

Volume 33

PV POWER PLANT TECHNOLOGY AND BUSINESS

November 2022 (Q4)

ONSHORING SOLAR'S SUPPLY CHAIN

Charting efforts to bring more PV manufacturing closer to end markets, p.16



Solar and land use in the UK, p,26



SYSTEM Integration

New PV module technology impacting LCOE, p,40

FINANCIAL, LEGAL, Professional

How PPA aggregations can benefit project developers, p.66



STORAGE & Smart Power

European market reforms for energy storage, p.84



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Introduction



The impacts of the global energy crisis triggered by Russia's invasion of Ukraine have reverberated across the PV industry, driving up solar deployment plans as economies seek to wean themselves off imported fossil fuels and shifting module delivery dynamics amid soaring European demand.

As the European Union (EU) presented its plan in March to reduce demand for Russian gas by two-thirds by the end of the year, the bloc's climate chief Frans Timmermans called for renewables to be added "at lightning speed".

Europe's solar sector has stepped up accordingly, with SolarPower Europe forecasting a 48% increase in PV installs this year. The trade body said European solar "is set to overshoot even our highest deployment projections for 2022".

As well as boosting corporate demand for power purchase agreements (PPAs), the energy crisis has prompted a raft of EU policy changes (p.33), such as slashing red tape for new solar projects and capping the revenues of some existing power plants.

Against this backdrop, PV module deliveries to Europe have surged; PV Tech's research team forecasts that almost 67GW of solar modules will be shipped to the continent this year.

However, as our cover feature (p.16) details, efforts are well underway to onshore more PV manufacturing – perhaps most notably to the US and India – amid warnings of supply chain bottlenecks as China continues to increase its dominance of the global solar supply chain.

With the US promising extensive support for domestic solar manufacturers as part of its recently passed Inflation Reduction Act, we take a deep dive into the landmark legislation's likely impact on solar deployment while looking at what legal and regulatory hurdles remain (p.68).

In terms of technology advancements, George Touloupas of Clean Energy Associates explores how new modules can increase quality risk (p.40) and affect the levelised cost of electricity. We also chart how new tracker launches are opening up the potential to install solar projects on more uneven terrain (p.44).

In our Financial, Legal and Professional section, Schneider Electric's Meghan McIntyre reveals how PPA aggregations can expand the off-taker pool for project developers while also allowing smaller organisations to secure renewable power at a fixed price (p.66).

As you'll read throughout the pages of PV Tech Power 33, the solar and energy storage industries are successfully navigating the turbulence caused by the energy crisis, incorporating new technologies and taking renewables generation to new heights.

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

Jules Scully

Section editor Solar Media REGULARS

Contents



08-14 NEWS

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

16-24 COVER STORY

- 16-21 **Onshoring solar's supply chain** Efforts are gathering pace to diversify the PV supply chain. Jules Scully details the challenges ahead.
- 22-24 **Strategies to support the scale-up of Europe's solar manufacturing sector** By Johan Lindahl, secretary general at the European Solar Manufacturing Council.

26-35 MARKET WATCH

- 26-28 Solar and land use in the UK: balancing energy and food security Molly Lempriere investigates how much land the UK needs for utility-scale PV plants as it transitions to net zero.
- 30-32 **Fact-checking US solar deployment with satellites** By Daniel Cruise and Joseph Triepke, partners at Lium Research.
- 33-35 From PPA prices to policy updates: how Europe's energy crisis is impacting solar With European solar deployment soaring on the back of sky-high electricity prices, Jules Scully examines how the PV sector is navigating the ongoing energy crisis.

40-45 SYSTEM INTEGRATION

- 40-42 New PV module technologies' impact on quality and LCOE By George Touloupas, senior director at Clean Energy Associates.
 44-45 Terrain-following trackers opening up solar's
- 4-43 **potential on uneven project sites** Tracker manufacturers are enabling projects to be built on more uneven terrain. Molly Lempriere profiles the latest product launches.

48-57 PLANT PERFORMANCE

- 48-50 **From optimum yield to maximum profit:** developing PV parks with O&M in mind By Jörn Carstensen, managing partner at greentech.
- 52-57 **Challenges of PV soiling in desert climates** By Brahim Aïssa, Juan Lopez-Garcia, Benjamin Figgis and Veronica Bermudez of the Qatar Environment & Energy Research Institute.

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58-64 DESIGN & BUILD

- 58-60 **'Everything is becoming more efficient': new floating PV construction methods take hold** Jonathan Touriño Jacobo looks at how floating solar project construction has changed and what new technologies are being used.
- 62-64 **Project briefing: Overcoming logistical challenges to build Europe's largest solar project** George Heynes details how Iberdrola completed its 590MW Francisco Pizarro plant in Spain.

66-71 FINANCIAL, LEGAL, PROFESSIONAL

- 66-67 **PPA aggregation increasing offtaker pool for project developers** By Meghan McIntyre, energy analyst at Schneider Electric.
- 68-71 **An IRA deep dive: how significant is it and what uncertainties remain?** Sean Rai-Roche explores how industry players can benefit from tax credits in the US's Inflation Reduction Act.

76-88 STORAGE & SMART POWER

- 76-77 **Three V2G/V2X projects getting around major challenges of consumer vehicle space** Cameron Murray talks to three companies taking a practical approach to scaling their vehicle-to-grid and vehicle-to-building offerings.
- 78-80 Second life energy storage firms position themselves ahead of EV battery boom Using batteries from electric vehicles in energy storage systems can provide a potentially low-cost way to sidestep supply chain bottlenecks, writes Cameron Murray.
- 81-83 Southeast Asia's emerging energy storage opportunities
 Amid an uptick in energy storage investment in Southeast Asia, Andy Colthorpe speaks with the companies working to gain a foothold in the region.
- 84-88 European energy strategy must reconcile the need for flexibility

By Julian Jansen and Lars Stephan of Fluence.





REGULARS

03 Introduction

- 36 Products
- 90 Advertisers index





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EUROPE

EU policy

EU countries agree to renewables revenue cap, SolarPower Europe 'deeply concerned'

European Union (EU) countries have introduced a revenue cap on operational solar PV plants as part of a package of emergency measures. Ministers from the bloc's 27 member states agreed to cap the market revenues at €180/MWh (US\$177/MWh) for 'inframarginal' electricity generators, such as renewables, nuclear and lignite. The mandatory cap on market revenues applies from 1 December 2022 to 30 June 2023. Member states agreed to include the possibility for individual countries to set a higher revenue cap, use measures that further limit market revenues, differentiate between technologies and to apply limits to market revenues of other actors, including traders. Trade body SolarPower Europe said it is "deeply concerned" about patchwork implementation as it urged member states to stick to the EU-level cap of €180/MWh and apply the cap on net market revenues only.

EU plans to fast-track solar permitting via emergency regulation

The European Commission has proposed a temporary emergency regulation to accelerate the deployment of renewable energy in the face of the energy crisis and the knock-on effects of Russia's invasion of Ukraine. Scheduled to last for one year, the proposal will remove administrative red tape around permitting and deployment, allowing renewable energy sources to be fast-tracked into operation. Solar PV deployed on artificial structures – buildings, car parks, transport infrastructure, sheds – and co-located storage systems and grid connections will have a maximum deadline of one month for permitting under the proposal. The measures will also exempt these types of installations, as well as solar farms below 50kW capacity, from certain environmental assessments.

France

France to fast-track 2.7GW of solar PV in response to energy crisis

France aims to enable the rapid commissioning of 2.7GW of solar PV awarded in recent tenders as part of efforts to speed up renewables deployment amid the energy crisis. The country's Energy Regulatory Commission (CRE) has tweaked the rules for the CRE 4 and PPE 2 tenders to enable project owners to absorb part of the rises in costs and rates by selling power generation on the market before the start of their support. There is also a provision that allows project completion deadlines to be extended and for winning bidders to increase the power supply up to 140% of that secured in the tenders. The measures will enable the rapid commissioning of more than 6.1GW of renewables projects that were successful in the tenders and "are currently in difficulty", CRE said.

Romania

Actis-backed Rezolv Energy to develop Europe's 'largest' PV plant in Romania

Rezolv Energy, backed by sustainable infrastructure investor Actis, has acquired rights to a 1,044MW PV plant in western Romania. Actis said the project is "expected to be the largest solar PV plant in Europe". Acquired from Monsson Group, the plant will include 1.6 million solar panels, be operational by 2025 and generate an annual average of 1,500GWh of power. Actis said that the power will be sold through long-term power purchase agreements to commercial and industrial users, though it has not specified if these have yet been agreed. It's also "likely" to include a 135MW battery storage system.

PPAs

Strong demand for European solar PPAs despite price rises

Demand for solar and wind power purchase agreements (PPAs) in Europe remains strong despite sustained price hikes, research from LevelTen Energy has revealed. According to the firm's P25 price index, European solar PPA prices in Q3 2022 reached €68.57/MWh (US\$67.45/MWh), a 53.3% increase year-on-year. A PPA marketplace operator, LevelTen's P25 price index represents an average of the 25th percentile PPA price from each market. With Europe hit by "eye-watering" wholesale electricity prices – north of €500/MWh in some markets – LevelTen said there has been a resulting boom in PPA demand as large energy consumers try to insulate themselves from high energy prices with longterm, fixed-price contracts.



An operational PV plant in Italy, where solar PPA prices increased 28% quarter-over-quarter, according to LevelTen.

M&A

ReneSola Power grows European solar pipeline with Emeren acquisition

Solar developer ReneSola Power has acquired UK-based utilityscale PV and battery storage developer Emeren as it expands its footprint in Italy and other European markets. With a pipeline of more than 2GW of solar and 500MW of storage under development, Emeren formed a partnership with ReneSola last year to develop PV projects in Italy. Guido Prearo, CEO at Emeren, said the acquisition "offers unique synergies", combining his company's knowledge of European solar markets with ReneSola's project development expertise and resources.

Iberia

Aquila Capital secures financing to construct 2.6GW of renewables in Spain and Portugal

German investment firm Aquila Capital has raised €1 billion (US\$992 million) in financing to support the development and construction of a 2.6GW renewables pipeline in Spain and Portugal over the next three years. Predominantly solar PV and wind assets, the pipeline features more than 50 projects from Aquila Clean Energy EMEA, Aquila Capital's clean energy development platform in Europe. While Aquila Capital has not disclosed the capacity for each technology in the pipeline, the company confirmed to PV Tech that the vast majority will be solar PV.

AMERICAS

Deployment

US utility-scale solar deployment fell 23% in Q3 amid module procurement issues – ACP

The US installed 1,877MW of utility-scale solar during Q3 2022, a 23% drop year-on-year, amidst ongoing policy issues, according to trade body the American Clean Power Association (ACP). Total utility-scale clean energy installations fell 22% compared with Q3 last year, and there's been an 18% year-to-date drop off as the US clean energy sector saw its slowest quarter in three years. Delays in solar installations boil down to module procurement. "The solar market has faced repeated delays as companies struggle to obtain panels as a result of an opaque and slow-moving process at US Customs and Border Protection," said JC Sandberg, interim CEO and chief advocacy officer at ACP. The ACP also cited issues with securing grid connections as a reason for the backlog of uninstalled projects.

Canada

Canada introducing ITC for solar PV, energy storage and low-carbon hydrogen

Canada's government will introduce tax incentives for clean energy technologies, including solar PV, battery storage and hydrogen. Announced in November by Deputy Prime Minister Chrystia Freeland as part of Canada's Fall Economic Statement 2022, the move has been welcomed by renewable energy, energy storage and manufacturing trade groups. The government proposes to introduce a refundable tax credit equivalent to 30% of the cost of capital investment into electricity generation systems, stationary electricity storage systems, low-carbon heat equipment and industrial zeroemissions vehicles and related charging or refuelling equipment. Projects that do not meet requirements on local labour conditions will get a 10% reduction in the minimum tax credit rate.

M&A

Brookfield Renewable acquires Scout Clean Energy and Standard Solar

US renewable energy major Brookfield Renewable is spending up to US\$2 billion to acquire both renewables developer Scout Clean Energy and Standard Solar, a company focused on the development, funding, and ownership and operation of commercial and community solar assets. The move sees Brookfield acquire Colorado-based Scout for US\$1 billion, with the potential to invest an additional \$350 million to support the business's development activities. Scout's portfolio includes a pipeline of over 22GW of solar, wind and storage projects across 24 US states, including almost 2,500MW of underconstruction and advanced-stage projects. Brookfield is acquiring Standard Solar for US\$540 million, with the potential to invest an additional US\$160 million to support the company's growth.



A community solar farm from Standard Solar in Maine.

RWE buys Con Edison's renewable energy subsidiaries, adds 3GW of operating US assets

German utility RWE has signed an agreement with Con Edison to acquire all the shares in its renewable energy subsidiaries, Con Edison Clean Energy Businesses. The transaction has been valued at US\$6.8 billion and is expected to close during the first half of 2023. With nearly 3GW of operational assets, 90% of which are solar PV, the acquisition of Con Edison CEB will almost double RWE's renewables portfolio in the US to 7.2GW.

Mexico

Atlas Renewable Energy brings online 300MW PV project in Mexico

Miami-headquartered Atlas Renewable Energy has begun operations on its 300MW La Pimienta solar project, located in the Mexican state of Campeche. The plant is forecast to generate 789GWh of power annually, with a 15-year power purchase agreement signed with Mexican state-owned utility Federal Electric Commission. Atlas said that the project is the second-largest PV installation in Mexico, and the first large-scale solar project in Campeche. The plant comprises over 1 million solar modules spread across 651 hectares. Atlas said that it will execute a 450-acre reforestation programme and has installed a 'natural corridor' within the plant to maintain natural flora and fauna.

Commercial solar

US commercial PV capacity doubles in last 2.5 years, accounts for 14% of solar market

Commercial solar capacity in the US increased from 9.8GW at the end of 2019 to 19GW in June 2022. That is according to research from trade body the Solar Energy Industries Association, which found that since the end of 2019, tech and retail giants have led the increase in commercial solar, which currently accounts for 14% of all installed solar capacity in the US. The recent growth was due to an accelerated procurement of off-site solar, which currently represents more than half (55%) of all commercial solar use. Meta has the largest corporate solar portfolio with 3.6GW, more than treble the following company on the list, Amazon, with 1.1GW of solar capacity. Apple closes the podium with 987MW of installed capacity as of the end of June 2022.

