenie Fotowoltaiki, told PV Tech last year that there was a “constant growing need for large-scale PV” in the market and that PPAs offered an attractive model for developers and investors.

Government auctions were popular at their inception, but the price volatility that bolstered rooftop solar following the Ukraine war dampened the December 2022 auctions. Of the seven issued, only four auctions were settled. But 97% of the roughly 490MW of awarded capacity went to solar PV projects.
Market challenges
One challenge looms larger than any other for Poland’s solar sector: the grid. SPE says in its market outlook that most of Poland’s grid infrastructure is over 25 years old, and portions are even over 40 years old.

Beyond ageing infrastructure, there is simply a lack of it. As a result, the queue for a grid connection is increasingly drawn out – data on the queue times for utility-scale solar projects is currently impossible to verify, SolarPower Europe said, and likely exceeds the 1.5-year best-case scenario.

Furthermore, the connection process itself is “ambiguously and inefficiently regulated” and untransparent according to SPE, and has resulted in the national distribution system operator (DSO) issuing over 7,000 refusals for grid connection in 2022, mostly to renewables and distributed energy sources.

Market drivers and forecast
Political will is likely to sustain the growth of solar in Poland. The Polish government has introduced other favourable amendments to its Renewable Energy Sources (RES) Act. Specifically, the government announced measures to support hybrid RES installations and operational and modernisation support for projects.

Upgrades to the grid are also in the pipeline. Earlier this year, the transmission system operator (TSO) Polskie Sieci Elektroenergetyczne (PSE) announced a plan to invest PLN64 billion (US$16 billion) in new transmission lines by 2034. The TSO projects that the expansion and upgrades would allow 45GW of new solar PV access to the grid – 20GW of utility-scale and 25GW of rooftop projects.

The government has also introduced ‘cable-pooling,’ the ability for multiple renewable energy sources to share the same grid connection. This has the potential to increase renewable energy sources’ access to the country’s grid.

Poland met and exceeded its NECP for solar in 2022, which SPE said was because “the technology wasn’t on the radar at the time of writing the NECP”. Despite this, solar is expected to continue to grow, though at a lesser rate than in recent years. Poland is forecast to connect 25.1GW in 2024-2027.

Czech Republic
In 2023, the Czech Republic re-entered the ranks of GW-scale solar markets for the first time in 13 years.

As with much of the region, the war in Ukraine and the ensuing energy crisis triggered a resurgence in the Czech solar market. This came alongside a simultaneous revival in subsidies for residential solar in 2021 and a scheme to support business-to-business solar projects in 2022 under the EU’s Recovery and Resilience Fund (RRF).

As such, Czechia’s boom period is driven by the residential sector, which shows no signs of slowing down. During the first half of 2023, almost 45,000 new projects were commissioned; 95% of them are below 10kW.

Market challenges
Utility-scale solar is stagnant in Czechia. Some projects are getting over the line, but the wider picture is rather static. SolarPower Europe estimates that 13 projects above 1MW were installed in the first half of 2023, most of them on rooftops. The Czech Solar Association said that of the roughly 170,000 installed PV systems in the country as of the end of last year, roughly 150,000 are rooftop installations.

Large-scale energy storage projects are currently not permitted in Czechia, something which SolarPower Europe says “has been blocked by some fossil fuel companies”. A change to this would likely aid the rollout of utility-scale solar.

Market drivers and forecast
Czech industry is expected to play a major role in the fortunes of the solar market in 2024 and 2025. Heavy industries such as steelworks, the automotive sector and chemical plants all have obligations to decarbonise, and the EU has allocated at least CZK150 billion (€6 billion) for projects aimed at reducing the impact of the decarbonisation of industry in Czechia and facilitating the shift towards renewable energy by 2030. Moreover, this funding could actually increase as the Modernisation fund from which it comes is linked to the price of CO2 emissions certificates, SolarPower Europe said.

The Czech power mix also includes a relatively large nuclear and coal presence. While nuclear capacity will ultimately be expanded, nothing is expected before 2036, and coal plants are increasingly becoming unprofitable. Renewables – led by solar in terms of both cost and ease of deployment – will be needed to account for growing electricity demand.

In its optimistic forecasts, SolarPower Europe sees the Czech Republic installing around 2.5GW of solar annually. This requires the current barriers for utility-scale projects to be removed and a number of other scenarios, including legislation around energy sharing that would unlock solar power for the large number of Soviet-era apartment blocks. A “realistic” projection sees between 1.2-1.4GW installed a year and a pessimistic outlook sees relatively flat growth from now until the end of the decade.

Hungary
Hungary’s star has been rising fairly consistently since 2017. Favourable policies for small-scale projects drove significant demand for residential and commercial systems below 50kW, whilst larger ground-mount systems rose steadily from 1.4GW in 2020 to 3.28GW in October 2023.

Then, like its Eastern European neighbours, the energy price spike following the war in 2022 triggered a rapid uptake in small-scale solar. This coincided with the government’s decision to ban its feed-in-tariff scheme for residential installations, which saw demand spike as people looked to install solar in the two weeks before the scheme ended.

However, the inflexion point might have been reached for the country’s growth. The spike in capacity ahead of the feed-in-tariff ban has subsided, and SolarPower Europe observes that “order books of residential PV systems have significantly decreased” over the last year. Moreover, grid capacity is being used up, and the
projections for new utility-scale PV sites are getting less positive.

**Market challenges**
Grid infrastructure raises its head again here. Hungary’s updated NECP seeks 12GW of solar by 2030, but the grid is close to reaching capacity. SolarPower Europe estimates that it has not been possible to get a grid connection for a project over 50kW since April 2021, with the capacity online since then either already allocated or dedicated to the large rise in rooftop systems.

Adám Szolnoki, president of the Hungarian solar association MANAP, has said that grid application reforms were delayed until mid-2023, which led to fewer permits being granted. Of the roughly 1.5GW large-scale permits granted in 2023 (3.9GW were submitted), almost all were for 2028-29.

MANAP also wrote an open letter to the Hungarian energy minister expressing concerns about the financing model for residential solar tenders. It said that the market was becoming less competitive and efficient as the restrictive new financing model – which has proved popular for consumers – pushes out small- and medium-sized businesses.

**Market drivers and forecast**
Hungary will likely meet its NECP targets, but the brakes have likely been put on its rapid growth. The aforementioned rooftop legislation and lack of grid capacity will combine to slow down deployments in 2024 and beyond.

For utility-scale, most of the projects due in 2024 have already been granted grid access, so SolarPower Europe predicts that around 600-700MW of new capacity will come online. Into 2025 and beyond, however, the situation is far less certain. The government announced a 440MW grid-scale energy storage tender in February this year which is designed to open up access for more renewable energy to the grid.

The residential sector has already slowed down and that looks set to continue. Future growth will rely on residential solar-plus-storage taking off as the government has announced an incentive scheme for residential co-located projects, though details are yet to be clarified.

**Romania**
Romania’s solar forecast hinges on political action more than most countries in the region. Last year saw it become another Eastern European success story, as it breached the 1GW annual installation mark for the first time and installed 308% more than the previous year. The main increase was in the distributed generation sector which went from 417MW to 1.16GW over the year.

The government has taken several actions to streamline and promote solar. Its contracts for difference (CfD) scheme launched in September 2023, seeking 1GW of projects in its first tender, and permitting reforms for both utility-scale and distributed solar projects have streamlined the grid access process. Utility-scale projects under 50 hectares (roughly 40MW) have seen their permit times reduced from 18 to six to 12 months, and distributed projects under 400kW are able to obtain their documentation within a month.

**Market challenges**
However, large-scale projects on over 50 hectares are currently beleaguered by permitting issues. According to Irene Mihai, policy officer of the Romanian Photovoltaic Industry Association (RPIA), the Ministry of Agriculture and Rural Development (MARD) has incited an “arduous process” for gaining permits for large solar sites.

Regardless, a number of very large sites are in the pipeline in Romania. Notably a 600MW facility from Romanian renewables developer Econous Green Energy and the mammoth 1,044MW planned by Rezolv neos announced a plan for 500MW of solar in Bulgaria in April 2024 as part of a wider 2GW, €2.2 billion (US$2.39 billion) regional commitment.

**Bulgaria**
Bulgaria is the sunniest place on this list, and that’s reflected in its solar market outlook. From 2020-2023, it nearly tripled its deployed capacity, and its national trade association predicts that capacity to more than double again by 2030. It is forecast to meet its NECP target in 2024. Summer 2023 saw solar account for 41% of the total energy mix on multiple occasions. Industries are increasingly seeking solar PPAs to decarbonise their operations and benefit from its low levelised cost of electricity (it’s the cheapest form of energy available in Bulgaria) – continued awareness and interest will only increase the market’s allure in the coming years.

Notably, Greek project developer Mytilineos announced a plan for 500MW of solar in Bulgaria in April 2024 as part of a wider 2GW, €2.2 billion (US$2.39 billion) regional commitment.

The country’s Association for the Production, Storage and Trading of Electricity (APSTE) expects growth of 450-750MW of new solar capacity each year over the next three to four years, indicating it will easily meet its revised NECP target of 5.2GW. However, APSTE also notes that concerns over grid-connection capacity in the coming years as more PV comes online could prompt a tightening of the requirements of financing institutions and drive investment in energy storage.

*With its enviable resources, Bulgaria’s solar market is starting to lift off.*

Credit: Sunotec
Anker SOLIX at Intersolar 2024: Premiere for energy storage system Anker SOLIX X1 and Anker SOLIX Solarbank 2

Anker SOLIX, as the most popular brand of mobile charging and balcony power storage system in the world, will launch its first home energy storage system at Intersolar 2024, the leading solar trade fair in Munich. The Anker SOLIX X1 energy storage system and the Anker SOLIX Solarbank 2 Series, which will be presented to the public in Europe for the first time, will celebrate their premiere.

**Anker SOLIX X1 Energy Storage System: Powerful, efficient and modular power solution**

The modern all-in-one energy solution from Anker SOLIX X1 features a stackable and compact modular battery design, wide temperature range performance and an innovative energy optimiser. Compared with the traditional solution of inverter + energy storage system, the all-in-one design will redefine residential storage with a more intelligent, sleek and convenient solution, helping users save costs and enhance the user experience.

"Soaring energy bills, power outages and the shift toward eco-friendly living are driving more people to residential solar energy backup," said Shaun Xiong, General Manager of Anker SOLIX. “You need a way to store that energy — and the Anker SOLIX X1 is the answer. With Anker's experience in battery technology, the X1 delivers excellent off-grid performance, especially in extreme cold or heat. We want to provide a way for homeowners to store and manage residential energy use for a more sustainable future.”

The Anker SOLIX X1 Home Energy Storage System is crafted to provide residential developers with a comprehensive and scalable energy storage system for smart homes globally. The Anker SOLIX X1 boasts a sleek design and advanced features ensuring a steady and sustainable power supply.

- Energy optimisation: Powered by an energy optimiser, each battery pack operates independently, significantly increasing available capacity during the lifecycle.
- Minimalist and slim all-in-one design: Integrates power and battery modules in a sleek, minimalist 5.9-inch design that complements any decor.
- Extreme temperature performance: Whether you live in an area with long, cold winters, Anker SOLIX X1 is engineered to perform reliably in extreme temperatures from -25°C to 60°C.
- Customised power with modular design: Offers a flexible energy capacity range from 5kWh to 180kWh and power output from 3kW to 36kW.
- Off-grid capabilities: The X1 system provides 24/7 whole-home backup that switches to backup power in only 10 milliseconds, allowing consumers to enjoy the smooth, seamless connection to keep life powered on, no matter what.
- Save money on bills with energy storage management systems.
- Award-winning: Cleantech Breakthrough Award for energy efficiency company of 2024 and UX Design Award-nominated mobile application.

**Anker SOLIX Solarbank 2 series: DIY solar and storage solution**

Just a few weeks ago, Anker SOLIX launched the latest iteration of its smart solar and storage solutions, the Solarbank 2 Series. The new Solarbank 2 Plus and Solarbank 2 Pro set new standards in terms of performance, efficiency and simplicity when utilising solar power. The focus model of the series -- the Solarbank 2 Pro -- is the world’s first 2,400-watt all-in-one balcony solar power station including storage solution and is equipped with four MPP trackers with 600W each, allowing a total of four solar modules to be connected in parallel for all directions. The inverter is directly integrated in both the Solarbank 2 Plus and the Pro version, meaning that no cables need to be laid. This makes the two Solarbank 2 models a genuine plug-and-play solution that can be set up easily by all users without any prior knowledge. Users can enjoy green energy anytime and anywhere, achieving independent power consumption in multiple scenarios.

**Anker SOLIX**

Leveraging its leading position in battery storage and power, Anker SOLIX is committed to developing energy solutions that enable energy independence for people around the world. These include modular, solar-powered battery storage systems for homes, solar-powered balcony solutions for apartments and a growing portfolio of portable power stations.

For more information about Anker SOLIX, visit anker.com/anker-solix
Anker SOLIX X1
Extreme Performance Energy Storage System

2000kWh+  5.9"  -25°C to 60°C
2000kWh+ More Power*  5.9" Ultra-Slim  Extreme Performance from
with Innovative Energy Optimizer  Humanized Design  -25°C to 60°C

*Based on a system containing 3 battery modules (15kWh) compared to traditional parallel batteries over 10 years.

LIVE IN POWER
@ankersolix.com

All images and specifications mentioned in this document are subject to change. For the most accurate product information, check the official Anker SOLIX release.
European PV manufacturing: where is it and what might it become?

Upstream | Multiple gigawatts of domestic PV manufacturing are needed in Europe to support the continent’s solar deployment targets and underpin future energy resilience. Will Norman reports on the pros and cons of ongoing efforts to reshore European manufacturing.

S omewhat belatedly, Europe has joined the global race to try and bring solar manufacturing in-house and claw back some of the industry from China’s dominance.

The European Parliament approved the Net Zero Industry Act (NZIA) in April with a collection of measures to support clean energy manufacturing on the continent. Shortly before this, the European Commission established the Solar Charter alongside trade bodies SolarPower Europe and the European Solar Manufacturing Council (ESMC) and representatives from the 27 EU member states.

Low module prices, high power prices and a lack of industry protection have combined to push the European solar manufacturing industry towards the brink of extinction. A number of significant companies have either paused their operations or abandoned their European facilities altogether – Meyer Burger, REC Group and Norsun are notable examples.

There were multiple calls for aid before any of those companies jumped ship – most vocally from the ESMC, whose members constitute the majority of significant non-Chinese manufacturers across the value chain. But it is not isolated to the ESMC. Dries Acke, deputy CEO of SolarPower Europe – whose members encompass major Chinese manufacturers and downstream developers – says: “There is no doubt that we need a European solar manufacturing supply chain.”

“It’s absolutely essential,” he tells PV Tech Power. “Solar manufacturing is a small industry in Europe for the moment, we are lucky to have at least one international player on the polysilicon side (Wacker Chemie), but besides that there is very little activity – especially in the ingots and wafers section.”

Acke says that the only real activity in Europe is in module assembly, which constitutes “just putting a frame around components that are imported from outside of Europe.”

Geopolitically, Acke says Europe “shouldn’t be naïve. It’s about resilience, and resilience is like a form of insurance – insurance against supply chain disruptions of any type, whether geopolitical like a conflict in China and Taiwan or practical, like a ship stuck in the Suez Canal.”

“Europe has to pay insurance on its energy transition.”

A revival in Europe’s PV manufacturing base is seen as essential to supporting decarbonisation and energy security goals

How much is enough?

In the current solar industry, nobody will be able to rely solely on domestic supply – not for sometime and perhaps not ever. The US has put the most political and financial weight behind building up its solar manufacturing industry, but it still relies overwhelmingly on imports from Southeast Asia, which are (mostly) made by Chinese companies.

The EU has an official target of 30GW of production capacity across the solar value chain by 2025, from polysilicon to modules. “I think it’s fair to say we’re far from that,” Acke says. But, echoing the statements made in SolarPower Europe’s market outlook report from last year, he says that 30GW would still be a good target to provide some useful resilience for European supply.

“What you need is scale – enough that you can scale up in case of a crisis. Having 1GW or 2GW of cell capacity is not going to cut it, you need somewhere around 10-15GW.”

Generating and sustaining operations at scale is perhaps the fundamental challenge that Europe faces. SolarPower Europe has calculated that support for this capacity would require around €8 billion (US$8.6 billion) over the next 10 years.

In addition to expanding new capacity, there is dormant capacity in the EU. In an interview with PV Tech online in March, the ESMC said that supporting these existing facilities – those that are left, at least – would save time and money in the EU’s efforts. It estimates around €800-850 million in opex support to account for the disparity in price between imported modules and those made in Europe and keep facilities afloat.

‘A middle way’

Europe is seeing some of the lowest module prices in the world. At the same time, global module supply is far in excess of demand. In April, PV Tech head of...
research Finlay Colville said that he foresaw “no barrier” for Chinese manufacturers importing into the EU and, subsequently, no real upswing in module prices on the horizon.

In 2023, Europe had over a year’s worth of module supply in storage after a huge influx of Chinese imports. Colville said that the lack of barriers to the market and the consistent oversupply would lead to a repeat situation this year.

Sustained low prices and oversupply raise the question of whether Europe can support a domestic supply chain without severely limiting imports. Though imperfect, the US – which has far more stringent import laws and subsequently higher prices – has so far managed to attract far more solar manufacturing investment than Europe.

In answer to this question, Acke says that Europe needs “a middle way”. “Resilience is the middle between what you could call naive global liberalism and nationally imposed protectionism,” he says. “We have to work on resilience, but we cannot have the pendulum swing in the direction of protectionism.”

He says the NZIA serves as this middle ground by introducing auctions with non-price criteria that reserve part of the procurement market for European products. Doing this “gives demand offtake flexibility to European solar manufacturers,” Acke says. “That’s what they’re struggling with today; EU solar manufacturers have stock that they can’t sell.”

Jochen Rentsch, head of technology transfer at German solar research centre Fraunhofer ISE, says similarly. He says that if one looks at the solar market purely from a capacity approach, then it makes no sense to build in Europe: “There is already overcapacity by at least a factor of two in each section of the value chain. But it’s unhealthy if an entire and quite decisive technology for future energy provision is only focused within one country.”

Rentsch advocates for “keeping the markets open” in the interest of maintaining overall deployment figures and not shutting the borders to China as the US has. At the time of writing, US president Joe Biden had announced a doubling of import tariffs on solar cells from 25% to 50% under the Section 301 tariff – this is a firm and decisive move (for good or ill) from a president who has already put more money into renewable energy manufacturing than any government outside China.

Instead of this, Rentsch advocates a “certain minimum share of locally produced modules to be more resilient”.

**Looking forward**

Plenty of work has been done to scope out the possibility of reviving the European PV manufacturing industry. Last year the German government funded the ‘Libertas’ project, an industry-led feasibility exercise aimed at scoping out what it would take to reestablish the full PV manufacturing “ecosystem” in Europe again. The study has been coordinated by the trade association VDMA, PV manufacturing services provider RCT Solutions and R&D institution ISC Konstanz.

Although the report is in the process of being finalised, PV Tech Power understands that the study has concluded that due to the higher costs of key inputs such as materials and labour in Europe, the difference in cost difference between PV equipment produced in a theoretical SGW ingot-to-module Topcon facility in Europe versus the equivalent in China is around €0.10 per watt.

The report will argue that to close this gap, some kind of initial support is required to help Europe’s PV manufactur-

ing industry back to its feet and achieve the economies of scale needed to compete on a global level.

One favoured means of providing this support is the aforementioned resilience auction concept gaining popularity in policy circles, which would encourage the procurement of locally made equipment and thus spur domestic production.

Beyond auctions, there are also import laws coming into force. As mentioned above, operations at scale are key to Europe’s ability to sustain meaningful manufacturing. Rentsch says that the price difference could be most effectively addressed through the EU’s Forced Labour Ban and Carbon Border Adjustment policies – things that would outlast direct financial support.

“What is more important [than direct, initial financing] in terms of EU regulation is the Forced Labour Ban. That might have an impact. The Chinese companies will definitely change their supply chain routes, which will have an impact on their side.”

The US’ import laws – namely the Uyghur Forced Labor Prevention Act (UFLPA) and antidumping/countervailing duty (AD/CVD) tariffs – succeeded in moving US solar supply from China to Southeast Asia, albeit with products from largely the same companies.

Rentsch also cites the EU’s Carbon Border Adjustment Mechanism and Ecodesign directive. The former applies prices to imported products based on the carbon footprint inherent in their production. He says that European solar modules are produced with a lower CO2 footprint than Chinese modules, which would benefit them in terms of price.

The Ecodesign directive sets mandatory ecological requirements for energy products sold in the 27 EU states. On paper, this also leads to preferential pricing and competitiveness for European modules.

‘Half-hearted’

But these policies might not be effective. The Forced Labour Ban will take three years before it comes into force, which is a long time in the PV industry, and Rentsch is critical of the current Ecodesign laws.

“What has been proposed so far on an EU level will lead completely in the wrong direction,” he says. Currently the Ecodesign Directive accounts for the “use-phase” of a solar module, Rentsch says – meaning the module’s deployment in a solar array. This means that Chinese-made modules, which are often larger with higher power outputs, perform more favourably despite often being manufactured with higher carbon footprints.

He says: “That, of course, needs to be changed; otherwise, it’s completely stupid.”

Despite the rhetoric coming from the industry, the Solar Charter agreement and the NZIA, there remains a sense that Europe has to stop dragging its feet if it is to reshore solar manufacturing. No direct, concrete financial commitments have been announced to back up the Solar Charter’s apparent response to the industry’s “very fragile situation”.

Dries Acke says the situation is “Frustrating. Because we see that the Commission is taking on technology-specific funds for other technologies.”

He said the Solar Charter shows political commitment, but “it’s still a bit half-hearted.” In his estimation, the Commission must “follow up on that signature.”

“It’s unhealthy if an entire and quite decisive technology for future energy provision is only focused within one country”
In its latest “EU Market Outlook” report, trade body SolarPower Europe hailed the “outstanding performance” of the European solar sector in recent years. Authors Walburga Hemetsberger, Dries Acke and Michael Schmela praised European investors and lawmakers for starting to realise the “immense potential” of solar by connecting 56GW of new solar capacity in 2023.

However, the report’s authors also describe the coming years as a “critical juncture” for the European solar sector, calling for a greater rate of new capacity additions and an expansion of national climate targets. They warned that with recent energy price pressures easing and a host of potential roadblocks on the horizon, EU policymakers needed to “step up now” to maintain the investor-friendliness of solar PV in Europe and ensure the sector’s ongoing growth.

Some of the financial insecurities affecting Europe as a whole are among the key obstacles to greater solar deployment across Europe. The scale of investment required to meet Europe’s clean energy targets is huge, with the latest figures from Bloomberg New Energy Finance (BNEF) suggesting that Europe will need to mobilise US$332 trillion of new investment to deliver a net-zero economy by 2050.

This is to say nothing of the macro-economic factors that have dissuaded investment in solar in recent years. These include inflation, which reached a peak of 12% in Europe in 2022, and tumbling energy prices, which fell by as much as 80% in the third quarter of 2023 in some European countries, according to the European Commission (EC).

As a result, there is a great need for European solar financing, with private capital likely to be an integral component of meeting the continent’s climate change goals. Perhaps to Europe’s advantage, the presence of the EU as a singular lawmaking body means that legislation can be deployed and regulations standardised to encourage investment.

“The good thing that Europe is doing, and should do and will do more and more, is to provide a bit of visibility on the investor conditions in Europe as a whole [such as] warranties, certain permitting times [and] certain grid connection times,” explains Naomi Chevillard, head of regulatory affairs at SolarPower Europe.

“Also to make sure that the basic rules for grid connections of projects are the same across Europe,” continues Chevillard. “Europe is going into quite technical legislation [and the EU needs] to ensure that we have more or less the same rules across Europe.”

Market mechanisms

Across Europe, the capital requirements of solar PV are well-documented, with SolarPower Europe estimating that more than three-quarters of the price of a solar electron is tied up in capital costs and “directly impacted by rising cost of materials”. The body also notes that macro-economic factors, such as the European Central Bank’s (ECB’s) raising of interest rates to more than 4% has a bearing on the perceived riskiness of an investment.

Chevillard argues that it is those organisations operating on a continent-spanning scale that could be uniquely positioned to help minimise spiralling capex and ensure investor confidence in European solar.

“What’s very important is the role of the EU to maintain stability and investor certainty and avoid [undoing] support schemes,” says Chevillard. “It was quite tough to do that in the energy crisis that we just had. We have member states that wanted to completely change the rules of the energy market and it didn’t happen.

“For me that’s quite a big achievement for Europe to have managed to keep everyone together despite the tensions.”

Chevillard, for instance, suggests that the European Investment Bank (EIB), which aims to deploy €65 billion (US$70.3 billion) of funds across Europe this year, could provide guarantees to banks that invest in solar projects, to help de-risk these investments.

There is a range of continent-scale systems and mechanisms in place to encourage more investment in the European solar sector and minimise the risks.
associated with those investments. Last summer, updates made to the EU member states’ National Energy and Climate Plans (NECPs) raised the EU’s solar installation target by 90GW, with EU members now aiming to install 335GW of solar capacity by the end of the decade.

Are we investor-friendly?

“Are we investor-friendly?” asks Chevillard, addressing the fundamental question for prospective European solar investors. “Just look at our track record in the way the market has grown quite a lot in the past year, so it means that yes, there is an interest, but we need to maintain that environment, especially because we’ll probably run into challenges in the future.”

Describing European solar as an investor-friendly environment, but one that faces questions if it is to maintain its level of investor appetite, is apt. These uncertainties are exacerbated by the range of individual markets across the continent; while the EU can help to standardise the processes involved in project finance and development, the range in maturity of national markets and disparities in different jurisdictions means creating a single investing framework for a bloc of 27 countries is a challenge.

“Investors need a higher return for solar projects [in less mature markets] than in boring, low-risk markets like Germany and China,” explains BNEF analyst Jenny Chase. “This higher return pushes up the required price in the power contracts and makes them less attractive.”

This phenomenon is evident in some of the smaller European solar markets, where private, subsidy-free investment is often lacking, compared to some of the larger markets. According to SolarPower Europe, Czechia was a gigawatt-scale market in 2023, for the first time since 2010, but much of the recent growth was driven by heavily subsidised distributed solar schemes. In the first half of 2023, 45,000 new solar projects were commissioned, with 95% of them boasting capacities below 10kW.

While this has been a boon for the distributed solar sector, there are questions about the ability of utility-scale solar to expand in these conditions. The SolarPower Europe report notes that, in stark contrast to the plethora of rooftop projects commissioned, in the first half of 2023, just 2,350 projects were completed with a scale between 10kW and 1MW, while a mere 13 projects with a capacity of larger than 1MW were commissioned.

Boxout: Skills, permits and supply chains

SolarPower Europe has called on the EU to make a number of policy changes to encourage further investment, including growing a pool of certified and skilled workers. The trade body expects the European solar sector to employ 1.2 million people by 2027, around double the 648,000 that were employed in 2022, and calls on national governments to “amend our education systems and launch communication campaigns” to better prepare people for working in the solar industry.

Sonia Dunlop, CEO of the Global Solar Council, suggests that the EU could be uniquely positioned to help push through some of these reforms, which she notes affect financial decision-making across the global solar sector, to create a unified system of qualifications across Europe.

“When an investor invests in a project, they need to make sure that all the people building that solar farm, or building that solar rooftop, are adequately trained and gone through the different health and safety processes and so on,” says Dunlop. “At the moment each project developer has its own in-house training and safety skills courses, and so the investor, as I understand it, has to go and check each one of those individually.”

SolarPower Europe has also called for simpler permitting processes to accelerate the installation of new solar power projects. The group praised implementation of the RES Booster package last year, which sought to fast-track renewable installations, but noted that more than half of the EU members are yet to designate renewables as important enough to “override public interest”.

Chevillard goes a step further and suggests that European power regulation as a whole is too slow-moving to be truly effective with regard to integrating rapidly changing renewable technologies, such as solar.

“I think in Europe, we have an issue with innovation in regulation,” Chevillard says. “We have to change the whole architecture whenever there is a new technology, and we have difficulties in [welcoming] innovations, where they don’t fully fit in the regulatory framework.”

The trade body also acknowledges improvements that must be made on a national level, which will require the involvement of specific governments, not just the EU as a whole. It points to the example of Germany, which has struggled to generate interest in building a 10GW German solar manufacturing supply chain, as an opportunity for national governments to consider new financial incentives and offer greater direct government support, for such upstream parts of the solar supply chain.

Growing the pool of skilled labour is one way the EU can maintain its investor-friendliness

Improving investment conditions

When asked about how Europe can go about improving its attractiveness to would-be investors, Chevillard says: “The first one is tackling inflation. The EU, for example, is going to propose guidance on how to do auctions and how to adapt the price in auctions to inflation, so there are actions being taken.”

In May, the EC published new guidance on permitting and renewable installations, calling for an acceleration of the permitting process for the renewables sector as a whole. The new guidelines have particular benefits for the solar sector, as the commission recommends fast-tracking the permitting processes for projects involving community ownership, such as community-owned solar.

Chase also calls on national governments to invest more heavily in grid infrastructure to help minimise the impacts of delayed grid connections, which can discourage investment in new solar projects as would-be investors are sceptical that the project will make a return on investment promptly.

“I am more concerned that there is a lack of investment in new grid, which is needed to support the energy transition,” says Chase. “BNEF estimates that about as many dollars will need to be invested in grid as in solar and wind farms, to set the world on a net zero pathway for 2050.”

Figures from the EC, published last November, suggest that Europe’s power grids will need an additional €584 billion (US$631.9 billion) in investment by 2030 if the grids are to support the vast quantities of solar capacity organisations including SolarPower Europe hope to be brought online. Consequently, it is not only European solar that could be in need of continued investment, but European solar, grids and adjacent clean energy technologies.
Europe’s power grids are under the spotlight like never before, having emerged as a key bottleneck in the energy transition, which is rapidly gaining pace. Clean technologies are being added to the grid at record rates, with both wind and solar additions breaking records in 2023. This acceleration began with the EU Green Deal, which significantly raised ambition. Further urgency was injected by Russia’s invasion of Ukraine and the subsequent rush to find alternatives to costly fossil gas. Simultaneous to these events, the economics of renewables and other clean technologies are ever improving. This combination of factors explains why the demands placed on Europe’s grid infrastructure have escalated so dramatically.

The road ahead doesn’t look easy: the European Commission expects electricity consumption to increase 60% by 2030, by which time the power mix should be roughly 70% renewables, up from 44% in 2023. This cleaner, expanded power system is expected to meet more than 50% of the EU’s total energy demand, even as early as 2040. Put simply, the electricity network will be at the heart of Europe’s future energy system. With the energy transition already in full swing, all of the processes shaping Europe’s power grids need to quickly shift from a mode of incremental changes to a new era of rapid expansion and modernisation that could last decades.

Grid connection delays are already commonly cited as the top barrier to deploying new wind and solar power – the drivers of Europe’s energy transition. Furthermore, curtailment of renewable generation is increasing, wasting cheap power and potentially harming the case for new investments. The present grid challenges have their origins in decades of under-investment in ageing grid infrastructure, linked to persistent underestimation of renewable energy growth, which is now coming home to roost. What we’re left with is a grid that is unprepared to deliver power from the best renewable locations to our economic centres.

The IEA used its first major analysis of power grids last year to send a warning to Europe: failure to develop grids quickly will not only result in higher carbon emissions but also continued dependence on fossil gas. In that sense, grids represent a critical piece in Europe’s security puzzle. It has also repeatedly been shown that by enabling a more integrated European electricity market, grids create efficiencies that ultimately save consumers money.

Arguably the most important roles in this critical project belong to Europe’s Transmission and Distribution System Operators (TSOs and DSOs for short). They are the technical enablers of the energy transition,
responsible for planning and executing the necessary grid enhancements. But there are important roles for others, too, from regulators to policymakers; all parties need to pull together to tackle the problems urgently.

In the rest of this piece, I will discuss five key challenges for Europe’s grids, before discussing some of the solutions that have been proposed, including by Ember’s own research. Those challenge areas are: grid connections, planning and oversight, permitting, transparency and collaboration, and investments.

The challenge
Grid connections
The simple fact is that many more assets are trying to connect to the grid in a much shorter time than ever before. The situation has exposed our current processes – which may have worked in yesterday’s world of fewer, larger, less frequent connection requests – as cumbersome and inefficient.

While data on grid connection queues is scarce, the few available numbers are eye-watering. According to Wind Europe, at least 100GW of renewables projects are waiting for grid connection in Spain, with more than 50GW in Romania and 40GW in Bulgaria. While it should be noted that many of these projects will be somewhat speculative, the numbers far exceed the operational capacities in these countries.

SolarPower Europe reports that the average lead time to connect ground-mounted PV projects can go up to eight years, with an average of around four years. Even small PV can take up to a year to connect. Grid connection times are even longer for wind projects, such that WindEurope now cites these delays as the top barrier to accelerating roll-out. Just last month, the Netherlands announced a one-year delay in reaching its target of 21GW offshore wind due to grid connection delays.

Grid connection rules are complicated, often unclear and highly non-uniform across member states. Compounding this is a lack of administrative capacity to help developers navigate the bureaucratic labyrinth. Paper documentation is still central to parts of the process in many member states, which is scarcely believable in the 21st century.

Planning and oversight
Moving on to my second challenge, a historic failure of planning is one of the reasons for the connection bottleneck and shortage of grid capacity. At the risk of sounding trite, the best time to plan for a highly renewable and electrified energy system was 10 years ago, but the second best time is today. Transmission system planning at the national level is typically conducted on a two-year cycle with a 10-year outlook. In theory these plans feed into the Europe-level 10-year planning process orchestrated by the network of system operators (ENTSO-E), which evaluates interconnection needs.

However, Ember’s research highlights a fundamental problem: national grid plans frequently lag behind the latest national energy targets, which in turn lag behind EU energy targets (due to delayed transition), which in turn lag behind the reality of the accelerating energy transition. The result of this cascading delay is that grid plans are always playing catch-up to the latest ambition and the real economy. This is exactly the opposite of what should be happening – networks should enable, not limit, the expansion of clean energy.

One of the key buzzwords around grids at the moment is ‘anticipatory’ investments. This is the idea that grid capacity can be built in anticipation of its being needed. Bringing this concept to reality was a key theme of the EU Action Plan for Grids (EU APG), and it is desperately needed. Anticipatory planning is imperative for anticipatory investments, as you cannot proactively build infrastructures without bold and forward-looking planning.

It would be unfair to lay too much of the blame for this with TSOs or DSOs. In many ways they are limited in what they can plan for by the regulatory framework. Furthermore, oversight of development plans by national regulators remains largely limited to financial implications, ignoring the question of whether the planned infrastructure is sufficient to deliver on energy and climate goals.
Permitting
My third challenge area is grid permitting. We have heard a lot about the permitting of new generation projects, but slow permitting of grid projects is also an important blockage. As well as the time taken to permit new grid capacity, there are also efficiencies to be gained in the sequencing. For a new project, it is currently common for the generation part and the grid part (if necessary) to go through permitting one after the other. The EU DSO Entity has, sensibly, called for these to be conducted in parallel where possible. This would, however, require better cooperation and communication between project sponsors and local grid operators, which brings me to the next challenge.

Transparency and communication
Communication between all actors involved in building grids and connecting renewables is insufficient. Grid users lack information on where they are likely to obtain a timely grid connection, helping them to plan projects in greater harmony with the existing grid. Many DSOs produce so-called ‘hosting capacity maps’ with this information, but there is a great variation in content and quality across Europe’s 2500 DSOs. Simultaneously, DSOs are often not informed as early as they could be about new assets wanting to connect to the grid. Greater openness and willingness to collaborate is needed both ways.

The issue of poor communication is not helped by a lack of data transparency around grids. Official permitting and connection data are not made available by public administrations. TSOs and DSOs do not collaborate closely enough on data exchange, nor is data exchange sufficient between them and grid users. The resulting lack of data exacerbates several problems.

Firstly, the debate as a whole is starved of information, which these grid improvements would help them between regions and member states, efforts should be made to standardise and clarify and streamline grid connection rules. Governments and system operators must therefore change, broadly moving from the widespread “first come, first served” system to “first ready, first served”. Projects could also be clustered for the purposes of assessment. Furthermore, connection management processes need to be optimised, primarily through digitalisation. These would be major steps towards reducing complexity for renewables developers and investors.

Grid connections
Grid connections are large infrastructure players who know how to handle capital-intensive projects. The problem is the framework in which they operate doesn’t yet incentivise the right volume or types of investment, and access to finance is becoming a problem. Investments have been slow to pick up, especially in Central and Eastern Europe, where the available EU funds (for example, the Modernisation Fund) have also been under-used for electricity grids. Under the current model, grid operators recoup their costs through tariffs, but a reluctance by regulators to allow higher tariffs has limited investment. The share of tariffs allocated to grid costs has even decreased in some countries.

As well as sluggish capital investment, there are insufficient incentives for the uptake technologies that would improve the operation of the grid, such as smart grids, network efficiency and innovative technology. This is because system operators are typically remunerated based on their capital expenditure, with little consideration for their operational expenditures, which these grid improvements would help to minimise.

The solutions
The solutions to the above challenges are being debated at the highest political levels. The problem and its solutions are so cross-cutting, from finance to planning to skills, that it is vital to sustain this political attention. Improvements need to be made across all processes and rules that dictate not only what gets built, but also why, when, and how.

Grid connections
Governments and system operators must clarify and streamline grid connection rules. The way connection requests are assessed also needs to change, broadly moving from the widespread “first come, first served” system to “first ready, first served”. Projects could also be clustered for the purposes of assessment. Furthermore, connection management processes need to be optimised, primarily through digitalisation. These would be major steps towards reducing grid queues and achieving faster, more efficient integration of assets. Alongside these changes to rules and processes, efforts should be made to standardise them between regions and member states, reducing complexity for renewables developers and investors.

All this should be done without forgetting the rights of energy communities, who play a key role in the energy transition.
but often lack the resources to compete for grid capacity. Good practice would be to prioritise community energy projects or reserve grid capacity for their use. The EU APG proposes another important solution, instructing national regulators to provide a clear framework to discourage connection applications by unsubstantiated projects, which can block useful grid capacity for years.

Planning and oversight
When it comes to grid planning, longer-term perspectives are needed. Plans need to consider Europe’s 2030 (REPowerEU) and 2040 targets (when agreed), and the shared 2050 climate neutrality goal. Some TSOs already look beyond the mandatory 10-year horizon. The Dutch TSO publishes a ‘target grid’ for 2045. German TSOs publish outlooks to 2037 and 2045 (Germany’s net-zero date).

While it’s true that longer outlooks are less certain, only by taking such perspectives can TSOs understand the need for anticipatory investments and achieve timely execution of large projects that can take a decade or more.

Planning at the distribution level is subject to even less scrutiny than the transmission level. To address this, the EU DSO Entity is instructed by the AGP to support DSO grid planning by mapping the existence and characteristics of distribution development plans. National regulators are also encouraged to provide guidance to DSOs on planning and promote consistency among plans. This is a good start, but we need much stronger assurances and guarantees that these sub-national plans will be fit for purpose. The end goal should be high-quality plans that are aligned and consistent across voltage levels as well as regions and member states, and which are fully compatible with Europe’s climate and energy targets.

We also need more forward-looking regulation, allowing more risk when it comes to grid planning and investments, but without totally transferring this risk to end consumers. We must not forget that limiting development to current system needs may increase future system costs more than over-investing. At the level of cross-border interconnection, oversight is provided by ENTSO-E and ACER, who do consider energy and climate goals in the planning process. How can we embed the same considerations into the way national and sub-national systems are planned? The introduction of a net-zero mandate for national regulators is one way of achieving this.

Permitting
The revised Renewable Energy Directive aims to accelerate permitting of both generation and grid. Member states can optionally designate ‘dedicated infrastructure areas’ – similar to the much-discussed ‘renewables acceleration areas’ – where grids and storage infrastructures can benefit from more streamlined environmental assessments. This could accelerate grid build-out significantly, but timely implementation at the national level will be key. The APG commits the Commission to providing specific guidance on dedicated infrastructure areas by mid-2025. In the meantime, member states should look to do whatever they can to accelerate the authorisation and permit granting processes, without undue harm to the environment or exclusion of the citizens.

Transparency and communication
A quick win for data transparency would be the publication of regular data on congestion, curtailment and available grid capacity. This would lead to improved understanding of grid conditions for all potential grid users, steering development towards available capacity and focusing solutions on problematic areas. In turn, potential grid users should provide data on their projects to DSOs at an early stage, helping them plan and understand future grid needs.

Better cooperation between TSOs and DSOs is required for active system management as the traditional one-way power system becomes a more distributed ‘two-way’ system. This should help both to realise the coordinated use of distributed flexibility, which in turn could reduce the need for new grid investments. Regional collaboration is also important, especially among Central and Eastern European Member States where interconnection is relatively low. Shared capital investment for interconnection capacity across multiple governments, and more coordinated planning, could help this region reach EU interconnection targets.

Investment
Finally on investments, one of the most significant things provided by the EU APG is the promise of guidelines on anticipatory investments. This cannot come soon enough.

The plan also promises new financial instruments for grid investment. However, it’s not just about making money available. More needs to be done to promote the use and facilitate access to these funds, especially for the distribution grid.

Beyond tinkering with the current system, we need a deeper re-think of the value provided by electricity grids and who pays for them, especially as we enter a more electrified world with the power system at the heart of Europe’s energy system. Such a re-think presents opportunities to connect the way we develop grids to how we address more structural problems such as energy poverty, and how to incentivise electrification in a just way. Future energy bills will be increasingly linked to interest rates due to the capital-intensive nature of the energy transition, including investments in grids. In this context, and considering the wider societal benefits that clean energy brings, we should be questioning whether electricity bills are the best way to pay for grid upgrades going forward.

Conclusion
There’s no doubt that significant progress has been made in the last 12 months in our collective understanding of Europe’s grid problem and solutions. The case for continued focus is strong. According to Eurelectric, around 90% of future grid investments could be captured by EU companies, delivering economic benefits to all regions of Europe. The speed of change is also possible, given the political will. The project to decouple the Baltic states from Russia’s power system is inspirational. Already an ambitious project, involving construction or reconstruction of over 1,200 km of high-voltage lines, the deadline was brought forward following Russia’s invasion of Ukraine. This shows that complex grid projects can move rapidly with enough political will and support in place.

This is the spirit that policymakers, regulators, grid operators and administrators alike need to adopt. The shape of our future energy system will be defined by the grid - we need to ensure it can support the sustainable, electrified, resilient, and people-centred energy system that Europe needs.

Authors
Chris Rosslowe is a senior energy and climate data analyst at Ember. He uses future energy scenarios to provide insight and guide policy-making for the energy transition. Chris’ recent work focuses on the barriers and enablers of wind and solar power, as the key technologies that will deliver a clean energy system for Europe.

www.pv-tech.org | May 2024 | 45
In 2023, the Chinese photovoltaic industry delivered results that far exceeded expectations. According to official figures, China saw the annual addition of approximately 216.88GW of PV capacity in 2023. But perhaps even more striking was the addition of over 96GW in distributed PV installations, which became a highlight and set a new historical record.

Over the last three years, China has witnessed explosive growth in added PV capacity, particularly in the distributed PV sector. Data from the National Energy Administration shows that in 2021, China's distributed PV installations for the first time surpassed centralised PV installations, with new installations reaching 29.28GW, making up about 55% of all new PV installations for the year.

In 2022, distributed PV installations saw significant growth, reaching 51.11GW; and in 2023, new distributed PV installations soared to 96.29GW, an 88% increase year-over-year. The data on installations shows that the annual growth in capacity has consistently exceeded 70%, with the 2023 increase nearing 90%. By the end of 2023, China’s cumulative distributed PV installations hit 254GW, accounting for 42% of total PV capacity, marking an impressive achievement.

Market boom spurs competition and innovation

The recent surge in distributed PV in China not only brought about a vast market and substantial performance but also opened up a lot of room for imagination for 2024 and beyond, attracting an increasing number of PV companies to compete in what has become a highly competitive space.

Leading PV companies are increasingly focusing on the distributed market, rolling out new products, technologies and innovative service solutions tailored for this market.

Trina Solar led the way with its 210R rectangular silicon wafer combined with n-type TOPCon technology modules, adopting a strategy under the slogan, “700W+ on the roof, integrating PV and storage for new scenarios”, which has been well-received in the commercial and industrial PV market.

In October 2023, LONGi Green Energy introduced a distributed product, the Hi-MO X6 high-efficiency anti-dust PV module, targeting the industry pain point of dust affecting power generation performance. Notably, LONGi wasn’t the only one to launch anti-dust modules; GCL had previously introduced similar products.

Meanwhile, JA Solar launched its DeepBlue 4.0 Pro series for the distributed PV market, incorporating multiple quality and efficiency-enhancing technologies. The distributed PV market has hit a development sweet spot, and string inverters have greatly benefited. Inverter companies such as Sungrow, Huawei, Ginlong, GoodWe and APsystems are active in this field, with each company seeing rapid growth in performance.

Additionally, PV brand merchants are not only focusing on product innovation but also increasingly emphasising their service capabilities for distributed customers, gradually shifting from a manufacturing mindset to a service-oriented approach.
On the operational and maintenance challenges of distributed power stations, CHINT Anneng’s household PV maintenance brand “Xiao’an to Home” has integrated big data and PV maintenance through a smart cloud platform, managing the entire process from roof survey and installation, to post-installation monitoring and maintenance online. Users can access power generation and fault troubleshooting information through the app.

Another notable brand, Skyworth PV, introduced the innovative BiPV product “Xiao Yang Lou” for household PV, integrating PV panels with rooftop architecture, suitable for self-built villas and cast-in-place flat roofs, effectively adding a free layer to buildings, enhancing their value and generating income for users through electricity production.

Challenges in grid connection and consumption

While the distributed PV sector is booming, problems associated with rapid development are beginning to emerge, especially as this market’s installations become a significant part of China’s new PV installations. The difficulties of grid connection and consumption have become pressing issues.

By the end of 2023, several provinces and cities announced that there was no additional capacity for new distributed PV connections. Provinces such as Shandong, Heilongjiang, Henan, Guangdong, Fujian, Hebei, Inner Mongolia, Hubei, Liaoning, Guangxi and Jiangxi faced issues with distribution grid capacity reaching saturation or warning levels.

Interestingly, these regions were among the top contributors to China’s distributed PV installations in recent years. According to Energy Administration data, in 2023, Henan province led the distributed PV addition rankings with 13.89GW, followed by Jiangsu with 12.17GW and Shandong with 10.13GW in distributed PV additions.

Faced with grid capacity crises, these provinces had no choice but to temporarily halt the filing of distributed PV projects, making grid-connected power generation one of the major complaint areas in the new energy and renewable energy sector in 2023.

Gao Jifan, chairman of Trina Solar, points out: “Alongside rapid development, issues such as power consumption, and the temporal and spatial mismatch between new energy and electricity demand are becoming increasingly prominent.”

Gao believes that power consumption challenges could limit the large-scale sustainable development of domestic new energy. “Large centralised PV plants are constrained by ultra-high voltage transmission limits, leading to insufficient room for further development. In the case of distributed PV, provinces such as Henan and Shandong have sequentially issued consumption warning risks, significantly dampening the growth expectations and enthusiasm for the distributed PV market.”

Xiaobin Zhang, vice president and secretary-general of the Shandong Solar Energy Industry Association, notes: “From the perspective of distributed PV generation and grid connection, the rapid pace of PV installations is outstripping the capacity for grid expansion and line construction. When investments and costs in PV plants have not yet returned to a rational range, it can be detrimental to the healthy development of the industry.”

Zhong Baoshen, chairman of LONGi Green Energy, also highlights in an interview that both rural household distributed PV and urban commercial and industrial distributed PV are developing rapidly but are facing consumption challenges.

“For example, some logistics and storage companies in cities have large rooftop spaces but minimal electricity needs, making it difficult to feed surplus electricity back to the grid, and thus preventing full utilisation of rooftops for PV installations.”

Zhong suggests that considering the temporal and geographical distribution of electric loads in rural areas, after the rural grids are upgraded, local PV electricity consumption should be transmitted to higher-level grids, at least up to the county or city level.

Multiple measures to enhance grid capacity

It’s noted that in addressing the challenges of new energy consumption, governments, businesses and consumers have been collaboratively strategising solutions.

According to the “Guidelines for High-Quality Development of the Distribution Network under New Circumstances” (hereinafter referred to as “the guidelines”) issued in early February 2024 by China’s National Development and Reform Commission and the National Energy Administration, by 2025, the distribution network’s carrying capacity and flexibility are expected to significantly improve, with about 500 million kilowatts of distributed new energy and approximately 12 million charging piles capable of being connected.

The digital transformation of the distribution network will be comprehensively advanced and the smart control and operation system will be rapidly upgraded. By 2030, the transformation towards a flexible, intelligent and digital distribution network should be fundamentally completed, effectively promoting the integrated development of distributed smart grids with the larger grid.

“The guidelines focus on addressing the new energy consumption issue, with enhancing the grid’s carrying capacity being one of the key points. With the application of appropriate energy storage and long-duration energy storage in the future, the construction and operation of distributed PV are expected to break through development bottlenecks.”

A March 2024 report from China Development Bank Securities stated.

The guidelines propose that, in line with the development goals of distributed new energy, targeted strengthening of the distribution network’s construction is necessary, along with improving the means to ensure stable grid operation and energy quality. It’s important to coordinate the capacity of the distribution network, load growth, and regulation resources, systematically conduct new energy grid connection impact analyses, assess the carrying capacity of the distribution network, establish mechanisms for announcing and warning of new energy capacity that can be accommodated, and guide the scientific layout, orderly development, nearby connection, and local consumption of distributed new energy.

Gao Jifan believes that promoting a new energy installation model that synergises PV and storage can effectively solve grid absorption pressures and break through PV installation bottlenecks, opening up the market’s potential and becoming a key to the next phase of new energy development.

In this regard, a research report from CITIC Securities predicts that if domestic PV consumption bottlenecks are addressed, it could significantly expand the space for new PV installations in China, coupled with a bottoming out of module prices, potentially boosting the willingness to install downstream. The demand for PV installations in China in 2024 is expected to exceed expectations, with the annual growth rate revised upwards to 20-30%; the total new PV installations for the year are expected to reach 260GW to 280GW (previously projected at 230GW for 2024).
Currently, utility-scale PV solutions mainly rely on traditional centralised inverter solutions and string inverter solutions. Compared to centralised solutions, the string inverter is superior in the following aspects: 1) smaller power units mean less outage loss; 2) more MPP tracking = longer generation time and more adaptability for complex environments; 3) OPEX is lower; 4) greater flexibility in product iteration and plant designing.

CHINT power system (CPS) is a professional PV products and solutions provider founded in 2009. It is mainly focusing on PV inverters and integrated solutions, from 5kW to 350kW and both single-phase and three-phase string inverters. Topping in market share for 3-phase string inverters in US since 2015 and market share for PV inverter in Korea since 2020.

The CPS 350kW series is designed for environmental adaptation. It does not have any de-rating at 350kW@45ºC ambient temperature, offering significant benefits for PV power plant design. Some technical details as follows:

- MPPT: 12 or 15(2/MPPT)
- Max. DC current per MPPT: 40A
- Max. AC Power: 352kVA

**Resistant to high temperatures, less de-rating, higher generation**

The physical property of a PN junction dictates that current decreases as temperature increases. Therefore, as a component operates over an extended period and the environmental temperature rises, its own temperature will become higher, which will lead to a reduction in output. The CPS inverters start to derate at 350KVA@45ºC, which is far superior to common competitors in the market, leading to higher generation and more profit.

This figure illustrates the power generation of an inverter over a certain period of time in a typical scenario. Zone 2 indicates the generation of the inverter with a common derate restriction, while zone 1 indicates the extra generation that can be obtained by installing the CPS 350KW series inverters. As a result of the high compatibility of ambient temperature, the total generation of CPS 350kW series inverter solution can be obtained with a maximum value of zone 1 plus zone 2, as shown in the figure. According to the field measurement, the Max. generation can be increased by 0.2~1.1%; this reference PV farm is located in Gansu province in north and west China.

**Highly efficient cooling, high service lifetime**

Due to the features of large power transmission and high integration, utility-scale inverters are confronted with extremely challenging heat dissipation problems. The CPS 350kW series inverter is equipped with self-developed high-efficiency heat exchanger, with internal and external forced air cooling. By ensuring a superior heat dissipation of power modules, the junction temperature of IGBT can be maintained at a low level, leading to a significant increase in lifetime to 55% operated time.

**Adaptable and versatile for cabling**

In order to adapt to the complex wiring needs in the international context, the product is equipped with a compatible one-piece feed-through cabling panel, which is wrapped with TPE material on the outside to ensure waterproofing and dustproofing when accessing single-core or multi-core cables.

The internal terminal blocks of the wiring box panel are made of copper-aluminium alloy, which is compatible with direct access of copper or aluminium wires. By alloying copper and aluminium, the problem of primary cell between copper and aluminium is avoided, leading to a reduction in costs. The terminal blocks of the CPS 350kW series inverter meet the standard of UL 1509.

Overall, the CPS 350kW series inverter demonstrates high compatibility and stability under multiple extreme situations of utility-scale PV plants.

More detailed information or reports can be obtained from solution@chint.com
Enduring High Temperatures
The temperature of rated output power is up to 45°C

Inverter 333/350kW

CONTACT
E-mail: salesgroup@chint.com

Intersolar Europe
Booth NO. A1.260
June 19-21, 2024, Munich, Germany
India marches on towards 2032 solar goals

Market update | Despite India’s ambitious solar targets, challenges remain on policy, financing and grid infrastructure. Simon Yuen talks to experts in the solar industry to examine the challenges and opportunities in the Indian market.

The Indian government has set an ambitious target of installing 500GW of renewables by 2030. Currently, the country aims to increase solar’s share in its power mix from 5% in FY 2022 to 17% by FY 2027 and to 25% by FY 2032. According to its 14th National Electricity Plan (NEP14), India plans to achieve 185.6GW of solar capacity by 2027, reaching 364.6GW by 2032.

However, India only added 12.9GW of solar capacity in 2023. The latest figures for clean power capacity additions from the Indian Ministry of New and Renewable Energy (MNRE) show the country added 15GW of new solar capacity in the 12 months to the end of March 2024. These installations have pushed India’s total operating solar capacity to 81.8GW as of March 2024. Of this capacity, solar PV and solar-plus-wind projects accounted for 7,393MW and 2,140MW respectively. The remaining capacity was from wind projects.

A major solar PV project from Adani Green Energy that started operation this year is a 551MW solar project in Gujarat, India. It is also part of a plan to build a 30GW renewable energy park located in Khavda, a village in the Kutch district of Gujarat.

Meanwhile, the state-owned Solar Energy Corporation of India (SECI) allocated 1.5GW of solar capacity in a recent tender, with four businesses winning the bid at an average price of INR2.56 (US$0.031) per kWh. JSW Neo Energy secured the highest share of 700MW, followed by Sunsure Solarpark Fourteen (300MW), Tejorupa Renewables India Project (250MW) and NTPC Renewable Energy (250MW).

Federal and state-level policies

Policies play a crucial role in driving India’s solar sector growth. At the national level, Renewable Purchase Obligations (ROPs) are “driving a guaranteed market for solar power producers”, according to Naqvi, as the obligation to consume power generated by renewables could boost clean power auctions, while distribution companies will be pushed to sign off-take agreements.
RPOs are mandates set by the Indian government to ensure a certain percentage of electricity consumption comes from renewables. These obligations are imposed on entities responsible for the distribution, transmission and trading of electricity. Distribution companies (DISCOMs) and open-access consumers are some of the entities to which PROs apply.

Meanwhile, Vibhuti Garg, director of South Asia at the Institute for Energy Economics and Financial Analysis (IEEEFA), says the Indian government’s targets of 175GW of renewables by 2022 and 500GW of renewables capacity by 2030 are driving multiple policies and fiscal initiatives to support solar capacity deployment in the country.

One example is the PM-Kusum scheme, which aims to ensure energy security for farmers in India. Under this scheme, 10GW of decentralised grid-connected renewables power plants, ranging from 500kW to 2MW, are set up on barren land.

The renewables projects are installed within a 5km radius of the substations to avoid the high cost of sub-transmission lines and reduce transmission losses. Local DISCOMs will purchase the generated electricity at a pre-fixed tariff.

Financially, India’s Central Electricity Regulatory Commission (CERC) amended the sharing of inter-state transmission charges in 2023 to waive interstate transmission system charges for renewables projects commissioned by 30 June 2025, which could lower the cost of renewables in India.

In some states, the governments have taken different measures to increase solar installation capacity. According to Ember, Gujarat and Karnataka are well prepared to continue the electricity transition and have integrated renewables into their power sectors.

In collaboration with the IEEFA, Ember’s report “Indian States Electricity Transition (SET) 2024” examines 21 Indian states to help identify areas that require action and attention at state levels. Three electricity transition dimensions are included in the report: decarbonisation, readiness and performance of the power ecosystem and market enablers.

Gujarat and Karnataka are the only Indian states that have become top performers across all dimensions. In the market enable category, Karnataka boasts a competitive incremental green tariff rate of INR0.5 (US$0.006) per kWh, an existing renewable energy policy applicable until 2027, and the adoption of green open access rules.

Karnataka also leads with a high number of electric vehicle (EV) public charging stations, boasting one station per 62 EVs as of January 2024. The state also surpasses Delhi and Maharashtra with 5,059 public EV charging stations.

Gujarat is one of the “frontrunners” with functional state renewable energy policies, and its green tariff rate (INR1.5 per kWh) is the highest among all states.

Challenges of reaching India’s renewables goal

However, meeting the renewables goal requires more effort from the government and the renewables sector.

Vinay Rustagi, senior director and global head of renewables at Indian analyst firm Crisol, says: “The utilities are increasingly concerned with how much renewable power they can absorb into the grid because of its variability profile.”

The Indian government plans to augment the transmission network. In the Indian power ministry study, “Transmission System for Integration of over 500GW RE Capacity by 2030”, the Indian government presents a transmission system roadmap for reliable integration of 537GW renewable energy capacity by 2030.

The transmission schemes have been planned with battery energy storage systems (BESS) to meet the requirement for round-the-clock power. Several high-voltage direct current (HVDC) transmission corridors have also been planned for the evacuation of power from large renewable energy potential zones.

Moreover, the length of the transmission lines and substation capacity planned under the Inter State Transmission System (ISTS) for the integration of additional wind and solar capacity by 2030 has been estimated at 50,890 circuit kilometres and 433,575MVA (mega volt-ampere) respectively at an estimated cost of INR2,442 billion (US$29.3 billion).

The additions represent an increase in cumulative inter-regional transmission capacity from 112,250MW to about 150,000MW in 2030.

“But most of that plan is running significantly behind schedule. We are already seeing a tremendous shortage of evacuation infrastructure in most states across the country,” Rustagi adds.

Naqvi says policy continuity could be a concern although current initiatives are encouraging. “Changes in government or political priorities could lead to instability and deter investors,” he comments.

This year’s Indian general election takes place between April and June. With the existing government looking likely to win the election, Rustagi doesn’t expect any changes in favourable policies.

“But even if there are any changes in the government, the overall fundamentals of the solar sector are so compelling that we expect policy support to continue broadly in the same form,” Rustagi says.

Finance

Financing is another challenge that could hamper India’s efforts to increase its installed renewables capacity. In India, financing solar projects has traditionally been a challenge due to high upfront costs and limited access to long-term debt, but Naqvi believes there is positivity on the financing front.

In April, the Reserve Bank of India kept the key interest rate unchanged at 6.5% for a seventh straight policy meeting. According to a Reuters report in March, the majority of analysts predicted that the rate would go down in the second half of 2024.

“Key rates in India are expected to decline significantly by year’s end, allowing Rooftop PV is expected to make a significant contribution to India’s PV goals
developers to access cheaper rupee-denominated debt and breathe some life back into project financing,” he says.

Meanwhile, foreign exchange rates could also add uncertainty. The appreciation of the rupee against the US dollar could benefit dollar-linked debt, but it could also hurt export-oriented manufacturers in the solar sector who rely on US dollar sales.

Aside from foreign exchange rates and interest rates, India is expected to witness a significant increase in renewables investment in 2024. The country’s power ministry said in late 2023 that India will witness a more than 83% increase in investments in renewables projects to about US$16.5 billion in 2024.

There are several reasons for the increase in investment. First, commercial and industrial (C&I) consumers are increasingly opting for renewable energy thanks to its decarbonisation advantage and cost-effectiveness.

Rustagi adds that the corporate market in India is growing rapidly as most large corporations have adopted aggressive targets for decarbonisation. “They’re turning to renewables to reduce their emissions and become green as part of that process,” he says.

Naqvi says this demand is boosting investment in solar and wind power, with hybrid models gaining popularity for their reliable power supply and reduced balancing costs.

Currently, funding sources are diversifying beyond traditional debt and equity options, although they are still dominant sources. Venture capital, mergers and acquisitions, and private equity deals are gaining popularity in the Indian solar industry.