PPA

SB Energy and Google pen 942MW PPA for four Texas solar projects

California-based renewables operator SB Energy has sealed a 942MW power purchase agreement (PPA) with Google for power produced in four of its Texas-based solar projects. The power will be used to fuel a data centre in Midlothian, Texas. Google will purchase 75% of the 1.2GW capacity produced at the Orion 1-3 and Eiffel solar projects, which are expected to be operational by mid-2024. This PPA is Google's largest combined clean energy transaction in Texas to date and comes as part of its professed commitment to operate "every hour of every day" on carbon-free energy by 2030.

MIDDLE EAST & AFRICA

UAE

Shanghai Electric completes phase B of 900MW solar park in Dubai

Chinese engineering, procurement and construction (EPC) contractor Shanghai Electric has completed phase B of the fifth phase of the 900MW Mohammed bin Rashid (MBR) Solar Park in Dubai. After connecting phase A to the grid in 2021, and with phase B now done, construction for phase C is underway and is expected to be completed by 2023, said project manager at Shanghai Electric, Meng Chuanmin. Saudi Arabian developer ACWA Power enlisted Shanghai Electric as the contractor for the fifth phase of the project in 2020, which consists of three stages (A, B and C), with a total installed capacity of 1,050MW.



Phase 5 of the Mohammed bin Rashid Al Maktoum Solar Park

M&A

Shell acquires African C&I solar provider Daystar Power Energy major Shell is acquiring Daystar Power, an Africa-based commercial and industrial (C&I) solar provider. It is expected that the deal will allow Daystar to grow its operations in West Africa while helping it expand across the African continent. The company closed a US\$38 million Series B funding round in 2021, which it said would help accelerate its expansion in Nigeria, Ghana, Côte d'Ivoire, Senegal and Togo. According to Daystar's website, it currently runs more than 300 power installations with an installed solar capacity of 32MW. It aims to reach 400MW of solar by 2025.

Nigeria

Sterling and Wilson to construct 961MWp of solar in Nigeria

A subsidiary of solar EPC Sterling and Wilson has signed a memorandum of understanding with the government of Nigeria to develop and construct a portfolio of PV and battery energy storage system (BESS) projects in the country. Sterling and Wilson Solar Solutions, along with its consortium partner Sun Africa, will develop 961MWp of solar at five locations along with BESS with a total installed capacity of 455MWh. Financing for the projects is under negotiation between the US Export-Import Bank, ING and the government of Nigeria. The installations will ultimately be owned and operated by Niger Delta Power Holding Company, a Nigerian government-owned entity.

Israel

Belectric to repower Enlight PV project in Israel, raise capacity to 88MWp

German developer Belectric has signed an EPC contract with independent power producer Enlight for Israel's "largest" repowering solar project. Retrofitting works will increase the capacity of the Halutziot solar farm – which is located in the Negev desert and was originally commissioned in 2015 – from 55MWp to 88MWp, while an energy storage system will be installed. Belectric will replace 180,000 mono-facial 310Wp modules with 161,000 bifacial 540Wp dual glass modules, with the retrofitting including the replacement of the inverters and transformers on site. Replacement and construction works have already started and are expected to be finished by the second quarter of 2023, with Belectric also taking on operation and maintenance services for the project.

Green hydrogen

Globeleq to develop green hydrogen hub in Egpyt with 9GW of solar and wind

Africa-focused independent power producer Globeleq has signed a memorandum of understanding to develop a green hydrogen hub in Egypt with up to 9GW of solar PV and wind power. The development, planned for the Suez Canal Economic Zone, will be carried out in three phases, starting with a pilot project using a 100MW electrolyser and with an initial focus on green ammonia fertilisers. Other end-uses of green hydrogen will be explored in the medium and longer term, including green fuels. Once fully operational, the project will total 3.6GW of electrolysers and use 9GW of solar PV and wind power generation.

South Africa

South African coal plant to be repurposed using renewables and storage

The World Bank has approved funding for a US\$497 million renewable energy project in South Africa that will see 150MW of solar and 70MW of wind capacity installed in place of the coal-fired Komati power plant. The primary aim of the project, fully entitled the 'Komati Just Energy Transition Project', is to decommission and repurpose the Komati coal-fired plant, one of 15 coal-fired plants in South African public electricity utility Eskom's fleet that constitutes 39.8GW of the country's 52.5GW installed capacity. The power sector accounts for 41% of South Africa's greenhouse emissions, in large part due to this fleet of coal-fired plants. The project will also feature 150MW of battery storage.

Voltalia inks 148MW solar PPA with Rio Tinto in South Africa

Renewables company Voltalia has signed a corporate power purchase agreement (PPA) with mining company Richard Bay Minerals, a subsidiary of Rio Tinto, in South Africa. The power will be provided from a 148MW solar plant – developed, constructed and operated by the French renewables company – in South Africa's Limpopo province that is expected to begin generating electricity in 2024. Under the 20-year PPA contract, Voltalia will supply up to 300GWh of annual solar generation capacity to RBM's smelting and processing facilities in KwaZulu-Natal.



Tier-1 Solar PV Module Mfr

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ASIA-PACIFIC

PPAs

Corporate PPAs hit record levels in Asia Pacific – WoodMac

Corporate power purchase agreements (PPAs) have hit record levels in the Asia Pacific region as fuel prices rise and the cost of renewables falls, according to Wood Mackenzie principal analyst, Kyeongho Lee. The region is forecast to see 7GW of renewable capacity contracted to corporations this year, an 80% increase on 2021. Lee said that the soaring costs of LNG, oil and coal – all more than doubling since 2019 – and falling costs of renewables over the same period have seen clean PPAs become increasingly attractive as a reliable and affordable energy source. Utility-scale solar has seen a 4.9% price drop since 2019, whilst commercial solar has fallen 14.2%.

M&A

NovaSource acquires First Solar's Australian O&M assets NovaSource Power Services has acquired First Solar's Australian

operations and maintenance (O&M) business, adding approximately 500MW of PV projects to its fleet in the process. The deal, which closed on 30 September 2022, follows O&M services provider NovaSource's acquisition of First Solar's North American O&M business, in a transaction announced in 2020. Completing that deal last year, US-based NovaSource claimed it was the "world's largest" solar O&M provider. It currently operates more than 20GW of solar power plants across 11 countries. NovaSource said the Australia agreement signals its focus on expanding its platform and driving growth in a strong, renewable energy-focused market.



NovaSource Power Services currently operates more than 20GW of solar power plants.

Sembcorp secures 559MW of Indian solar assets with acquisition of Vector Green Energy

A wholly owned subsidiary of Singapore-based energy company Sembcorp Industries has secured a deal to acquire Indian independent power producer Vector Green Energy. Sembcorp Green Infra has signed an agreement with a fund managed by Global Infrastructure Partners India to buy 100% of Vector Green for a base equity consideration of approximately INR27.8 billion (US\$342 million). With renewables power generation assets in 13 Indian states, Vector Green's portfolio includes 495MW of solar capacity and 24MW of wind capacity in operation as well as 64MW of PV projects under development. The acquisition sees Sembcorp's portfolio of installed or under-development solar assets in India reach 1GW.

Australia

Australia backs transmission projects to unlock more renewables

Australia's government is supporting the development of two major transmission projects to facilitate the connection of additional renewable energy capacity. The Labor Party, which went into office this year under the leadership of prime minister Anthony Albanese is creating Rewiring the Nation, an AU\$20 billion (US\$12.6 billion) initiative to modernise the electric grid. Low-cost loans have been confirmed for the Victoria-New South Wales Interconnector KerangLink project to increase interconnection capacity between the two states, as well as for Marinus Link, a project to connect the island state of Tasmania to Victoria, and therefore to the National Electricity Market. There will also be financing available for the development of renewable energy zone projects in Victoria.

New South Wales launches renewables auction, targets 12GW of deployment by 2030

The Australian state of New South Wales (NSW) has opened its first tender for renewable energy and long-duration energy storage. Over the next ten years, the tenders will be held biannually to replace retiring coal power as NSW targets 12GW of renewables and 2GW of long-duration storage by 2030, according to Matt Kean, NSW's Minister of Energy. The tenders are expected to incentivise up to AU\$32 billion (US\$20.75 billion) in private capital in the next decade as the region retires four out of five of its coal-fired power stations.

ACEN Australia to begin construction of 400MW PV project in New South Wales REZ

Renewables developer ACEN Australia is poised to commence construction on its 400MW Stubbo solar project after having executed key contracts and reached a final investment decision, continuing its recent expansion in Australia's renewables market. The Stubbo project is located in the Central-West Orana renewable energy zone in New South Wales (NSW), and its approval contains provision for a 200MWh battery energy storage system, which ACEN said will contribute to grid stability in the area by storing and then distributing renewable energy at peak times. It will connect the project to an existing 330kV network. Stubbo was granted development permission in 2021 by the NSW government and construction is due to commence in late 2022.

Floating solar

ACWA Power to build 110MWac of floating PV projects in Indonesia

Saudi Arabian renewables developer ACWA Power will enter the Indonesian market with two floating solar PV projects after being chosen by PT Perusahaan Listrik Negara (PLN), Indonesia's stateowned electricity utility. The plants – Saguling Floating Solar PV project and Singkarak Floating Solar PV Project – will constitute 60MWac and 50MWac of capacity, respectively, and mark both ACWA Power's first floating PV project and its first installation in Indonesia. The installations represent an investment of US\$105 million combined. ACWA holds a 49% stake in the projects, whilst the rest is owned by Indonesia Power, a subsidiary of PLN.



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MANUFACTURING

Polysilicon

Global polysilicon capacities to reach 536GW by year-end 2023, CEA says Global polysilicon capacities are on track to reach 295GW by the end of 2022 as six new facilities ramp up production this quarter, according to new research from Clean Energy Associates (CEA). The solar and storage advisory firm forecasts polysilicon production will then soar to 536GW by year-end 2023, assuming all projects in the pipeline develop as planned. The projected increases follow sustained polysilicon price hikes this year, in part

planned. The projected increases follow sustained polysilicon price hikes this year, in part due to power rationing in China and silicon shortages. CEA research published in August said that polysilicon prices will drop throughout 2023 as sizeable manufacturing capacities come online.

Europe

European solar PV manufacturing at risk from soaring power prices – Rystad

Around 35GW of PV manufacturing projects in Europe are at risk of being mothballed as elevated power prices damage the continent's efforts to build a solar supply chain, research from Rystad Energy suggests. The consultancy noted that the energy-intensive nature of both solar PV and battery cell manufacturing processes is leading some operators to temporarily close or abandon production facilities as the cost of doing business escalates. It added that the power prices are increasing the risk that planned projects which have not secured funding yet may fall through.

European consortium begins perovskite-silicon tandem cell research project

Europe will benefit from a new research and innovation (R&I) project intended to advance the continent's tandem solar PV cell manufacturing and production capabilities, focusing on tandem siliconperovskite cells. Entitled PEPPERONI, the project will run for four years and is co-funded by the European Union and coordinated by climate research institute Helmholtz-Zentrum Berlin (HZB) and solar manufacturer Qcells. Qcells said that a pilot line for tandem production will be established at its European headquarters in Thalheim, Germany, aiming ultimately at industrial production of perovskitesilicon tandem cells.



The project aims to help advance silicon-perovskite technology towards mass manufacturing.

India

India's approves second round of PLI scheme, aims to support 65GW of module manufacturing

India's government has approved the second round of the production-linked incentive (PLI) scheme to incentivise domestic solar PV module manufacturing. The scheme expects to add 65GW of manufacturing capacity of fully and partially integrated solar PV modules, which will bring direct investments of nearly INR940 billion (US\$11.59 billion). Selected manufacturers will receive the PLI for five years.

Company news

JinkoSolar signs two polysilicon supply contracts totalling nearly US\$30 billion

JinkoSolar has signed a major polysilicon supply contract worth more than RMB103.3 billion (US\$14.9 billion) just weeks after it signed a contract worth RMB102.1 billion (US\$14.7 billion) with Xinte Energy, as the company looks to lock in long-term polysilicon supply. On 10 September, JinkoSolar announced it had signed a major procurement contract with Tongwei for roughly 382,800MT of polysilicon products from the company's subsidiaries. Based on the average transaction price of RMB305,100/MT (US\$44,010/MT) – inclusive of taxes – the total contract amount is estimated to be about RMB103.3 billion. The actual purchase price shall be negotiated monthly, and the total trading volume shall be subject to the final transaction.

LONGi sets 26.81% efficiency record for heterojunction solar cells

Solar manufacturer LONGi has set a world record conversion efficiency level of 26.81% for silicon heterojunction (HJT) PV cells. Validated by the Institute for Solar Energy Research in Hamelin, the record was achieved using mass production processes and full-size silicon wafers, according to the Chinese manufacturer. The milestone comes after LONGi reached 26.5% HJT cell efficiency last June, achieved on M6 full-size monocrystalline silicon wafers.

Canadian Solar to focus on n-type TOPCon moving forward, with 30% of total shipments for 2023

Canadian Solar expects to start shipping its first TOPCon products early next year and will focus on the technology in the future with all new cell production capacity. N-type TOPCon is expected to account for a third of the company's total solar module shipments in 2023, according to Yan Zhuang, president of CSI Solar, Canadian Solar's manufacturing subsidiary. The company shipped 6GW of modules during the third quarter of the year, increasing by 62% on results in the corresponding quarter of 2021.

First Solar selects Alabama for 3.5GWdc module manufacturing factory

Thin-film manufacturer First Solar has confirmed that its fourth US factory will be opened in Lawrence County, Alabama. With a planned manufacturing capacity of 3.5GWdc, the facility will represent an investment of approximately US\$1.1 billion. Expected to be commissioned by 2025, the vertically integrated factory is part of First Solar's expanding manufacturing and development footprint in the US. Its three factories in Ohio – one of which is due to become operational in early 2023 – are accompanied by R&D facilities in California and Ohio.

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Onshoring solar's supply chain

Manufacturing | Amid potential supply chain bottlenecks as China increases its PV manufacturing dominance, companies in markets such as the US, India and Europe are looking to leverage new policy support to scale up domestic production. Jules Scully charts the industry's efforts to onshore solar module manufacturing.



which China strengthening its position in recent years to dominate the PV supply chain, efforts are gathering pace to onshore some manufacturing to end markets as governments aim to support domestic production and reduce their reliance on imports.

China's share in all key manufacturing stages of solar panels exceeds 80% today, according to a report published earlier this year by the International Energy Agency (IEA). For key elements including polysilicon and wafers, this is set to rise to more than 95% in the coming years, based on publically announced manufacturing capacity under construction. The research said the solar industry supply chain is one of the most geographically concentrated supply chains globally.

Heymi Bahar, a senior analyst at the

IEA and lead author of the report, tells *PV Tech Power* that China's dominance has been achieved through an extensive industrial policy supporting both supply and demand, as the country chose solar as a strategic industry for economic development.

"It's an important thing to understand why China is the largest producer – because they achieved the economies of scale, they achieved innovation and then thanks to this expansion of solar PV in China, the world enjoyed an 80% cost reduction of solar PV modules. That's one reality that I think it's important to acknowledge," Bahar says.

The second reality, he argues, is that without a solar PV industrial policy, including demand- and supply-side policies and innovation, it will be difficult to bridge the Enel's 3Sun Gigafactory in Italy is on track to reach 3GW of HJT module production in 2024. cost gap with China. "I think countries are a little bit waking up to this," Bahar says.

The importance of scaling up solar manufacturing in the US was highlighted by President Joe Biden, who said in a memo published in June that action to expand the domestic production of PV modules and components "is necessary to avert an industrial resource or critical technology item shortfall that would severely impair national defence capability".

Why diversify?

Although 38 countries have module assembly facilities, China was still responsible for about 70% of production in 2021, the IEA research revealed. With crystalline silicon cell manufacturing concentrated in the Asia-Pacific, large PV demand centres



PV manufacturing costs in China are 10% lower than in India, 20% lower than in the US and 35% lower than in Europe, according to the IEA.

in the US, India and Europe depend strongly on imports for the main solar module components. The IEA said although these markets often possess multi-gigawatt module production capability, most of the plants simply assemble modules from parts shipped from manufacturers located mainly in mainland China.

China's dominance in the PV supply chain is perhaps most obvious in terms of wafer production, with the country accounting for 97% of global manufacturing capacity, according to the IEA. It said that Chinese companies were able to become cost-competitive in wafer production relatively quickly, preventing other market participants from attaining significant market shares.

Among the advantages of onshoring some production closer to end markets is securitisation of supply. Increasing local manufacturing capability will go some way to ensuring supply disruptions for local development are minimised, says Sylvia Leyva Martinez, a senior analyst at research firm Wood Mackenzie. "Developing a domestic supply will reduce the reliance on other countries and will shield buyers from any changes in trade policy."

Martin Meyers, director of market intelligence at solar and storage advisory firm Clean Energy Associates (CEA), argues that the most important benefit for US developers of increasing domestic PV manufacturing would be the significant reduction in supply chain frictions associated with trade and customs requirements, which have significantly impacted developers in recent years. He says a significant additional benefit would be much lower logistics risks, which were experienced by all trans-Pacific shippers in 2021.

As well as creating a greener supply

chain by reducing shipping-related emissions, onshoring more manufacturing could also help the industry decarbonise by producing more components in areas with high levels of renewables penetration.

Currently, coal fuels 62% of the electricity used for solar PV manufacturing, significantly more than its share in global power generation (36%), largely because production is concentrated in China mainly in the provinces of Xinjiang and Jiangsu - according to the IEA. The organisation said reducing the carbon intensity of manufacturing could thus be a prime opportunity for the PV sector to further decrease its carbon footprint.

While some countries are looking to realise these benefits as they earmark more resources to support domestic manufacturing, significant headwinds lie ahead as China continues to increase its market share, benefiting from economies of scale.

"The big challenge is everything boils down to cost differentials," says Bahar. "Obviously, the cheapest way of producing solar PV panels in the world is in China and some of the countries in Southeast Asia."

PV manufacturing costs in China are 10% lower than in India, 20% lower than in the US and 35% lower than in Europe, the IEA's report revealed. It said the key reasons for this include longer construction and development timelines, labour and material costs, the higher cost of capital, a lack of economies of scale and a dearth of know-how in developing mega-scale PV manufacturing facilities.

In the absence of subsidies and manufacturing support, achieving significant reductions in energy and labour costs remains challenging, the IEA said, adding that diversifying solar PV manufacturing will depend on the ability of nascent and

new markets to match the cost efficiencies in China.

The markets outside East Asia that show the strongest potential for building a domestic solar panel manufacturing industry are the US and India, says Leyva Martinez, while Meyers also puts the European Union (EU) in that category.

IRA drives growth in the US The significant obstacles facing the US solar sector were revealed in a Department of Energy report published in June, which warned trade and supply chain frictions had resulted in an acute shortage of PV equipment, potentially risking an abrupt slowdown in solar installation rates.

However, owing to the Department of Commerce's inquiry into alleged circumvention of antidumping and countervailing duties, Biden announced a two-year freeze on new tariffs on solar imports from Southeast Asia in June. This allowed industry players to kickstart deployment, and more good news was on the horizon.

Following months of speculation and political uncertainty, US lawmakers finally reached a deal in the summer to pass legislation that earmarks US\$369 billion for decarbonisation efforts, featuring

IRA triggers flurry of US solar manufacturing

Since President Joe Biden signed the US's Inflation Reduction Act into law on 16 August, solar manufacturers have shown their confidence in the legislation by announcing a host of new PV manufacturing facilities in the country.

Enacting the IRA has already resulted in billions of dollars in new solar manufacturing investments, according to trade body the Solar Energy Industries Association. Here are some of the key announcements.

- Italian utility Enel is planning to build a new solar cell and module manufacturing facility in the US with an initial capacity of at least 3GW. The factory is intended to produce bifacial heterojunction PV cells, while the modules will have a tandem structure, utilising two stacked cells. Enel said there will be the possibility to scale up production at the facility to 6GW annually.
- Thin-film solar manufacturer First Solar announced in late August will invest up to US\$1.2 billion to expand its manufacturing operations in the US, including setting up a vertically integrated factory in Alabama with an annual capacity of 3.5GWdc. The company's CEO said the IRA "has firmly placed America on the path to a sustainable energy future".
- Spain-based solar tracking solutions provider PV Hardware is planning to set up a 6GW tracker manufacturing facility in the US state of Texas that is due to be operational by June 2023.
- US microinverter manufacturer Enphase will aim to establish four to six new manufacturing lines in the country by mid-2023, the company revealed in its Q3 results announcement.
- Solar developer SPI Energy plans to build 1.5GW of US wafer manufacturing capacity by 2023 and reach 3GW by 2024.



A production plant from First Solar. The company aims to reach more than 10GWdc of US solar manufacturing capacity by 2025.

expanded tax credits for utility-scale solar as well as manufacturing credits for a host of PV components.

Adopting a holistic approach and including a suite of policy options focused on long-term demand drivers, the Inflation Reduction Act (IRA) has incentives "that will, over time, lead to a renaissance in American solar manufacturing", trade association the Solar Energy Industries Association (SEIA) said in a report.

"The IRA is the first true attempt at clean energy industrial policy in US history, and it has transformed the outlook for America's solar and storage manufacturing sector," John Smirnow, vice president of market strategy and general counsel for SEIA, tells PV Tech Power. Since the legislation was signed into law by Biden in August, manufacturers in the US have announced more than US\$1 billion of investments in clean energy products and inputs such as solar modules, microinverters, trackers and racking.

Components eligible for manufacturing modules, thin-film or crystalline PV cells, wafers, polymeric backsheets, solar-grade polysilicon, inverters and trackers.

According to SEIA, the IRA established two credits for manufacturers: a 30% investment tax credit for eligible investment costs in facilities and equipment as well as a manufacturing production credit for certain components based on

the volume of product manufactured. Manufacturers can only seek to take one or the other.

As a direct result of the IRA, SEIA expects to see significant new investments in domestic solar module, tracker, inverter and racking capacity within the next two to three years, followed by new investments in solar ingot, wafer and cell capacity within three to five years. The trade body said the IRA will be instrumental in ensuring the US solar industry meets a goal of having 50GW of domestic solar manufacturing capacity across all key industry segments by 2030.

"The IRA is the first true attempt at clean energy industrial policy in US history, and it has transformed the outlook for America's solar and storage manufacturing sector"

"With the proper application and sequencing of the IRA's incentives, coupled with state-level policies, we believe this law will help us meet or even exceed that goal," Smirnow says.

Currently, however, the US has no domestic solar ingot, wafer, or cell manufacturing capacity and only modest capacity to produce solar modules. SEIA has called on US PV manufacturers to consider the timing of demand for their products. For example, it said while module, inverter, mounting system and tracker manufacturers can expect to see immediate demand, it will take time to build demand for segments such as ingots and wafers.

Smirnow says this strategic sequencing helps minimise the chances of stranded assets and maximises the speed, efficiency and cost-effectiveness of building out a full US solar supply chain.

With a deficit of PV cell suppliers compared to market demand, CEA vice president of manufacturing services Mark Hagedorn says: "Choreographed growth in the global and local supply chains throughout the value stream is required to achieve the meteoric growth teed up by the IRA."

As crystalline silicon cell manufacturing is concentrated in Asia-Pacific, large solar PV demand centres in the US, India and Europe depend strongly on solar module component imports. However, the IEA report said that with some thin-film manufacturing capacity, the US is relatively less dependent on China for supply chain components than other markets.

Just two weeks after Biden signed the IRA into law, thin-film solar manufacturer First Solar revealed it will invest up to US\$1.2 billion to expand its manufacturing operations in the US, including setting up a vertically integrated factory in the country's Southeast with an annual capacity of 3.5GWdc. The US-headquartered company plans to invest up to US\$1 billion in the new factory - its fourth in the country - which is expected to begin operations in 2025.

"We believe that locating supply close to demand allows us to mitigate numerous risks, not least those posed by an overreliance on transoceanic shipping while enabling competitive pricing and supply reliability for our customers," says Samantha Sloan, First Solar vice president of global policy, sustainability and marketing.

As well as constructing the new factory in the US Southeast, First Solar is expanding its two operating facilities in Perrysburg and Lake Township, Ohio, by 600MWdc to 3.6GWdc of annual Series 6 module capacity. It will also scale up its third Ohio factory, due to be commissioned in the first half of 2023, to 3.5GWdc of annual Series 7 module capacity. The company is aiming to reach more than 10GWdc of US solar manufacturing capacity by 2025.

In terms of IRA support, First Solar antici-

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pates guidance on the domestic content bonus that project owners may seek under the new production tax credit and extended investment tax credit for solar, Sloan says. She adds that given First Solar's manufacturing process, which transforms raw materials into a finished module under one roof, the company expects its product to qualify as US domestic content and secure bonus incentives.

Another US thin-film module manufacturer that is ramping up production on the back of the IRA is Ohio-based Toledo Solar, which revealed in September is aims to reach 2.8GW of module capacity by 2027, up from 100MW today.

The federal government's commitment to renewable energy security has allowed Toledo Solar to commit larger amounts of capital for expansion over the next five to ten years, says the company's CEO, Aaron Bates. Prior to the IRA, Bates says such investments "were difficult for companies like ours to commit with such an unlevel playing field in imported solar".

Among the most significant part of the legislation for Toledo Solar is a more than 40% investment tax credit for domestically manufactured PV modules, which "has been a great way for Americans to be incentivised to purchase our modules", Bates adds.

In addition to ramping up production in the US, First Solar revealed plans in 2021 to construct a 3.3GWdc module assembly facility in India. According to Sloan, the company aims to replicate its US strategy of primarily using domestically made components and materials at the company's first India factory, due to come online next year. Duties and incentives in India As part of government efforts to become more self-reliant, India has doubled down on a strategy of supporting domestic PV manufacturers by implementing duties and financial incentives. The country's module and cell manufacturing capacities are set to reach approximately 30GW and 10GW, respectively, by the end of the year, according to CEA research.

However, a report published earlier this year by consultancy JMK Research & Analytics and think tank the Institute for Energy Economics and Financial Analysis (IEEFA) revealed that India has no manufacturing capacity for the initial stages of the PV value chain, from polysilicon to wafer. It said developing significant manufacturing capacities in raw materials, especially polysilicon, "will be highly capital intensive and technologically complex but it is of paramount necessity".

To encourage vertically integrated PV production facilities, India's government introduced a production-linked incentive (PLI) scheme, which provides grants to companies manufacturing high-efficiency cells from locally produced supply chain components, from polysilicon to modules.

Aiming to support 10GW of integrated manufacturing capacity, the initial PLI tender received a more than fourfold oversubscription, leading the government to announce a second phase that intends to add 65GW of manufacturing capacity of fully and partially integrated solar PV modules.

Indian conglomerates Reliance Industries and Adani Group and transformer manufacturer Shirdi Sai Electricals were winners of the first PLI tranche and are looking to set up 12GW of integrated solar manufacturing.

Alongside its 2021 acquisition of solar module manufacturer REC Group, Reliance Industries invested US\$29 million in German wafer manufacturer NexWafe. Davor Sutija, CEO at NexWafe, told *PV Tech* earlier this year that Reliance will build gigawatt-scale facilities in India using his company's technology.

Another Indian manufacturer looking to capitalise on India's growing demand for domestically produced modules is Goldi Solar, which revealed in September it plans to increase its module manufacturing capacity from 2.5GW today to 6GW by the end of 2025, when it also aims to have 5GW of cell capacity.

The company has confirmed to *PV Tech* it will participate in the next PLI tender. "It is a very good initiative by the government... and it will help us to scale our capacity," says, Bharat Bhut, director at Goldi Solar.

Although capacities awarded in the first PLI tranche are expected to start coming onstream from 2024, the scheme has been delayed significantly as bidding for the second stage is yet to be completed, according to Vinay Rustagi, managing director at consultancy Bridge to India, who says it is too early to judge how successful the PLI scheme has been.

Rustagi argues that India's biggest policy support for solar manufacturers is the basic customs duty, which came into effect in April, introducing a 40% and 25% import duty on modules and cells, respectively. "The proposed duty level is quite a bit higher than estimated cost disadvantage of making modules in India," Rustagi says.