Investments are also flowing into domestic solar equipment manufacturing. In August 2023, solar manufacturer Waaree Energies announced that it would expand its ingot, wafer, cell and module production capacity by 6GW following a second-round equity funding raise of around INR10 billion (US$121 million). The funding was led by Indian-headquartered investment firm ValueQuest and follows the INR19.23 billion awarded to Waaree under the Indian government’s production-linked incentive (PLI) scheme in March 2023.

**Will India reach its renewable goal?**

After considering the challenges and favourable conditions in the Indian solar industry, the experts are optimistic about India’s solar industry between now and 2030. “The country has a huge solar potential with some parts of the country having 300-330 sunny days a year. Moreover, India is rightly adopting the whole ecosystem approach, where the country is trying to reduce import dependence across the supply chain. Availability of critical minerals will be key, and India again is addressing the huge critical mineral requirement by expanding exploration or tying up with other countries for sourcing,” says Garg.

She adds that India should consider developing off-grid projects, as land availability can become a bottleneck.

Rustagi also mentions the importance of rooftop solar PV systems in India’s renewables goal. Historically, the residential rooftop market has accounted for only about 15% of total solar installations in India. “But the government is giving a lot of emphasis in this sector, and we expect robust growth in the rooftop solar sector,” he says.

In February, the Indian government announced its interim budget for 2024-25, including plans to allow the public to access solar and allocate more resources to the Ministry of New and Renewable Energy (MNRE).

One of the plans is to allow 10 million households to obtain free solar electricity every month. Indian finance minister Nirmala Sitharaman proposes that free 300kWh of electricity will be provided to 10 million households in India every month under the rooftop solar plan. The beneficiaries can save up to INR18,000 (US$216) from free electricity and sell the surplus to distribution companies.

Lastly, Naqvi says investing in grid infrastructure and exploring innovative financing solutions could help India reach its solar goal. “Next year is expected to surge in commissioning activity, especially in the first half, as developers rush to use the 100% waiver on interstate transmission charges. Additionally, the government’s ambitious plan to equip 10 million households with rooftop solar PV systems promises significant growth in the residential segment,” he says.
A global election year: what does this mean for solar?

**Policy** | This year promises to be a bumper year for vital elections, with voters in India, the EU and the US among those going to the polls. With solar and clean energy becoming increasingly politicised, Ottilie Von Henning assesses how any changes in the political wind will impact solar’s global prospects.

Regions accounting for two-thirds of the global GDP are holding elections in 2024, with the majority of key Western players set to open polling stations in the latter half of the year. For the immediate future, this will slow policymaking, and highlighting any political uncertainty could hinder energy transition investment or solar policy support.

As countries and organisations ramp up towards 2030 targets and beyond, these elections have become crucial; certain leadership changes could have major, long-term ramifications for flagship renewables programmes.

This piece will cover the EU Parliament elections in June, the US General election in November, the UK General election—the date for which is currently undecided, but the absolute deadline is January 2025—and the Indian election, which is only just coming to an end.

The likely impacts of the political changes arising from 2024’s election bonanza on the respective country or region’s solar industry will vary considerably. For example, the Indian election is expected to result in a third-term victory for Prime Minister Narendra Modi, who is an outspoken advocate for furthering India’s solar economy.

However, the more divisive elections, such as the US general, could result in more drastic changes to current legislation. This includes the renowned Inflation Reduction Act (IRA), which has received significant regard and praise for its support of clean energy infrastructure development.

The UK election polls indicate a change in leadership from the currently governing right-wing Conservative Party to the left-wing Labour Party. Despite the seemingly substantial shift from one side of the political spectrum to the other, a pullback from both parties in the past year on separate net zero ambitions has led experts to question how much will change in practical terms.

Arguably, the election with the most uncertainty in terms of practical outcomes is the EU Parliament election. A shift to the right is expected among the 705 elected members of the European Parliament (MEPs), but the implications of such a shift have yet to become clear.

**EU Parliament**

Citizens from 27 EU countries will elect MEPs in the first week of June 2024, with current polls suggesting the Parliament will shift to the right. The centre-right group, the European People’s Party (EPP), will likely remain the largest representative bloc but is unlikely to secure enough seats (361) for an outright majority.

What will make a difference is that the centre-left Greens-European Free Alliance and liberal Renew Europe are forecasted to suffer substantial losses, leaving seats available for groups to the right, namely the European Conservatives and Reformists (ECR) and Identity and Democracy (ID).
As a result, the EPP may seek to create an informal alliance with right-wing allies, thus weakening support for climate-friendly energy policies advocacy within the Parliament; the ECR and ID have previously performed poorly in supporting climate and nature policies.

As explained by the trade association Solar Power Europe’s deputy CEO, Dries Acke, “The third position in the EU Parliament, which is now in the hands of the liberal and green parties, might now be in the hands of an extreme right-wing party. It is certainly a change; there is no doubt about that.”

A key policy likely to draw attention is the 2040 emissions-reduction target, which is expected to be announced in the first half of 2024. The European Commission has suggested a minimum 90% reduction goal and a 90-95% reduction was recommended by the European Scientific Advisory Board on Climate Change, but it must first be approved by the Council and Parliament.

It is also worth noting that 2024 marks the beginning of the EU Green Deal’s implementation, which aims to achieve a net-zero and nature-positive economy by 2050.

Victoria Cuming, head of global policy at BloombergNEF, said that Parliament’s anticipated shift to the political right “could mean watered-down targets (like the 2040 emissions targets), weaker regulations, and more concessions to the industry.”

However, BloombergNEF’s lead solar analyst, Jenny Chase, is more optimistic. She says: “Most of the EU plans for solar energy are fairly unambitious. We actually expect them to be overshot.”

“The main exception is Germany, which will have 215GW by 2030, which is quite a lot and would generate the equivalent of about 39% of 2022 German generation. The plan to achieve this is a regular schedule of auctions awarding long-term power contracts to solar and wind projects, a low export tariff for rooftop solar, and debotlenecking constraints like permitting and grid,” Chase adds.

Although the expected shift to the right is not particularly good news for the solar industry, it is not expected to result in the reversal of any existing legislation. Still, it could potentially impede the application of certain schemes and the transition going forward.

Acke explains: “We are not looking at a massive reversal of the legislation; that is not a threat. However, what is a threat is that the implementation of said legislation will not be followed through as strongly as it should be.

“The Green Deal is only now cemented in law. It has not yet been implemented on the ground, and we are asking the coalition to implement proactive political things instead of a technocratic reenactment. That is going to be the main difference.”

Cuming agrees, saying: “We do not expect an about-turn in existing EU climate policy regardless of the outcome, such as the net-zero commitment for 2050 and the solar energy strategy released by the European Commission in 2022.”

**US general election**

As one of the more unpredictable elections discussed in this piece, the fact that the result will decide how a leading piece of legislation – the IRA – will be implemented makes it all the more critical.

A re-election for Democratic Party candidate Joe Biden would likely mean a continuation of the current administration’s ambitious climate subsidies and international partnerships. In contrast, Republicans under nominee and former president, Donald Trump, have vowed to repeal the IRA, Biden’s signature bill and the backbone of the US decarbonisation efforts, and double down on oil and gas production and exports.

The party’s links to the oil and gas sector will make tax credits favoured by the fossil fuel industry, such as the 45Q carbon capture credit and the 45V clean hydrogen credit, especially hard to end.

Similar to the EU Green Deal, it is highly unlikely that Trump could fully repeal the IRA, as constituents and businesses will work to prevent the removal of benefits they have now planned around.

Cuming expands: “We do not expect the IRA as a whole to be repealed—Republicans would need a majority in both chambers and the presidency, and even then, it could be tough to get enough Republican votes. Republican-leaning states have also attracted far more IRA-driven investment and jobs in clean-tech manufacturing capacity than Democrat-leaning states.”

Nevertheless, a Republican legislature could weaken the IRA without repealing it entirely by imposing new tax credit requirements or repealing investment vehicles such as the Greenhouse Gas Reduction Fund.

In terms of foreign relations affecting the US solar industry, Trump is expected to further exacerbate tensions between China and the US, which could easily affect trading relationships.

“Geopolitical tensions between the US and China seem likely to increase going forward even if Biden is re-elected,” says Cuming. “However, they would be even more elevated under Trump, who has pledged to put 60% tariffs on imports from China.”

Jenny Chase adds: “The Trump admini-
“We need the best possible policy at a national level, which means participating in elections, engaging with government representatives and engaging with policymakers to constantly ensure that the details of the policies and regulations at a national level support PV.”

UK general election
As mentioned previously, despite being on opposing sides of the political spectrum, the two leading parties for the UK election share relatively similar values for the solar industry; both are committed to achieving 70GW in the UK by 2035. Nevertheless, the left-wing Labour Party currently sits 20 points ahead in election polls, which suggests it will likely take over from the governing right-wing Conservative Party, and it is widely believed that this will mean more favourable policy decisions for solar.

Cuming says: “A change in government—whether Labour alone or in a coalition—would mean more support for low-carbon technologies like solar. PV would be expected to play a crucial role in achieving a clean power system by 2030, as pledged by Labour leader Keir Starmer at the party conference in October—five years earlier than the current target.”

Chris Hewett, chief executive of the British solar trade association Solar Energy UK, concurs. "In the UK, both the Conservative and Labour parties are committed to ambitious growth for solar on a trajectory to 70GW by 2035, so whatever the outcome of the election, we expect market conditions to be good for solar and energy storage," he says.

“The main difference between the parties currently is the Conservatives have a significant number of MPs who actively oppose solar farms and net-zero policies more generally. This is creating uncertainty for investors. Labour has put the clean energy transition at the heart of their economic policy.”

A scheme that has been crucial to growing Labour’s reputation as the more solar-favourable party is the Green Prosperity Plan, which includes much-needed planning reform for grid connections and onshore wind and solar projects, building decarbonisation incentives and power-market reform.

"Solar projects would also benefit from other support measures in the Green Prosperity Plan," agrees Cuming. "It includes notably much-needed planning reform, which should make it easier to get permits and grid connections."

It is also worth noting that if Labour does not achieve a majority in the House of Commons, it will likely agree to a coalition with its allies—the Liberal Democrats or Greens. Should this be the case, a further ramp-up in green policy support is expected.

However, both the Conservatives and Labour have pulled back on certain green initiatives and power-market reform. Labour have pulled back on certain green policies in the past year. Current prime minister Rishi Sunak set out a ‘new path to net zero’—which included delaying the zero-emission vehicle mandate by five years—and prospective prime minister Keir Starmer reduced planned green investment from £28 billion to £15 billion.

These changes have created uncertainty among industry members, but BNEF’s Cuming believes this will not affect solar as drastically as newer technologies.

"Much has been made about Labour’s announcement in February to reduce planned green investment to £15 billion per year—down from £28 billion. However, this scaleback is more likely to affect less mature and more expensive technologies than solar," she says.

"It would also still mean almost 50% more green spending than under the current government, which has spent recent years decreasing low-carbon support and pushing back deadlines on fossil-fuel bans under its “new approach to net zero”.

Indian election
Narendra Modi, the current prime minister of India, stands in a strong position with polls favouring his third victory in this electoral process, marking the start of a potential third term.

The 2019 elections were the first time that Modi’s ruling Bharatiya Janata Party (BJP) and the main opposition party, the Indian National Congress, included climate change and the environment in their manifestos.

Sonia Dunlop, CEO of the Global Solar Council, speaks highly of Modi’s past and present activism. She says: “Modi has been a strong supporter of solar PV for almost a decade, and he was the co-initiator of the International Solar Alliance in 2015.

“That is the kind of political representation that we, as a global solar industry, need to invest in. At every level—the global, regional and national—we must ensure that we have the best possible policy for the environment.”

The Indian solar industry has flourished as a result of Modi’s previous two terms. It is expected that this support and growth will continue in the likely scenario where Modi wins his third term.

Dunlop explains: “India has very aggressive solar targets and has done a lot of work in promoting residential solar; the future is bright for the Indian solar industry.” India’s solar market is explored in more depth on p.48.

Global perspective
In the majority of these elections, a substantial change to leadership is expected; for the UK and India, this will help support the furthering of solar adoption as part of the green transition, but for others, primarily a potential Trump re-election, it could hinder progress.

Ultimately, key legislation already passed into law, such as the IRA or the EU Green Deal, will be safe from total reversal, but the implementation and funding around said legislation could be slowed.

What is clear is that any region’s solar industry would struggle without support from policymakers and legislative protection. Dunlop argues that industry involvement in politics is crucial to solar development on every level.

She says: “We need the best possible policy at a national level, which means participating in elections, engaging with government representatives and engaging with policymakers to constantly ensure that the details of the policies and regulations at a national level support PV.”

www.pv-tech.org | May 2024 | 55
The key to structural reliability of power plants for high long-term asset performance

Trackers | Trackers play an integral role in bolstering PV system resilience in the face of high wind and other extreme weather events. Nextracker’s Jake Morin examines some of the recent developments in tracker hardware that together are helping reduce the risk to solar assets worldwide.

According to the US Energy Information Authority, solar is projected to be the US’s top energy source by 2033 and make up almost 25% of the country’s power supply by 2035. More solar applications are being deployed worldwide than ever before to keep up with demand, but they’re not all standing up to the rigours of rising climate change [1].

With this hyper-growth planned for substantial global scaling, the solar industry has made significant strides in improving its design and adaptation practices to deal with extreme weather events, but more can and must be done. Given the increasing prevalence of non-traditional, non-modelled “natural catastrophe”, or NatCat events, with their potential to inflict tens of millions of dollars in damage to utility solar plants, extreme weather management tools must be deployed to reduce these asset risks.

Australia, the Middle East, Latin America and Europe have all seen commercial solar power systems fail in high-wind events due to the dynamic loads (defined as “a force that changes in direction, position, and magnitude over time”) they experience over their lifetimes.

One important way to manage extreme weather is through the use of smart, well-engineered solar trackers, which can alter panel orientation before or during weather events, incorporate intelligent stowing and utilise enhanced weather event management software. Such tracker systems, when used in combination with appropriate PV panel technology selection and well-defined plant operational practices, offer the best path to mitigating the extremes of Mother Nature.

Hardware, software and structural design all work together to mitigate risk associated with extreme weather on solar power plants. The combination arms plant operators with advanced operational tools and stowing capabilities to manage their solar assets before, during and after severe weather events. Active stowing capabilities do not depend on grid power, and the tracker’s variety of stowing strategies can be configured for different types of events. Real-time operational control and monitoring tools can also adapt to site-specific factors and be incorporated into the system operator’s overall weather event preparation and response plans.

In some commercial solar installations, catastrophic failures have occurred due to wind. When system failure is not an option, solar tracker system engineering and design play a critical role in preserving the integrity of the PV system and panel. Nextracker’s early investments in wind-testing R&D and defensive stow strategies, along with the company’s use of quality components and proprietary lockbolt racking fasteners, contributed to no substantial wind failures on thousands of the company’s NX Horizon systems over the last seven years.

For long-term resilience and minimising long-term operating costs, every component of the solar power plant must be considered and designed to withstand weather events, which vary from site to site. As an example, some industry leaders include dampers in their solar tracker designs to absorb the forces put onto the rows during extreme weather and design their torque tube and pile thickness to withstand local weather events. But even when components seem to be engineered correctly, an oft-overlooked detail can still leave the system vulnerable to high winds further down the line.


“Chronic fastener loosening seen with several types of bolted joints is due to underlying and fundamental design and/or installation problems. These bolted joints often lack the ability to achieve and sustain the minimum clamping forces needed to hold when exposed to weather events… It cannot be stressed enough that the connections in a PV system are the most likely cause of or contributor to failures.” [2]

Advanced single-axis trackers are flexible structures. They shouldn’t be held together with the same kind of fasteners as a high-rise building or a bridge, which experience much lower rates of vibration.
throughout their lifetimes. The dynamic movements that a solar power plant experiences challenge a conventional threaded fastener’s ability to perform its function long-term.

Wind is a dynamic environment with classic dynamic excitation, such as wake buffeting. When coupled with solar tracker, unique dynamics (such as torsional divergence, also known as torsional galloping) can cause rapid failures but also contribute to the loosening of traditional nuts and bolts, resulting in long-term failures.

Torsional divergence occurs when the wind picks up rapidly in a storm, and trackers are caught at a low tilt angle (between zero and 20 degrees). Some systems inappropriately select a low tilt angle to stow (to minimise panel pressures), while others do not have adequate drive systems to ensure trackers reach the intended stow position.

This is what happened in 2018 at the 55 MW Oakey 2 installation in Queensland, Australia [3]. A severe storm hit the site, and the trackers were stowed at zero degrees to reduce wind resistance on the panels. Even when stowed at zero degrees, however, static wind load on a row of panels is still high. Wind sheds alternately between the leading and trailing edges of the tracker, leading to larger and larger rippling oscillations across the span of the module. The ends of the row twist back and forth, then begin to twist into the centre of the row, where the system is most rigid. This torsional motion throughout the rows (picture the childhood game of ‘crack the whip’) results in collapse if there are no mechanisms built into the system to stop this motion.

Torsional divergence can reduce a power-producing asset to damaged rows of solar modules twisted into helixes with the piles that hold them in the ground bent by the strain. Loose wires can be introduced into standing stormwater and become hazardous to workers and people walking near solar farm fence lines.

When the dust settled after this disaster, more than 2,000 modules of the 100MW system were badly damaged. The neighbouring 100MW installation with solar trackers manufactured and installed by Nextracker was undamaged by the same windstorm.

As Nextracker CEO Dan Shugar explains: “There was a windstorm for two days in the mid-40 miles-an-hour, 45 miles-an-hour plus or minus. When the dust settled on all that, there was zero damage on the Nextracker system. The other system was a severe train wreck. The part of their system that didn’t fail was shielded by us because of the way the systems were laid out."

Similar instances of damage caused by such wind events have been recorded in the Middle East and South America. Each time when the wind died down, side-by-side power plants that experienced the same storm looked completely different. The Nextracker-mounted modules stood undamaged and continued to produce power, while the adjacent power plants needed extensive repair.

Contributing to Nextracker’s system resilience and expertise in high wind environments, the company commissioned CPP Wind Engineering in 2015 to study and deeply understand the effects of high wind on rows of tracker-mounted panels. More on the results from this study can be found in CPP’s published paper [4].

“We sponsored the preeminent wind engineering company in the world for structures like this (CPP) to characterise trackers dynamically,” comments Shugar. “We were able to replicate and actually create these dynamic instabilities in a lab environment, characterise them, and then re-engineer our product to ensure they were addressed.” [5]

Based on the study findings and ongoing investment in R&D, Nextracker’s leading wind research has led us to invest in key product differentiators. Our balanced, rapid-moving architecture allows us to “out-run” rapidly forming thunderstorms, and our engineered lock bolt fasteners are vibration-proof, skipping costly and labour-intensive requirements to re-torque thousands of nuts and bolts on an annual basis. Now, just surpassing 100GW of solar trackers shipped since the company’s inception – the first US solar company to achieve this milestone – this investment in high-quality engineering and product design underscores the company’s technology and market leadership.

Estimated results shown here were compiled from previous tests completed by Bolt Science, LTD, Huck International, Inc and Henkel Corp [6]
A tale of two fasteners

Fasteners can be easily overlooked, but any system is only as good as the parts that hold it together. Traditional threaded bolt fasteners, used by many companies that install commercial-scale solar, self-loosen over time as they are exposed to wind. Loose bolts quickly become disconnected, leaving them vulnerable to wind even if the trackers stow during extreme weather as planned.

Lockbolts simply outperform threaded fasteners when withstanding the decades of vibrations that a solar system must endure. According to Jon Ness, author of a report on the problem of loosening bolts in PV systems: “The key to reliable bolted joints is to develop and maintain a high clamp load in the joint such that the joint does not slip or open under the applied loads. Unfortunately, this is easier said than done. The solar PV industry is in its infancy compared to other industries; as a result, best practices, codes, and standards are not mature and do not yet provide assurance of structural reliability.”[7]

Often in solar applications, traditional threaded bolts are prone to loosening over time. This is especially true where the two parts being joined are composed of thin steel and aluminum. Because the solar industry is still hammering out its best practices, it’s not yet required that designers and installers use lockbolts to hold together the critical points in a solar racking system.

Lockbolts are not new. They were invented in the 1940s by Louis C. Huck (and originally called Huckbolts) under the direction of the U.S. Navy to address the tendency of traditional bolts to loosen under severe vibration. Since their invention, lockbolts have been used in trains, military vehicles, automotive engines, aviation, agriculture, mining and other applications that experience severe dynamic loads.

Solar power plants are exposed to wind, corrosive environments and extreme temperature swings. When solar modules are mounted on trackers, the joints they hold together are in constant motion throughout the day. Over time, all of those millions of small movements can loosen traditional threaded bolts. If maintenance isn’t performed regularly to re-tighten loose bolts, the looseness that’s been introduced into the system across thousands or even millions of fasteners can have catastrophic effects when exposed to extreme weather.

To quote Ness again: “In most PV racking joints, the loads are transmitted through the joint interface through the preload and resulting clamp load that develop in the fastener during the assembly process. If the residual preload in the joint can’t handle the loads experienced in service, the joint components will separate or slip, or both, and if this joint movement happens repeatedly, the fastener joining the joint will likely fail due to fatigue. Developing and maintaining the fastener preload and clamp load throughout the life of the PV installation is critical to the reliability of the PV racking joint in service.”[6]

Similar to how the screws in dining room furniture come loose and need to be periodically tightened, traditional threaded bolts loosen over time. Magnify that tendency across thousands of potential failure points in a commercial solar installation (all mounted on trackers that are constantly in motion), then send in some extreme weather the day before scheduled maintenance, and it’s a recipe for a potential crisis.

Simply adding more torque to threaded bolts upfront does not fix the problem. Using impact wrenches can make torque ratings as inaccurate as ±40% or worse, leaving many threaded bolts installed with a much lower preload than expected. Expensive and time-consuming inspection of bolted joints is required to ensure performance, and even then the delivered performance varies substantially.

When installers tighten bolts in the field, the force applied can vary greatly. This inconsistency results from several factors, such as errors in the amount of torque used, differences in friction at the points where joints slide, the quality of the bolt itself and the technique of the person doing the assembly. As a result, the tightness of these fasteners can differ by as much as ±25% on the low end to ±60% on the high end. This tendency is known as ‘preload scatter’.

A simple way to reduce preload scatter in fasteners is to use lockbolts rather than bolts that need to be tightened with specific torque. Lockbolts are installed using precise power tools that apply direct
tension to the bolt and then swage a permanent, vibration proof collar, locking the bolt in place. This method and the design of the lockbolts reduce errors due to worker skill and tool inconsistency. The consistency of lockbolts results in a much smaller variation in tightness, about ±5%. Lockbolts have shallower threads and larger cross-sectional areas throughout, which allows them to be tightened to slightly higher preload without sacrificing stability.

Lockbolts are a safer, more reliable fastener.

Lockbolts are similar to threaded bolts, with one key difference. Both bolts are initially assembled by rotating the collar (or ‘nut’; as it’s more commonly known) relative to the bolt until flush with the two surfaces the bolt is holding together. This is the end of the similarity.

For threaded fasteners, torque is applied to the nut in an attempt to reach a specified tension in the bolt. For a lockbolt, a special tool is used to directly apply the specified tension and crimp the collar over the thread form of the bolt. This eliminates bolts’ tendency to loosen and makes the fastener permanent and tamper-proof.

Dismantling a lockbolt once it’s crimped into place requires a special cutting tool — also making them theft resistant.

An experienced installer can assemble lockbolts in less than five seconds and negates the need for inspection of the bolt. The cost difference is negligible when spread across the thousands of fasteners needed for the average commercial installation.

Lockbolts are immune from self-loosening since the internal and external threads are locked together with a crimping tool during their assembly.

Lockbolts are permanent. They cannot be retightened, but when maintenance is needed, they can be dismantled quickly with a special tool that splits the collar.

Testing in extremes

In summary, it is critical that the solar industry comes together to prevent events like what happened in Australia. Every time a solar installation is damaged by extreme wind, the costs of repair are far beyond just financial, damaging trust in the industry as a whole. Building that trust begins with industry leaders testing their components against extreme weather, gathering data, and making improvements — and Nextracker is proud to be leading the way in these efforts.

Even with no substantial wind failures over the last seven years, Nextracker continues to dedicate R&D and continuous design engineering resources to enhance the quality and reliability for long-term resilience — especially as solar continues to scale globally in sites with varying weather conditions.

In 2020, Nextracker entered into a collaboration with NREL to help advance the reliability of trackers during extreme weather events. Nextracker and NREL built and instrumented 18 rows of self-powered PV tracking systems across 3.5 acres of NREL’s Flatirons campus in Colorado to study the impact of extreme weather events on such systems. The Flatirons campus routinely experiences 90+ mph winds that whip down from the Rocky Mountains, making it the perfect place to conduct such research.

“As far as I know, no other big industry player has done anything like this,” NREL researcher Scott Dana said of the collaboration. “Nextracker is using the results of the experiment to start a strong dialogue about what the design standards for PV trackers should be. They have information and data that no one else has. The measurements they are collecting with NREL are really helping to support a strong narrative on why the building code standard is not sufficient. It’s really an industry-wide conversation. It’s definitely born out of the work at NREL.” [8]

With substantial data collected over its entire global installed base, Nextracker is well positioned to leverage extensive expertise in working with customers across projects to not only develop enhanced product offerings but also learn and refine best practices for defensive stow strategies. The bottom line is that structural design, high-quality components and materials play a key role in long-term solar asset management and system resilience. As the pace of scaling utility-scale solar continues to accelerate, getting seemingly small things right is key to fostering the PV system integrity, solar plant performance and long-term resilience the energy transition depends on.

References


Author

Jake Morin is senior vice president product management at Nextracker. A licensed professional engineer, he is oversees the company’s product development programmes, setting strategic direction for new product lines.
Solar Energy: Innovations at Intersolar Europe 2024

The European solar market is developing dynamically, as is the British market: In 2023, the cumulated capacity in the United Kingdom grew by more than 1GW, reaching 15.6GW. With the tremendous market growth, there has been a flurry of innovations in the marketplace: New solar cell designs are on the rise. Inverters are taking over new functions. Dual land use is gaining popularity. These trends are detailed below – and you can experience them first-hand at Intersolar Europe 2024!

**New solar cell technologies**

Solar energy can only succeed if solar cell technology is constantly improved. This guarantees a future-oriented, fast-growing solar industry and the consolidation of solar energy’s pole position as the cheapest electricity generation technology. A technological shift is underway, moving away from PERC cell technology to TOPCon cells. The Fraunhofer Institute for Solar Energy Systems ISE forecasts that, within the next two years, TOPCon cells will dominate the market with a share of almost 40 percent. The introduction of silicon-based tandem solar cells with two different semiconductors is eagerly awaited – and with it, the industrial use of perovskite. Perovskite-silicon tandem solar cells promise efficiencies of over 30 percent – manufacturer LONGI even achieved a record 33.9 percent in the lab. At Intersolar Europe 2024, you can check out innovative solar cells in the exhibition area for PV cell and module manufacturers in halls A1, A2 and A3!

**Stabilising the grids with grid-forming inverters**

As the share of renewables in the power grid increases, grid stabilisation is becoming the new challenge because the power grid was designed for large power plants and centralised generation. In an energy system dominated by renewable energies, grid-forming inverters increasingly include frequency stabilisation and voltage compensation functions – up to now, these functions have mostly been performed by synchronous machines in large thermal power plants. Inverters are programmed to behave like a voltage source. Combinations with large battery energy storage systems (BESS) are now forging new paths. In Blackhillcock, Scotland (UK), a 300 MW/600 MWh pilot plant is being built that is set to be one of the largest in the UK, and a global pioneer in the provision of grid stability services through grid-connected battery storage systems. The system will be connected with a distribution grid operator that acts as off-taker of grid stability services. Find out more about the latest inverter technologies at Intersolar Europe 2024 in halls B3 and B4.

**Agricultural PV: Combining PV with agriculture**

In terms of generation, dual land use concepts, especially agricultural PV, are gaining momentum and are on the cusp of a market ramp-up in Europe. The advantages of agricultural PV are obvious: Agricultural land can double its yield if PV is added. Schletter Solar GmbH, a manufacturer of mounting systems and exhibitor at Intersolar Europe 2024, quotes a value of 80 percent plus 80 percent, depending on the system: agricultural PV generates 80 percent of the solar yield of a conventional ground-mounted system, and 80 percent of the agricultural land remains usable. This dual yield gives farmers the opportunity to diversify their income.

As the effects of climate change intensify, the positive effects of PV play an increasingly important role: Many types of crops can benefit from the shade provided by PV modules, particularly in the face of prolonged droughts. Depending on the type of support, modules also protect against increasingly frequent extreme weather events, while shading and wind protection prevent rainwater from evaporating.

Three types of models have become established: elevated, tracker and vertical installations. Agricultural PV typically distinguishes between horticulture, viniculture, arable land and pasture applications. In terms of increasing yield, some types of berries, grape vines and olives achieve the best results.

Intersolar Europe 2024 is committed to the agricultural PV trend and aims to drive this crucial application forward. Over 50 companies, including BayWa r.e. AG, Zimmermann PV-Stahlbau GmbH & Co. KG and SunFarming GmbH, will present their agricultural PV projects and the latest technologies in mounting systems, trackers and special solutions for agricultural PV. At the agricultural PV special exhibit in the Outdoor Area, you will learn everything there is to know about the combination of PV and agriculture.

**Intersolar Europe 2024**

As the world’s leading exhibition for the solar industry, Intersolar Europe demonstrates the enormous vitality of the solar market. It has been providing a networking opportunity for the key players – from manufacturers, suppliers and distributors to installers, service providers, project developers, planners and start-ups – all under the motto “Connecting Solar Business”. It focuses on the latest trends, developments and business models – such as dual land use, cell technology and grid stabilisation. For the next edition, there will be more than 1,370 exhibitors in an exhibition space of 111,000 square meters. Intersolar Europe will take place from June 19–21, 2024 as part of the innovation hub The smarter E Europe, Europe’s largest alliance of exhibitions for the energy industry, at Messe München.

[www.intersolar.de/start](http://www.intersolar.de/start)
2024 – 2025

INTERSOLAR EVENTS

The World’s Leading Exhibition Series for the Solar Industry

- **JUNE 19–21, 2024, MUNICH, GERMANY**
  www.intersolar.de

- **AUGUST 27–29, 2024, SÃO PAULO, BRAZIL**
  www.intersolar.net.br

- **SEPTEMBER 3–5, 2024, MEXICO CITY, MEXICO**
  www.intersolar.mx

- **FEBRUARY 25–27, 2025, SAN DIEGO, CA**
  www.intersolar.us

- **FEBRUARY 2025, GANDHINAGAR, INDIA**
  www.intersolar.in

- **APRIL 7–9, 2025, DUBAI, UAE**
  www.intersolar.ae

- **INTERSOLAR SUMMITS WORLDWIDE**
  www.intersolar-summit.com
Renewable energy is, by its very nature, abundant – therein lies one of its fundamental and most obvious benefits. But in transitioning to a world that runs on renewable power, governments, businesses and society will have to come to terms with the issues that scarcity presents. The time we have to decarbonise is running out, the raw materials needed to create a green energy infrastructure backbone (everything from wind turbines to electric vehicle batteries) are finite and in many parts of the world, land suitable for project development (that which is relatively flat) will be at a premium. Over 70% of the earth’s surface is covered by water – of that about 96.5% is saltwater – and this is where an ever-increasing proportion of the world’s energy infrastructure will need to be located.

It goes without saying that offshore areas provide vast expanses of space, a major consideration when it comes to the development of large-scale renewables. Onshore, these projects would be competing for land use with other activities, such as agriculture or urban development. Out at sea though, they are largely out of sight and out of mind.

Solar developers are increasingly coming around to the exciting potential of stationing hundreds of photovoltaic systems offshore. Solar irradiance levels are broadly higher at sea than they are onshore, meaning floating photovoltaics (FPV) have access to abundant renewable resources, leading to higher energy production potential and more consistent generation throughout the year.

Floating solar farms can also be located closer to densely populated coastal areas, reducing the need for long-distance transmission cables, thereby minimising energy losses. Moreover, by putting assets nearshore, they are less exposed to extreme weather events, such as hurricanes or flooding, bolstering resilience in the face of climate change.

Taking stock on progress to date
But for all the potential, the world is still some way off from having a commercially viable offshore FPV project. That is not to say there aren’t numerous FPV systems in operation, but most of those that are currently harvesting the sun’s power are inland, located on lakes or reservoirs. As such they typically don’t have to overcome the challenges posed by saltwater and wave motion. That being said, just recently, one of the world’s largest floating solar plants, at a dam in India, suffered severe damage during a storm. But generally speaking, this branch of floating solar has proved to be an easier nut to crack.

Several dozen pilot, demonstration and innovation projects, designed to prove the viability of offshore FPV, have already been successfully deployed or are in development. But there is a large and definite disparity in the technology-readiness level of these initiatives when compared to inland schemes. Efforts are ongoing to close this gap, but progress has been relatively, and understandably, slow to date. Encouragingly, the pace is quickening, and companies are willing to elevate their projects to a commercial level.

Locating PV system offshore is a new frontier for the industry and one fraught with technical challenges
Reliable analysis and established prototype installations are still needed to increase our understanding of how floating solar performs in exposed locations. For the most part, the projects that have been installed have been on a research and development basis by manufacturers. As a rule of thumb, these first-mover projects have an installed capacity of up to a megawatt, though that is higher for nearshore, with 181MW and 250MW systems stationed just off Taiwan.

Interest in offshore FPV is growing steadily, particularly from Big Oil and renewables players who are exploring combining the technology with offshore wind, Power-to-X developments and fish farms. Moreover, the Netherlands has included criteria for up to 50MW of floating solar in its latest seabed leasing round in a bid to accelerate the coexistence of technologies.

Battling the elements
Projects like these are also testament to the sector’s ability to conquer the key
design challenges and risks associated with offshore solar. Rougher waters, stronger winds and saltwater corrosion all take their toll on projects. It takes a great deal of engineering to create a system that can stand up to the rigours of the sea; making that system cost-effective is another thing entirely.

A leading energy company recently declined a move into offshore solar because of the saltwater consideration, which massively affects the durability of the system. PV modules, the key component in solar systems, are not designed for salty environments. Even when PV modules are located onshore but near to the sea, corrosiveness can be a problem. Similarly, electrical systems, such as inverters, will be in constant motion, something they are not designed for – this needs to be taken into account during design.

Should the scale of offshore and nearshore FPV increase dramatically, into the gigawatt scale, this would require many square kilometers of PV modules, covering vast swathes of the ocean surface. It is currently exceedingly difficult to know how this will affect sea life. Algae – the start of the marine food chain and source of all life in the ocean – needs sunlight to live and grow and the impacts of blocking this out is something developers need to be cognisant of.

There is also a chance to cultivate sea life, and there have been mentions of an increase in fish life around installations, which provide a safe haven from birds and the growth of mussels.

The small pilot systems that are currently being advanced can be installed with little or no impact on the surrounding environment, and this will remain the case for 1MW, 5MW and 10MW systems. But this will change once the technology becomes commercial and the demand for large-scale projects increases. The floating solar sector, in partnership with other stakeholders like government, must monitor the effects during upscaling to reduce the risk of large-scale projects in development being cancelled.

**The three offshore floating solutions vying for position**

Three main technological solutions that could hold the key to overcoming the sector’s engineering challenges are emerging. Two fall under the umbrella of ‘rafted exposed’ technology (elevated and low-profile), while the other is based on a ‘membrane’ design.
Finding the right floating fit for differing needs

But in what is still a fledgling sector, it is far too early to rule out any of these technologies based on their current shortcomings. Certain geographies will require certain solutions, and companies from various different countries are advancing their own versions of the three primary floating solutions.

Ocean Sun (Norway) and Bluewater Energy Services (the Netherlands) are pioneering the development of membrane-based floating solar, while the likes of Oceans of Energy (the Netherlands), Fred. Olsen 1848 (Norway) and Offsolar (France) are focusing on the development of rafted-low profile. Rafted elevated solar is primarily being advanced by SolarDuck (the Netherlands), SeaVolt (Belgium), and Moss Maritime (Norway), and at DNV we have been combining our knowledge of the solar energy and maritime industries to give floating solar developers the certainty and confidence needed to accelerate the deployment of this emerging sector.

Confidence is key

Validation of techniques and designs is a vital step in building sector confidence. The process of verification, or similar third-party assessments of developing concepts, is crucial to derisk the development process and ensure that the potential for issues, failures and shortcomings is reduced as much as possible before commissioning novel concepts. Cases like these will hopefully act as a springboard for similar developments, accelerating the pace of floating solar deployment in exposed waters.

There are three separate approaches that DNV takes when assessing new concepts:

1. Technology qualification: Advisory service guiding the concept owner by developing frameworks for qualification.
2. Third-party verification: Reviewing and independent analysis of the system to ensure that the methods and results comply with the selected approval framework.
3. Certification: Review and independent analysis according to DNV service specification to comply with accredited certification scheme as the approval framework.

Up to now the work that DNV has done has been verification of design methodologies (Ocean Sun, Sunlit Sea, Oceans of Energy, Moss Maritime, Sungrow). Going beyond this point does not mean it is necessary to conduct certification, but the level of involvement would need to be increased.

We are in the process of working with technology providers to establish when those FPV schemes that have received verification on a design basis level will be in a position to move onto evaluation of prototype or detailed engineering. Once achieved, this will be yet another step in giving project stakeholders – utilities, project developers, investors, lenders, insurance companies – the assurance and trust needed to spur on a wider rollout of floating solar technology in harsh environments.

Beyond certification, which can often take years, DNV can advise technology developers as the project progresses. By regularly giving third-party oversight to concepts, our experts can ensure they adhere to best practices and the latest industry standards.

Such ongoing input can be invaluable when it eventually comes to certifying a project, increasing the likelihood that assets will behave as expected in different conditions. Provided they operate within the specified frame, solutions can then be copied and pasted for use around the world.

External verification is also key to integrating FPV solar with other offshore renewables sources, such as offshore wind. Inevitably as the number of stakeholders increases, there is a greater requirement for detailed analysis and checks to keep multiple parties’ content.

An increasingly global sector

Advances in floating solar are not simply confined to Europe, though, and other regions are making good progress, feeding into a global marketplace that is becoming ever healthier and more intriguing. In Asia, the Philippines, Singapore, Malaysia, Japan, Indonesia and, of course, China are all extremely interested in the potential for floating solar. SolarDuck is advancing plans alongside Tokyo’s local government to set up an FPV test bed. Meanwhile, the 440MWp Changhua floating solar park near Taiwan became operational last year.

These projects and the real-world examples they provide will help create a blueprint for countries wanting to foster their own floating solar industry. Crucial to driving this growth will be the offshore skills that have been honed and sharpened in the oil and gas industry over many decades. Such knowledge of floating structures should give real cause for optimism that floating solar technology can work at scale. Inevitably, many of the people currently driving the FPV sector...
forwards started out in the maritime or offshore energy industries.

**Setting the foundations for a floating future**

Getting across this first hurdle – proving the technology and building certainty – is going to be so much harder than reaching the next hurdle – can you generate energy cost-effectively enough to make it viable? That is not to underplay the importance of design and technical engineering costs, but investment will be easier to come by once companies have proven that offshore and nearshore FPV is viable at scale.

DNV is in the process of writing two new standards for floating solar to help give the assurance needed for the sector mature. Two joint industry projects to develop dedicated FPV specifications, rather than the sector having to make use of standards designed for other systems, kicked off in 2022. Once these directions are in place, they will provide a solid foundation for the floating solar sector to build upon.

All of the above is to say that, as far as overcoming the engineering, logistical and other barriers of offshore floating solar is concerned, there is a ‘way’. What we really need now is a strong will from the offshore energy sector, government and investors. Very soon it will be crunch time for floating offshore solar – the challenges of realising the potential benefits of this sector are immense.

We mustn’t allow pessimism to creep in, though; if we don’t try to overcome the challenges that lie before us then there is a guaranteed, 100% chance that we never solve them and the progress that has been made so far will invariably be lost. Those companies that are serious about delivering floating offshore solar need to apply some serious engineering and prove the detractors wrong.

Floating offshore solar has already come a long way in recent years and there is a chance to replicate and better this progress in the years ahead. Countries such as the Netherlands are setting the space in this regard, putting the required time, effort, and money into developing the solutions that can move this sector from concept to commerciality.

---

**References**


**Authors**

Jasper Lemmens is a senior consultant and DNV’s global practice lead floating PV. He has master’s degrees in applied physics and business administration. In 2017, Jasper started working with floating PV when the floating PV market was about to emerge and initiated the development of services and standardisation which lead to DNV’s Recommended Practice on floating solar in 2021. During these years, Jasper has developed to an expert and on a continuous basis, he pushes the boundaries of the floating PV industry.

Magnus B. Johannesen is a senior engineer in the section for environmental loading and response. He holds a master’s degree in mechanical engineering with a focus on computational fluid dynamics. For floating solar, he has been involved in many projects and focuses on the mooring, floater motions and structural integrity of the systems. As the project manager for the DNV JIP on anchoring and mooring, he has also developed a thorough understanding of the challenges and solutions in the industry today.
Major Chinese module producer LONGi has launched the Hi-MO 9 series modules with the hybrid passivated back contact (HPBC) solar cell technology, boasting conversion efficiency of up to 24.43%.

**Market & applications:**
The module is designed for use in tough environments, including lakes, mountains, and deserts. LONGi will produce the modules at its Jiaxing production plant.

**Technical solution:**
This range includes modules with power outputs as high as 660W and a conversion efficiency of 24.43%, comparable to its Hi-MO X6 range of modules, which have a conversion efficiency of 25.5-25.8%. HPBC technology is a type of back contact cell without busbars on the front side of the module.

**Unique features & benefits:**
It boasts several core advantages, including uneven light irradiation tolerance and 30 years of lower degradation.

**Availability:**
The module is available now.

Solar module manufacturer Maxeon Solar Technologies has launched an n-type tunnel oxide passivated contact (TOPCon) module for distributed generation projects.

**Market & applications:**
As extreme weather events are getting more frequent, modules need to be designed against weather challenges like temperature swings, snow loads and hail. The module can be used in environments with extreme temperatures and hailstorms.

**Technical solution:**
The module features the latest generation of its patented TOPCon cell technology in a shingled-cell design, offering more effective shade management, mitigation of hotspots and cooler cell temperatures than standard modules.

The module incorporates two two-millimetre, high transmission heat strengthened glass. The front glass has an anti-reflection coating. It can resist 40-millimetre hail in diameter at 27.5 metres per second.

The module, measuring 1,790 millimetres by 1,134 millimetres, boasts a maximum annual degradation rate of 0.4%, with the first year minimum warranted output of 99%.

**Unique features & benefits:**
The 440-455W SunPower Performance 7 bifacial module boasts an efficiency of up to 22.4%. With a glass-glass design, the modules can withstand extreme weather events such as hail, wind, snow and fluctuating temperatures.

The module’s bifaciality reaches 80% and can be used in an environment between −40°C and 85°C.

**Availability:**
The modules are available for purchase by residential and commercial customers in Europe, the Middle East, Africa, and the APAC markets.
RE+ 24 brings the modern energy industry together to foster a cleaner future and marks its 20th year as the largest and most comprehensive event in North America for the clean energy industry. Get ready to explore solutions, exchange ideas, and discover new technologies!
German renewables firm BayWa r.e. has launched Ampero, a new fintech company that provides a solution to manage renewables portfolios with AI.

**Market & applications:**
Ampero emerged from Kaiserwetter, a company acquired by BayWa r.e. in 2021. Ampero developed cloud-based portfolio management software for renewables projects, including the introduction of the Aristoteles solution.

**Industry challenges:**
Solar project developers and owners need to handle a wide variety of data. However, it is difficult to manage data with a streamlined platform.

**Technical solution:**
Ampero reorganises the software developed by Kaiserwetter, building on existing strengths and integrating new features. Ampero offers portfolio management for owners of solar and wind plants, combining all relevant information such as financial and technical data as well as weather and energy market information. It harnesses data and AI, helping operators track variations in local energy grids, such as power supply, demand, and energy prices, to assess how efficiently a solar farm produces and sells electricity.

**Unique features & benefits:**
BayWa r.e. says Ampero’s holistic approach sets it apart from conventional methods and provides a quick overview for smart decision-making. It provides a comprehensive overview of complex asset portfolios, enables faster financial reporting and provides data-based information for strategic decisions.

Ampero can also automate previously manual processes, enabling portfolio managers to focus more on strategic tasks. It offers the option of benchmarking individual assets against the global portfolio.

Users of the software can also see production losses and underperformance, so they can reduce technical risks and trigger an investigation through service partners.

**Availability:**
It is available on the market.

---

Solar tracker manufacturer has launched SFOneX, a dual-row system that can be used in different types of terrain.

**Market & applications:**
SFOneX is designed to adapt to various types of projects. The company’s CEO says SFOneX is suitable for the US market due to its terrain adaptability, length, self-powered system, as well as its economic efficiency in installation.

**Industry challenges:**
Large and flat land is ideal for solar PV projects but it is getting more difficult to build large-scale projects in such terrain. In addition, as extreme events are more frequent, solar PV projects may need a tracker system to stow the modules to minimise damage.

**Technical solution:**
SFOneX boasts a self-powered system and is equipped with a dedicated module and a long-lasting battery so that the system can operate independently without sunlight for up to four days. Furthermore, its design with double rows connected by a flexible transmission axis not only lowers the number of tracking motors and controllers by half, but also offers a cost-effective solution for solar projects.

The system also has pre-assembled sets, standardised components and fewer foundation piles.

Similar to other tracker systems from Soltec, SFOneX features the adapted TeamTrack system that allows maximising energy capture by avoiding shading between rows. This algorithm can also balance production between diffuse and direct radiation to achieve maximum performance using bifacial modules.

**Unique features & benefits:**
SFOneX is the longest dual-row system in Soltec’s range with a length of 125 metres. It is also designed to adapt to various types of projects, minimising the need for civil works thanks to its terrain adaptability. Therefore, SFOneX can help reduce costs and associated environmental impact.

SFOneX can adapt to both north-south and east-west slopes of up to 15%, ensuring optimal land utilisation and simplifying the installation process through direct piling.

**Availability:**
The tracker is available now.
3rd Edition

RENEWABLE ENERGY REVENUES SUMMIT

21-23 May 2024 | Hilton London Tower Bridge

Navigating Trading, Power Purchase Agreements & Merchant Offtake

Confirmed Speakers Include:

Andrew Bowie MP
Minister for Nuclear and Renewables
UK Government

Bart White
Managing Director, European Head of Energy Structured Finance
Santander Corporate & Investment Banking

Benjamin Kennedy
Managing Director, Renewables
Ardian

Miranda Engdahl
Director of Power Sales Origination
Alight

Monika Paplaczyk
Investment Director
Thrive Renewables

Sulaiman Ilyas-Jarret
Head of Policy and Strategy, Renewable Delivery
Department for Energy Security and Net Zero

renewablerevenue.co.uk

Last Chance to Attend!

Our 2024 Sponsors

Gold Sponsor
Silver Sponsors
Bronze Sponsors
Supporting Sponsors

Save 15% on all tickets use code: PVTP15
Product reviews

Software

Stem launches centralised software for renewables portfolio management

Renewables solutions and services company Stem has launched the PowerTrac Asset Performance Management suite.

Market & applications:
The PowerTrac Asset Performance Management suite enables owners, operators and asset managers of renewables projects to centralise and streamline the management of storage, solar, and hybrid energy asset portfolios. It includes configurable, persona-based dashboards and workflows, allowing users to create and customise the interface and data they need most.

The system is developed based on Stem’s solar asset monitoring software PowerTrack and energy management system Athena. PowerTrack boasts a wide variety of data for analytics that can help reduce up to 5% of operating expenses and increase total energy production by 1-5%. This software is also a hardware-agnostic application, so it is capable of supporting data from third-party vendors.

Meanwhile, Athena integrates assets across the renewables ecosystem, including solar, storage and EV charging management. It interfaces with other platforms for data about weather, market prices, and utility rates.

Unique features & benefits:
The PowerTrac Asset Performance Management suite enables owners, operators, and asset managers of renewables projects to centralise and streamline the management of storage, solar, and hybrid energy asset portfolios. It includes configurable, persona-based dashboards and workflows, allowing users to create and customise the interface and data that they need most.

The suite is capable of performing portfolio-level technical and commercial performance monitoring and gathering site-level information and granular device-level data. According to Stem, the PowerTrac Asset Performance Management suite offers simplified and automated processes to help drive operational efficiency and ensure compliance.

Industry challenges:
The solar industry continues to grow in both scale of deployments and volume of capital. A streamlined platform can help project owners better manage solar PV projects.

Availability:
It will be available to selected customers in summer, and will be available to the wider customers at the end of the year.

Inverter

Imeon Energy develops inverter with 99% conversion efficiency

French inverter manufacturer Imeon Energy has developed an inverter which it claims has a power conversion efficiency of 99%.

Industry challenges:
How to lower the cost of power production is always a problem for solar PV project owners and operators. Enhancing conversion efficiency is one of the ways, while Imeon Energy claims that energy losses become nearly nonexistent in this inverter.

Technical solution:
In collaboration with researchers from electrical engineering and computer science school École Nationale Supérieure de l’Électronique et de ses Applications (ENSEA) and the GEEPS laboratory at educational institution CentraleSupélec, Imeon Energy uses transistors incorporating silicon carbide crystals to develop this inverter. The core material of this inverter is silicon carbide. Capable of conducting electricity while acting as an insulator, silicon carbide optimises solar energy conversion with efficiency exceeding 99%, according to Imeon Energy.

The company’s inverters are equipped with AI, allowing the inverters to evolve according to current and future technological evolutions including new batteries, connected objects and electric mobility.

Unique features & benefits:
With high energy efficiency conversion rates, the inverter can help reduce production costs for modules of the same size. Additionally, the inverter housing becomes half the size, thus accelerating the reduction of manufacturing costs.

The inverter can also generate active grid filtering. This function cleans the electrical grid, thereby avoiding the need for expensive equipment required to maintain grid quality.

Availability:
The inverter developed in this research will be used in the next series of smart solar inverters.
8th Edition
SOLAR FINANCE & INVESTMENT ASIA
24-25 September 2024
Singapore

Connecting Asia’s Solar & Storage Project Developers with Capital

Our Speakers

Adolfo Dindo Abueg
Senior Managing Partner
Abacap Infrastructure

M. Nicolas J. Firzli
Director-General
World Pensions Council

Kajal Bhimani Singh
Chief Commercial Officer
Gurin Energy

Steve Mercieca
ASEAN & Australia Project & Export
Finance Co-Head
Standard Chartered Bank

Sonia Dunlop
Chief Executive Officer
Global Solar Council

Christopher Ang
Group Head, Infrastructure &
Project Finance
United Overseas Bank

Anjali Viswamohanan
Director, Policy
Asia Investor Group on Climate
Change

Karim Megherbi
Founder & Executive Director
Orisun Invest

Key Themes for 2024

Scaling with 2050 Targets in View
Auctions, Regulation and Policy
Attracting Global Investment Partners
Emerging Asian Solar Markets
Grid Investment and Modernisation
Business Case for Co-located Storage
Alternative Financing for Renewables
Opportunities in Floating Solar

financeasia.solarenergyevents.com

2024 Partners

Editorial Partners

Media Partners

#SFIAsia

Save 15% on all tickets use code: PVTP15
PV modules are getting weaker – how should the industry respond?

Module strength | In recent years PV modules have become weaker as a result of their growing surface area and diminishing frame sizes. Colin Sillerud of CFV Labs reports on what testing has revealed about large-format modules and considers what the industry should do about it.

Over the past five years, photovoltaic (PV) modules have increased in area while their structural components, such as glass thickness and frame height, have been reduced. This has led to a dramatic mechanical weakening of PV modules, as shown in both laboratory testing and in-field results obtained by CFV Labs. A PV power plant is only as reliable as its components. The PV module, being the central component of a PV plant, must be mechanically robust enough to endure 20-30 years of environmental stresses.

From 2018 to 2024, the surface area of PV modules increased by 40-60% (Figure 1) on average. Concurrently, frames were reduced from 40mm in height down to 35mm, 30mm, and in some cases as short as 25mm. Further, most of the glass used in utility-scale modules has changed from 3.2mm with tempering to 2.0mm with heat-strengthening. An important feature of these changes also means that the module glass has an increased effect on the mechanical behaviour of the module relative to the frame.

Using glass as the primary load-bearing material can be problematic because it is a low-ductility material and suffers from brittle fracture (Figure 2). When glass is deformed, it either breaks or returns to its original shape. Metal, conversely, is ductile, so it can deform into the plastic regime before breaking. Glass is also inherently more variable because it breaks at existing weak points, called nucleation points, which can increase or decrease with the quality of the surface treatments, such as polishing.

While the PV module has changed, it is important to view it as part of a mechanical system. Modules require clamps and support structures. Many clamp options exist, including top-clamps and through-bolts, to name a couple. They are typically composed of aluminium or steel. Further, they come in a multitude of sizes and shapes, ranging from 200mm centre clamps to 1,400mm or longer rails. Then the support structures range from single-axis trackers of various heights and dimensions to fixed-tilt systems. Modules can be installed on trackers with a single module in portrait, two modules in portrait, or two modules in landscape.

Mechanical testing
To understand the mechanical properties of PV modules and how they’re qualified, it is important to understand the tests that the industry uses. Mechanical load testing is utilised by the industry to certify and/or qualify modules for different installations and loading conditions. Tests that are widely used today include static mechanical loading (SMLT), cyclic (dynamic) mechanical loading (CMLT), and test-to-failure (TtF).

The SMLT consists of a one-hour hold at a positive (downward), then a negative (upward) test pressure. This is repeated three times. Its goal is to test how a module performs under low frequency, high amplitude events such as snow loading or extreme wind. The CMLT consists of a five-second hold at a positive (downward), then a negative (upward) test pressure, usually +/-1,000 Pa. This is repeated 1,000 times and is designed to examine the module’s response to high-frequency low-amplitude events, such as a lifetime of moderate wind. The TtF consists of a constant ramp, 250 Pa/min for example, until the module either breaks or slips from the securement. TtF is used to gather breakage statistics and to set an upper strength limit for the module/clamp system.

While module manufacturers conduct testing during certification, and they supply installation instructions for a small subset of commonly used installation options, it is not possible for them to qualify every installation possibility ahead of time. As a result, larger PV projects require compatibility testing, which consists of a single SMLT on the site-specific module/clamp/torque tube combination using site-specific design/test loads. The test load is 1.5 times the design load.

Figure 1. A 2018 vintage PV module compared to a 2024 vintage PV module

Figure 2. A stress/strain plot comparing brittle (glass) to ductile (metal) materials [1]
However, the test requirements for project compatibility have been reduced over the last five years. Previously a compatibility assessment would require a standard SMLT conducted at \( \pm 2,400 \) Pa, a medium load of \( +3,600 \) Pa held for one hour and a snow load of \( +5,400 \) Pa held for one hour. Today, only the SMLT is conducted, and it is typically at a pressure below \( \pm 2,400 \) Pa. While testing and module strength were adequate in the past for normal operating conditions, qualitative results from field projects as well as quantitative results from laboratory testing show that they may not be sufficient for current designs.

### Modules getting weaker

Laboratory and fielded module test results point to a reduction in PV module mechanical durability. CFV’s results from compatibility testing in Figure 3, show an increase in the failure rate of these projects from 0% in 2018 and earlier to about 30% over the last three years. This means that module/clamp pairs that are being used in project designs are not able to withstand the site-specific pressures that current industry wisdom would expect them to.

Concurrently, the average test pressure has dropped from nearly 2,400 Pa to about 1,500 Pa, which may mean that the industry better understands actual site pressures. Or it may mean that site pressure estimates have been reduced to accommodate project approval. Either way, module failures have increased even as expectations have decreased.

CFV also manages projects related to various failures of fielded modules. CFV’s project bookings related to mechanical failures in fielded modules are up over 300% for the same time frame. These failures can be broken into two categories based on the type of damage – stress cracking and catastrophic breakage (Figure 4). Stress cracking manifests as a single or a few discrete cracks running through either or both the module’s front and rear glass sheets. Considering the projects that CFV has worked on, these can form early, sometimes before commissioning, and don’t correspond to an obvious high-stress event. They are hard to detect and usually don’t affect module power output in the short term. However, they can lead to insulation failures, which can put entire strings out of service and present a major safety risk.

Conversely, catastrophic breakage occurs when significant portions of a PV module’s glass is shattered, which usually corresponds with a high-stress event, such as high winds or impacts from hail or rocks. However, CFV has seen this type of damage even when meteorological data for a plant was within the design range. It is assumed that modules that are susceptible to stress cracks are also more susceptible to catastrophic failure, but this is currently anecdotal.

To validate our lab and field results, CFV conducted a dedicated test-to-failure experiment comparing modules from the past five years. The experiment was built to answer the following questions. 1) Are modules mechanically weaker today than they were five years ago? 2) What is the module breakage distribution shape and standard deviation? 3) Is the breakage distribution, or degree of variation, module size dependent/independent? 4) Is the breakage distribution clamp size dependent/independent? 5) Can we use test-to-failure to inform SMLT pressures?

To answer these questions, CFV utilised a test-to-failure approach. We sampled six module types, as shown in Figure 5. All modules were installed on an industry-standard single-axis-tracker torque tube using industry-standard 400mm centre clamps. Using our pneumatic test stand, pressure was applied in the downward direction to the front side of the modules at a rate of 250 Pa/min until the module failed mechanically, which we defined as glass breakage.

Our results show that modules have become at least 50-70% weaker since 2018. Further, module strength is dependent on size and frame height. As the module area increases, its TtF pressure drops. Likewise, as the module frame height drops, so does the TtF pressure. Figure 6 shows the breakage pressure for each sample set.

While examining the results, note that eight of the nine data points for Population 1 (1.950m², 40mm) that reached 5,400 Pa did not fail. The modules in this group reached a test pressure of \( +5,400 \) Pa and held that value for one hour. As a result, the true TtF value for this population is not yet documented, but it is greater than 5,400 Pa. For the purposes of this analysis, a TtF pressure of 5,400 Pa...
will be used.

Comparing Population 1 to Population 2, by reducing the frame height from 40 mm to 30 mm and by changing from glass/backsheet to glass/glass construction, the TtF pressure was reduced by 48.5%. Comparing Population 2 to 3, an increase in module size of 8.9% further decreased the TtF pressure by 15.2% for a total drop of 63.7% below Population 1.

Figure 7 zooms in on the left side of the plot to examine the larger modern modules. If the module area is held constant around 2.6m², increasing the frame height from 30 to 35 mm increased the TtF pressure by 4.7%, as shown by comparing Population 4 and 5. However, increasing size with the constant 35mm frame height still leads to a drop in TtF pressure, as shown by comparing Population 6 to 5. Specifically, population 6, with the largest area of 3.106 m², had the lowest TtF pressure, 5.3% below Population 5 and 67.2% below the benchmark, Population 1.

The degree of variation, or the likelihood that a single module represents the population, for this test population, was independent of the module size. The degree of variation, for a given sample population, is a function of the coefficient of variation, or the standard deviation divided by the mean. A value of 4.3 +/-0.2 was measured for the sample populations 2, 3, 4, and 5 when using a 400 mm centre clamp, which showed that the populations were similarly dispersed about the mean. These populations were chosen because they had large enough sample counts to extract basic statistics, and they broke during testing, unlike Population 1. This is a useful value, because it shows what to expect from an average glass/glass module with a 30-35 mm frame, an area of 2.0-3.2 m², and a 400 mm centre clamp. If a sample set is tested that falls outside of this range, it may warrant further investigation or planning.

Conversely, the degree of variation in the breakage distribution was dependent on the clamping size. The smaller the clamp, the larger the degree of variation, as shown in Figure 8, so the less likely it is that a single test will be representative of the mechanical strength of the population. The larger the clamp, the smaller the distribution, so fewer modules may require testing to provide a representative result.

One possible explanation is that the clamp size can change the module’s deflection profile. Figure 9 shows the deflection profiles for the same module type tested using 400 or 600mm centre clamps. Clearly, the way the module deforms under load is a function of the clamp width, which may contribute to the increased degree of variation.

Finally, the test-to-failure results for this sample set were able to predict a passing SMLT pressure. The TtF values were divided by the SMLT pressures on the same modules to calculate a percent difference that can inform a passing SMLT pressure. As shown in Figure 10, a consistent passing result for 400mm centre clamps was achieved when using an SMLT pressure that was 30% below the measured TtF pressure. In other words, if an interested party is uncertain about the strength of their system based on the result of a single test, they can run a TtF regime. CFV recommends testing three modules to failure, then using that result to conduct an SMLT to validate the test and design loads that are achievable with a given module/clamp combination.