Additional policies include a lower corporate tax rate of 15% for new manufacturers besides a non-tariff barrier in the form of an approved list of modules and manufacturers, whereby the government is basically deciding which companies may or may not sell modules in India, according to Rustagi.

Among the challenges facing India's PV manufacturing sector, said the JMK/IEEFA report, is limited funding for research and development, a lack of skilled manpower and export limitation. The research said that in the absence of a domestic certifying agency permitting the export of PV products, Indian manufacturers must rely on international authorities to obtain certification, a highly expensive and timeconsuming process "that is more prohibitive than attractive".

Bridge to India expects final module costs in India to be 20-25% higher than those of imported modules, eroding some of solar's cost advantage. Questioned whether module buyers will go back to procuring cheaper alternatives from overseas once policy support expires, Rustagi says: "That risk can never be discounted. Policy instability is a real issue in India and amongst the biggest risks for investors. But on the other hand, the government seems to be really determined this time around in doing whatever it takes to support domestic manufacturing."

Europe lags in policy support

As the US and India progress with their new policies to scale up PV manufacturing, some European manufacturers are fearful that the continent will become less competitive unless similar measures are introduced.

While the US and India imported 77% and 75% of their installed solar PV modules in the last five years, respectively, this was 84% for the EU, which also has notably higher PV manufacturing costs than its rivals, IEA figures reveal.

"It makes a lot of sense to invest in the US. But currently is simply not attractive, comparatively, to invest in Europe," Moritz Borgmann, chief commercial officer at heterojunction cell and module manufacturer Meyer Burger, said during a webinar hosted by SolarPower Europe in October. He added that the support in the US's IRA "is just so concrete, so simple, so transparent and so massive that it is very difficult for us in this current environment, unless things really change in the EU, to continue investing at the scale that is required".

European PV manufacturers are also faced with soaring electricity prices due to the ongoing energy crisis. This puts around 35GW of planned manufacturing facilities in Europe at risk, Rystad Energy recently warned. The consultancy said that the energy-intensive nature of solar PV manufacturing processes is leading some operators to temporarily close or abandon production facilities as the cost of doing business escalates.

Among the initiatives aimed at helping manufacturers is the European Solar Photovoltaic Industry Alliance, which is being formally launched in December and aims to help the EU reach 30GW of annual solar manufacturing capacity by 2025.

However, in terms of financial incentives, the IEA's Bahar says the EU is lagging behind. "I wouldn't put the European Union in the same category as US and India because there is not actual money, like a fund allocated or incentives allocated; it is expected but it's not there yet."

One area where EU manufacturers might gain an advantage is by producing modules with a lower carbon footprint. Recent analysis from market research firm InfoLink Consulting said the EU could win a competitive edge by focusing on n-type technology and low-carbon footprint products, which are two markets that China has yet to secure.

"PV panel manufacturing is already greener in the EU than in the rest of the world," says Eliano Russo, head of 3Sun Gigafactory at Enel Green Power. The solar module manufacturing subsidiary of Italian utility Enel, 3Sun is aiming to reach 3GW of heterojunction (HJT) module production in 2024 at its factory in Sicily.

Russo says the EU should continue to promote sustainability with the introduction of instruments such as non-price criteria in renewables auctions or price premiums for sustainable PV panels. "The establishment of an EU certificate that demonstrates that all production and manufacturing steps of the PV panels comply with the principles of human rights, sustainability and circular economy of the EU and its decarbonisation goals is essential."

Illustrating wider concerns that the EU may miss out on new PV manufacturing investments given the lack of support, Enel revealed in November it plans to build a 3GW HJT cell and module manufacturing plant in the US, leveraging its experience from the 3Sun Gigafactory. The company said tailwinds from the IRA serve as a catalyst for its US solar manufacturing ambitions.

The US IRA and efforts in India look set to generate notable PV manufacturing capacity, allowing local production to become more economically viable while alleviating some supply chain concerns.

First Solar's Samantha Sloan says the past two years have demonstrated that the solar industry's global hub-based manufacturing approach "represents a significant risk in the fight against climate change". She adds: "We must recognise that strategic domestic manufacturing provides a significant degree of certainty, efficiencies and price competitiveness that traditional hub-based manufacturing does not."



Solar cells from heterojunction PV manufacturer Meyer Burger.

Strategies to support the scale-up of Europe's solar manufacturing sector

Manufacturing | Europe is home to relatively low solar manufacturing capacities, with just 3% of global module supply in 2020. However, with industry players offering low-carbon products manufactured under robust labour regulations and without the cost of overseas shipping, Europe's PV manufacturing industry finds itself in a very timely position to ramp up, writes Johan Lindahl, secretary general of the European Solar Manufacturing Council.

Politically, Europe is currently focusing on breaking energy dependence on third countries, specifically the fossil dependence on Russia following the invasion of Ukraine. The introduced measures bring welcome investment opportunities to decarbonising the energy sector through the REPowerEU support package. On the other hand, another key dependency remains, one that could risk the large-scale green transition: the import dependency on hardware for renewable energy technologies, including photovoltaics.

Customs data analysis shows that the yearly negative extra-European trade balance of PV modules and cells is in the magnitude order of €10 billion (US\$10.3 billion). The industry organisation, the European Solar Manufacturing Council (ESMC), representing the European PV upstream Industry, envisions a larger portion of these monetary streams captured within the European region in the near future. It would favour the transition to green jobs and contribute with substantial tax revenues to the economic sector. It would also put the European countries in control over their green transition without having to rely on third-party countries that naturally have their own capacity expansion as priority.

It has not always been this way. In the early development of the PV Industry, Europe held a large share of the global market. A great deal of the early technology and industry development took place in Germany and was funded through extensive central support, laying the ground for the modern industry we see today. In the late 2000s, early 2010s, however, market shares were lost to Asia, thanks to their innovation in mass production and substantial incentives from the Chinese government. China was in a good



position to ramp up production and gain the benefits of large-scale manufacturing and standardisation. Many European manufacturers were forced into insolvency during this time.

The current situation for PV manufacturing in Europe

Europe is home to relatively low manufacturing capacities, especially compared to its glory days. With around 11% of the global PV silicon manufacturing, 1% of wafer production, 0.4% of cells and 3% of global module supply in 2020, Europe is seriously lagging behind Asia in terms of upstream industry output.

As can be traced from these figures, there are significant parts missing from the PV manufacturing value chain in Europe. In this context, China is the main competitor, with as much as 95% of the ingot and wafer production shares in 2020. The corresponding numbers for polysilicon, cells and modules are 79%, 76% and 68%, respectively. A solar cell from Oxford PV, which is focused on developing and commercialising perovskite-based solar technology. This has shown to be risky, as turmoil caused by COVID-19, Chinese domestic policies and increases in material prices have seriously affected the global supply chain in recent years, putting Europe in a weak position. Both manufacturers and developers have been forced into higher prices and delayed project times as a consequence of the beforementioned events.

Europe's PV assets

Just like in early Industry development, Europe has world-leading research and technology institutes. Fraunhofer ISE, Centro Nacional de Energías Renovables (CENER), Interuniversity Microelectronics Centre (Imec), Institut National de l'Énergie Solaire (Ines), L'Institut Photovoltaïque d'Île-de-France (IPVF), ISC Konstanz, Forschungszentrum Jülich and the Austrian Institute of Technology are examples of renowned research institutes from the ESMC member base.

European scientists are focusing on

COVER STORY

both breakthrough novel technologies and applied industry and system integration research. The Horizon program, amongst others, brings strong support to R&D&I, which helps ensure a future of innovation in the field of photovoltaics.

Europe also has a strong and expanding home market, and the European Commission (EC) has recently recognised the importance that the PV Industry has for the strategic autonomy of the EU. However, they have not yet put necessary regulations in place to create a level playing field with global competitors for European manufacturers. The European Union (EU), being the second largest market globally, is nowhere close to self-sufficiency in photovoltaics.

To counteract its position of energy dependency, as part of the aforementioned REPowerEU plan, the EC adopted the EU Solar Energy Strategy in May 2022. It identifies remaining barriers and challenges in the solar energy sector and outlines initiatives to overcome them and accelerate the deployment of solar technologies. The EU Solar Strategy sets a target of 750GWdc (600GWac) by 2030, which is a significant increase in pace compared to the 160 GW accumulated capacity in Europe at the end of 2021.

This accelerated deployment of PV is going to be supported by three main initiatives. The first is the European Solar Rooftops Initiative, including a proposal to gradually introduce an obligation to install PV in different types of buildings. Secondly, the EU large-scale skills partnership aims to help develop a skilled labour force in this area, as it currently constitutes a bottleneck in many member states. Lastly, the EU Solar PV Industry Alliance aims to become a forum for stakeholders in the sector and

Annual installed PV capacity in Europe

Annual installed PV capacity in Europe



help diversify the supply chains, retain more value in Europe and deliver efficient and sustainable PV products to help avoid supply risks for the necessary massive deployment of PV in the EU.

ESMC appreciates the creation of the EU Solar PV Industry Alliance, which will be the major framework for the proposals and decisions to create a long-term competitive European PV manufacturing industry. The EU should act quickly to elaborate concrete and targeted support measures for the European PV manufacturing industry, efficient enough to ensure the scaling of PV manufacturing capacities and trigger innovative solutions.

What challenges must be overcome?

In this context, ESMC talks in terms of a level playing field between European and Chinese manufacturers. There are several reasons why it is difficult for European PV manufacturers to compete with their Chinese counterparts. Being an electricityintense industry, the electricity price is a deciding factor. Chinese manufacturing is incentivised with subsidies on both water and electricity, while European companies must in turn cover their consumption and emissions just as any non-strategic industrial sector. In addition, labour is cheaper in China than in Europe, which has extensive regulations around fair labour conditions. While ESMC recognises and welcomes these laws, it distorts competition.

Lastly, full value chain control gives access to cheaper and more accessible materials for Asian products and processes. As a complete industrial PV value chain currently does not exist in Europe, European manufacturers find themselves at a competitive disadvantage. These factors are something that the EU must work to meet, by highlighting other advantages to European manufacturing and through capex and opex support in the build-up phase.

What policies would best support European PV manufacturing? To create a level playing field, the operational cost structure of the entire European PV value chain must reach a level equivalent to, or as close as possible, to non-EU manufacturers. In parallel, other support measures should be implemented to scale the European PV manufacturing capacities to improve its competitiveness further.

In fact, cost and policy benchmarking show that European solar manufacturing is at an average of US\$0.028-0.073/Wp disadvantage compared to China. National tax and policy incentives amount to a US\$0.036 reduction of the delivered cost in China, US\$0.021-0.023/Wp in India and 0.127-0.197Wp in the US. The corresponding figure is US\$0.001\$/Wp in Europe, effectively demonstrating the need for support measures for European manufacturers to experience fair competition.

Scaling the capacities by unlocked capital investments and lowered operational costs

There are several ways the EC and EU member states could support European PV manufacturers. For comparison, the US government recently launched the Inflation Reduction Act (IRA), including substantial support for its domestic PV manufacturing sector. This clearly classifies the industry as strategically important and supports it accordingly. With several US dollar cents in manufacturing credits per Wp of manufactured p-Si, wafers, cells and modules, this packaged large support is expected to effectively stimulate the American upstream PV industry.

Similarly, manufacturing in China and India is well supported. Introducing a similar scheme in Europe would create incentives for European manufacturers and simultaneously prevent the possible side effect of the IRA for Europe: that investments in new manufacturing turn to the US instead of Europe. The ESMC, however, recognises that there are differences in the constitutional frame of the two markets and that measures would need to be adapted to the opportunities and limitations that the EU holds.

ESMC acknowledges that there is no silver bullet, the industry needs a holistic

industrial policy approach of support in the EU policy framework. By introducing a strategic financial vehicle of at least €5 billion in form of state credit guarantees, ESMC envisions the anticipated scale-up of the EU PV manufacturing industry, while extensively reducing the capital and operational costs for the establishment of new PV manufacturing capacities in the EU.

Realistically, the European PV deployment market should be differentiated - one market for extra-European budget modules and another for locally produced modules, with its inherent benefits of lower carbon footprint and ensured socially sustainable labour conditions. Reasonable off-take agreements combined with tax exemptions and incentives would be the most sustainable way to boost European production in that direction. Additionally, by making imported goods and materials subject to the same standards on labour laws, hidden subsidisation and CO2 footprint, large parts of the unfair competition that European manufacturers experience would be excluded.

Lastly, the EU Innovation Fund is one of the world's largest funding programmes for demonstration of innovative low-carbon technologies. This fund is one option for support of large-scale manufacturing capacities. So far, there are examples of PV manufacturing among the projects that have been awarded funding but putting emphasis on breaking dependence for the roll-out of the fastestgrowing power source in the world would help make more funding available for such projects.

Ecodesign and energy labelling

Another way to support the European PV Industry is to introduce policies that help emphasise the sales arguments of European-produced equipment and technology. A package such as that is the EU energy labelling and Ecodesign legislation, which aims to improve the energy efficiency of products on the EU market.

Ecodesign sets common EU-wide minimum standards to eliminate the leastperforming products from the market. In turn, the energy labels provide a clear and simple indication of the energy efficiency and other key features of products at the point of purchase. By making PV modules and systems subject to this scheme, it would be easier for uptakers to make conscious choices. With the European countries' grid electricity mixes often being less carbon intense than other countries, "Supporting innovative and breakthrough PV manufacturing technologies is critical to maintaining the long-term and sustainably competitive advantage of European PV manufacturing"

it would help European manufacturers highlight the environmental advantages of their products.

However, the regulatory design will be critical for the outcome for local manufacturers. While several benefits exist, a robust verification system is crucial for the policy to be impactful. Secondly, as the European Industry has many SMEs, extensive reporting can be particularly troublesome and costly for European organisations and companies.

These two policies are currently under development, as the EC is assessing the need for regulation to manage the environmental impacts of photovoltaic products. In case the policy development unfolds appropriately, this measure could be effective in combination with off-take agreements – a measure that will hopefully be coordinated under the EU Solar PV Industry Alliance.

IPCEI for innovative PV technologies

Supporting innovative and breakthrough PV manufacturing technologies is critical to maintaining the long-term and sustainably competitive advantage of European PV manufacturing. Especially with Europe's strong research institutes, innovative technology could play a significant part in re-establishing the value chain for photovoltaics. There is an ongoing industry collaboration effort, the PV-IPCEI framework, to make this reality. So far, 60 Industry partners are collaborating in the consortium.