Questions for the industry

These results raise many questions for the PV industry. Firstly, is module mechanical durability an issue that actually needs to be addressed? Most commodities have a certain failure rate resulting from the cost/quality optimisation curve. As PV modules have become mechanically weaker from 2018 to 2023, their cost per watt has also dropped by approximately 21%. Is a measurable failure rate acceptable to achieve a lower module cost/watt?“
expected operating conditions. Today’s modules appear to be built specifically to meet the 1.5 safety factor, but they are breaking, so is the 1.5 safety factor enough to ensure mechanical stability of fielded modules? Increasing the safety factor is a catch-all solution that would necessitate the use of larger clamps to meet test loads for a given site load estimate. This solution is simple to implement for new projects, doesn’t require new tests to be designed and doesn’t require new technology. However, change at the standards level might be difficult, in which case, developers would have to implement it themselves, which may increase the cost of their bids outside of the industry rate.

Lastly, can this be solved with new methods or technologies? New construction materials, such as steel frames, will likely come to market shortly and have shown promising initial results. CFV has tested a small sample set of two PV modules using prototype steel frames. While the results are preliminary, the two glass/glass samples showed a TtF value in the downward direction of approximately 4,400 Pa, which was an increase in TtF pressure of 113% over the nearest similarly sized and constructed module with an aluminium frame that we tested.

In conclusion, utility-scale modules have got weaker between 2018 and 2023. Increased failures have been reported in test results and in field-related projects. Experimental test results concur, showing a decrease in TtF pressure of at least 50-70% for modern modules as compared to modules manufactured in 2018 and earlier. The degree of variation, or the likelihood that a single module represents the population, is not a function of module size, but it is a function of clamp size. When using thinner clamps, a single module is less representative of the population, which is important to keep in mind when analysing test results. As the stability of the mount is increased, the degree of variation drops, increasing the likelihood that a single module represents the population. Lastly, TtF can be used to inform the maximum SMLT pressure that a module can pass, which can be used to determine independent maximum test and design loads.

While unanticipated module glass breakage is occurring in today’s PV modules, it is important to note that solutions like larger clamps do exist using today’s resources, and it is likely that newer materials may also provide a solution.

References

Author
Colin Sillerud is the VP of engineering and head of reliability testing at CFV Labs in Albuquerque, NM. He has both collaborated on and designed IEC test protocols and published research on photovoltaic module mechanical and backsheet durability. Most recently, he spoke at the PV Reliability Workshop on changes in the mechanical durability of PV modules. He is also active on multiple standards committees such as IEC TS 63209-1, Extended Reliability Testing.

PV ModuleTech Conference Europe
26-27 November 2024 | Málaga, Spain

Understanding PV module supply to the European market

Your questions answered across the two conference days:

- Will TOPCon modules remain mainstream during 2025 and how are module suppliers optimizing the field reliability and performance of solar plants using this technology?
- Who will be the leading PV module suppliers to the European market in 2025 and beyond?
- How can module buyers fully understand module supplier traceability and ESG concerns?
- Has the average selling price (ASP) of PV modules in Europe bottomed out and will there be a rebound to 2022 pricing in coming years?
- Is there a move to standardize European PV module dimensions and cell/wafer sizes?
- Where is the growth from heterojunction module types coming from?
- How many of the PV module suppliers to the European market are now high-risk buying options, following a year of potential loss-making for PV manufacturing?
- How are PV modules in Europe being tested by third-party labs and are there new tests that need to be introduced going forward?
- Is 2025 going to finally be the year of strong investments into European module assembly and will this funding come from European or Asian companies?
- Is the growing trend to outsource manufacturing to Eastern Europe and Turkey a short-lived trend or something that will grow in coming years?
- How are PV module suppliers addressing low-carbon footprint manufacturing requirements to participate in selected end-markets across Europe today?

www.pvtechconferences.com/pv-moduletech-europe e: pvmoduletech@pv-tech.org

Exclusive 20% ticket discount
Use code: PVTP20
Bringing solar availability assumptions back down to earth: the case for adjusting to 97%

System availability | PV system modelling relies on a standard assumption of 99% availability as the basis for forecasting output. But, as Hannah Rasmussen of kWh Analytics and Ben Browne of kWh Analytics argue, the adoption of a more realistic metric would improve accuracy in financing and a more economically resilient solar asset class.

The growth of the solar industry in the United States has been staggering, with no signs of slowing down [1]. As the PV industry matures, there is a renewed focus on accuracy and financial stability as the solar industry reaches its adolescence. Financing of a given project is closely tied to its expected energy production, so more accurate energy projections will improve accuracy in financial modelling. The kWh Analytics 2022 Solar Generation Index [2] found that PV systems across the US are underperforming by 7-13% compared to their projected energy generation. There is a clear discrepancy between modelled forecasts and reality, and overly optimistic availability assumptions used in PV system modelling can contribute to this discrepancy. At a high level, availability is a metric that describes the degree to which an energy plant (in this case, a solar energy plant) is online and producing electricity, and has historically been assumed to be 99% for PV systems. Recent studies from kWh Analytics reveal that 99% availability is an overly optimistic value and that 97% is a more realistic metric to use when modelling photovoltaic systems. Using this more realistic availability assumption will lead to improved accuracy in financing and a more economically resilient solar asset class.

Faulty forecasts can threaten solar investments
Many external factors and internal components affect a PV system’s production, and all these are taken into account in projected energy modelling. Projected energy is affected by historical irradiance, system design, expected availability and many more site characteristics. Developers use probabilistic forecasting to estimate a PV site’s energy production and inform financing. Variability in yearly irradiance and uncertainty in modelling assumptions create a probability distribution (Figure 1) of the energy that a given PV system could produce in a single year. The metric used to describe the annual energy production that a PV system is expected to exceed 50% of the time is called a P50. For example, if a PV system has a P50 of 100MWh, it is expected to produce more than 100MWh for half of its operational years and less than 100MWh for the other half of its operational years (ignoring the effects of degradation). If the P50s are overestimated due to overly optimistic availability assumptions, a system will achieve its P50 target less than 50% of the time over its lifespan. As a result, investors won’t receive their expected return on investment. If this happens widely across the industry, faith in photovoltaics among the public will be shaken and investor willingness to finance PV will decrease. For these reasons, it is imperative to be as accurate as possible when developing models for this asset class.

Figure 1. Probability distributions are used to model PV systems’ projected energy generation. The P50 describes the projected energy value that a PV system is expected to exceed 50% of the time.
Finding clarity despite the DIY (‘define-it-yourself’) nature of availability

Availability is intended to describe the degree to which a PV system is fully operational. Availability calculations can include downtime due to equipment failures, equipment repairs and preventative maintenance for a partial or entire system. This metric does not typically include grid-related outages or curtailment. However, there is a financial argument to include all kinds of downtime in availability measurements, as any time a system is partially or completely offline, revenue is not being generated. The more precise definition of availability remains debated in the solar industry. Most PV system and operations and maintenance (O&M) contracts have their own definitions of availability, centred around events for which the O&M provider assumes responsibility.

It follows that availability definitions can vary greatly depending on what kinds of energy losses are excluded from the contract. The reported metrics can even go as far as to vary in units of measurement, as some definitions of availability are based on length of downtime and some are based on the amount of energy that could have been produced during downtime. It is worth noting that the definition of availability most useful to an O&M provider is likely quite different from that most useful to an asset manager. The O&M provider is incentivised to exclude energy losses that they do not feel are within their scope of work, while the asset manager would be most interested in any time the project is not producing revenue when it is expected to be. This disparity in perspective between the boots on the ground and the suits financing projects results in a lack of clarity about the definition of availability throughout the industry.

While the need for O&M providers to define availability on a per-contract basis is unavoidable, this variety in definition creates challenges to analysing availability data reported from the field. kWh Analytics suggests that in conjunction with O&M-defined availability, a standardised availability be reported. The IEC standard 63019:2019 [3] provides a framework for standardising the definition of energy-based availability for PV systems, while the “Best Practice for Developing Availability Guarantee Language in PV O&M Agreements” [4] from Sandia National Labs provides standardisation for calculating downtime-based availability. Adoption of one or both standards would help clarify the availability of data for everyone. Both energy-based and downtime-based availability calculations have unique use cases, but an advantage of reporting availability that was calculated using downtime rather than estimated energy lost is that these metrics would foster ease of comparison of availability between all PV systems, as the use of estimated energy lost in availability calculations introduces variance due to differences in probabilistic modelling methods across PV systems.

On a monthly or quarterly basis, O&M providers report metrics for a site in monthly operating reports (MORs) or quarterly operating reports (QORs). These MORs can contain availability data as reported by the O&M provider. Through our insurance products and through our data analytics product, HelioStats, kWh Analytics has collected data-driven insights from varied perspectives on PV site performance via these MOR reports. With this arsenal of data, we are able to analyse availability as reported by O&M providers themselves, from PV sites across varied regions, capacities, O&M providers and site designs. Despite the most useful definition of availability differing for O&M providers and asset owners, the O&M-reported metrics still provide valuable insight regarding PV availability. Since O&M contracts can define availability as excluding some downtime events, the “true” availability of the PV systems in this analysis may be even lower than the figures reported below. kWh Analytics has examined the common (but recently increasingly challenged [3]) industry assumption that PV systems can be expected to achieve 99% availability for their lifetime and should be modelled as such. We ultimately find that this is an unreasonable expectation for any PV site, regardless of season, size or region, and suggest a new industry availability standard of 97%.

Deciphering the data

The kWh Analytics database has hundreds of commercial & industrial (C&I) and utility-scale systems and hundreds of thousands of months of operating data. However, only 485 of the C&I and utility-scale systems in our database have reported availability data in their MORs, with about 26,000 availability data points in total. This reflects the lack of frequency with which availability data is reported in MORs. We acknowledge these caveats in the analysis that follows:

- Availability is sometimes reported at the quarterly level as opposed to the monthly level. Quarterly availability data is excluded from any monthly analyses.
- All the data in this analysis is defined by the O&M provider. MORs typically do not provide explicit definitions of how the availability values are calculated, so we are limited in our ability to conduct any adjustments on values reported in the MORs.
- Both downtime-based and energy-based availability is included in these analyses. It is often not reported how a given report’s availability values are calculated and thus is not feasible to distinguish downtime-based and energy-based calculations from each other.
- Below, we analyse reported grid, inverter and system-level availability. It is rare for all three to be reported in a given MOR – in fact, it is often the case that only one of the three is reported. Therefore, the set of system-years in each data set is different.
- Systems used in this analysis are limited to the contiguous 48 states.

Starting with 485 C&I and utility-scale systems in the kWh Analytics database with availability data, we took the following data-cleaning steps to include only the highest quality data in our analysis:

- Only include points that comprise a full system-year.
- Assume vaguely defined availability reflects system-level availability.
- Drop systems that ever report greater than 100% availability.
- Drop points that report 0% availability in case they are falsely reported null values.

After performing these data-cleaning steps, 165 systems with high-quality availability data remained to be included in this analysis. Many systems were dropped in the step to include only full system-years of data, such that this drop in systems reflects the lack of consistency with which availability data is reported across MORs. For example, if a system changes hands between O&M providers, and each O&M provider reports different kinds of availability (or one reported availability and the other did not), the full year of availability data is jeopardised. Asset owners have the power to ask for improved reporting of availability to allow for increased transparency of frequency of system downtime.
The industry should move towards required and standardised availability reporting to improve understanding of this important metric.

A left-skewed reality
From the cleaned data, kWh Analytics averaged availability across the three kinds of metrics most often reported in the MORs that we see: grid, inverter and system availability. The energy loss events included in each availability value are defined by the O&M provider, but in general, the following definitions provide an overview of these three kinds of availability:

- Grid availability: availability including lost energy only due to grid outages or curtailment.
- Inverter availability: availability including lost energy only due to inverter outages.
- System availability: availability including lost energy due to any unforeseen energy loss event.

All three types of availability have P50s close to 99%, as shown in Figure 2. However, a long-left-tail distribution can be seen for all three metrics, with some system-year availability values falling below 80%. The low values can be driven by equipment failures, equipment repairs and preventative maintenance, and are not a result of weather-related energy loss. The long left tails pull the average (“mean” or “μ”) availability down significantly, giving an average availability between 96.4% and 97.2% depending on the kind of availability. Others have published similar findings that availability realised in the field is significantly below the purported 99% [6].

P50s are useful to convey the centre of a dataset when the distribution the data follows is known to closely resemble a normal (bell-shaped) curve. This is especially true if there are outliers in the dataset that are orders of magnitude off from the rest of the data. The histograms shown in Figure 2 do not resemble a normal distribution at all and instead are heavily skewed left, so the usefulness of P50s to convey the expected availability of a PV site is immediately called into question.

At present, financial models of PV sites only include one availability number - usually 99%. Ideally, availability would be modelled using a distribution, like those shown in Figure 2. Instead, most current PV models use a single, constant availability value, and it would be a heavy lift to rebuild these models to include this kind of best-practice availability modelling. In the interim, we suggest using mean availability instead of P50s for a system’s single-modelled availability value, as mean availability takes the long left tail of the distribution of values into account, while P50s do not. Specifically, our analysis suggests that a mean availability of 97% would be far more reflective of PV site lifetime availability than a P50 of 99%.

The effects of season, size, and location on availability
A clear next step in our analysis was to investigate the effects of seasonality, DC capacity and region on availability. It must be noted that each of these omits some data from the larger dataset. The monthly dataset omits quarterly data used in the larger analysis. The DC capacity dataset and location dataset omit systems for which the kWh Analytics database does not have DC capacity and location data, respectively, as many MORs do not provide these metrics.

As shown in Figure 3, grid, inverter and system availability may have slightly different seasonality trends, but in sum, it seems that availability trends lower from April to September, when losses due to low availability are most costly. Possible causes for this lower availability include increased animal activity during these months (causing shorts in equipment), moisture infiltrating equipment in rainy climates, high temperatures increasing strain on electrical systems, curtailment, and outages due to severe convective storms. Further analysis comparing availability to maintenance logs would need to be conducted to identify which of these causes, and which other causes not listed, are chief drivers of low availability during these months.

In Figure 4, the main bars represent system availability P50s by DC capacity, and the black lines represent the range from P90 to P10 for each grouping of DC capacities to convey the shape of the distribution. 90% of values in a distribution fall above the P90, while only 10% of values fall above the P10. Simply put, a system owner would expect their asset to achieve availability over the P90 value 90% of the time. We find that system availability seems to be independent of site size across utility-scale systems and that the trend of a left-skewed distribution does appear to be present across all ranges of utility-scale systems. This highlights the need for PV systems of all capacities to adjust availability forecasts to match empirical findings.

The results of an analysis of system availability across three regions of the US is shown in Figure 5. The regions are defined according to the legend in Figure 5, and
Save 15% on all tickets. Use code: PVTP15

2nd Edition

Energy Storage
Central Eastern Europe

HOSTED BY
n-gen
energy system solutions

24-25 September 2024 | Hilton Warsaw City, Warsaw, Poland

Revenues and Regulations: Enabling Large-Scale Regional Energy Storage Deployment

Key Themes for 2024

- New Market Opportunities
- Forecast for Poland
- Financing and Funding Energy Storage Projects
- Deployment: Permitting and Connections
- Unlocking Revenue Streams
- Market Experts Roundtables
- Storage Supporting the Grid and Energy Security
- Regional Spotlights

Book now: storagecee.solarenergyevents.com

2024 Sponsors & Partners

Host Sponsor | Gold Sponsor | Supporting Sponsors | Exhibitor

n-gen energy system solutions | Jinko Solar | KXOXO | TWAICE

Host Event Partner | Editorial Partner | Partners

POLISH UNITED ENERGY ASSOCIATION | Energy Storage Hub | RENEWABLES.AZ
Can 99% lifetime availability ever be achieved?

Perhaps you are a responsible asset owner and wish to do so. We maintain that this is an unreasonable expectation, but if a PV site were to achieve it, we expect that it would do so by enacting the following best practices published by leaders in the industry.

The National Renewable Energy Laboratory’s “Best Practices for Operations and Maintenance of Photovoltaic and Energy Storage Systems” [6] provides an excellent guide for O&M providers that are focused on maintaining high availability. Among many other actionable recommendations, this guide states that “the higher the desired (or contractually required) availability for a plant, the more spare parts will have to be kept in inventory” (p.52). This handbook provides a comprehensive formula to calculate the number of spare parts to keep on hand for a given equipment piece and describes strategies to maintain a readily accessible stock of spare parts. A strained supply chain, the emergence of new technology and retired warranties have only made the challenge of finding new parts for sites more difficult since this best practice guide was published over five years ago, making the impact of a spare parts inventory on maintaining high availability even greater.

For an asset owner, the most impactful steps to achieve a high level of availability and ensures longevity of a PV site are taken before the PV system even goes online. Sandia National Laboratory’s “A Best Practice for Developing Availability Guarantee Language in PV O&M Agreements” [4] highlights the importance of intentionality in an O&M contract and states that the contract drives the “level and quality of [the] maintenance activities” that are necessary to achieve high availability. The guidelines provided by “Budgeting for Solar PV Plant O&M: Practices and Pricing” [8] recommend that an asset owner receive third-party feedback on a PV system’s O&M strategy from an independent engineer. This work also states that the lack of proper allocation of funds for O&M “can ultimately undermine a plant’s lifecycle performance economics” (p.5). This implies that without appropriate budgeting for O&M, a PV system is at risk of more frequent outages and slower return to 100% availability, leading to a negative feedback loop resulting in lower lifetime availability.

kWh Analytics’ empirical data clearly shows that 99% lifetime availability is not realistic and incredibly difficult to achieve. Many PV sites continue to be modelled with this high target metric, leading to an avoidable discrepancy between predicted and actual energy generation. Ideally, availability would be modelled as a distribution with a long left tail, shaped by data-driven findings and varied by seasonality, site design and location. A simple improvement that can be easily implemented with current modelling frameworks is to use a single value that is influenced by the shape of the real-world distribution of availability values. Given that this actual distribution of availability is strongly left-skewed, the mean is more representative of the range of outcomes than the P50, so we recommend using the mean value of 97%.

References


Author

Hannah Rasmussen is a data quality lead at kWh Analytics. Prior to working at kWh Analytics, she worked in a computational physics lab studying the effects of sterile neutrinos on the early Universe. Hannah has a B.A. in physics and mathematics from the University of San Diego. She is from Cincinnati, Ohio and currently lives in Denver, Colorado.
The PV industry’s leading Market Report to understand the strengths & weaknesses of all leading module suppliers today.

The PV ModuleTech Bankability Ratings report is compiled quarterly by the PV Tech Market Research team, led by Dr. Finlay Colville. The rigorous methodology applied analyses the manufacturing and financial health of module suppliers, their in-house production and global shipment coverage.

- Understand the key differences between module suppliers AAA-Rated and those listed lower in the Bankability Pyramid.

- Gain a comprehensive and detailed picture of all leading PV module suppliers today, across a host of key metrics updated quarterly.

- Find out how vertically-integrated each module supplier is; and where in-house capacity is located globally.

- Quickly identify the ‘red-flags’ in module supply by company, as global trade restrictions evolve.

- Engage directly with Dr. Colville and the PV Tech Market Analysts when you become a Report user.

Contact us to learn more

marketresearch.solarmedia.co.uk/reports  marketresearch@solarmedia.co.uk
How digital twins are revolutionising solar operations

**Digitalisation** | Using AI and machine learning technologies, digital twins are providing new methods for optimising the design, construction and operation of PV projects. In this article, two innovators in the space, SmartHelio and Sitemark, look at how digital technologies are streamlining all stages of a solar project’s lifetime.

Digital twins are virtual replicas of physical entities, updated with real-time data to optimise performance. In solar PV, they range from panel replicas to entire farms, evolving with real-world changes. They expedite technology development, improve product quality and refine energy management, fostering sustainability by minimising waste and optimising resources. Their potential is vast and is poised to transform renewable energy.

In the solar PV sector, digital twins manifest in various forms, such as detailed replicas of solar panels, entire solar farms, or even the broader network infrastructure they connect to. These sophisticated virtual models are not just static representations; they evolve and adapt, reflecting real-time environmental data and operational changes. This capability is invaluable in areas like reducing the time to bring new technologies to market, enhancing the quality and efficiency of solar products and refining the overall experience in energy asset management. The potential of digital twin technology in the solar PV industry is immense, promising significant strides in efficiency, sustainability, and innovation.

### Digital twins in solar – applications and usages

The construction and management of solar assets typically involves navigating a complex array of several different specialised tools, each addressing specific aspects of the job. This fragmented approach not only makes it challenging to maintain up-to-date information across all tools but also poses a significant risk of data loss as assets progress through their lifecycle and change hands among various stakeholders.

A common issue faced by asset managers is the loss of crucial data, such as topographies and original DXF design files, during the transition into asset management. This problem is exacerbated when operational plants are sold or when there’s a change in operations and maintenance (O&M) teams.

Often, the intimate knowledge of a site’s specificities rests with particular individuals who have extensive experience with the site. However, with rapid team expansions and frequent job changes, relying on individuals for such knowledge is unsustainable. There’s a pressing need for a robust system capable of preserving all the documentation and records of interventions for a solar plant. Such a system should seamlessly integrate all aspects of solar asset management, ensuring that critical information is not only preserved but also easily accessible, thereby enabling efficient and effective management of solar assets throughout their lifecycle.

The following details some of the many applications and use cases for digital twins:

- **Performance optimisation**: AI-driven digital twins can analyse data from solar panels to optimise their performance. This includes adjusting the operational features of the solar plant in real time to maximise the energy production of the solar PV system.
- **Fault detection and diagnostics**: Digital twins can swiftly identify and diagnose faults in the solar PV system. They can analyse data to pinpoint the exact location and nature of faults, such as inverter failures, panel shading, or electrical connection issues, enabling rapid response and resolution.
- **Predictive maintenance**: Using AI algorithms, digital twins can predict potential failures or maintenance needs of solar plants and their related equipment. By analysing historical and real-time performance data, they can identify patterns or anomalies indicating wear or impending failure, thus scheduling maintenance proactively to avoid severe system downtimes.
- **Energy yield forecasting**: AI models integrated with digital twins can accurately forecast the energy yield of solar PV installations. These forecasts take into account various factors like weather conditions, panel efficiency, and historical performance data, helping in better grid management and energy distribution planning.
- **Lifecycle management**: Digital twins can monitor and manage the entire lifecycle of solar PV installations, from design and construction to operation and decommissioning. This holistic approach ensures optimal performance throughout the system’s lifespan and assists in decision-making regarding upgrades or expansions.
- **Integration with weather systems & dynamic calibration**: By integrating with weather prediction systems, digital twins can anticipate changes in weather conditions, such as cloud cover, temperature fluctuations, or storms, and adjust operational parameters accordingly to maintain optimal performance and minimise damage risks.
- **Efficiency analysis and improvement**: These digital twins can continuously analyse the efficiency of solar panels, other electrical equipment and the overall system. A smart comparison between the simulated patterns, estimated by the digital twin, and the actual system behaviour can suggest potential improvements, such as cleaning schedules, or panel reconfiguration, or string/module testing to enhance the overall efficiency and energy output of the solar PV installations.

**Data-driven decision making for investments**: For investors and operators, digital twins provide comprehensive data analysis and simulation capabilities. This can inform decisions about where to invest in new installations, how to expand existing ones,
or when to replace components, based on detailed cost-benefit analyses and performance projections.

How digital twins work

The journey towards creating a digital twin is initiated by establishing a robust data infrastructure. This process starts with the development of basic models, which are then progressively enhanced by incorporating more sophisticated layers of data, analytics and real-time feedback mechanisms. The integration of artificial intelligence (AI) and machine learning (ML) plays a pivotal role in this evolutionary process.

The traditional way of developing advanced digital twins follows the below process:

**Building the data infrastructure:** The initial phase involves collecting and organising data from various sources, such as inverters, string combiner boxes, solar panel sensors, weather stations and other operational and maintenance logs. This data forms the backbone of the digital twin, providing the essential information needed for accurate simulation and analysis.

**Integration of the scientific models:** The integration of scientific models is a critical step in the development of a digital twin for the solar PV industry, situated between the initial establishment of data infrastructure and the application of AI and ML technologies. This phase involves embedding domain-specific knowledge and scientific principles into the digital twin to enable it to understand and simulate the system’s behaviour accurately based on its engineering design and the underlying science.

**Integration of AI and ML:** As the complexity of the digital twin grows, AI and ML algorithms become integral. These technologies are employed to analyse vast amounts of data, learning patterns and behaviours of the solar PV system. AI helps in predicting potential failures or inefficiencies by analysing historical and real-time data. For instance, AI can forecast the impact of weather changes on solar output or detect anomalies in panel performance that might indicate a need for maintenance.

**Real-time feedback and adaptation:** AI and ML enable the digital twin to adapt and respond to changing conditions in real-time. This capability is crucial for setting the expected performance KPIs and behaviour to sudden weather changes or sudden faults in the system or recently carried out operations and maintenance activities. By continuously learning from new data, the digital twin becomes increasingly accurate and reliable in its predictions and suggestions.

**Scalability and future expansion:** As digital twin technology evolves, it can scale to accommodate larger and more complex solar energy systems. Future developments may include more advanced AI models that can handle larger datasets and provide even more precise predictions and operational recommendations.

Digital twins in practice – pre-construction

Headquartered in Leuven, Belgium, Sitemark offers integrated software and aerial inspection solutions, enabling digitalised design, construction, and operational management throughout the entire solar site lifecycle.

Sitemark was hired by Alinea Solar to assist in the design of a 1.1MW solar power plant. The project’s engineering, procurement, and construction team initially claimed that the project site was more or less flat, which was a crucial factor in the plant’s expected yield and overall design. Upon conducting a detailed topography using drone survey technology, Alinea Solar discovered a significant slope of 40 metres, contradicting the EPC’s initial assessment. This new information suggested a substantial deviation in expected yield—from the projected 1,771 MWh/year to 1,670 MWh/year. This discrepancy pointed towards a potential lifetime yield loss of €111,155 for the client.

Alinea Solar utilised Sitemark’s drone-based digital solution. This included flying over the site, uploading data to the Sitemark Fuse Platform and obtaining a detailed topography. This allowed for the simulation of different designs in PVsyst, a solar PV system design software, without the need for a physical surveyor on-site.

Utilising Sitemark’s solution and its integration with PVsyst, Alinea Solar redesigned the site within a week. By slightly deviating the panels from the south and adjusting the pitch, they reduced shadowing and increased the performance of the solar plant to 1,745 MWh/year. This redesign significantly reduced the calculated lifetime yield loss from €111,155 to €35,522, a 68% reduction.

Digital twins in practice – construction

Enel Green Power, with assets in operation or under construction across 21 countries, recognised the need to digitalise its solar construction projects. The main challenge was the effective monitoring and management of mechanical activities during the construction phase of solar projects on a global scale, ensuring alignment with project schedules and designs.

Enel Green Power implemented Sitemark’s “Solar Construction Monitoring” solution, which enabled project configuration from the engineering phase. The solution also allowed for detailed project information and access to multiple users, such as managers and on-site coordinators.

The use of Sitemark’s solution led to significant time savings in verifying data provided by contractors, enhanced visualisation of project progress through images and colours on the platform, and improved on-site productivity. The platform also allowed for the generation of tables and graphs from the collected data, useful in project review meetings for stakeholders not present on-site. This holistic approach to solar construction monitoring provided a substantial added value to Enel Green Power’s construction process, leading to better coordination, more accurate progress tracking and efficient resource allocation.
Digital twins in practice – operational stages

SmartHelio’s physics AI- and digital twins-powered solution integrates advanced analytics and AI algorithms into a solution that revolutionises asset management for solar plants. It combines real-time plant data with weather data from different sources and compares it with similar plants to provide a comprehensive and accurate health status. The platform detects, predicts and categorises faults 10 times faster than existing solutions, thanks to the physics-informed AI models that help reach an accuracy of 86.46% for fault detection within day one of integration to the client’s SCADA/monitoring system.

SmartHelio helped Austria’s largest independent power producer grow its portfolio using predictive analytics. The IPP wanted to add 8TWh of green electricity to its portfolio by 2030, including solar assets. Its asset monitoring processes were heavily based on reactive maintenance which, for the most part, mandated a physical inspection of the site to zero down on the root causes of underperformance. Just 1% underperformance would lead to ~€1,200 per MW per year in lost revenue. This means that by 2030, a 1% underperformance of their portfolio would amount to €2.4 million of annual losses.

SmartHelio has built software with physics-informed Al-based algorithms that can automatically detect the early signature of faults before they impact a PV plant’s performance. The Austrian IPP was interested in integrating SmartHelio’s algorithms into its existing digital infrastructure, to empower its asset management team by having the flexibility to utilise their field experience to further improve a predictive analytics solution, with full transparency.

Post-implementation analysis of a project revealed significant insights into performance improvement opportunities. Detecting an average of 5% underproduction, with 80% recoverable faults, including tracker malfunctions, inverter failures, and vegetation growth, highlighted the efficacy of proactive monitoring. Moreover, employing predictive analytics could have averted 30% of total losses, potentially saving approximately €4,000 per MW per year in lost revenue. SmartHelio’s software demonstrated remarkable capabilities in early fault detection, empowering the Austrian IPP to optimise its O&M activities and mitigate performance impacts proactively.

Challenges and opportunities

Despite the promising advancements, there are challenges and limitations that need to be addressed. One major challenge lies in the standardisation and compatibility of different systems and data formats. As solar PV systems become more complex and widespread, ensuring that various digital twins can communicate and share data seamlessly is a significant hurdle. Another challenge is the sheer volume of data generated, which requires sophisticated algorithms and storage solutions for efficient processing and analysis.

There is also the aspect of data security and privacy, especially when dealing with sensitive information across multiple platforms. Furthermore, the reliance on advanced technology such as drones and AI for data collection and analysis brings its own set of challenges, including regulatory compliance, technical reliability and the need for specialised skills. Overcoming these challenges will be crucial for the successful implementation of digital twins in solar.

Nevertheless, the role of digital twins in solar is poised for a transformative evolution. There is a growing need for more seamless integrations that facilitate the sharing and analysis of data across different technological platforms. This integration will enable asset owners and operators to derive more nuanced insights from a combined dataset than what is possible from isolated systems. By integrating various data sources with traditional monitoring systems, solar asset management can reach new levels of efficiency, accuracy and yield optimisation.

With a focus on predictive analytics, digital twins facilitate early fault detection and failure forecasting, optimising operational efficiency and enhancing safety by mitigating risks such as over-voltage and fire hazards. These strides underscore a significant advancement in digital twin applications within the solar energy sector, promising both enhanced efficiency and safety.

Transitioning towards a more robust deployment of solar plants highlights the need to address the efficiency decline of ageing facilities. While technological evolution has yielded more efficient and cost-effective solar panels and inverters, ageing equipment remains vulnerable to the impacts of climate change. Harnessing the power of digital twins enables systematic evaluation of repowering underperforming older plants, ensuring economic feasibility and sustainability.