IPCEIs make it possible to bring together knowledge, expertise, financial resources and economic actors throughout the EU and to jointly support these transnational cooperation projects with major synergies with state aid. So far, The Spanish government has taken the role of leader of the PV-IPCEI from the member states' point of view, with Austria, Belgium, Lithuania, Luxembourg, Poland and Norway also committed to supporting the ongoing process.

In fact, there might be a window of opportunity for European manufacturers to re-establish the industry in the coming years. With technologies such as tandem perovskite, heterojunction, TOPCon (tunnel oxide passivated contact) and IBC (interdigitated back contact) cells coming to, or close to, market, a long-awaited technology shift is approaching. By becoming early adopters of these innovative high-efficiency technologies and taking them to gigawatt scale, Europe could find an advantageous position. Additionally, as the European market has high shares of distributed PV systems, it makes sense to partly focus on high-efficiency applications for the residential market.

All in all, the European PV manufacturing industry finds itself in a very timely position to ramp up, given that the EC takes a holistic approach to the strategic importance of the industry. With an accelerating home market, an energy crisis, and global supply chain constraints, the arguments for locally produced photovoltaics are well demonstrated. European manufacturers offer low-carbon, highefficient products, manufactured under robust labour regulations and without the cost or emissions of overseas shipping.

ESMC sees good opportunities for European PV manufacturing to become sustainably competitive during the next couple of years, if only a level playing field is provided by European policymakers. The EU Solar PV Industry Alliance is the appropriate framework for concretising and activating targeted support measures without delay – during the coming months – to create sustainable and fair conditions for the European PV manufacturing industry.

Author

Since being appointed secretary general of the European Solar Manufacturing Council in 2021, Johan Lindahl



works for the creation of a political environment to support industrial PV manufacturing and research. Following his doctorate in engineering physics solid-state electronics, he has worked in research, policy and market-related roles. Amongst others, he has been the Swedish representative in IEA PVPS Task 1 for 11 years.

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Solar and land use in the UK: balancing energy and food security

UK | Earlier this year, ex-UK Prime Minister Liz Truss labelled solar projects "paraphernalia", while her successor, Rishi Sunak, promised to not let the country "lose swathes of our best farmland to solar farms". Molly Lempriere investigates how much land the UK needs for utility-scale PV plants as it transitions to net zero, and whether the sector's growth poses any threat to food security.

The impact of solar on land use has hit headlines in the UK this year. Amid the cost of living crisis, the rising prices of food and energy have drawn particular focus, with some politicians and pressure groups suggesting that the two are at odds with each other.

In September, food price inflation hit 14.6%, according to the Office for National Statistics, the 14th consecutive month of growth. At the same time, power prices have hit record highs due to the gas crisis, which is expected to continue for at least two years and possibly out to 2030.

With households up and down the UK facing these considerable pressures, some politicians began attacking solar farms, arguing that their development was ultimately a risk to food security.

The solar sector hit back, highlighting the minimal land use – currently all the solar in the UK would only cover half of the Isle of Wight – and the additional benefits to the agricultural sector of adopting the technology.

But with both food and energy security set to remain key priorities, how do you balance solar and land use?

Political uncertainty and 'paraphernalia'

On 7 July, then-Prime Minister Boris Johnson announced he was resigning, triggering a Conservative leadership contest that saw Liz Truss and Rishi Sunak becoming the key candidates battling it out for the top job.

Throughout the husting process, solar became a key topic for both candidates, with Truss stating at an event on 1 August: "Our fields should be full of our fantastic produce ... it shouldn't be full of solar panels."

At the same event, Sunak argued that under his leadership Westminster would understand the needs of rural communi-



If every solar farm currently put forward was built it would still account for less than 0.4% of the UK's agricultural land, according to Solar Energy UK.

ties, "making sure our fields are used for food production and not solar panels".

Such comments, which looked to position solar and agriculture in opposition to each other, continued throughout their campaigns. Speaking in Darlington, Truss notoriously dubbed solar "paraphernalia".

"I'm somebody who wants to see farmers producing food, not filling in forms, not doing red tape, not filling fields with paraphernalia like solar farms. What we want is crops, and we want livestock," she said, continuing to highlight that both food and energy security are key issues currently due to the war in Ukraine.

Meanwhile Sunak looked to set out his "pro-farmer" stance in an op-ed in newspaper *The Telegraph*.

"We must also protect our best agricultural land," he wrote. "On my watch, we will not lose swathes of our best farmland to solar farms. Instead, we should be making sure that solar panels are installed on commercial buildings, on sheds and on properties."

The comments caused significant concern in the UK solar sector, which has been growing at pace thanks to the low cost of the technology and the need to transition to low-carbon energy sources to tackle the climate crisis.

"The language used so far over the course of the Conservative leadership race regarding solar and land use is deeply concerning, and the REA urges the candidates to recognise that solar farms do not encroach on agricultural land," said Mark Sommerfeld, head of power and flexibility at the Association for Renewable Energy and Clean Technology (REA), in August.

"The solar industry aims to work in conjunction with, not against, agricultural use of land, commonly by either building on marginal land or ensuring multi-land use applications. In doing so, it provides additional revenue to farmers – supplementing, not stopping, more traditional livestock and arable farming activities."

While the comments were undoubtedly concerning, the response in support of solar was strong and from a broad group of people and organisations, highlighting the minority appeal of such an attack.

"Some of Truss and Sunak's comments were clearly designed to attract some die-hard NIMBY votes from the very narrow electorate that selects the leader of their party, notwithstanding the fact that 73% of Conservative Party members actually support solar farms," wrote Chris Hewett, CEO of trade association Solar Energy UK, in a blog for *PV Tech Power's* sister publication *Solar Power Portal* at the time.

"But what is interesting in the last month has been the breadth of criticism that their remarks have drawn from natural allies in right wing think tanks, media and the farming industry."

How much land does solar actually use?

There is little evidence to suggest solar is at odds with agriculture in the UK. Currently, solar farms in the country have a combined capacity of around 14GW, according to research from Solar Media, of which 9.6GW is made up of groundmounted installations.

Every megawatt of solar power requires about six acres of land, according to Solar Energy UK, meaning solar covers 230km2 in the UK. This is 0.1% of the land.

There is a total of 242,495km2 of land in the UK, according to Carbon Brief, 56% of which is agricultural land, with 70,000km2 used for pasture, and around 67,000km2 used for growing cereals and legumes.

Therefore it seems evident that the use of land for solar pales in comparison with agriculture, as it does for other land uses. For example, golf courses cover 1,256km2, while airports cover 493km2.

As the UK continues to transition to decarbonised sources of electricity, more utility-scale solar is being installed. However, even taking this into consideration, if every solar farm currently put forward was built it would still account for less than 0.4% of the UK's agricultural land and 0.28% of the country's entire land area, according to Solar Energy UK.

What type of land does solar use?

In the UK, the land is classified into grades from 1-5 as part of the Agricultural Land Classification (ACL) scheme, with a number of subsections within this. Grade 1 is considered excellent quality agricultural land, best for growing fruit and salad crops for example, whilst Grade 5 is very poor quality agricultural land, suitable mainly for just permanent pasture or rough grazing.

Solar farms are rarely built on land considered Best and Most Versatile (BMV) within the ALC, as there is a planning presumption against solar development. Instead the majority of solar farms are

"The solar industry aims to work in conjunction with, not against, agricultural use of land"

> developed on land that is designated as 3B, therefore land which is only considered capable of supporting moderate yields of a narrow range of crops, principally cereals and grass.

However, there have recently been suggestions that these categories could change, with reports that former environmental secretary Ranil Jayawardena was looking to redefine land categories to make the development of ground-mount assets harder in October 2022. This would include extending the land considered BMV to include 3B, effectively banning solar from around 41% of land in England, or about 58% of agricultural land.

At the time, Solar Energy UK's Hewett said the solar sector was "alarmed" by the attempts to put major planning rules in the way of the cheap, homegrown energy source.

"Solar power is the answer to so many needs and policy demands: it will cut energy bills, deliver energy security, boost growth and help rural economies. Ranil Jayawardena's opposition to solar farms must surely make him part of the 'anti-growth coalition," he added.

Recent changes in political leadership over saw Jayawardena step down from his role as Secretary of State for Environment, Food and Rural Affairs on 25 October, to be replaced by Thérèse Coffey.

But despite the hopes of the solar sector, the plans to redesignate BMV reportedly remain. Responding to a question within the House of Commons on 17 November, Coffey said: "It is really important that we make the best use of our land, to have the food security that was referred to earlier."

"It is also important, when considering land use, that we think about the best place to put renewable energy. By and large, I think most people in this country would agree: let us have good agricultural land for farming, and let us use our brownfield sites for other energy projects too."

Such a change is of significant concern for the UK solar sector, in particular in the middle of an energy crisis driven by high gas prices. In the Contracts for Difference (CfD) auction earlier this year, solar cleared at a strike price of £45.99/ MWh (US\$55.15/ MWh), making it one of the cheapest sources of power in the country.

Additionally, solar projects had the shortest development time of any of the technologies by far, making it one of the fastest routes to reduce the country's dependence on gas.

What do farmers think?

Whilst it seems clear that there is a level of opposition from notable politicians, what do those who actually work with the land in question believe?

Currently, 22% of farmers in England have solar on their land, with 32% of farms having an installation in 2021. The partnership between solar and agriculture is well established, therefore, with around 70% of solar being owned or hosted on agricultural land.

Speaking at the UK Solar Summit in September 2022, Jonathan Scurlock, chief adviser for renewable energy and climate change at the National Farmers Union (NFU), highlighted that when it is done well, the land take for solar is "very modest" in comparison to other renewables.

By comparison, whilst solar covers around 19,000 hectares currently, 107,300 hectares of land was used in 2021 to grow crops for bioethanol. Scurlock therefore highlighted that the continued development of solar was "not going to bring the nation to its knees".

Instead, he suggested that if farmers

could get a solar installer onto their site in the next nine months, "Do it!" as the economics of an installation are extremely good. In particular given the volatility in the power market, solar installations can help provide long-term security for farmers, as they can for other commercial developers.

Government figures show that farming and other businesses paid 98% more for gas in the second quarter of 2022 than in the same period the previous year, and 45% more for electricity.

If the 78% of farmers without solar were to adopt it, over the next two years their energy savings and the potential revenue they could generate from the installation could be up to £1 billion. This would almost balance out the increase in fertiliser costs, which are estimated to be £1.1 billion over the next two years.

"Farmers are being hit by a double whammy of rising energy costs due to the surge in the gas price, and record prices for synthetic fertilisers which are made using gas. On top of that many are losing income as crops fail due to extreme weather driven by climate change. Some are choosing to leave the industry altogether as a result," said Matt Williams, climate and land programme lead at think tank the Energy and Climate Intelligence Unit.

"MPs campaigning against solar farms might want to check that they are really reflecting the views of their constituents and not alienating them."

Solar leases can offer farmers between £600 to £1,000 an acre, depending on the site, according to the NFU, meaning farmers can expect to make around four times as much from solar than from crops such as wheat and barley, and with a lot more security.

Additionally, well-designed solar farms can boost biodiversity, helping to support thriving wildlife habitats. Research from Solar Energy UK in May showed that solar farms can actually help reverse Britain's declining wildlife through animal habitat enhancements, providing previously arable land with a break from intensive cultivation and ultimately boosting biodiversity, soil health and regeneration.

This built on research from Lancaster University released at the end of 2021 that found changes to how solar PV land in the UK is managed could see sites support four times as many bumble bees.



An agrivoltaics installation from German renewables company BayWa r.e.

As such, it is probably unsurprising that many farmers are viewing solar as a way to diversify their revenue streams by providing guaranteed income over a period of time, in a way that can also boost the production of their land in the long run and tackle climate change – which is by far the biggest threat to land use, as changes to the weather in the UK could see BMV land reduce from 38.1% down to 11.4%, according to agricultural and environmental consultancy ADAS.

What could solar land use look like in the future?

The need for more solar and other renewables to decarbonise the energy sector in the UK, providing more security and resilience, is clear. As is the limited impact of land use that solar poses, helping instead to offer alternative revenue streams to farmers facing increasingly challenging market conditions, and helping to mitigate climate change, which poses a far greater risk to the industry.

But solar developers must still tread carefully, ensuring they are working together with communities and farmers to protect the countryside.

One particular area of consideration must be Nationally Significant Infrastructure Projects (NSIPS). These are projects over 50MW of capacity in England, which cannot be granted planning consent from local authorities but must instead submit an application for a Development Consent Order to the Planning Inspectorate. At the time of writing, there are 12 of these projects submitted to the Planning Inspectorate, but only one that has been granted approval so far, the 350MW Cleve Hill Solar Farm, which was acquired by Quinbrook and renamed Project Fortress in September 2021.

Because of the sheer scale of these projects, they have attracted more local opposition than conventional solar farms. This was a concern highlighted by Scurlock, who said NSIPs pose a "reputational risk" when speaking at the UK Solar Summit.

Cleve Hill will be the sector's first real look at what a solar farm of this scale will look like in the UK, and key lessons must be learnt from it, ensuring those that come after it are developed truly in partnership with the local communities.

Collaboration with the custodians of the countryside

Despite comments earlier in 2022, it seems clear that far from being in opposition for food security, solar can be a boon to the agricultural sector. The technology offers a level of revenue security, often utilising land that has minimal value in terms of crop production due to the ACL, as well as helping to tackle the long-term threat of climate change.

But there is an onus on the sector to continue to push for best practices in all its developments, ensuring there are biodiversity improvements and collaboration with the local community as well as farmers, in particular as the scale of sites in the UK continues to grow.



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Fact-checking US solar deployment with satellites

US | While collecting verified bottom-up project data in real time has previously been cost-prohibitive, satellite data can now be leveraged to make comprehensive market intelligence attainable for investors. Daniel Cruise and Joseph Triepke, partners at energy intelligence firm Lium Research, reveal how satellites can provide more reliable insights into the construction of US utility-scale solar projects.

Since the inception of the utility-scale solar industry, market participants have largely relied on anecdotes, surveys, conjecture from industry lobbyists and government/ISO data for market intelligence.