With AI-based solutions like ChatGPT already impacting multiple sectors, the solar industry is poised to embrace these advancements for enhanced profitability. Now is the opportune moment for the solar energy sector to revolutionise the design and operation of solar facilities, maximising economic returns and environmental sustainability.

Authors

Govinda Upadhyay is CEO and co-founder of SmartHelio. A climate and energy researcher by background, he delivers cutting-edge solutions that revolutionise the design and operation of solar facilities, maximising economic returns and environmental sustainability.

Neeraj Dasila is CTO and co-founder of SmartHelio. He has developed big data and AI-based products for Tata and electrified regions in India with government support.

Maxine Cronier is SmartHelio’s head of global partnerships and sales. With a background in sustainable investment and social entrepreneurship in Europe and China, she has developed energy access in rural areas of Kenya to empower women.

Stanislas van der Vaere, the managing director and head of sales at Sitemark, leads the business development team, driving renewable energy innovations globally. With a background in electronics and aviation, he delivers cutting-edge solutions that empower clients and transform industries.
Intersolar Mexico
Connecting Solar Business

SEPT 03-05 2024
CENTRO CITIBANAMEX, MEXICO CITY
THE INTERNATIONAL EXHIBITION AND CONFERENCE FOR THE SOLAR INDUSTRY

www.intersolar.mx
Enhancing reliability in bifacial PV modules: a novel approach to albedo estimation

Bifacial | The measurement of albedo, or surface reflection, is crucial in calculating the output of a bifacial solar system. Researchers from Enertis Applus+ and the University of the Basque Country report on a new methodology developed to improve the accuracy of bifacial performance assessments by reducing errors in albedo estimation.

The solar PV energy market is witnessing remarkable global growth. According to the latest data from the International Renewable Energy Agency (IRENA), solar accounted for the largest share of the global renewable power capacity, reaching 1.419GW by the end of 2023. The selection of PV plant locations hinges on estimating their financial profitability based on projected systems performance throughout their lifespan. This estimation relies on various models, whose accuracy is partly contingent on precise measurement of input parameters.

In bifacial solar PV systems, albedo is a critical parameter, representing the percentage of radiation reflected by a surface. Any error in albedo estimation can result in a performance estimation error ranging from 2% to 8% [1]. Enertis Applus+ adopts a customised approach to albedo characterisation, tailored to specific market requirements, ensuring the highest level of accuracy in performance estimations. This estimation relies on various models, whose accuracy is partly contingent on precise measurement of input parameters.

In bifacial solar PV systems, albedo is a critical parameter, representing the percentage of radiation reflected by a surface. Any error in albedo estimation can result in a performance estimation error ranging from 2% to 8% [1]. Enertis Applus+ adopts a customised approach to albedo characterisation, tailored to specific market requirements, ensuring the highest level of accuracy in performance estimations. To this end, various complementary methodologies are proposed for measuring albedo, including surface albedo measurements or estimates derived from satellite data.

Recent research indicates that, due to the high spatial variability of albedo, the most reliable measurements are obtained through long-duration surface campaigns with high spatial resolution (areas less than 100m²) [2], supplemented by satellite measurements when surface data is limited.

However, particularly in new PV system locations, conducting long-term albedo measurements may not be feasible. In these cases, albedo values need to be estimated from short-term measurements lasting a few hours or days. A recent study by the Enertis Applus+ R&D team, in collaboration with the Institute of Microelectronic Technology of the University of the Basque Country (TIM-UPV/EHU), has demonstrated that characterising albedo using a single short-term measurement campaign results in significant variability due to meteorological or seasonal changes [3]. Furthermore, albedo variations of more than 60% have been observed within the same day.

As an example, Figure 2 depicts the distribution of specific albedo measurements, recorded every minute over the course of one year at a meteorological station in Sabinal (Texas, USA). These measurements are correlated with the clarity index (Kt), representing the degree of cloudiness, and are further analysed based on various levels of daily precipitation. This data, made publicly accessible through the DuraMAT consortium coordinated by the US National Renewable Energy Laboratory (NREL), underscores the complexity of albedo calculation.

Various factors, including high levels of cloudiness and precipitation, contribute to significant dispersion in albedo values, as illustrated in Figure 2. This high variability highlights the necessity of considering multiple environmental factors when calculating albedo and it underscores the potential for significant errors in long-term albedo estimation if based solely on single short-term measurements. Therefore, it is critical to take temporal and spatial variability into account when interpreting and using albedo data for solar energy and climate-related applications.
The proposed model provides a flexible tool that can be adapted depending on the type of soil or climate to define the admissible percentage of albedo measurements within an acceptable margin of uncertainty. When applying this model in a practical scenario, we illustrate how its predictive capacity can be used to evaluate the validity of albedo measurements in different environments. For example, when considering albedo measurement on gravel surfaces with a maximum margin of uncertainty of 5%, equivalent to an albedo variation between 0.19 and 0.21 for a base albedo of 0.2, the model reveals that up to 90% of these measurements could be considered valid (Valid albedo). This suggests high reliability in the precision of measurements on this type of surface, with only a minimal fraction of measurements outside the acceptable margin of uncertainty. In contrast, when applying the model on sand surfaces, valid measurements would not reach 60%. This discrepancy implies that, statistically, at least four out of 10 albedo measurements on sand surfaces could have an uncertainty greater than 5%, suggesting greater variability or difficulty in the precision of measurements in this specific environment.

The model, as presented in Table 1, has been adapted for a wide range of conditions, covering different types of surfaces and climates. Furthermore, it has been evaluated when comparing albedo values from short-term and long-term measurement campaigns, and when comparing short-term and satellite data. The data obtained by satellite correspond to the Solargis database [4]. This platform provides a single monthly albedo value obtained from multiple satellite measurements for each location.

Results suggest that albedo variability follows a non-random pattern and that the percentage of valid albedo values can be modelled as a function of the admissible uncertainty using the exponential function presented in Equation 1. Therefore, we can predict how albedo measurements vary with a certain degree of precision, depending on the admissible margin of uncertainty.

The developed model allows us not only to understand the nature of this variability, but also to establish an indicator of the minimum number of measurements required for each type of surface or climate. This ensures that, within a predefined admissible uncertainty, the obtained albedo values correspond to long-term measurements or satellite data.
Figure 5. Percentage of valid albedo data as a function of admissible uncertainty for three different surfaces. Only albedo values with Global Horizontal Irradiance (GHI)>500W/m² were considered in the analysis. Squares indicate the values derived directly from the data, while the solid line indicates values derived by fitting the data to Equation 1

It is worth noting that while surface measurements and satellite data yield comparable results, satellite data exhibits greater scatter. This suggests that while satellite data provides valuable information, adjustments may be necessary to enhance its accuracy for specific applications. This scatter is influenced by the homogeneity or heterogeneity of the terrain, as Solaris data has a spatial resolution of 1 x 1 km². Figure 6 displays three satellite images of different PV plant sites, illustrating variations in terrain homogeneity. This suggests that the variability in satellite data can be related to the variability in the homogeneity of the terrain, confirming observations made by Enertis Applus+ in its albedo measurement campaigns (Figure 6).

Moreover, it is important to acknowledge that while satellite data offers a quick and cost-effective option for preliminary studies, additional adjustments may be needed to improve the accuracy of this data. The proposed model helps estimate uncertainties associated with albedo measurement during campaigns, optimising them to provide better performance estimates for PV systems in specific locations.

The results of the study carried out by Enertis Applus+ and TiM-UPV/EHU have been published in the journal “Renewable Energy”, in volume 221 of February 2024 [5].

Table 1. Valid albedo tuning parameters for each climate and surface type for short-duration surface data versus long-duration data and satellite data, respectively

<table>
<thead>
<tr>
<th>Climate / Surface</th>
<th>Long duration</th>
<th>Satellite</th>
<th>Long duration</th>
<th>Satellite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Valid albedo (%)</td>
<td>β (%)</td>
<td>Valid albedo (%)</td>
<td>β (%)</td>
</tr>
<tr>
<td>Arid</td>
<td>91.35</td>
<td>2.815</td>
<td>95.76</td>
<td>21.110</td>
</tr>
<tr>
<td>Continental</td>
<td>93.96</td>
<td>4.523</td>
<td>96.88</td>
<td>16.573</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>83.46</td>
<td>2.099</td>
<td>99.85</td>
<td>58.230</td>
</tr>
<tr>
<td>Subtropical</td>
<td>101.50</td>
<td>3.621</td>
<td>85.26</td>
<td>6.748</td>
</tr>
<tr>
<td>Sand</td>
<td>79.34</td>
<td>4.261</td>
<td>87.23</td>
<td>11.690</td>
</tr>
<tr>
<td>Gravel</td>
<td>91.81</td>
<td>1.741</td>
<td>95.23</td>
<td>23.041</td>
</tr>
<tr>
<td>Grass</td>
<td>96.68</td>
<td>4.120</td>
<td>110.22</td>
<td>32.144</td>
</tr>
</tbody>
</table>

Figure 6. Satellite images of three climates studied: Mediterranean (Site A), subtropical (Site B) and arid (Site C). Sorted from least spatial homogeneity (Site A) to greatest spatial homogeneity (Site C) (top). Comparison of albedo measurements from a long-term campaign with satellite data obtained over a period of one year for two different projects carried out by Enertis Applus+ (below)

References


Authors

Eneko Ortega is assistant professor in the Department of Electricity and Electronics at the University of the Basque Country (UPV/EHU) and member of the Technological Institute for Microelectronics (TIM). His research is focused on the field of PV systems monitoring and characterisation.

Sergio Suarez is the global technical manager of testing and optimisation at Enertis Applus+. He is currently taking a PhD in electronics at UPV/EHU (Spain), an institution involved in the manufacturing of bifacial PV cells, participating in R&D projects as principal researcher and developing new testing methodologies.

Juan Carlos Jimenez has been a professor at the University of the Basque Country since 1995 and is director of its Technological Institute of Microelectronics. His R&D focus since 1981 has been on bifacial technology and screen printing manufacturing.

Mario Martinez is the global technical deputy of testing and optimisation at Enertis Applus+. He is currently taking a PhD in PV Solar Energy at UPV/EHU (Spain), participating in research into the development of new materials and concepts for the PV industry.

Ignacio J. Fernandez is the head of testing and optimisation at Enertis Applus+. With more than 11 years of experience in the PV industry, Ignacio has managed TDD processes, contract negotiations, expert works and QA/QC campaigns related to PV plants worldwide.

Sofia Rodriguez is the R&D manager at Enertis Applus+. She has worked on the development of innovative defect detection systems in PV modules, coupled with categorisation and classification techniques.
2024 Asia #1
Smart Energy Connected Expo

Co-Located 4 Events

June 25(Tue.)-27(Thu.) 2024
KINTEX, SEOUL, KOREA

Visitors
25,000

Exhibitors
500

Value of Buyers Consulting(Est.)
US$0.575B

Exhibition Space
20,000sqm

Booking Now!!
E. interexpo@infothe.com
www.exposolar.org  www.essexpo.co.kr  www.batteryexpo.co.kr  www.derexpo.com

Early Bird Booking
15% OFF
Closed loop PV recycling still elusive but global efforts gathering pace

**Recycling** | As PV deployment accelerates globally, the question of what to do with the waste is rising up the agenda. Tom Kenning reports on efforts around the world to tackle the growing volumes of end-of-life PV modules and some of the emerging innovations for reusing the materials they contain.

When driving past a sea of PV modules and structures at a large-scale solar plant it is natural to ponder what will happen to all those panels when they reach end-of-life. In the rush to mitigate climate change, the world’s focus has been highly concentrated on deploying PV as quickly as possible, but the necessity of having robust and circular recycling technology is becoming ever more urgent. Until recently, significant proportions of the most valuable solar panel material could not be recycled, but companies in France and the US are leading the way with the most advanced techniques.

Many PV systems will continue to operate past their initial design lifetime and remain economically productive for more than 30 years, while others will retire early, which confuses predictions of used PV panel volumes in the future. Either way, with a planetary goal to deploy 75TW of solar capacity by 2050, gigantic numbers of structures, modules and equipment are guaranteed to need processing in the future, whether in the form of scrapping, recycling or reusing.

This article explores how some of the most developed PV markets deal with PV waste and recycling and what efforts are being made to prepare for the future onslaught of PV waste.

**Frontrunner nations**

France is a leader in PV recycling, having set the minimum recovery rate of PV panels at 85% and the recovery of materials at 80% in its environmental code at an early stage. French company ROSI has technology capable of recycling 95% of a solar panel, which is enabled by separating the solar panel glass from the aluminium and silicon without breaking the glass. It does this by heating and melting the glue that holds the panel together before separating the glass sheet. Not only does this recover a high percentage of the material but it also uses less energy than the traditional method of breaking and crushing these materials. Spanish company CERFO also uses similar technology with comparable percentages of material recycled.

Specialist PV recycler Solarcycle in the US also has a patented process that can recover at least 95% of the value of a panel and then returns it, in some way, to the domestic supply chain.

**Global movement**

Industry veteran Jan Clyncke, the managing director of PV Cycle, a PV-focused producer compliance scheme based in Belgium, outlines positive progress in several countries on the PV recycling problem.

In India, for example, solar PV has been put onto and taken off the e-waste laws several times, says Clyncke. Yet, with more than 73GW of PV installed, the subcontinental giant will eventually need to come to terms with this end-of-life phase. Module recycling discussions are being held between the Environment...
Solarcycle breaks through PV glass recycling obstacles

Using recycled PV material in other industries is a positive step, but the holy grail is to have a circular model where old PV panel material can be reused to make new solar modules. US company Solarcycle has made huge strides by demonstrating that it can use broken glass pieces – known as cullet – taken from old modules by Solarcycle’s proprietary glass removal tools to make brand new high-quality solar glass with up to 50% recycled content.

“Our goal would be to eventually do it with 100%, but that starts getting harder,” says Jesse Simons, CCO at Solarcycle – adding that a great deal of innovation and a number of different technologies were needed to make 50% possible.

Furthermore, a major multinational glass manufacturer has verified that Solarcycle’s crushed glass is both pure and high-quality enough to be put directly into a standard industrial-scale glass furnace for manufacturing PV glass sheets – a step forward that has never been proven before.

Using recycled solar glass for other applications such as making fibreglass is better than landfill, but keeping this glass usable within solar manufacturing is a major bonus because not all glass is made equal. A large proportion of glass has a high iron content, which makes it less transparent and therefore less effective for solar applications. The iron can dilute sunlight hitting a panel and lower the conversion of the sun’s energy into electrons.

“The problem is we’re taking some of the most valuable glass on the planet, super low iron glass that is transparent for solar and has all these special benefits, and now we’re grinding it down to making fibreglass,” says Simons.

Furthermore, new solar glass and modules require sourcing virgin material from all over the world, and fibreglass can already be made with the lower-quality glass of old bottles and windshields. It was this transparency and quality issue that led to Solarcycle’s idea of creating the new glass recycling factory specifically to create new solar sheets with all the benefits of manufacturing domestically in America.

Installing its new PV glass recycling technology, Solarcycle plans to build a US$344 million recycled solar glass manufacturing facility in Polk County, Georgia that can produce between 5GW and 6GW capacity of solar glass annually. Construction is scheduled to begin in 2022, with operations in 2026.

“There’s over 5GW of solar manufacturing being built in this country and there’s zero gigawatts of solar glass being made here,” says Simons. “So, our ability to provide a premium product that also has all these sustainability benefits is something that we’re finding the big manufacturers really want to do.”

For example, Canada and US-based PV manufacturer Silfab Solar has signed a supply deal for US-made solar glass with Solarcycle that will see glass shipped from the Georgia facility to Silfab’s 1GW/1.2GW cell and module production plant in South Carolina.

Using this glass, Silfab claims that its operational manufacturing emissions will be reduced by 30% and shipping emissions by 50%. The two companies have already signed a module recycling agreement, and with this glass supply deal have formed one of the first forays into a ‘circular’ economy for solar in the US.

Solarcycle’s domestic glass could also make reaching the threshold for tax incentives for renewable energy production and manufacturing more achievable. The Inflation Reduction Act (IRA) contains a Domestic Content Adder which sees eligible solar modules receive a 10% tax break on top of the standard IRA incentive. To qualify, at least 40% of a panel’s total cost must be covered by US-made components, rising to 55% from next year.

Solarcycle can produce new solar glass sheets from recycled, crushed glass.

Ministry (MOEFCC) and Ministry of New and Renewable Energy (MNRE), partly with EU help.

“A few small-scale private initiatives are also underway to set up recycling facilities but there is no major urgency or fears on this front in India,” adds Vinay Rustagi, senior director, global head of renewables, at Indian analyst firm CRISIL. “As for use of land thereafter, it is a very scarce and precious resource in India. Most likely, it will be used to set up new projects (assuming continued technology viability by then) or repurposed for alternative uses.”

PV Cycle has also been working with Indian authorities to finalise how PV should show up in the waste laws. At present the Indian version of producer responsibility, which uses recycling certificates, puts complete liability on the shoulders of the recycler, an approach that Clynecke criticises.

Japan does not have extended producer responsibility (EPR) legislation, but it does have a requirement for large-scale PV plants of >1MW. Owners of such projects must also set aside money in a fund, which is managed by the Ministry of Trade and Industry (MOIT). The requirement is also linked with the feed-in tariff (FiT) subsidy, says Clynecke. There are also discussions in Australia, but they are moving slowly.

“They are realising. ‘Wow, we have 25GW installed, we have to do something about the end-of-life phase,’” says Clynecke. “Maybe not tomorrow, but hopefully within 15-20 years, it will be there.”

Since Brazil has installed 25GW in just five years, Clynecke has also been working with Brazilian authorities trying to convince them about the need for some form of EPR scheme, which can be done in a relatively inexpensive way.

“Brazil is a country like India where everybody thinks waste does not exist because waste always has value,” says Clynecke. “They sometimes scrap the good parts, and the dirty parts end up in the environment. That’s not what we want, of course, as an industry.”

There has also been significant recent news in Europe with the European Council amending its Waste from Electrical and Electronic Equipment (WEEE) Directive, stating that solar module manufacturers will bear responsibility for the waste disposal and recycling of modules in the EU.

Spanish attempts at closed loop

Spain has several of its own PV recycling companies, such as Recyclia and CERFO, that are responsible for taking all the modules and inverters and recycling them, says Hector De Lama, technical director of Spanish PV association UNEF. These companies can either carry out their own recycling processes or pass the material on to other companies. Recyclia works with all products that come under Europe’s WEEE Directive, such as comput-
ers, televisions, PV panels or inverters and to do so it hires a company that is special-
ised in one of these products. CERFO, on the other hand, is a specialist PV recycler. The Directive mandates at least 85% of the panel to be recycled.

When importing modules in Spain, the contract between seller and plant owner must include a guarantee paid to the public treasury. When the owner of the plant wants to recycle those modules 30-years later, it can then call on that guarantee and pass the panels on to Recyclia for example.

Aluminium and glass can be recycled separate to silicon. Crushed solar panel glass goes to the glass industry in Spain, which has a very established recycling supply chain that recycles up to 95% of all glass in the country. The same goes for the aluminium industry, for which recycling is well-established in Spain. However, used silicon, the most valuable of the three main materials, is exported from Spain. Some of the more expensive materials in PV panels, such as silver, can sometimes be lost in processing. Most modules avoid landfill, but some self-consumption rooftop panels are thrown away by consumers when broken. Although many solar panels are exported to Africa for reuse from around the globe, none are coming from Spain, claims De Lama

“Spain is unique in recycling because the old power plants installed in 2006-08 have a feed-in tariff (FIT) and if you change too many components, you can lose the FIT and no one wants to lose the FIT, so they’re really careful to do the right maintenance,” says De Lama.

As a result, the volume of modules being recycled in Spain is quite small – in the range of hundreds of megawatts – and De Lama says most of these are not old panels but mainly the roughly 0.5% of modules that arrive in Spain broken from transit.

At present, Spain has more than enough recycling capacity for current PV waste volumes, with its recycling facili-
ties running at around 50-60% capacity. Looking ahead to the larger capacities of modules that will come offline in the coming decades, De Lama says that Spain’s capability to recycle modules is slowly increasing.

However, the initial surge of solar installations in Spain amounts to just 4GW over a few years, whereas presently Spain is installing around 5GW of large-scale plants and 1-2GW of rooftop capacity alongside this annually, so in the bigger picture, recycling or revamping volumes in the next few years will remain “peanuts” compared to what is coming further down the line.

UNEF is currently developing a study about recycling in Spain looking at both the technology and science behind it. Spanish utility Iberdrola is also collaborat-
ing with industrial waste management company FCC Ambito to promote the industrial-scale recycling of solar PV panels.

**Typhoon waste streams in Japan**

The Ministry of the Environment in Japan has provided guidelines for the recycling of PV modules alongside some other related documents for the recycling of PV modules, says Masaaki Kameda, general manager of the technology department, at the Japan Photovoltaic Energy Association. The country also has more than 30 dedicated recyclers and supporting organisations situated domestically that can recycle more than 80% of the materials from PV modules.

At present, PV modules in Japan can still either be landfilled, recycled or reused but the country is seeking out ways of making a circular economy for PV module waste, says Kameda.

Despite being one of the earliest adopters and largest solar PV markets in terms of installations in the world, Japan has few second-hand modules and is yet to reach a stage where repowering is a suita-
ble option for a large amount of capacity, so its PV waste streams are still relatively small. Each year, several thousand tonnes of PV modules go to waste in Japan, says Kameda, and a significant amount of these come about due to damage from earth-
quakes and extreme weather, given Japan experiences regular typhoons.

“Quite a few of these PV modules are still usable,” says Kameda.

Most end-of-life modules are reused, with the rest mainly sent for recycling. However, most of these modules go outside of Japan, usually to various Middle Eastern countries or to South Asia.

Kameda says that the recyclers are strug-
gling to find circular ways to recycle used solar glass, instead of just sending crushed glass to the construction industry or having it used for improving water quality or improving soil quality for agriculture.

Japan sends no more than several hundred tonnes of PV waste to landfill each year due to the difficulty of treating solar panels to reach landfill suitability requirements and some landfill compa-

ies not accepting PV modules. On the other hand, dedicated recyclers are happy to accept panels as there are fairly low volumes at present.

In preparation for the huge volumes of panels due to reach end-of-life in the next decade, JPEA has called on the govern-
ment to construct a platform for the PV module recycling system. The association is also actively connecting companies to participate in a recycling scheme. Kameda says that although there are many Japanese PV recyclers, “there are not enough” and efforts should be made to proliferate such companies for the future high waste streams.

**Australian modules reaching end-of-life early**

Meanwhile, in Australia, the problem of managing PV is “more immediate than
Connecting Asset Owners and Optimizers to Enhance Strategies for Maximizing Storage Assets

12-13th November, 2024
San Diego, California

Register Now ➔
batterysummit.solarenergyevents.com
previously anticipated”, with waste volumes emerging in the next two to three years, particularly in New South Wales, Victoria and Queensland. This headline finding of a report by the University of New South Wales (UNSW) and the Australian Centre for Advanced Photovoltaics (ACAP) contradicts earlier forecasts that solar energy waste would not appear in Australia until after 2030.

The report, “Solar panel end-of-life management in Australia”, recommends having large-scale PV waste management facilities in the five big cities of Sydney, Melbourne, Brisbane, Perth and Adelaide, given that there is no current national PV waste legislation or stewardship programme in Australia.

Rong Deng, researcher at UNSW and one of the report authors, says these five locations were chosen mainly due to historical PV installations and predictions that the waste stock will be high enough in these areas, but also because they are located near other recycling infrastructure as well. Australia has eight companies that have already been active in the solar recycling space in several states.

With no current legislation in Australia for when panels reach end-of-life, it remains a free market. However, a ‘Product Stewardship Scheme’ for which draft proposals have been published, is due to come in next year, which will make either the manufacturer or the large-scale asset owner financially liable for the end-of-life.

At the end of year 10 of a module’s life, it is estimated that cumulatively 23% of PV panels installed in small-scale systems would be decommissioned, due to panel breakage, upgrading to more efficient systems and other motivations of the homeowners, while just 12% of modules in large-scale projects would be decommissioned. Australia’s market is mainly dominated by distributed rooftop systems, which were deployed very early in the global PV timeline, with many systems already 10-20 years old.

“That’s why in 10 years, we see a very high percentage of decommissioning,” says Deng. “That’s also why we think Australia is a huge reuse market because many panels coming off are technically working.”

Without recycling infrastructure in place, end-of-life modules are currently either landfilled, stockpiled in anticipation of a future reuse solution, or exported to Africa, says Deng.

A key section of the report also claims that initially, “the volume of end-of-life solar panels is expected to grow rapidly in New South Wales, Victoria and Queensland, which calls for immediate action by the industry to prevent landfiling”.

How well the global PV industry will deal with the coming tidal wave of used PV equipment remains unknown at this point, but the two founders of Texas-based PV recycling firm Solarcycle, Suvi Sharma and Jesse Simons, are optimistic. Despite claims that PV module lifetimes are averaging 15 years instead of 20-30, meaning significant volumes of end-of-life panels are going to arrive much faster than anticipated, they also showed that recovering almost all of the material in a PV panel is possible in their recycling processes and they believe large-scale illegal dumping of PV equipment can be avoided.

From a waste industry perspective, the long lifetimes of solar PV modules can hinder the economics of setting up recycle and reuse infrastructure, according to Jan Clyncke, the managing director of Belgium-based PV Cycle.

PV panels are “not a great waste proposition”, says Clyncke. This is because optimisation of collection, recycling and decommissioning costs requires knowing when the product will need to be recycled. Unlike smartphones, which have a regular turnover, PV panels are built to last decades, which does not lend itself to investing in building recycling lines and scaling up. Furthermore, decommissioning occurs so far in the future that it’s unclear if the original installers and owners will still exist at that time.

Clyncke claims that decommissioning requirements in the US are inadequate, with the dominant focus still on large commissioning plans, which leads to a lack of accountability at a project’s end-of-life. There is also a common misconception that the value of recovered aluminium frames and other equipment can cover the costs of decommissioning.

Achieving a zero-cost recycling solution for the producer, who must finance the collection and recycling of the PV equipment, is difficult given the additional costs of transport, shipping, overheads and labour. “This is all ignored in some of the decommissioning plans,” claims Clyncke.

In terms of recycling and reuse of modules, Washington State – where there is very little PV installed – is the only US state that has advanced plans for an extended producer responsibility scheme for PV panels. After several postponements, it is due to start in 2027. Several other states have draft bills in place, but Clyncke says a federal law imposed across the US would be a more effective strategy.

In the UK and European Union, on the other hand, PV modules and inverters have come under extended producer responsibility legislation since 2014 as part of the Waste Electronics and Electrical Equipment (WEEE) Directive. This requires reporting how much product has been placed into or taken out of the market each quarter as well as what has been treated or recycled.

“It’s not doom and gloom,” adds Clyncke, noting that waste legislation initiated in Europe has started to spread globally where there was none before. Meanwhile, PV Cycle has taken back old panels from Europe, Panama, Senegal and other parts of Africa, while huge Asian manufacturers, including those in China, are contacting the company to process surplus panels.

“It’s not always that waste goes to Africa,” adds Clyncke. During his waste industry career, Clyncke saw many illegal waste shipments go to Africa, so he is committed to helping avoid that trend with PV modules. Worldwide there are issues with inspection authorities and many loopholes and weak points in the global system that can allow waste to be leaked into illegal environments.

From a waste industry perspective, the long lifetimes of solar PV modules can hinder the economics of setting up recycle and reuse infrastructure, according to Jan Clyncke, the managing director of Belgium-based PV Cycle. PV panels are “not a great waste proposition”, says Clyncke. This is because optimisation of collection, recycling and decommissioning costs requires knowing when the product will need to be recycled. Unlike smartphones, which have a regular turnover, PV panels are built to last decades, which does not lend itself to investing in building recycling lines and scaling up. Furthermore, decommissioning occurs so far in the future that it’s unclear if the original installers and owners will still exist at that time.

Clyncke claims that decommissioning requirements in the US are inadequate, with the dominant focus still on large commissioning plans, which leads to a lack of accountability at a project’s end-of-life. There is also a common misconception that the value of recovered aluminium frames and other equipment can cover the costs of decommissioning.

Achieving a zero-cost recycling solution for the producer, who must finance the collection and recycling of the PV equipment, is difficult given the additional costs of transport, shipping, overheads and labour. “This is all ignored in some of the decommissioning plans,” claims Clyncke.

In terms of recycling and reuse of modules, Washington State – where there is very little PV installed – is the only US state that has advanced plans for an extended producer responsibility scheme for PV panels. After several postponements, it is due to start in 2027. Several other states have draft bills in place, but Clyncke says a federal law imposed across the US would be a more effective strategy.

In the UK and European Union, on the other hand, PV modules and inverters have come under extended producer responsibility legislation since 2014 as part of the Waste Electronics and Electrical Equipment (WEEE) Directive. This requires reporting how much product has been placed into or taken out of the market each quarter as well as what has been treated or recycled.

“It’s not doom and gloom,” adds Clyncke, noting that waste legislation initiated in Europe has started to spread globally where there was none before. Meanwhile, PV Cycle has taken back old panels from Europe, Panama, Senegal and other parts of Africa, while huge Asian manufacturers, including those in China, are contacting the company to process surplus panels.

“It’s not always that waste goes to Africa,” adds Clyncke. During his waste industry career, Clyncke saw many illegal waste shipments go to Africa, so he is committed to helping avoid that trend with PV modules. Worldwide there are issues with inspection authorities and many loopholes and weak points in the global system that can allow waste to be leaked into illegal environments.
Be Part of the EU PVSEC 2024 and Register Now!

DISCOVER THE FUTURE OF SOLAR PV AT THE EU PVSEC 2024 IN VIENNA

The EU PVSEC 2024 provides an unrivalled platform to explore cutting-edge PV technologies, network with leading experts and engage in science and collaboration. Join us and experience the latest scientific breakthroughs, industry trends and policy discussions that will shape the future of photovoltaics.

Why you can't afford to miss this event:

**Exclusive insights:** Get early access to groundbreaking PV breakthroughs.

**Global networking:** Network with the world’s leading PV specialists and industry pioneers.

**Collaborative learning:** Participate in an open, accessible environment that encourages knowledge transfer.

**Innovation at your fingertips:** Discover new partnerships and project opportunities.

Be at the forefront of solar innovation with us in Vienna! Visit [www.eupvsec.org](http://www.eupvsec.org).