Consensus forecasts are not grounded in visual research carried out on a project-byproject basis as a general rule. There are two main reasons for this knowledge gap, and both are changing now.

First, the industry used to be much smaller so conventional wisdom was 'good enough'. When less than a hundred projects were under construction at any given time, bottom-up project assessments weren't as important. Over the past five years, the US only installed an average of 8GW of utilityscale solar capacity per year. In that environment, relying on sometimes biased and sometimes inaccurate industry chatter was good enough for many folks to check the 'we've got market intel' box. This is changing now. Over the next five years, annual US utility-scale installations will more than triple to >30GWac with over 200 big projects now in construction and another 400 in pre-construction mode. The scale inflection, increasing sophistication of the market, billions of dollars flowing into the space and an ever-growing number of market participants require capital allocators to be better informed with verified and actionable data. Relying on guesswork is increasingly risky, irresponsible and potentially costly.

Second, collecting verified bottom-up project data in real time was cost-prohibitive. Getting eyes on every US solar project each and every day the old-fashioned way would cost an arm and a leg. Imagine hiring one full-time employee to drive out to two sites under development each day and take pictures. At today's rate of construction, you'd need more than 300 full-time employees to monitor the US utility-scale solar market that way. That'd cost you US\$15 million a year. Obviously not happening. This is changing now. Satellite data can be leveraged in conjunction with proprietary algorithms and time-tested research methods to make comprehensive real-time market intel attainable and cost-effective for many investors

and market participants. Furthermore, satellites can generate even better bottom-up project insights than the old boots-on-theground approach can at a fraction of the cost. As the adoption of satellite monitoring of potential solar sites grows, hard data will begin to eliminate the cognitive dissonance we sometimes see in discussions about industry trends today.

If you had eyes on every large-scale solar project in the US construction queue every day, what would you see that others miss? Where would bottom-up data depart from the top-down industry narrative? What could be learned about individual company market share and performance that could create new business for suppliers and developers or alpha for investors?

How solarSAT is being used

Introduced by Lium Research in mid-2022, solarSAT is a new indicator for US utility-scale solar activity that leverages satellite intel to track construction progress in real-time. How does it work? Utilising machine learning, proprietary algorithms and human





touch, solarSAT interprets thousands of real-time images from satellites trained on hundreds of potential US solar projects, including all projects 50MW or greater, for complete US Lower 48 coverage.

Daily changes are monitored to track groundbreaking (firstDIRT), panel delivery and installation. Data is then aggregated into various datasets and monthly summary outputs. With visual verification, this approach removes the guesswork from trend assessments.

Data can be analysed at the industrywide, project or company level. For the first time, investors and corporate management teams can now monitor the status of all US large-scale solar projects, including the day each project broke ground, timing of panel deliveries, supplier relationships and final completions. Some of the use cases being pursued by early adopters of this new technology include:

- Leading indicator statistics for panel and tracker installations
- Forecasting future capacity and installations
- Market share assessments on developers and supply chain providers (i.e., trackers and panels)
- Identifying vendors on a project-byproject basis
- Independent company benchmarking
- Monitoring project timing, delays and details
- Customer tracking, supplier tracking and competitive landscape analysis

When reality departs from the mainstream narrative

Getting eyes on field-level progress comprehensively is really the only way to confirm or challenge, with absolute clarity, the narratives percolating in the industry today. And for investors and management teams, being on the right side of these trends can make a huge difference for the bottom line.

At times, what satellites see actually happening in the field departs from certain

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ideas that have become deeply rooted in consensus thinking, revealing actionable opportunities for capital allocators.

A recent example was in April 2022 when misleading surveys related to tariffs exaggerated fear and misallocated investor capital. Alternatively, tracking industry data with satellite imagery would have painted a very different (less draconian) and more accurate picture of what was actually happening on the ground.

Based on satellite data, new activity has been much stronger than generally thought among the industry this year. In fact, as shown in the graph below, Q2 2022 (a quarter when fear and misinformation about shutdowns were rampant) was actually the best quarter for new project starts ever, at over 6GWac.

Just as satellite data sometimes challenges the status quo, it can also sometimes lend confidence to consensus by providing independent validation.

As an example of where satellite fact-

checking showed the industry getting it right, solarSAT data tracking actual panel deliveries through the first half of 2022 has been consistent with anecdotes and panel import data suggesting lower installation activity. In solarSAT data, the number of panels installed in the field for the first nine months of 2022 was down almost 20% compared to the same period last year. A key driver of these lower installations has been solar tariff and import friction, which solarSAT data can tie back to 3-4GWac related to projects with the most affected manufacturers.

Trends and outlook from solarSAT Data

One area where satellites have recently generated some valuable predictive data is the growing backlog of projects that have been finished at the field level but are not generating electricity yet.

Specifically, there is a huge list of US solar projects that have completed construction



and are just waiting to flip the switch. Based on solarSAT data, almost 6GWac is essentially ready to go (construction complete, but not yet online), potentially leading to record fourth quarter 2022 US solar activations.

This backlog is more than triple the <2GWac that was waiting for connection in early 2022 and 50% higher than the backlog at the same time last year. This is also much larger than US Energy Information Agency data that classifies only 1.5GWac as 'construction complete, but not yet in commercial operation'.

With a growing queue of projects waiting to turn online, Q4 2022 activations of utilityscale solar capacity in the US could total almost as much as was turned online in the first nine months of the year.

Looking more through the projects 'ready to go', Texas stands out by far. In fact, almost half of the projects set to come online over the next 90 days will be in ERCOT. These projects alone will add 30% solar capacity to the Texas stack and on track to get the state close to 10% generation from solar next year (vs <1% in 2019).

Looking ahead, the prospects are bright for the large-scale US solar market. The Inflation Reduction Act has dramatically changed the energy landscape, the supply chain is working out the kinks and scaling up, and big solar projects will play a pivotal role in energy production going forward.

The data underpinning business decisions in the sector is becoming increasingly sophisticated, thanks in part to new ways to monitor projects, such as with satellites. As the industry grows from here, the eyes in the sky will be watching and what they tell us can help market participants work smarter and more profitably as the large-scale industry grows into a juggernaut.

Author

Daniel Cruise and Joseph Triepke are partners at energy intelligence firm Lium Research. Each has more than 15 years of



energy finance experience working in both buyside and sellside analyst roles. Daniel attended Texas A&M University, graduating with degrees in both accounting and finance, and is an alumnus of Jefferies, Evercore-ISI and Wells Fargo Securities.

Joseph Triepke has a finance degree from UT Austin and previously held positions at Jefferies, JP Morgan, Guggenheim and Citadel.



From PPA prices to policy updates: how Europe's energy crisis is impacting solar

Europe | Sky-high electricity prices and an increasing urgency to curb fossil fuel use have



ith Russia's invasion of Ukraine triggering a rapid shift in energy policy and wholesale electricity prices reaching record highs in recent months, many European countries are looking to supercharge solar deployment to wean themselves off imported fossil fuels.

Speaking at the SolarPower Summit event in March, the European Union's (EU) energy commissioner Kadri Simson talked of a renewed political will and a practical need for boosting the continent's renewables capacity. "Solar has also become an instrument, not just for boosting renewables and for our energy independence, but also to shield citizens from volatile prices," she said.

Given that the energy crisis has spurred increased renewables deployment targets and that some governments are working

to reduce barriers to add new capacity, solar installs across Europe are set to soar this year. Trade association SolarPower Europe forecasts that the EU will hit 40GW of installations, 48% higher than 2021, while research organisation Wood Mackenzie expects utility-scale PV additions in 2023 to be 70% higher than last year.

Europe's energy crisis has created a mindset shift, according to Axel Thiemann, CEO of independent power producer Sonnedix, who says while previously there was a focus on the intermittency risk for renewables, now there is a realisation that supply risk for conventional electricity generation is not to be underestimated.

"In the past, people were thinking of energy transition as something that should be done, but now you see a clear shift in the perception that it has become a must," Thiemann tells PV Tech Power. "Therefore, in

A 50MW solar PV plant from Sonnedix in Spain. SolarPower Europe forecasts that the EU will install 40GW of solar this year.

the long term the energy crisis has created a more favourable environment for investing in solar due to the increased targets to reduce carbon emissions."

With Europe's gas crisis turning into a power crisis, pricing and volatility have surged, reaching "stratospheric levels" at the end of August, recent research from advisory firm Pexapark found. It revealed that German and French front-year power contracts broke €1,000/MWh (US\$1,034) for the first time.

A study from consultancy EnAppSys said that in many EU countries day-ahead prices in Q3 2022 were between two and four and a half times as high as Q3 2021, which was itself seen as an expensive quarter compared to the preceding third quarters.

While such prices have led to renewed calls for faster renewables deployment, they have also slashed payback times for

newly installed projects. Considering the average monthly spot prices for August in some European countries were all well over €400/MWh, the economics for utility-scale renewables "appear to be compelling", Rystad Energy said in research published in October.

The consultancy found that for a generic 250MW solar asset in Germany, a long-term electricity price of \in 50/MWh would have a payback period of 11 years. However, a price of \in 350/MWh or above results in a payback period of just one year.

If the high prices remain, Rystad said developers and financiers alike "should be trying to get projects up and running as quickly as possible and with maximum exposure to wholesale prices".

Meanwhile, with Europe's energy crisis showing no signs of relenting and electricity prices soaring, this has put upward pressure on power purchase agreement (PPA) prices, which were already on the rise due to escalating demand and development costs. That's according to renewable transaction infrastructure provider LevelTen Energy, whose blended European P25 Index – an average of the P25 wind and solar PPA price indices in European countries – increased by 11.3% between Q2 and Q3 2022, reaching €73.54/MWh.

PPA appetite on the rise

Gabriel Umaña, customer success manager, Europe, at LevelTen says that buyer demand for solar PPAs remains very high as European companies seek to hit sustainability targets and insulate themselves from high wholesale electricity prices.

But while such prices are generally not reducing appetite for PPAs, Umaña warns that some corporate buyers are hesitating due to broader inflationary pressures and market uncertainties. "As long-term contracts with values dependent upon wholesale electricity markets, PPA economics can be more difficult to predict during periods of extended market volatility," he says.

Corporations across Europe are actively seeking PPAs because of the high power prices and the fluctuation, and they generally accept that PPAs come at a premium because of the rising demand, says Joop Hazenberg, director at the RE-Source Platform, an alliance of stakeholders representing clean energy buyers and suppliers.

"Also, more and more sectors notably from energy-intensive industries are very impatient to sign a PPA and there

France takes 'impressive' PV policy action but permitting problems persist

France has made a host of legislative changes to speed up solar deployment since the energy crisis began, but permitting delays mean many PV projects are currently on hold.

Recent months have seen the country enable the rapid commissioning of 2.7GW of solar awarded in tenders, while new projects backed by contracts for difference schemes will be able to sell electricity on the market for 18 months before locking in their contracts.

In addition, legislation approved by the French Senate in November will require existing and new car parks with at least 80 spaces to be covered by solar panels.

Daniel Bour, president at French PV trade association Enerplan, says the country's solar sector "has seen an impressive number of changes to its legislative and regulatory framework", some of which have allowed project developers to better manage the impacts of the crisis, thanks to the swift application of the policies.

However, when it comes to permitting procedures, delays in some of the government's changes have led "hundreds of megawatts of projects to be put on hold, awaiting muchneeded clarifications", Bour says.

According to Bour, a bill is currently being discussed in the French Parliament to speed up renewables additions, including permitting simplification, increasing eligible areas for ground-mounted solar and scaling up rooftop PV mandates on rooftops.

> is general frustration that there are not enough projects on the market. So I would say that the appetite is only increasing," says Hazenberg, noting that the market has flipped in the past year to become a sellers' market.

Illustrating this trend is a plan by German renewables company BayWa r.e. to tender 10TWh of green electricity, describing the move as a "turning point" for Europe's PPA market. The company said it will issue Europe's first tender initiated by a developer for corporate PPAs, with the energy to come from a portfolio of renewables projects in Germany and Spain. The tender was due to take place in autumn, but at the time of writing there have been no further announcements.

Although PPA appetite may be increasing, demand could take a hit as the allure of high electricity prices means some developers opt to sell more output in the merchant market, potentially securing higher returns.

"This is reducing capacity available for PPAs amid an already strained supply/ demand dynamic, placing further upward pressure on PPA prices," says Umaña. The LevelTen report suggests that banks – growing more accustomed to renewable economics and current wholesale conditions – are increasingly comfortable financing projects on a merchant basis.

Nonetheless, Sonnedix's Thiemann believes the recent price volatility will

create a step change in PPA demand for the foreseeable future, helping the roll-out of renewable energy more broadly. While Sonnedix has seen increased interest from existing and new customers who are looking to contract green electricity for the long term, Thiemann warns that the industry faces headwinds in the form of regulatory uncertainty.

"It is clearly necessary to protect the end customers," he says. "But changing price caps and windfall taxes on top of supply chain tightness, increasing capex and increasing interest rates are making investments currently difficult to assess."

EU caps solar project revenues

Following proposals put forward by the European Commission (EC) aimed at helping energy consumers reduce their bills, EU countries confirmed in September they would introduce a revenue cap on 'inframarginal' electricity producers – technologies with lower costs, such as renewables – which are providing electricity to the grid at a cost below the price level set by more expensive marginal producers.

Such operators "have made unexpectedly large financial gains" because of the role of coal and gas as price-setting marginal sources that currently inflate the final price of electricity, according to the EC. "These companies are making revenues they never accounted for, they never even dreamt of," EC President Ursula von der Leyen said during her State of the Union speech in September.

Ministers from the EU's 27 member states agreed to cap the market revenues of such generating plants at \in 180/MWh, with the policy in place from 1 December 2022 until June 2023. With the vast majority of long-term PPA prices falling below \in 180/ MWh, the cap will not impact the way settlements occur for most contracts, says Umaña.

Solar developers that focus on government tenders or PPAs shouldn't be affected much by the policy, says Daniel Tipping, a solar analyst at Wood Mackenzie. He believes the caps are more likely to stall merchant solar deployment.

The new regulation also includes the possibility for EU member states to implement a lower revenue cap and differentiate between technologies. If countries do deviate from the EU-wide cap, it could have a distorting effect on the renewable energy market that could halt investments, according to the RE-Source Platform. "We are very worried about the cap, and it may greatly harm existing and future PPA contracts," says Hazenberg.