PV Academy
3rd edition
22 September 2024
www.pv-academy.com


Agrivoltaics: Innovative business models may unlock new opportunities

Agrivoltaics | Despite the huge interest in agrivoltaics, sound strategies for developing this fast-emerging market segment are yet to be established. Caroline Plaza of the Becquerel Institute looks at how new business models involving farmers, landowners and energy companies could open up new opportunities in the coming years.

PV installations on agricultural land have been present since the early days of PV development. In many cases, agricultural activities have been replaced, redirecting land use towards electricity generation. However, as PV adoption rates increase, competition for land intensifies, leading some countries to regulate the use of agricultural land for PV installations through legislation or stringent conditions in tenders. Nevertheless, agricultural areas represent a mostly untapped solar PV potential. Agrivoltaics offers a distinct approach, enabling the dual utilisation of land for both food and energy production. PV systems can provide valuable services to farmers by protecting crops and livestock from the increasing frequency of extreme climatic events, while generating additional revenues.

The potential of PV installations on agricultural land and their contribution to renewable energy targets have received significant attention. While government and developer interest in this segment has grown, so has opposition from certain farmers’ organisations and segments of the public opinion. Concerns have arisen regarding the risks associated with “alibi agriculture” and the necessity for appropriate regulatory frameworks to mitigate conflicts over land use. Legislators face the challenge of striking a balance, between achieving renewable energy production targets and safeguarding food production.

Given the predominant economic significance of energy production in combined activities, there’s a risk of creating an imbalance between agricultural and electricity production revenues. In some cases, income solely from land rental for PV installations may surpass the earnings generated by actual farming activities. Following pioneer countries such as Japan, where the concept of “solar sharing” has been established since 2003, Germany, France and Italy have recently implemented national frameworks. However, a sound strategy for developing this rapidly evolving market segment is yet to be established in many countries.

To develop, agrivoltaics must engage actors from both sectors and navigate the economic and contractual complexities of combining the two land uses. Contracts, ownership structures, remuneration schemes, risk-sharing mechanisms and levels of control must be carefully crafted to balance performance objectives with existing constraints. Additionally, determining how value will be distributed among energy developers, landowners and farmers goes beyond land rental agreements. New value can emerge from the efficient combined use of land and water resources and from positive externalities. Developing “win-win” frameworks between farmers and energy companies could further unlock the potential of agrivoltaics.

PV potential in agricultural areas surpasses 2030 EU goal

Based on a market potential analysis by the Becquerel Institute, the EU has a technical potential of 480GWp, assuming 1% utilisation of selected agricultural areas (UAA). This could significantly contribute to achieving the REPowerEU PV target of 750GW by 2030. Even a smaller portion of this potential could surpass the current cumulative installed capacity of approximately 266GW by the end of 2023.

PV potential on agricultural land has also
Your indispensable guide to achieving business growth in 2024

PV TECH PREMIUM

US$ 315 per year

PREMIUM ARTICLES
- Regular insight and analysis of the industry's biggest developments
- In-depth interviews with the industry's leading figures
- Exclusive access to PV Tech's PV Price Watch series of content

PV TECH POWER
- Unlimited digital access to the PV Tech Power Journal Catalogue - past editions from 2014 to today

PHOTOVOLTAICS INTERNATIONAL
- Unlimited digital access to the Photovoltaics International Journal Catalogue - past editions from 2008 to today

TECHNICAL PAPERS
- More than 1,000 technical papers written by recognised industry experts

EVENTS
- Exclusive webinars and interactive ‘Ask the Editor’ sessions
- Discounts on Solar Media’s portfolio of events, in-person and virtual

Subscribe at: pv-tech.org/pv-tech-premium
been studied in other countries. In Japan, mapping revealed that 10% of agricultural land could accommodate 440GW of PV, while Japan’s cumulative installed capacity was 91GW in 2023. South Korea aims for 10GW by 2030, over a third of the cumulative installed capacity at the end of 2023 (27.8GW).

Looking at this important PV potential, government and PV developer interest has increased. However, mobilising only a fraction of agricultural land may be necessary in the coming year. It’s likely only a fraction of all existing farms will host a PV power plant in the coming years.

**A wide diversity of project designs**

Different types of PV systems have already been developed to increase production per unit of land by integrating agricultural and energy production. PV systems installed over crops offer new services such as protection against crop-damaging hazards, water conservation through reduced evaporation and adaptation to current or future climate conditions. This requires a specific design of PV systems.

One technical solution implemented is mobile elevated PV plants, where PV panels adjust their position to optimise either PV production or crop growth based on local weather conditions and crop requirements. Elevated PV systems without tracking have also been deployed, with PV density adjusted to suit crop needs. The amount of light reaching the crops is determined by the PV plant’s design, either by spacing modules apart or by the modules’ design itself. Additionally, PV systems have been integrated into greenhouses for several years. The photovoltaic modules either replace glass elements or are positioned above the greenhouse to provide shading.

Crops, grassland and animal husbandry can be accommodated between the rows of PV plants. One of the new designs being implemented is vertical bifacial PV, which adjusts the space between rows to accommodate agricultural machinery. In all cases, the system must preserve the land’s agricultural function. The design of the PV plant must be tailored to the specific activity, including providing sufficient space between rows, adjusting height to accommodate breeding needs and ensuring electrical and dust protection.

The competitiveness of PV plants depends on various factors, including system costs, PV yield and the business model permitted by local regulations. PV system costs may be slightly higher compared to cost-optimised ground-mounted PV plants, due to additional expenses associated with specific elevations and lower density. The PV yield can vary depending on the mounting of PV modules, whether fixed-tilt, with tracking, or vertical systems, as well as the project location and solar radiation levels. However, when tracking is optimised for agricultural production, it may affect PV yield and fail to reach its maximum potential. Consequently, system costs and profitability can differ significantly among different designs.

**Recent regulatory developments for agrivoltaics in Europe**

Recently, countries have established legal frameworks outlining the permitting conditions and financial support for various types of agrivoltaic systems. These frameworks often impose stricter definitions compared to conventional PV installations. Germany, France and Italy have introduced national frameworks, standards or guidelines in this regard.

In France, agrivoltaics was formally defined in the Law for the Acceleration of Renewables in 2023. It is described as an installation directly contributing to agricultural activities, including improving agronomic potential, protecting against climatic hazards, enhancing animal welfare and ensuring significant agricultural production.

Germany’s framework is shaped by the standard DIN SPEC 91434, which outlines criteria, some of which are based on maintaining agricultural yield. Italy has also established requirements for planning permission and support, distinguishing between agrivoltaic systems and “advanced agrivoltaic” systems, which have more stringent criteria and are eligible for incentives.

In these frameworks and support mechanisms, several types of PV projects are considered. PV plants that maintain agricultural production are typically cost-effective and often participate in competitive tenders or sell through power purchase agreements.

On the other hand, PV plants that meet advanced criteria and enhance agricultural production and farmer revenue, known as “agrivoltaics” under stricter definitions, prioritise agricultural profitability over energy production. While the cost of these systems may be higher, they often qualify for incentives or can compete in specific tenders. Agricultural production profitability must dominate, and energy production is an added value.

**Addressing agricultural challenges through agrivoltaics**

Food sovereignty remains a central concern, as recent crises have shown. However, agricultural actors face numerous challenges, including rising material and energy costs, meeting environmental...
Expanding roles and models, the dual activity impacts on business model dynamics

In a traditional large-scale PV project, various actors are involved: the project developer, financial institutions, EPC companies, landowners, electricity buyers, local authorities, grid managers, and maintenance teams. Agrivoltaic projects introduce new actors throughout all phases.

Agrivoltaics involve multiple stakeholders and various business models, impacting both farming and energy production. Different business models exist. The farmer can lead and be the main stakeholder of the agrivoltaic plant, selling or saving electricity alongside farm revenue.

However, this model may have limitations for larger projects requiring substantial investment. Alternatively, a PV developer may take the lead, operating the project as a common business model for utility-scale projects. A dedicated project company (special purpose vehicle - SPV) can be established to host the agrivoltaic project.

The SPV leases land from the owner, and a contract between the farmer and the SPV outlines remuneration and responsibility. With the development of agrivoltaics, new business models are emerging. In some cases, the SPV doesn’t pay rent or remuneration to the farmer but provides services such as hazard protection or data collection. This business model depends on the PV installation’s impact on the farm. If the agricultural production is affected, rents paid to the farmer can be considered economic compensation. If there is no degradation or even an improvement in agricultural production, other models can be imagined.

However, concerns about decoupling agricultural and photovoltaic activities, as well as imbalances in decision-making processes, have been raised. Shared ownership of the SPV with the farmer is highlighted for its potential to enhance agricultural and PV synergies, ensuring the focus remains on agricultural purposes and shared value.

A path to resilience and sustainability

Agrivoltaics offers a promising alternative, allowing land to be used for both food and energy production. Currently, it’s still an emerging market segment compared to the global solar PV market. Governments and developers increasingly see its potential, developing strategies and considering factors such as agricultural needs and land suitability, alongside current and future climate change. A long-term vision is crucial for efficiently using land and water to achieve energy and food sovereignty goals; agrivoltaics could address some of the actual challenges.

However, concerns about land speculation and a fair distribution of economic benefits must be addressed to ensure a widespread acceptance. Collaborative business models, involving shared ownership and value-sharing, are gaining traction, while tailoring business models to local contexts is key. Unlocking new business models involving farmers, landowners and energy companies could open more opportunities and favour the development of agrivoltaics in the coming years.

“Collaborative business models, involving shared ownership and value-sharing, are gaining traction, while tailoring business models to local contexts is key. Unlocking new business models involving farmers, landowners and energy companies could open more opportunities and favour the development of agrivoltaics in the coming years”

Author

Caroline Plaza has been deeply engaged in the energy transition for over 15 years, with a specific focus on solar energy, particularly photovoltaics (PV). Today, she applies her expertise to strategic consultancy for our customers around the world. As managing partner at the Beccquerel Institute in France, she brings her in-depth knowledge of innovation and solar ecosystem dynamics, as well as her experience in solar project development, technical and economic assessment across different market segments.
The UK’s New Landscape for Utility & Rooftop Solar: Opportunities Within a GW+ Annual Market

Key Themes for 2024

- Sizing the UK Solar opportunity
- Large-Scale Solar Farms as Part of UK’s Energy Mix
- GW+ Annual Deployment on UK Commercial Rooftops
- Storage Co-Location & Mixed Energy Hubs
- Exploring Hybridisation of Solar & Wind
- Planning, Developing & Operating Solar Farms in the UK
- Public Sector & Community Solar Developments
- Optimising Solar to the Grid & the Evolution of PPAs

Book now: uss.solarenergyevents.com

Our 2024 Sponsors

Gold Sponsors

- EDF renewables
- JinKO Solar
- JA Solar
- SMA

Silver Sponsors

Bronze Sponsors

Supporting Sponsors

Exhibitors

Editorial Partners

Partners
STORAGE & SMART POWER

NEWS
The latest news from the world of energy storage

104-108 Grid-forming technology and its role in the energy transition
SMA’s Aaron Philipp Gerdemann on the quest to maintain grid stability

110-111 The benefits of longer-duration storage and energy project co-location
Ireland’s first 4-hour duration battery storage project

112-116 The evolving landscape of international BESS transportation
TROES on the role of shipping in BESS project logistics and economics
Welcome to another edition of ‘Storage & Smart Power,’ brought to you by the team at Energy-Storage.news.

I was reminded recently that it was only in the 2017-2018 timeframe that more than a gigawatt of battery storage deployments was recorded globally for the first time ever.

It feels like a short time ago—and it was—but even so, to now look back and think that 42GW of storage was deployed in 2023 alone according to the International Energy Agency (see news page); certainly, some of the right elements are coming together to facilitate energy storage’s rightful place as a key energy transition technology.

And while it remains to be seen what sort of genuine impact it will translate into, since the last edition of PV Tech Power, the G7 nations have set a global ‘1,500GW by 2030’ energy storage deployment target.

This quarter, we look forward to hearing from our contacts in the industry about what else needs to be done to translate ambition into action.

Our team will be on the road for some of that time, visiting events, including Intersolar Europe in Germany, the Energy Storage Summit Australia, and the Energy Storage Summit Asia. We look forward to meeting many of you and hearing about the dynamics of accelerating storage deployment in very different markets around the world.

In this edition you can read about:

Shipping battery storage systems: The logistics of getting BESS equipment on site can be complex, and rules and best practices are evolving almost as quickly as the technologies. Canadian commercial and industrial (C&I) specialist TROES looks at the different aspects of shipping BESS to projects safely and on time, and some of the strategies that can be considered.

Ireland’s first 4-hour BESS: A battery storage project at Cushaling wind farm in Ireland’s midlands sets a new standard for duration in the country’s large-scale energy storage market. Rory Griffin, head of grid services at Statkraft Ireland, tells the story behind its development and considers what the project means for the future of BESS development on the Irish grid.

Advanced grid-forming inverters: Providing inertia to the grid has perhaps been overlooked as an application where inverter-based resources can step in and directly replace the role of thermal generators. SMA’s Aaron Philipp Gerdemann writes about the potential for inertia and other vital system stability services to be provided by battery storage systems equipped with grid-forming inverters, with reference to some real-world examples.

Andy Colthorpe
Editor
Energy-Storage.news @ Solar Media
California: ‘Energy storage revolution is here,’ says governor as US leader state surpasses 10GW

California now has more than 10GW of battery storage, with Governor Gavin Newsom hailing the state’s ‘energy storage revolution’, which is underway.

Cumulative installations have now reached 10,379MW in the state, and on 16 April, for the first time ever, batteries became the single largest contributor of power on the grid for a short time during the evening peak.

At 8:10 pm on that day, 6,177MW of power was being fed into the California Independent System Operator (CAISO) grid from BESS resources, exceeding the contributions of the four other biggest sources of power: renewables (4,603MW), natural gas (5,121MW), large-scale hydropower (4,353MW), and energy imports (3,936MW).

The 3,287MWh Edwards & Sanborn solar-plus-storage in California helped batteries briefly become the largest contributor of power in the state on 16 April.

CATL unveils ‘five-year zero degradation’ BESS with 6.25MWh per container

Lithium-ion battery manufacturer CATL has launched its latest grid-scale BESS product, with 6.25MWh per 20-foot container and zero degradation over the first five years, the company claimed.

The China-headquartered company announced the ‘Tener’ BESS solution (Tianheng in Chinese) in April with several claims of industry-leading technical specifications.

The foremost among them is that the lithium-ion (Li-ion) batteries inside will not suffer any degradation over the first five years, the company said.

This has been achieved thanks to biomimetic SEI (solid electrolyte interphase) and self-assembled electrolyte technologies, which CATL said has ‘cleared roadblocks for the movement of lithium ions’.

‘World’s largest’ compressed air energy storage project connects to the grid in China

A compressed air energy storage (CAES) project in Hubei, China, has come online, with 300MW/1,500MWh of capacity.

The 5-hour duration project, called Hubei Yingchang, was built in two years with a total investment of CNY1.95 billion (US$270 million) and uses abandoned salt mines in the Yingcheng area of Hubei, China’s sixth-most populous province.

It is the largest grid-connected CAES project of its size in the world, engineering firm China Energy Engineering Corporation claimed in its announcement of the project.

Energy storage market grew faster than ever in 2023, BESS was most invested-in energy tech, according to BNEF, IEA

According to the International Energy Agency (IEA) and BloombergNEF, battery storage was the most invested-in energy technology in 2023, with the biggest-ever annual growth in deployments recorded.

The IEA said 42GW of batteries were deployed across utility-scale, behind-the-meter, off-grid and solar home stationary energy storage installations in the year and that battery storage was the most invested in of all commercially available energy sector technologies in 2023.

Meanwhile, BloombergNEF counted annual energy storage deployments in 2023 – excluding pumped hydro energy storage (PHES) and therefore largely comprising battery storage installations – at 44GW/96GWh.

Europe installed 10GW of energy storage in 2023, EU policies to drive major growth this decade

Europe has seen its first year when energy storage deployments by power capacity exceeded 10GW in 2023.

The eighth annual edition of the European Market Monitor on Energy Storage (EMMES) was published recently by consultancy LCP Delta and the European Association for Storage of Energy (EASE).

It found that total installations in Europe – including European Union (EU) and non-EU countries – across the residential, utility-scale, and commercial and industrial (C&I) market segments throughout last year added up to around 10.1GW. That was more than double the 4.5GW recorded across Europe for 2022.

Energy Vault China project commissioned and new Australia BESS order

Commissioning has been completed on the first commercial-scale project using Energy Vault’s gravity energy storage technology, while the firm has also secured a 400MWh BESS order for a project in Australia.

The 25MW/100MWh system in Rudong has passed commissioning by customer China Tianying (CNYT), a waste and environmental services group, and will start commercial operations once final provincial and state approvals have been granted.

Energy Vault also announced a two-stage 400MWh order for developer and independent power producer (IPP) ACEN Australia, part of Philippines-based holdings firm Ayala Group.

Australia: Construction begins at biggest battery storage project so far

Construction has kicked off at the largest battery project in Australia to date, with a storage capacity equivalent to that of the entire country’s fleet of projects under construction at the end of 2022.

The government of Western Australia (WA) announced in March that the construction phase has begun at Collie, a BESS project with 500MW output to the grid and 2,000MWh energy storage capacity. It will be built in two phases, the first part coming online in Q4 2024 and the second in Q4 2025.

www.pv-tech.org | May 2024 | 103
Grid-forming technology and its role in the energy transition

In the quest for stable power systems, ensuring grid stability is paramount, particularly with the increasing integration of volatile renewable generators such as PV and wind. Grid stability relies on the dependable provision of essential grid services such as frequency response (FRT), voltage stability, and inertia.

Traditionally, synchronous generators provided these reserves at the transmission system level. However, the emergence of large-scale battery storage technology presents an alternative solution.

Battery storage offers rapid delivery of stored power and energy, outperforming conventional synchronous power plants in terms of response time and efficiency. With its impressive technical performance and increasing commercial competitiveness, battery storage is poised to play a pivotal role in future power systems with 100% renewable penetration.

Global solar inverter manufacturer SMA has utilised advanced power conversion systems and control technologies that have significantly contributed to grid stability by encompassing inverters, medium voltage solutions, plant control and engineering services.

The provision of grid-following inverters proved instrumental in maintaining operational continuity and ensuring an uninterrupted power supply during severe grid disturbances in Odessa in 2021 and 2022.

Additionally, advanced grid-following controls have proven effective even in weak grid environments, as demonstrated in the West Murray region of Australia.

This article explores the pivotal role of advanced inverter and control technology, especially concerning grid stability. We look at SMA’s contributions in this field of successful grid integration ever since, exemplified by its involvement in projects also today like the groundbreaking Blackhillock project.

Understanding grid-forming technology and its evolution

Developing the grid-forming solution was not merely about replicating a synchronous generator; instead, the focus was on preserving relevant features and emphasising beneficial capabilities. This approach diverged from the conventional term “virtual synchronous machine,” as the goal was to enhance functionality beyond traditional methods.

In the initial stages of discussions,
there were doubts about the feasibility of grid-forming technology. Demonstrators, such as the one on the island of St. Eustatius in the Caribbean Sea, played a crucial role in dispelling these concerns. In 2017, this MW-scale application demonstrated the operation of an entire island’s electric energy supply in diesel off mode without any synchronous machines. Rigorous testing, including Frequency Response Testing (FRT) and sudden diesel disconnection, validated the efficacy of grid-forming technology in real-world scenarios.

Software (SW) plays a pivotal role in grid-forming operation, where grid parameters are stabilised in response to deviations. This involves adapting island grid SW to react to frequency gradients instead of frequencies for grid-tied operation, resulting in a unique combination of droop and inertia control. This approach ensures stability and resilience, allowing inverters to emulate the behaviour of synchronous machines effectively.

Hardware (HW) enhancements are also integral to grid-forming solutions. Given that grid-following inverters typically offer limited short-circuit level (SCL) contributions compared to synchronous condensers, SMA’s Large Scale Hardware incorporates a short-term boost capability. This involves improving thermal management and providing design headroom for short-term overload, ensuring grid-friendly behaviour across various operational conditions.

In summary, the evolution of grid-forming technology has involved refining software and hardware components to deliver robust grid stability and resiliency. By harnessing the stability and flexibility of battery energy storage systems, grid-forming solutions offer a pathway to a more sustainable and reliable energy future. These solutions for grid-forming on-grid applications ensure seamless integration of renewable energy sources while maintaining grid stability. The emergence of additional stability services like inertia, system strength, and islanding capabilities underscores the necessity for grid-forming (GFM) controls at both inverter and plant levels.

**Impact on energy storage systems**

The integration of grid-forming technology into energy storage systems entails certain considerations. Retrofitting existing systems with GFM controls can enhance grid support functionality, albeit with some adjustments in plant operation and capacity reservation. However, the long-term benefits, including enhanced grid stability and cost-effectiveness, outweigh the initial complexities.

**Advantages of grid-forming inverters over traditional solutions**

Grid-forming inverters offer several advantages over traditional synchronous generators. Firstly, they behave similarly to synchronous machines, acting as a voltage source behind an impedance without the physical constraints associated with rotating machinery. This enables them to independently create their own three-phase voltage vector with a balanced sinusoidal waveform, reacting promptly to grid disturbances. Unlike grid-following assets, grid-forming inverters represent a true voltage source rather than a current source.

One significant advantage lies in the control capabilities of grid-forming inverters. Advanced grid-forming controls enable these inverters to exhibit synchronous, inertial, and damping behaviour of the voltage vector. This results in an instantaneous, delay-free power response to grid events. Moreover, the parameters of this response, including voltage amplitude, phase angle, and frequency, are adjustable. This flexibility allows for tuning of characteristics such as damping behaviour over the lifetime of the asset, enhancing its performance and adaptability.

Additionally, integrating electrochemical battery storage with grid-forming inverters further enhances their versatility and cost-effectiveness. Battery storage replaces the rotating mass traditionally used for mechanical storage in synchronous machines. As a result, grid-forming inverters combined with battery storage can provide not only inertia and short-circuit-level (SCL) but also capacity for congestion management and other ‘traditional’ energy services. This multi-purpose functionality makes grid-forming inverters with battery storage a highly efficient and adaptable asset.

Furthermore, the introduction of current boost capability by SMA eliminates the last remaining advantage of synchronous condensers, ensuring a high firm response at rated power. This capability enhances the performance of grid-forming inverters, making them even more competitive and suitable for various applications.

**Technical comparison**

A technical comparison between grid-forming inverters and traditional synchronous solutions reveals

---

**Grid-forming projects in Australia: A key use case**

Australia’s ambitious federal goal of achieving 82% renewable energy generation by 2030 has propelled the nation to the forefront of renewable energy adoption. With a vast potential for wind and solar energy, Australia faces the challenge of integrating these intermittent energy sources into its grid seamlessly. Battery energy storage systems (BESS) equipped with grid-forming technology have emerged as essential components to enable the required grid-hosting capacity for renewable energy.

Australia’s unique energy landscape offers valuable insights into the future of energy supply and grid stability. As an islanded power system with extensive distances for power transmission and high renewable energy penetration, Australia encounters challenges that other regions may face in the future. Recognising the importance of grid-forming technology in enhancing grid stability and resilience, the Australian Renewable Energy Agency (ARENA) has allocated substantial funding to support grid-connected BESS projects with GFM capabilities. Initially releasing a funding round of AUS$100 million (US$66.25 million), ARENA later extended this to AUS$176 million, underscoring the significance of accelerating the deployment of grid-forming technology. SMA has secured a significant portion of this funding, aligning with its commitment to advancing grid stability solutions in Australia.

The deployment of robust GFM technology is crucial for the Australian grid’s progression, as outlined in the Integrated System Plan released by the Australian Energy Market Operator (AEMO). With a shift towards renewable energy sources connected to the grid through inverter-based resources (IBR), traditional IBR without grid-forming technology fall short in providing adequate grid support services. Grid-forming functionality is essential to address this gap, enabling IBR coupled with BESS to contribute to network strength and stability.

While Australia serves as a prominent use case for grid-forming technology, interest and adoption extend beyond its borders. Regions grappling with similar challenges of integrating renewable energy sources into their grids are increasingly turning to grid-forming solutions. Countries with ambitious renewable energy targets, such as the United Kingdom, Germany, and the United States, are actively exploring the deployment of grid-forming technology to enhance grid stability and resilience.

---

**www.pv-tech.org**  |  May 2024  |  105
The Blackhillock project: A case study

Project overview
A world first, the Blackhillock project stands as a groundbreaking initiative in Scotland, spearheaded by developer Zenobē Energy, to propel the UK towards a net-zero economy. Situated between Aberdeen and Inverness, this pioneering project harnesses cutting-edge battery technology to provide essential stability services crucial for grid reliability. Partnering with SMA, a renowned provider of grid-forming solutions, battery inverters, and medium-voltage power stations, along with Wärtsilä as the BESS supplier, Zenobē ensured the seamless integration of renewable energy while bolstering grid stability. The project’s state-of-the-art inverters, power stations, and advanced control systems deliver vital grid services, marking a significant advancement in renewable energy integration.

Key objectives
The primary aim of the Blackhillock project is to enhance system stability in the most cost-effective manner for consumers. Leveraging grid-forming technology and battery energy storage, the project targets to boost grid resilience, curtail carbon emissions, and reduce consumer bills. Additionally, it aims to bolster inertia and short-circuit levels at crucial interconnection nodes, thereby enhancing the overall reliability of the electricity grid.

Implementation and outcome
Phase 1 of the Blackhillock project, comprising 200MW is planned to be commissioned in the summer of 2024, with Phase 2, an additional 100MW, slated for completion in the latter half of 2026. Upon completion, it will be the largest transmission-connected battery in Europe, offering a comprehensive suite of active and reactive power services. By facilitating greater integration of wind power into the transmission network, the project is expected to prevent approximately 2.3 million tonnes of CO2 emissions over 15 years.

Key technologies and partnerships
SMA supplied critical components for the project, including 62 medium-voltage power stations boasting 333MWs of inertia and 84 MVA of SCL. Collaborating with industry leaders like Wärtsilä and H&MV, Zenobē ensured the successful implementation of the project, setting new benchmarks in grid stability and renewable energy integration.

Zenobē, SMA and Wärtsilä are partnering again for a comparable project located in South Kilmarnock, also Scotland. This new endeavor aims to surpass previous performance with an impressive power output of 300MW, coupled with 1,314MWs of inertia and 249MVA of SCL capacity.

Summary
The Blackhillock project not only represents a significant milestone in maintaining grid stability based on inverter-based resources (IBRs) but also in the UK’s journey towards achieving net-zero emissions. Leveraging innovative technologies and forging strategic partnerships, Zenobē and SMA are helping showcase the transformative potential of energy storage in revolutionising the electricity grid.

As the Blackhillock and Kilmarnock projects evolve, they will serve as a beacon of sustainable energy development, propelling the UK closer to its renewable energy objectives while ensuring a stable, cost-effective, and environmentally friendly energy future.

The Blackhillock project is a world-first, demonstrating significant advantages. Grid-forming inverters exhibit robust control capabilities, enabling precise voltage and frequency regulation. Unlike traditional synchronous solutions, grid-forming inverters can independently create their own three-phase voltage vector with a balanced sinusoidal waveform, offering more flexibility in responding to grid disturbances.

By leveraging advanced control algorithms and innovative hardware designs, SMA’s grid-forming solutions deliver superior performance and reliability, ensuring optimal grid stability under varying conditions and over a plant’s lifetime – according to the changing characteristics at point of interconnection (POI).

Furthermore, the integration of battery energy storage transforms grid-forming inverters into multi-purpose assets capable of providing inertia, SCL, congestion management, and other energy services. This versatility makes grid-forming inverters with battery storage a cost-effective solution for modern power systems, outperforming traditional synchronous solutions in terms of efficiency, adaptability, and reliability.

Economic considerations and cost analysis
While the initial investment in grid-forming technology may be higher than traditional solutions, the long-term benefits far outweigh the costs. Grid-forming inverters offer enhanced grid stability and reliability, significantly reducing the risk of grid outages and downtime. This translates into substantial savings in terms of avoided losses due to power interruptions and improved operational efficiency.

Moreover, the flexibility afforded by integrating battery energy storage systems with grid-forming technology enables dynamic response to changing grid conditions. This optimisation of energy efficiency and grid performance leads to additional cost savings over time. With renewable energy penetration on the rise, grid-forming technology becomes increasingly indispensable for ensuring grid stability and resilience in the face of fluctuating renewable energy output.

Despite the higher upfront costs associated with retrofitting energy storage systems with grid-forming
Emissions-Free Technology
Towards a renewable energy future

Energy storage is a key component of any serious attempt to integrate large shares of renewable energy and a key flexibility tool for modern energy networks all over the world, both on and off-grid.

Our insights into industry developments and notable projects provide key intelligence for the global market.

News, views and interviews, analysis and opinion from across the energy storage value chain for a business audience.

240 countries
Over 3,700,000 Annual pageviews

www.energy-storage.news

Part of the Solar Media Ltd group, which includes the world’s number 1 solar PV technology website
By leveraging advanced control algorithms and innovative hardware designs, grid-forming inverters for on-grid applications deliver superior performance and reliability compared to traditional solutions. This ensures optimal grid stability and resilience, making them a cost-effective and future-proof solution for modern power systems.

**Final thoughts and future outlook**

In conclusion, grid-forming technology represents a pivotal advancement in ensuring the stability and resilience of energy systems, particularly in the context of increasing renewable energy integration. As highlighted throughout this article, advanced inverter solutions, such as those provided by SMA, are crucial in enabling grid stability by offering innovative grid-forming capabilities and seamless integration with battery energy storage systems.

The success in pioneering projects in the UK, Australia, US and Germany underscores the pivotal role of grid-forming technology in shaping the future of energy systems. The future will continue to be shaped by rapid technological advancements, evolving regulatory landscapes, and growing environmental imperatives. Grid-forming technology is poised to remain at the forefront of this transformation, driving the transition towards a sustainable and decentralised energy future.

As renewable energy penetration increases worldwide, grid operators, policymakers, and industry stakeholders must collaborate to address the challenges and opportunities posed by this transition. By embracing stability services markets, grid-forming solutions and investing in robust grid infrastructure, we can build more resilient and adaptable energy systems capable of meeting the demands of a rapidly changing world.

Furthermore, ongoing research and development efforts are essential to further refine and optimise grid-forming technology, enhancing its efficiency, reliability, and scalability. By harnessing the collective expertise and innovation of the global energy community, we can accelerate the deployment of grid-forming solutions and unlock new possibilities for a cleaner, more sustainable energy future.

In conclusion, grid-forming technology represents a cornerstone of the energy transition, offering a pathway towards a more resilient, flexible, and sustainable energy ecosystem. By embracing innovation, collaboration, and forward-thinking policies, we can pave the way for a brighter tomorrow powered by clean, renewable energy.