RE-Source said in a paper that while many PPAs are signed at prices below the value of the EU cap, the way that many PPA contracts are structured could make them subject to the cap, compromising existing contracts and preventing the signing of new ones.

Concerns have also been raised by Italian utility Enel, which said in a statement sent to PV Tech Power: "Enabling member states to maintain or introduce additional national measures that deviate from the European inframarginal cap risks creating a mix of uncoordinated provisions that could ultimately undermine investments in the clean energy sector."

Despite the uncertainty stemming from the revenue cap, Europe's solar sector will be boosted by REPowerEU, the EC's plan to make Europe independent from Russian fossil fuels well before 2030. Released alongside the plan in May, the EU Solar Energy Strategy sets a target for the bloc to reach 740GWdc of installed solar PV by 2030.

Among the initiatives put forward by the EU Solar Energy Strategy include shorter permitting procedures and encouraging greater rooftop deployment via the European Solar Rooftops Initiative. It also includes the launch of a European Solar PV Industry Alliance that aims to facilitate the expansion of a resilient industrial solar value chain in the EU.

Tipping says that although permit timelines are being shortened, many developers have complained that not enough has been done to help reach the REPowerEU 740GWdc solar target.

Progress was made in early November when proposals were unveiled that would see solar farms below 50kW of capacity be exempt from environmental impact assessments. The EC tabled a temporary emergency regulation that would also see solar deployed on artificial structures – buildings, car parks, transport infrastructure, sheds – and co-located storage systems have a maximum deadline of one month for permitting.

Demand goes through the roof

As homeowners and businesses seek insulation from high energy bills, rooftop solar deployment is surging. Residential solar build in Europe is on track to reach 10.4GW in 2022, a 42% rise on last year, research organisation BloombergNEF predicts. "Demand for residential and commercial PV is quite literally through the roof," says Dries Acke, policy director of SolarPower Europe. "Installers are struggling to keep up with demand, with the wait times for installations going up to years in some parts of Europe."

Citing figures from French distribution system operator Enedis, Acke says there are 60,000 new prosumers in France this year, compared to 3,000 prosumers added to the grid in 2015.

Solar demand from households, small and medium-sized enterprises and public administrations to benefit from cheap renewable energy, especially through selfconsumption schemes, has never been so high, says Daniel Bour, president at French PV trade association Enerplan.

A similar trend is being seen in Spain, where trade association UNEF expects self-consumption solar deployment in the country to reach 2GW this year, a 67% increase on 2021.

"We have seen a dramatic increase in both residential and commercial installations this year across most major European markets, with skyrocketing electricity rates offsetting the impact of increasing technology and installation costs," says Juan Monge, principal analyst, EMEA power and renewables, Wood Mackenzie

With REPowerEU mandating rooftop solar on all existing public and commercial buildings larger than 250m2 by 2027, the outlook for the commercial and industrial solar sector appears promising.

While there is perhaps increased urgency among governments to mitigate the energy crisis and ramp up renewables additions, experts contacted by PV Tech Power caution that the solar industry faces significant headwinds in areas such as recruitment and a lack of domestic manufacturing. "The energy crisis is happening right at the same time where many governments, TSOs and other public stakeholders are launching restrictive rules, further payments and costly technical requirements," says Thorvald Spanggard, head of project development at Danish renewables developer European Energy.

These challenges, Spanggard says, are in addition to long grid connection queues, sky-high construction costs and a strained supply chain.

With the number of solar jobs across the EU set to at least double by 2030, the EU Solar Energy Strategy recognises that there is already a lack of skilled workers.

Residential and commercial installers in markets such as Spain, Germany and Italy have admitted it has become challenging to cope with the spike in solar demand due to a lack of available installation crews and local expertise, says Wood Mackenzie's Monge.

The EU Solar Energy Strategy calls for a partnership to develop a vision of upskilling and reskilling measures to support solar's expansion. This could include training cooperation between companies along the value chain, social partners, training providers and regional authorities.

Despite challenges such as these as well as the threat of revenue caps and windfall taxes, the REPowerEU strategy illustrates Europe's commitment to supporting the solar sector to achieve the install targets.

Volatility in power markets, government interventions, geopolitical interests, the prospect of increased interest rates and maybe a recession are not helping in the short-term to create a stable investment environment, says Spanggard, but medium term "we are more positive than ever that we can play a key role in solving the energy crisis and the green transition".



A PV plant in Germany from IPP Sonnedix, whose CEO Axel Thiemann says the energy crisis has created a more favourable environment for investing in solar.

Product reviews

Modules

Product outline: Tongwei Solar's shingled modules, built on 210 cells, are based on the company's innovative patented shingled technology, forming flexible interconnects and a unique internal circuitry, enabling higher efficiencies and better power generation performance. The maximum power of a single module can now reach 670W and efficiency has been enhanced to 21.6%.

Problem:

1. With the rapid development of renewable energy sources around the world, land resources available for projects are becoming increasingly scarce. This requires PV systems to maximise power generation and efficiency in order to achieve maximum return on investment from each project.

2. During module operation, the risk of

Product outline: Sungrow has intro-

duced its newest ST2752UX liquid-cooled

battery energy storage systems (BESSs),

featuring an AC/DC coupling solution

for utility-scale power plants, and the

ST500CP-250HV for global commercial



hot spots not only affects power output, but also causes safety risks, potentially reducing module durability.

3. The solder ribbons inside the modules contain lead, which can cause environmental pollution.

Solution:

1. In comparison to other module BOS costs, Tongwei's shingled modules feature higher power. Their utilisation of bracket, pipe pile and cabling is higher, resulting in a reduction in construction cost per watt of a

power station and, logically, lower levels of investment.

2. Compared to conventional modules, shingled modules involve a cell cut into strips. The technology results in both the string current within the module and the risk of hot spots being lower.

3. Shingled modules use shingled bonding technology instead of connection via solder ribbons, so lead content is also significantly reduced. Testing has shown that Tongwei's shingled modules are resistant to extreme weather conditions and perform better under shading, resulting in extended working life and service condition.

Application: Residential, commercial and industrial and centralised systems.

Availability: Currently available.

Energy storage Sungrow launches liquid-cooled BESS for utility-scale and C&I applications



This can lead to problems such as high auxiliary power consumption and low heat dissipation efficiency, having a negative effect on project income.

Solution: Sungrow's ST2752UX and ST500CP-250HV BESS solutions use advanced liquid cooling technology to dissipate heat more evenly from the battery, with the enhanced thermal conductivity of the coolant reducing the auxiliary power consumption required for system cooling.

Application: The

ST2752UX liquidcooled battery cabinet has a maximum capacity 2,752kWh, with a liquid cooling unit, 48 battery modules (64 cells per module), 4 DC/DC (0.25C, 4 hours) or 8 DC/DC (0.5C, 2 hours), with additional firefighting capability. According to customer requirements, the total energy capacity of each battery cabinet can be tailored to

achieve the best economics for a specific project.

The ST500CP-250HV C&I solution has a maximum capacity of 535kWh, including a liquid cooling unit, 20 battery modules (60 batteries per module), switchgear, a fire protection system and a PCS cabinet of 250kW.

Platform: Power plants and C&I applications.

Availability: Already available in Europe.

and industrial (C&I) applications. The new systems offer minimised system cost, higher dischargeable energy capacity and greater flexibility. Problem: With industries around the world beginning to recover from the impact of COVID, energy demand has

increased significantly, creating an imbalance between supply and demand. Renewable energy is seen as a long-term solution, and in combination with energy storage can help resolve issues of volatility in supply.

However, while energy storage is a rapidly growing market in many parts of the world, large utility-scale battery storage plants face numerous challenges, including high capital cost, low energy output, low flexibility and safety issues. To date, the vast majority of battery storage systems have used HVAC for air cooling, and direct paralleling of multiple battery racks to increase energy density.


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PV Production in Europe is catching up



The critical changes in global supply chains and logistics which has lead to a massive increase in prices by the pandemic has forced PV manufacturers to come back Europe over the last few years. Moreover, product innovations have led to the resurgence of European PV production as a hot topic in the industry.

The war in Ukraine and the subsequent rise in the cost of fossil-based energy production gave a boost to the demand for photovoltaics. This made it even more important to bring the production along the entire PV value chain back to Europe. This trend is further driven by the research and mechanical engineering expertise represented on the continent.

Pioneering initiatives have been launched and profitable investments have been made. Nevertheless, the resurgence of PV production in Europe is at risk of being hindered by the rising costs of materials and electricity, ground-breaking incentive programs in the US and India and the fact that political support in Europe is still reluctant. The European Union recently launched the Solar Photovoltaic Industry Alliance, which aims to create 30 gigawatts (GW) of production capacity on the continent by 2025. The European Commission will be providing an additional 20 million euros for the RePowerEU plan.

The European PV industry welcomes the latest efforts but is calling for more determined actions in order to achieve the urgently needed scaling up of production rather than just focusing on the promotion of technological innovations. "For decades, Europe has been technology leader within the industry. But even with innovative products available, the current, totally deficient industrial ecosystem and the lack of a competitive regulatory environment mean that there is not enough stimulation for rebuilding the entire value chain. The PV industry needs political support to achieve fast growth in order to reach economies of scale," explains Dr. Moritz Borgmann, Chief Commercial Officer at Meyer Burger.

The strong increase in demand within Europe is also triggering a U-turn in the PV machine engineering sector: According to the German Mechanical Engineering Industry Association (VDMA), in the second quarter of 2022, Europe has overtaken Asia for the first time in 14 years in terms of order intake.

Intersolar Europe, the world's leading exhibition for the solar industry, will once again dedicate an exhibition space to PV production technologies in 2023 (hall A2). The exhibition will take place as part of The smarter E Europe at Messe München from June 14–16, 2023.





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New PV module technologies' impact on quality and LCOE

Modules | PV modules will keep changing in the quest for higher efficiency and energy yield. However, the rapid and sometimes simultaneous introduction of new technologies increases overall quality risk, writes George Touloupas, senior director at Clean Energy Associates.

he rate of change of PV module technology has markedly accelerated in the last four to five years, bringing new challenges for performance and quality. Chart 1 is based on CEA's Quality Assurance data going back to 2017, when the most common utilityscale product still was a 72 full six-inch cell, multi technology, glass-backsheet PV module, which was first launched back in 2008.

In the last five years we have witnessed the transition from multi crystalline AI BSF cell technology to mono PERC, the wide adoption of half-cut cells, the dominance of bifacial glass-glass products, the introduction of multiple busbars (wires), the shift towards large format wafers (166mm and then 182mm and 210mm), the introduction of gallium doped p-type wafers and recently the rise of n-type cell technologies, and predominantly n-TOPCon.

Looking at chart 2, we observe that 210mm and 182mm formats have split shares globally. However, 210mm lines can produce 182mm cells and most 182mm lines are "future proofed" to quickly convert to 210mm, if needed, so the split between 210mm and 182mm is quite flexible.

"Exotic" formats such as 218mm are unlikely to prevail, however we have recently seen 182mm variants being introduced, e.g., with 182mm (width) x 185mm (height), to minimise the white space between cells in the long direction of the module. Trina recently launched a 210mm variant, with 182mm (width) x 210mm (height) to offer products following the 182mm product group module width. As all these variants rely on either the M10 or G12 ingot platforms, we do not make a distinction in our forecasts.

Although n-type expansions appear limited, suppliers can accelerate the pace once the technology and cost hurdles are surpassed. TOPCon is especially favoured, as most existing PERC capacity can be upgraded to TOPCON.

Several large suppliers have formed 182mm or 210mm cell alliances to standardise module dimensions and reduce component and balance of system (BOS) costs. Suppliers of PV components like glass, inverters, trackers and others have become a part of these alliances, which will further unify component supply chains and reduce risk of supply chain bottlenecks.

Because TOPCon shares much of the same equipment and infrastructure as PERC, no changes in module form factors are expected when TOPCon surpasses

Distribution of Cell Capacity By Maximum Wafer Processing Size

PERC in availability. Similarly, HJT products already exist that have adopted standard-ised dimensions.

Impact on PV module quality

The rapid and sometimes simultaneous introduction of new technologies increased overall quality risk. CEA's quality assurance teams collect masses of datapoints during factory inspections: findings and defects of various severities and frequencies. The high bars in chart 3 of CEA's Pre-Shipment Inspection data, focusing on just five major PV module suppliers from 2018 to 2022, signify higher risk. It is obvious that, although there are ups and downs, the overall quality risk





Notes | Data aggregated by CEA based on company announcements and disclosures. Data does not account for utilization, ramp times, or other potential production delays. Timelines are based on supplier statements or industry best practices if no timeline data was reported.

Chart 2.



score has gone up.

CEA's data show that cracks, weak soldering and misalignment are the main factors that may cause "spikes" in risk scores for some projects, resulting in an increased number of batch rejections and rework rate. Suppliers have a hard time optimising and troubleshooting their new or upgraded lines and adapting to the new technologies. Hands-on quality assurance has always been a must for PV modules, and the need is even more pressing now.

Chart 4 shows testing data from CEA's QA batch testing programme, from various projects since 2019. Looking at LID performance, the introduction of gallium doped wafers has improved LID, with Q1 2022 LID average value being close to 0.40%. However, we can still find outliers, possibly because the transition to gallium from boron has not been uniform across the industry. Regarding LETID, we have seen that LETID control has improved, but, occasionally, we do see outliers.

The mainstream module design is using half-cut cells and multiple wire ribbons, sometimes with reduced distance



Chart 4.

Chart 3.

between cells. Although microcracks are controlled at the factory, at least when robust quality assurance is in place, we have noticed a spike in a new type of edge ribbon crack in field inspections. This is a particularly insidious type of crack that can develop into tree cracks after installation and operation. It is important to have good quality assurance protocols during production and onsite, and contractual provisions to mitigate this risk.

Half-cut module production requires that the cells be cut in half to form the half-cut cells. The cutting process risks damage to the edge of the cell that can create initiation points for cell microcracks, with the most common location for cracks to form on the cut edge being under the wire ribbon. This risk is enhanced by module designs with dense interconnection (paving, tiling) and cutting methods that reduce the mechanical strength of the silicon wafer. Edge cracks are often very small initially and therefore challenging to detect during factory quality control, even if they are present before the module leaves the factory.