---

**Author**

Aaron Philipp Gerdemann is a senior business development manager in SMA’s Large Scale and Project Solutions Segment. For the past 2.5 years, he has guided TSOs, IPPs and developers towards the understanding and deployment of stability services from battery inverter solutions to their power systems and assets, such as the Grid Booster in Germany and the Stability Pathfinder projects in the UK.
Get the inside track on the energy storage sector

Enjoy 12 months of exclusive analysis

Premium subscription benefits include

**ESSENTIAL & FRESH ANALYSIS**
- Regular insight and analysis of the energy storage industry’s biggest developments
- In-depth interviews with the industry’s leading figures

**PV TECH POWER JOURNAL**
- Unlimited digital access to the PV Tech Power catalogue, previously published by PV Tech, dating back to 2014. Including more than 30 editions

**EVENTS**
- Discounts on Solar Media’s portfolio of events, in-person and virtual

Just $249 USD/year

Subscribe at: energy-storage.news/premium
The benefits of longer-duration storage and energy project co-location

Project design | Statkraft’s Rory Griffin writes about the challenges and opportunities encountered in developing Ireland’s first-ever 4-hour duration battery storage project, which is co-located with a wind farm.

Construction is underway by Statkraft at Ireland’s first 4-hour grid-scale battery energy storage system (BESS) in County Offaly, in Ireland’s midlands.

The 20MW, 4-hour BESS solution is supplied by a global market leader in utility-scale energy storage solutions and services, Fluence. It will be co-located with the company’s 55.8MW Cushaling Wind Farm, which too is currently under construction.

As in other countries, grid capacity in Ireland is becoming scarce, so as Statkraft develops further onshore wind and solar projects, there is a good opportunity to sensibly locate storage to mitigate the risk of local constraints and support congestion management.

The Cushaling battery project will enable energy from renewable sources in the midlands area to be stored during times of low demand, reducing costly curtailment, and later dispatched at times of peak electricity demand. It will also support the TSO EirGrid in ensuring network stability by delivering fast-acting system services as more non-synchronous renewable generation comes online. Additionally, by securing a 10-year capacity market contract, the project will contribute towards energy security in Ireland.

Greater trading opportunity

The Cushaling BESS and wind farm projects together received planning approval in September 2020. The Statkraft team’s decision to size the storage system was shaped by the market conditions in Ireland at the time, available site size and technology maturity looking beyond 2-hour duration.

The team also considered how to optimise the rating of the main grid transformer to share capacity with our Cushaling wind project. While sharing of Maximum Export Capacity (MEC) grid connection capacity is unfortunately not currently permitted in Ireland, Statkraft sees significant potential in co-location/hybrid assets under the same grid connection and is urging for policy changes in this area to maximise system benefit.

While system constraints can last longer than four hours, the 4-hour Fluence system was seen as a technology we had the confidence to deliver and one that could mitigate the constraint risk. As wholesale prices have also been volatile, there is also a greater energy trading opportunity by increasing to 4-hour duration.

Following the receipt of planning permission, the next step was to secure a 10-year capacity contract that would be the anchor revenue stream to support bringing the project to investment decision. Considering the capacity market auction timelines, the T-3 2024/2025 10-year capacity auction was targeted. Bids were placed in the first quarter of 2022, and in April of the same year, the project was awarded the 10-year capacity contract.

Perfect storm

However, between placing the auction bids and receiving the auction award, the price of the raw material lithium carbonate doubled. Russia’s invasion of Ukraine, combined with ports operating at lower capacity in the wake of the Covid-19 pandemic, proved to be a perfect storm. By November 2022, the price of lithium carbonate had tripled to RMB600,000 (US$83,000) per tonne, significantly impacting the overall capex. Balance of plant and construction costs also escalated.

The BESS capex was the main driver, accounting for circa 70% of the project cost, and for the entire 12 months of 2022, the BESS project was unable to make the internal hurdle rate for financial investment decision.

The capacity contract deliverables meant a decision needed to be made in the first half of 2023. Fortunately, the cost of raw materials reduced sufficiently in the six months from November 2022, and in June 2023, the financial investment decision was made.

Construction progress has been good to date despite the higher-than-average rainfall over the last nine months. The BESS solution comprises the Fluence Generation 6 lithium-ion Cubes with PE inverters, arranged in seven strings, giving a total storage capacity of 91.2MWh. In terms of the project status, the concrete bases are installed, and the BESS cubes are scheduled to be delivered to site in May 2024.

The project has experienced some difficulty securing transmission outages...
to energise the new substation, but the project is targeting connection in Q4 2024. As the project progresses to the operational phase, Statkraft Ireland will operate and trade the asset in a similar model to its two operational BESS projects at Kilathmoy and Kelwin-2.

Energy arbitrage

As the team looks ahead to our next projects, we will need to see new routes to market to incentivise longer-duration storage as well as changes to the market systems to fully allow traders to optimise asset capability. We believe there should be more favourable treatment of network charges with respect to energy storage based on its ability to offer flexibility to help shape the demand and manage network congestion.

As it stands, current network charges (namely Demand TuoS) represent a significant barrier and constrain the energy arbitrage opportunities for energy storage, thus limiting the benefits energy storage can offer to the system.

In Ireland, storage is required to pay demand network charges even though it is not the final consumer of the energy stored. Instead, it shifts that energy to a time when it is more beneficial for other users to consume, or when the network can better accommodate it (where the same energy volumes attract import charges for a second time). Network charges applicable to energy storage in Ireland are long overdue reform, and Statkraft continues to call for policy changes in this area.

For market access for BESS in Ireland, there are currently three revenue streams: the DS3 system services market, the capacity market and ISEM energy trading opportunities. With each of these markets having its own challenges, it can come down to how an individual developer forecasts them and their risk appetite. The early BESS projects could underpin the revenue stack using the DS3 and capacity markets, but a quick review of the current state of play shows why Ireland needs storage-specific auctions (specifically targeting longer duration) to support the Irish government’s 2030 targets of 80% of generation from renewable sources.

The current DS3 system service market regime has been in place since 2017, with regulated tariffs designed to support the 2020 target of 40% of generation supplied from renewable sources. This was achieved within a central expenditure cap of €235 million (US$254 million).

The DS3 market design provided the opportunity to earn additional revenue through incentivising certain technology providers through product scalars for provision of fast-acting frequency response (reserves) to respond as quickly as 150ms and sustained to 20 minutes. There were also system-wide incentives to be available at times when the generation mix comprised high levels of non-synchronous generation on the system condition (temporal scarcity scalars).

The DS3 Programme did provide a clear route to market which encouraged investment in short-duration energy storage and six years later, there is now circa 800MW of 0.5-hour, 1-hour and 2-hour BESS projects operational on the system. This scale of deployment is impressive relative to the size of the Irish system when you consider that the country’s largest single infeed remains at 500MW, at least until the 700MW Celtic Interconnector comes online. This is scheduled to take place at the end of 2026.

There are now more fast-acting reserves available on the system than the largest single infeed (which is the metric used by the TSO to set the required reserves) and the benefit to the system is a tighter operational frequency range, even if a large conventional generation unit was to trip.

Tariff reduction risk

However, the DS3 market is now overheated, as evidenced by the TSO signalling downward pressure on DS3 reserve tariff rates, and scarcity scalars in the latest DS3 rate consultation that came out in late March 2024. Ireland’s energy regulator (CRU) previously cut the tariffs to avoid breaching the expenditure cap. The CRU allowed the expenditure cap to be breached last year, but the industry is again facing tariff reduction risk.

It is not clear what the tariff rates will be between now and April 2026 when the existing DS3 market is overdue to be replaced by the Future Arrangements System Services (FASS) market. All of the above leads to significant uncertainty for existing and future grid-scale energy storage investment decisions, resulting in a significant problem in respect to “missing money” required to make up the business case.

Since the Cushaling BESS secured a 10-year T-3 2024/25 capacity contract, auction derating factors have been eroding for storage. The derating factors did incentivise longer duration storage systems (which pointed the Statkraft team towards four hours), but they have since halved, and the capacity auctions are no longer providing the revenue certainty required to make an investment decision. In late 2023, the TSO asked for industry feedback on what a long-duration energy storage (LDSS) specific auction would look like via a Call for Evidence to which Statkraft responded. The company is currently awaiting the next step in this process, the publication of a recommendations paper to policymakers. Publication of the related DECC Electricity Storage Policy Framework for Ireland is due in June of this year.

As mentioned previously, as in many other countries, good grid access is becoming harder to secure. As part of wind and solar development, developers need to price in lost energy through market dispatch down (system-wide curtailment and local constraints), which drives up auction bids. While the market registration of full hybrid market units is not currently permitted in Ireland, we still see the benefits of co-location of storage with wind and solar that could help to lower auction bids. Co-locating storage with solar might be easier to forecast, but we also see the merits of co-location with wind to reduce lost energy while sharing capex costs across two technologies.

Authors

Rory Griffin is head of grid services at Statkraft Ireland. He has held operational roles with Ireland’s TSO in conventional power generation and, more recently, in developing grid services assets. In the TSO, he worked in Power System Protection for five years, followed by five years in the National Control Centre. Since 2022, he has managed Statkraft Ireland’s Grid Services team which develops storage and grid stability projects.
The evolving landscape of international BESS transportation

Logistics | The energy storage market is a global one. With the transportation of battery energy storage systems accounting for up to 15% of a project’s cost, careful consideration is needed to ensure the right solution, writes Vienna Zhou of Canada-based system integrator TROES.

Battery energy storage systems (BESS) are rapidly becoming a crucial component of the global energy transition. BESS technologies enhance grid reliability, flexibility and efficiency by storing excess renewable energy and discharging it during peak demand periods.

As BESS deployment surges internationally, driven by ambitious renewable energy targets and grid modernisation initiatives, the complex logistics of transporting these systems come into sharp focus.

BESS are commonly equipped with lithium iron phosphate (LFP) batteries. These batteries are temperature-sensitive and if mismanaged, abused or defective can cause high heat, which can result in fire. For this reason, they are considered Class 9 Miscellaneous Hazards in US shipping.

This article delves into the evolving landscape of international BESS transportation, exploring key aspects like shipping routes, modes of transport, the impact of global disruptions, associated costs and future trends.

Charting the course: global BESS shipping routes

The majority of BESS units travel internationally by cargo ship. Major shipping routes for BESS transportation connect the world’s manufacturing hubs to expanding BESS markets.

Asia, particularly China, dominates BESS manufacturing. According to Wood Mackenzie, China accounted for over 80% of global BESS manufacturing capacity in 2022. Other notable manufacturing centres include South Korea, Japan and the United States.

Europe and North America are the leading BESS deployment regions outside China itself, driven by strong policy support for renewable energy integration and grid modernisation. The US Energy Information Administration (EIA) projects that US utility-scale energy storage capacity will quadruple by 2025, with BESS representing the dominant technology.

Similarly, Europe witnessed a record year for BESS installations in 2022 and again in 2023.

Leading shipping lines have recognised the growing importance of BESS transportation and offer dedicated services. These companies provide specialised solutions for BESS cargo, catering to factors such as temperature control, secure handling and efficient loading/unloading due to the often large size and heavy weight of BESS units.

Containerised versus modular: choosing the right shipping approach

The mode of BESS transport depends on the specific system design and capacity. Here’s a breakdown of the two main approaches:

Containerised transport

While containerised transport offers an efficient solution for shipping BESS units, factors beyond physical size must be considered for successful implementation.

First and foremost, the BESS system must comply with critical transportation regulations such as UN3536, ensuring
the safe transport of lithium-ion batteries. Additionally, containerised transport necessitates standardised BESS unit designs.

This standardisation ensures compatibility with ISO containers and facilitates efficient logistics throughout the transport journey. The BESS unit's dimensions must seamlessly fit within standard ISO containers, typically 20ft or 40ft in length. This eliminates the need for custom packaging and simplifies loading and unloading processes at ports and destination sites. Standardised BESS units also facilitate easier handling throughout transportation. This reduces potential delays and complexities associated with non-standard designs.

Advantages of containerised transport
Standardised ISO containers provide a well-established and efficient method for transporting BESS units. Their uniform size simplifies logistics throughout the entire journey to their end destination. Standardised dimensions ensure compatibility with cranes and other handling equipment at ports and destination sites, minimising delays and complexities associated with non-standard cargo. Additionally, standardised containers facilitate easier completion of customs documentation, potentially expediting the shipment process.

Utilising readily available ISO containers offers significant cost benefits compared to custom packaging solutions, eliminating the need for custom-designed packaging for each BESS unit. The widespread use of ISO containers allows shipping companies to leverage economies of scale, potentially offering lower shipping rates compared to specialised transport methods for non-standard cargo.

The robust construction of ISO containers also provides a secure and weather-proof environment for BESS units during transport. This offers protection from environmental factors, shielding the BESS unit from exposure to rain, sun, wind and other harsh weather conditions that could potentially damage the unit during transport. The container's rigid structure also offers a degree of protection against shocks, vibrations and potential impacts that might occur during handling or transport, safeguarding the sensitive internal components of the BESS unit.

Disadvantages of containerised transport
Standard ISO containers, even the larger 40ft models, have inherent size limitations. This restricts the total energy storage capacity that can be transported in a single container. For large-scale BESS projects requiring high capacity, containerised transport might not be feasible.

For projects requiring BESS units exceeding container dimensions, fragmentation into smaller, container-sized units becomes necessary. This can lead to inefficiencies such as an increased number of containers, which translates to higher overall transportation costs compared to a single, larger unit, and complexity of reassembly at the destination site, adding logistical complexities and potentially extending project timelines.

The requirement for standardised design might limit innovation in BESS technology. BESS system providers with cutting-edge designs that deviate from standard dimensions wouldn't be suitable for containerised transport. In some cases, squeezing a BESS unit into a standard container might also necessitate design compromises. This could potentially impact the unit's efficiency, cooling capabilities or overall performance.

A further drawback of containerised transport is that it doesn't offer much flexibility for project-specific customisations. This can be a disadvantage for situations requiring unique BESS configurations to meet specific site requirements.

A final major consideration is safety. Lithium-ion batteries, the core technology behind BESS units, pose potential safety risks during transport if not handled correctly. To address these concerns, the United Nations (UN) has established the UN Model Regulations for the transport of dangerous goods. Within these regulations, UN3536 specifically addresses lithium-ion battery installations in transport.

UN3536 outlines a comprehensive set of requirements for:

- **Packaging:** The BESS unit packaging needs to meet specific criteria to ensure adequate battery protection during transport. This might involve using special inner packaging materials or incorporating shock-absorbing elements.

- **Labelling:** Clear and informative labels must be prominently displayed on the containerised BESS unit. These labels identify the contents as lithium-ion batteries and provide necessary handling instructions for safe transportation.

- **Stowage:** Regulations dictate designated stowage locations on ships or other transport vessels. This minimises risks associated with potential battery malfunctions during transport.

- **Segregation:** UN3536 mandates the segregation of containerised BESS units from incompatible materials that could react with the batteries in case of an incident. Compliance with UN3536 is a mandatory requirement for the safe and legal transport of containerised BESS units. By adhering to these regulations, BESS system providers, shipping companies, and port authorities can ensure the safe and efficient movement of these vital energy storage solutions.

Containerised transport offers a cost-effective and efficient method for shipping BESS units. However, achieving this efficiency requires BESS units to be designed for standard containers and comply with UN3536 regulations. This combination ensures smooth logistics while prioritising the safe transport of lithium-ion batteries, paving the way for a more sustainable and reliable energy future.

However, meeting UN3536 regulations might necessitate using specialised packaging materials or incorporating additional safety features within the containerised BESS unit. These measures can add to the overall cost of transportation. Lithium-ion batteries are also subject to stricter scrutiny at customs due to potential safety concerns. This might lead to delays for containerised BESS unit shipments, compared to traditional cargo.

Modular transport
Advantages of modular transport
Customised BESS systems or half-completed systems are typically transported in a modular fashion. This involves breaking down the system into its components, such as battery racks, enclosures and power conversion systems (PCS). These components are then shipped separately and reassembled at the destination site.

Such an approach has a number of advantages, such as scalability. Modular transport truly shines in its ability to handle high-capacity BESS units. Unlike containerised transport with size limitations, modular transport allows for the transport of massive systems crucial for grid-scale energy storage projects. This flexibility accommodates the growing demand for the larger BESS project sizes.
that are increasingly common in maturing markets.

Modular transport also allows for customisation to cater to specific project needs. This can be particularly beneficial for:

- **Trade Agreements Act (TAA) compliance**: Projects subject to TAA regulations might require the use of specific components manufactured in certain countries. Modular transport facilitates the sourcing and transport of these components to meet compliance requirements.

- **Local content requirements**: Similarly, some regions might have local content requirements for BESS projects. Modular transport allows for incorporating locally manufactured components while ensuring efficient delivery of other essential parts.

Lastly, modular transport offers greater adaptability than containerised transport, which can be limited by port infrastructure or access roads. Individual components can be delivered by various methods, such as trucks, trains, or even barges, depending on the site accessibility and project requirements.

**Disadvantages of modular transport**

As with containerised transport, modular transport has numerous downsides. For example, the separate transport of components necessitates additional documentation and permits compared to containerised transport, where a single container serves as the primary focus.

Modular transport doesn’t necessarily guarantee lower overall costs. Several factors can contribute to potentially higher expenses.

Unlike pre-assembled containerised units, modular systems require on-site assembly and commissioning. These processes involve labour costs, potentially specialised equipment and additional time compared to simply connecting a containerised unit. Successful reassembly of a modular BESS also requires skilled personnel with expertise in BESS technology and assembly procedures. The availability of such expertise at the destination site can be a crucial factor for project success.

Lastly, individual components during modular transport are more susceptible to weather elements compared to pre-assembled and enclosed containerised units. Implementing adequate weatherproofing measures during transport is essential to safeguard BESS components.

**Reassembly: where and by whom?**

Reassembly of modular BESS systems typically occurs at the destination site, which could be a power plant substation, an industrial facility, or a dedicated energy storage facility. Responsibility for reassembly falls on one of two entities: either the BESS system provider or an engineering, procurement and construction (EPC) contractor.

Many BESS system providers offer complete turnkey solutions. This ensures a seamless process for the customer but might come at a premium cost. Alternatively, the project owner might choose to hire a separate EPC contractor. The advantage of this approach lies in potentially lower costs compared to a turnkey solution, but it requires specialising in BESS installations.

By selecting a BESS system provider, the project owner can avoid the hassle of managing between the EPC contractor and the BESS system provider. It also helps reduce project complexity, expedite timelines, mitigate risks and provide a single point of accountability for your system’s performance.

**Understanding BESS transportation costs**

The cost of transporting BESS units varies depending on several key factors. Larger and heavier BESS systems naturally incur higher transportation costs due to increased fuel consumption and potential limitations on containerised transport.

The other factors that are taken into consideration are:

- **Shipping route**: Distances travelled and prevailing fuel costs significantly impact costs. Longer routes with higher fuel prices will naturally translate to higher transportation costs.

- **Containerised versus modular**: Containerised transport is generally cheaper due to simplified logistics and handling.

- **Insurance**: Lithium-ion batteries require specialised insurance due to potential safety risks.

While specific costs can vary depending on project specifics, industry estimates suggest that transportation costs for BESS systems can range from 5-15% of the total project cost. Insurance adds an additional 1-2% to the overall cost.

**The impact of 2022: navigating disruptions in the global supply chain**

The global supply chain disruptions of 2022 significantly impacted BESS transportation. Several factors contributed to the challenges:

- **Port congestion**: Major ports experienced bottlenecks due to a surge in cargo volume and labour shortages. This resulted in extended waiting times for ships, delaying BESS deliveries.

- **Container shortages**: A global shortage of shipping containers further exacerbated the situation, significantly pushing container freight rates.

- **Rising fuel costs**: The increase in global fuel prices due to various geopolitical factors translated into higher transportation costs for BESS units.

These disruptions led to extended shipping times, increased transportation costs and potential project delays for...
24-26 September

NEC Birmingham

The UK’s largest renewable energy exhibition

30,000+ Attendees
We understand the value of a live event comes from the quality of networking opportunities. To facilitate this, we have a dedicated networking app for all visitors

250+ Speakers
Industry leaders share their views and expertise on key topics such as: ChargeEV, Storage & Batteries, Large Scale Utility Solar and much more

450+ Exhibitors
A free to attend exhibition featuring new ways of thinking and novel partnerships to generate solutions to help power the energy transition

GET YOUR FREE TICKET

www.terrapinn.com/ssllondon/home
The final step of the BESS shipping journey is the installation and commissioning of BESS transport. The landscape of BESS shipping has undergone a significant shift between 2022 and 2024. While containerised transport remains the go-to method for pre-designed, standardised units, the increasing demand for larger, custom-designed BESS units is driving the need for more intricate transport solutions.

In 2022, containerised transport dominated BESS shipping, offering a one-size-fits-all approach for smaller units. However, the growing popularity of large-scale BESS projects with unique specifications has necessitated a move towards project-specific logistics.

For exceptionally large or complex BESS systems, this means chartering dedicated ships specifically equipped for oversized cargo. These vessels offer greater flexibility in accommodating the unique dimensions and weight requirements of these systems. While not as common as dedicated ships, oversized trailers are also increasingly being utilised for BESS systems that can be transported overland. This method offers a potentially faster and more cost-effective solution for certain projects, especially where shorter distances are involved.

Challenges and considerations
This shift towards customised solutions presents new challenges and considerations for BESS transportation.

Project-specific solutions necessitate meticulous planning and coordination between various stakeholders, including BESS manufacturers, shipping companies and port authorities. Precise route planning that considers factors like infrastructure limitations and potential road closures becomes essential.

Larger BESS systems also often require specialised cranes and other handling equipment at ports and destination sites to ensure safe and efficient loading and unloading. This may involve mobilising specialised equipment to remote locations, adding to project complexity.

Meanwhile, as BESS technology continues to evolve, regulations governing the transportation of lithium-ion batteries, a core component of BESS units, are likely to become even more stringent. Staying updated on and adhering to these regulations is crucial for safe and compliant transport.

Regulations for lithium-ion BESS transport
It is paramount to transport lithium-ion batteries safely. If not handled and transported correctly, lithium-ion batteries pose potential fire and explosion risks.

To address these concerns, in addition to the UN regulations, the International Maritime Organization (IMO) regulates the transport of dangerous goods, including lithium-ion batteries, under the International Maritime Dangerous Goods (IMDG) Code. These regulations specify:

- **Packaging:** Strict packaging requirements ensure adequate protection for batteries during transport.
- **Labelling:** Clear labelling identifies the contents as lithium-ion batteries and provides necessary handling instructions.
- **Stowage:** Regulations dictate designated stowage locations on ships to minimize risks in case of an incident.
- **Segregation:** The IMDG Code mandates segregation of lithium-ion batteries from incompatible materials to prevent potential reactions. The chosen mode of BESS transport also impacts safety. Containerised transport generally offers a more controlled environment, with the entire BESS unit housed within a secure container. Modular transport requires careful handling and packaging of individual components to comply with IMDG Code regulations.

The future of BESS transportation
As market leaders such as the US and Europe aim to reduce reliance on overseas manufacturing and strengthen domestic supply chains, BESS production facilities are expected to be built closer to these markets. This will significantly reduce transportation distances and associated costs.

Meanwhile, advancements in battery technology might lead to more compact and lighter BESS designs. This could facilitate easier and cheaper containerised transport for larger systems. For example, research into next-generation battery chemistries like lithium-sulphur holds promise for increased energy density, potentially reducing the size and weight of BESS units.

Nevertheless, the transportation of BESS systems plays a critical role in enabling the global energy transition. As BESS deployment continues to accelerate, a comprehensive understanding of the evolving landscape of international BESS shipping is essential. By optimising transportation strategies, minimising costs and prioritising safety, the industry can ensure the efficient and secure delivery of these vital energy storage solutions, paving the way for a more sustainable and reliable energy future.

Author
Vienna Zhou is a seasoned expert with 17+ years in renewable energy, clean tech, and a background in Fortune 500 companies and government roles. With a mechanical engineering and MBA background, she founded ROES in 2018, an energy storage and microgrid solution company.
The most iconic renewable energy procurement platform

ENERGY TAIWAN

PV TAIWAN
- PV Materials and Components
- PV Manufacturing Equipment
- PV Systems
- PV Cells and Modules Manufacturing
- O&M
- Inspection Equipment
- PV Testing & Verification

WIND ENERGY TAIWAN
- Raw Materials
- Balance of Plant (BoP)
- Wind Turbine Systems
- Components and Subsystems
- Developer & Operator
- Accommodation Modules & Cargo Carriers
- Modules Manufacturing
- Talent Development

SMART STORAGE TAIWAN
- Batteries
- Smart Meters
- Energy Management Systems
- Smart Grids
- Electric Vehicles

EMERGING POWER TAIWAN
- Hydrogen Production Materials
- Fuel Cell Systems
- Storage & Delivery Systems
- Hydroelectric Power
- Geothermal Power

2023 Show Review
- 380+ Exhibitors
- 1,650 Booths
- 30,000+ Visitors
- 43% Show Scale-up
- 25% Attendance Growth
- USD 10 million Business opportunity

Types of Exhibitor
- Emerging Power: 8%
- Net-Zero: 12%
- Storage: 19%
- Wind: 25%
- PV: 36%

Visitor Categories
- Sales: 25%
- R&D: 15%
- Procurement: 11%
- Marketing: 8%
- Manufacturing: 6%
- Government Investment: 2%
- Industry Analyst Investment: 2%
- Management: 8%

2024
2 – 4 OCT
Taipei Nangang Exhibition Center, Hall 2 (TaiNEX 2)

Contact
TAITRA
Ms. Carol Chang
+886-2-2725-5200 #2856
energy@taitra.org.tw

Official Website

Organizers

TAITRA
semi
CESA
## Advertisers & Web Index

<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Web address</th>
<th>PAGE No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anker Solix</td>
<td><a href="http://www.ankersolix.com">www.ankersolix.com</a></td>
<td>37</td>
</tr>
<tr>
<td>Battery Asset Management Summit</td>
<td>batteriesummit.solarenergyevents.com</td>
<td>93</td>
</tr>
<tr>
<td>Chint</td>
<td>en.chintpower.com</td>
<td>49</td>
</tr>
<tr>
<td>Energy Storage News</td>
<td><a href="http://www.energy-storage.news">www.energy-storage.news</a></td>
<td>107</td>
</tr>
<tr>
<td>Energy Storage Summit Central Eastern Europe</td>
<td><a href="https://storagecee.solarenergyevents.com/">https://storagecee.solarenergyevents.com/</a></td>
<td>79</td>
</tr>
<tr>
<td>EU PVSEC</td>
<td><a href="http://www.eupvsec.org">www.eupvsec.org</a></td>
<td>95</td>
</tr>
<tr>
<td>Expo Solar Korea</td>
<td><a href="http://www.exposolar.org">www.exposolar.org</a></td>
<td>89</td>
</tr>
<tr>
<td>Huasun</td>
<td><a href="http://www.huasunsolar.com">www.huasunsolar.com</a></td>
<td>19</td>
</tr>
<tr>
<td>Huawei</td>
<td>solar.huawei.com/en</td>
<td>5</td>
</tr>
<tr>
<td>Intersolar</td>
<td><a href="http://www.intersolar-events.com">www.intersolar-events.com</a></td>
<td>61</td>
</tr>
<tr>
<td>Intersolar Mexico</td>
<td><a href="http://www.intersolar.mx">www.intersolar.mx</a></td>
<td>85</td>
</tr>
<tr>
<td>Jinko Solar</td>
<td><a href="http://www.jinkosolar.eu/ess">www.jinkosolar.eu/ess</a></td>
<td>27</td>
</tr>
<tr>
<td>PV Hardware</td>
<td>pvhardware.com/axone-duo/</td>
<td>15</td>
</tr>
<tr>
<td>PV ModuleTech Bankability Ratings</td>
<td>marketresearch.solarmedia.co.uk</td>
<td>81</td>
</tr>
<tr>
<td>PV ModuleTech EU</td>
<td><a href="https://www.pvtechconferences.com/pv-moduletech-europe">https://www.pvtechconferences.com/pv-moduletech-europe</a></td>
<td>75</td>
</tr>
<tr>
<td>PV Tech</td>
<td>pv-tech.org</td>
<td>65</td>
</tr>
<tr>
<td>PV Tech Premium</td>
<td><a href="http://www.pv-tech.org/paywall-tags/premium">www.pv-tech.org/paywall-tags/premium</a></td>
<td>97</td>
</tr>
<tr>
<td>RE+</td>
<td>re-plus.com</td>
<td>67</td>
</tr>
<tr>
<td>Renewable Energy Revenues Summit</td>
<td>renewableenergy.co.uk</td>
<td>69</td>
</tr>
<tr>
<td>Risen</td>
<td><a href="http://www.riseneenergy.com">www.riseneenergy.com</a></td>
<td>7</td>
</tr>
<tr>
<td>SNEC</td>
<td>pv.snecc.org.cn</td>
<td>31</td>
</tr>
<tr>
<td>Solar &amp; Storage Live</td>
<td><a href="http://www.terrapinn.com/exhibition/solar-storage-live/">www.terrapinn.com/exhibition/solar-storage-live/</a></td>
<td>115</td>
</tr>
<tr>
<td>Solar Finance &amp; Investment Asia</td>
<td>financeasia.solarenergyevents.com</td>
<td>71</td>
</tr>
<tr>
<td>Sunpro</td>
<td><a href="http://www.sunpropower.com">www.sunpropower.com</a></td>
<td>13</td>
</tr>
<tr>
<td>Tongwei</td>
<td>en.tw-solar.com</td>
<td>IFC</td>
</tr>
<tr>
<td>Trina Solar</td>
<td><a href="http://www.trinasolar.com/en-glb">www.trinasolar.com/en-glb</a></td>
<td>OBC</td>
</tr>
<tr>
<td>UK Solar Summit</td>
<td>uss.solarenergyevents.com</td>
<td>100</td>
</tr>
</tbody>
</table>

### Next Issue

**US interconnection issues**

**Tax credit transfers**

**Next-generation module reliability**

SUBSCRIBE TODAY!  [www pv-tech.org/power]
A GLOBAL LEADER IN THE PV INDUSTRY

The company excels in

- **Reliability**
  Top Performer Module Supplier by PVEL for Eight Times

- **Efficiency**
  Highest Efficiency Commercial Solar Modules 2023 according to TaiyangNews

- **Bankability**
  100% bankable according to BNEF (2023)

- **ESG**
  Listed in 2023 Forbes China ESG Innovative Enterprise

sales@jasolar.com  marketing@jasolar.com
@ www.jasolar.com
Leading in the Nera era of solar energy

720W+