Edge cracks can also develop during transportation from highly stressed centres (seed cracks) that initiate the crack formation with the movement and vibration of the modules. Even when cracks are present and detectable many manufacturers allow for a minimum crack length in their factory EL criteria. As a result, the small edge cracks can be considered acceptable regardless of quantity. Once formed, the cracks have the potential to grow during shipment, installation and operation.

LCOE and price premium

LCOE is a very important KPI in selecting the components and design parameters of a PV plant. Bifacial TOPCon modules, although currently more expensive than PERC, have the potential to achieve lower LCOE than PERC modules because of reduced BOS cost due to higher efficiency, as well as higher energy yield, due to higher bifaciality, lower temperature losses and lower first-year degradation.

To understand the impact of high efficiency, advanced technology modules on LCOE, we studied a 100MWdc PV system, located in Spain, using single axis horizontal trackers. For our comparison, we selected two PV module products with the same construction, 78 cells, half-cut, bifacial modules, one with PERC cells and one with TOPCon cells. Several assumptions for BOS components cost for the baseline PERC system were informed from several sources (Fraunhofer ISE, supplier data) and the module cost and price data points were taken from CEA's PV Price Forecasting Tool and price tracking. PV Syst was used to derive the respective energy yields.

To perform our analysis, we defined a useful new metric, the "maximum price premium" which is the price premium of a high efficiency PV module, TOPCon in this case, that could be commanded with respect to a PERC PV module baseline price, if the goal is to achieve 0% LCOE advantage. In our analysis, we equalised the LCOE for PERC and TOPCon systems, by deriving the TOPCon module price, via adding the maximum price premium to the PERC module base price.

In chart 5, we calculated a maximum price premium of TOPCon is US\$0.0319/W in 2022 and forecasted it to be even higher, at US\$0.0327/W in 2025, due to the expected increased efficiency advantage of TOPCon to PERC.

Naturally, it doesn't make sense for a



Results from post shipment EL inspection were compared from 7 projects in North America and Europe with half-cut cell modules. These projects utilized modules from 5 different Tier 1 manufacturers. All but one project had modules affected by edge ribbon cracks

buyer to pay the maximum price premium and gain 0% LCOE advantage. However, it does make sense to pay a fraction of the maximum price premium to reduce the LCOE. Chart 6 shows the sensitivity of the LCOE advantage to the price premium, with premiums ranging below 50% of the maximum resulting in LCOE advantages of **Image 1** 2.5% or higher.

The maximum price premium is sensi-

tive to three main factors:

- 1. Efficiency advantage, that affects the BOS capex.
- 2. Specific energy yield advantage, that



Chart 5.





in turn depends mainly on bifaciality, power temperature coefficient and affects the cashflow.

 First- and subsequent-year degradation in the module warranty, that affect the cashflow.

By varying these parameters individually with respect to the base case, we estimated their effect on price premium, with some interesting results:

- 1. Even if the specific energy yield advantage is reduced to 0%, the maximum price premium is still 60% of the base case, because of the BOS capex savings.
- 2. Increasing the efficiency advantage from 3.7% (base case) to 8%, increases the price premium by 28%.
- Increasing the first-year degradation from 1% to 2% results in a price premium reduction of 23% and increasing the annual degradation from 0.40% to 0.45% results in a reduction of 11%.

Conclusions

PV modules will keep changing in the quest for higher efficiency and higher energy yield, leading to lower LCOE. However, technology forecasts remain risky, especially regarding the timelines, because moving beyond tipping points accelerates change. Finally, the introduction of new technologies, new production methods at new facilities (perennial ramping up) create new risks, which must be continuously investigated and assessed.

Sustainability will be an important future KPI, but LCOE is currently the most significant driver in technology selection. New technologies invariably offer advantages related to efficiency, energy yield and degradation and durability, all leading to lower LCOE. However, due to the complex interaction of multiple parameters affecting the LCOE, suppliers' claims to higher performance and lower LCOE must be carefully assessed and verified.

Author

George Touloupas has been a senior director at CEA since 2015, with 12+ years of experience in technical consultancy,



manufacturing, project development and EPC. George is leading CEA's technology, quality and intelligence teams for PV, energy storage and hydrogen. Prior to this, he was the COO/CTO at Philadelphia Solar, technical operations director at Recom and founder of an EPC firm in Greece.

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Terrain-following trackers opening up solar's potential on uneven project sites

Trackers | As solar projects become ever larger, sites with slopes and uneven terrain are becoming the norm for project development, leading tracker manufacturers to adapt their offerings accordingly. Molly Lempriere details the latest launches that aim to address this issue.

round the world, solar developments are getting bigger and bigger, making site selection more challenging. As such, perfect postagestamp shape sites with grid connections in many areas are seemingly a thing of the past.

However, technology is stepping up to open up sites that wouldn't have previously been possible, or would have been prohibitively expensive. Core to this has been the launch of terrain-following trackers, allowing solar developments on uneven terrain and steeper gradients.

"As we mature as an industry and get larger and larger projects, the land available is actually a lot worse than it was even four or five years ago," says Nick Price, director, global sales engineering at Nextracker, but by changing from a fixed-tilt tracker to a terrain-following alternative, it can make sites that weren't feasible or economical "pencil out".

New products on the market

Nextracker launched its NX Horizon-XTR terrain-following single-axis tracker in March. Like many of these new tracker technologies, it came about through collaboration with engineering, procurement and construction companies (EPCs), with the view of making new sites economically viable for development.

For Nextracker, one of the early EPC adopters of the XTR was SOLV Energy, which is responsible for a number of the 15 operational sites using the technology so far.

"NX Horizon-XTR's ability to follow terrain can significantly reduce earthwork, allowing these otherwise-infeasible sites to become economically and environmentally viable solar projects. Less earthwork means lower upfront costs and improved scheduling," said VP of engineering, Donny Gallagher of SOLV Energy.

Amongst the companies to have now launched terrain-following trackers is Array Technologies. The company launched its OmniTrack product at the RE+ conference in Anaheim, California, in September, which is forecast to reduce the amount of site grading work required by up to 98%.

"I can tell you from our developer customers in particular, who are constantly looking at opportunities for permitting new land, they are incredibly excited about what this does open up for them, particularly in places where maybe land is either at a premium or it just isn't as readily available anymore," says Erica Brinker, CCO, Array. "The market reception has been huge. Just because you're going to have to do very little to choose a piece of land that otherwise ten years ago, you wouldn't have even looked at. So definitely, definitely a big opportunity, not just for Array, but really for the solar industry in general."

Also on display in California, was new kid on the block Sunfolding's TopoTrack product. Using AirLink technology, it can reduce earthwork by 97%, according to the company.

"The TopoTracker is actually a very special configuration of our innovative core technology, which is the T 29 Tracker," says Rahul Chandra, Sunfolding's VP product.

"So we use compressed air to point the modules towards the sun ... [our actuator] has two bladders on either side of it. In whichever side we want the module to point towards, we compress that side, we blow it up full of air, or we use the other side. That's how we do the controls algorithm."

Terrain-following trackers are gaining a lot of attention currently, but what are the main benefits of the technology?

Easing the permitting process

The biggest benefit to terrain-following trackers is the dramatic reduction in grading needed to make site development feasible. Levelling out the ground to create a flat enough surface for conventional solar farms comes with a range of challenges, and can add a considerable cost.

"There are some things you cannot out-engineer, and in my experience well-established topsoil is one of them," says Nick de Vries, SVP technology and asset management at US independent power producer Silicon Ranch, which uses Nextracker's XTR.



"Deploying traditional trackers on sites with varied terrain has required extra earthwork and longer foundation piles, which increases project costs and adds risk. Earthwork is especially painful as it affects a solar project three times: first performing grading, next reseeding the exposed dirt and later fixing the inevitable erosion and hydrology issues that come from the lack of well-vegetated topsoil."

Even before work begins, being able to prove there will be a limited amount of grading can ease the permitting process for projects. In the US, the siting and permitting process can take more than three to five years to complete, according to trade body the Solar Energy Industries Association. Using terrain-following technologies to reduce the need for grading can help avoid potential challenges within this process by removing some of the environmental risk.

The goal of a tracker should be to allow a solar farm to be developed as organically on a site as possible, explains Chandra. This includes disturbing the land underneath as little as possible.

"When you think about project risk, that's one of the biggest risk milestones early on in a project because it's an openended timeline, right? How long it'll take for you to get permitting. And if you don't rearrange the underlying land, then your permitting requirements become that much easier.

"In Minnesota, for example, if you disturb an acre of land or more for your project, you automatically need to file a bunch of extra stormwater permits. And so you think about all of these additional requirements that come into place, just because you're doing a ton of this grading."

As well as minimising the time required to gain a permit, it can also make securing a permit on a site with additional challenges more likely. For example, Nextracker's XTR has been used at Melbourne Water's 9.54MWdc Winneke Solar Farm in Australia.

"The specific challenge of that site was that because of the cultural heritage of that site, there was no grading allowed, so you couldn't do any earthwork," explains Price.

"But actually, originally that site was pegged to go fixed tilt. And so that's one of the things we're seeing more and more is on these really challenging sites, people are looking at fixed tilt, but then you're losing 20-30% production by going to a fixed-tilt system. So by having the XTR system, we really changed the game on that particular site."

Reducing weight to reduce labour

Once a planning permit has been secured for a site, terrain-following trackers can also reduce the work required for installation. For example, Sunfolding's technology, thanks to its air drive system, is significantly lighter than traditional fixed-tilt trackers.

"Every penny that you could save, on installation costs, upfront capex, operating costs, permitting costs, all of that matters," says Chandra.

"So the other benefits of this technology is the simplicity of this design. Our actuator is so light, it's actually designed to be easily installed, it weighs somewhere in the neighbourhood of 40 to 50 pounds, which means two individuals can easily pick it up and put it on top of a post, not something you can do with these traditional trackers. And then that means how posts are so much lighter."

This is particularly advantageous given the risks of driving piles into the ground, reducing the health and safety considerations within this. They also do not need to be driven as deep because they are lighter, needing to be driven around four feet into the ground as opposed to six or seven for traditional, heavier trackers.

By reducing the weight and therefore the depth of the piles, the trackers can be fitted faster than alternatives. This reduces the number of manhours needed to develop a site, helping to tackle challenges around labour shortages as well as reduce costs.

The final core benefit of using terraintracking technology is the reduction in the environmental impact through reducing grading. This makes reseeding easier, but also decreases the likelihood of flooding at the site, as disturbances to the soil can affect soil moisture and nutrient distributions.

"So a lot of times during the construction phase, when they're moving all this topsoil around you have the worst flooding on a site, worse than the 100-year flood because once you move that topsoil, you have nothing to absorb that rain. So when you have rains come through, it's a mess out there. So just having a cleaner site like this is another side benefit as well," says Price.

How much land does this open up?

The development of terrain-following trackers could potentially open up a huge number of sites that were previously unsuitable for solar due to being too undulating or steep. Part of this is making those that were previously too cost prohibitive to develop due to the large amount of grading required, possible.

"Really, it depends on the economics and PPA rates and things like that to do a full-scale analysis of whether this can make sense or not," says Price.

"But when you're going out and saying, 'Oh, I'm gonna spend 10 cents a watt on grading', that could change whether the project is viable or not. You cut that in half with XTR, five cents on a utility-scale project – that's massive numbers."

Already the company has seen projects that wouldn't have been built otherwise, or would have taken years in design to ensure that the land available can be efficiently used. Using terrain-following technology can therefore speed up the development process, easing the financial considerations.

How much land this can open up in many ways remains to be seen, and will vary dramatically from region to region depending on the terrain and the maturity of the sector.

"We're still in the learning phase. I know our pipeline shows that the US is very, very much headed towards challenging terrain, we're seeing close to 85% of that pipeline look like it's challenging terrain. And that's a pretty hefty number," says Chandra.

"What we're more concerned with is how many projects are being discarded early on without having conversations with trackers and module suppliers to even just say, is this feasible or not. They're just being discounted because the internal estimation models sort of show that it's too cost prohibitive.

"What we're trying to do now is have conversations with developers without any project in mind, let's go to as early in the project lifecycle as possible to say, 'Let's have a conversation about this particular project, or what we can offer in terms of value and think about projects that you haven't been able to take forward.' So we're very interested, while it's harder to point to a specific number."

Ultimately, it seems clear that terrainfollowing trackers will become a bigger segment of the market in the coming years, as solar developers look to more innovative solutions as the land available continues to become increasingly constrained. Companies will need to balance the additional cost of such trackers with the cost-savings they offer, to ensure the most efficient development with the smallest impact on the ground.

Join Japan's Largest PV Industry Show!

Japan's largest PV industry show, PV EXPO, organised by RX Japan, will be held from March 15 (Wed) - 17 (Fri), 2023 at Tokyo Big Sight as part of World Smart Energy Week – the world's largest-scale smart energy event.

Photovoltaic power is expected to play an ever increasing role as the main power source in achieving carbon neutrality by 2050. PV EXPO brings together a full range of products and technologies from next-generation solar cells to solar power plant construction, maintenance and operation, and is well-established in the industry as a business platform which attracts experts from all over the world.

Since Prime Minister Kishida announced that almost all travel restrictions have been lifted as of October 11, we have seen a rush of applications to exhibit and are expecting to welcome ^(*1)50,000 industry professionals and ^(*2)1,200 exhibitors in 2023. Join Japan's largest PV industry show to expand your business in Japan & Asia.

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Visitor Profile:

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Show Outline:

PV EXPO 2023 - 16th Int'l Photovoltaic Power Generation Expo Dates: Mar. 15 (Wed) - 17 (Fri), 2023 Venue: Tokyo Big Sight, Japan Web: PV EXPO - About the Show (wsew.jp)

*1 Among largest for expected visitors, including concurrent shows.
*2 Largest in terms of exhibitor numbers and net exhibition space for trade shows with the same focus.









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From optimum yield to maximum profit: how to develop solar projects with O&M in mind

O&M | Rarely does the planning and design phase of solar farms consider the subsequent operational management and its costs. Jörn Carstensen, managing partner at greentech, explores how unforeseen effects from development, procurement and construction can have a significant impact on the economic viability of PV plants.



The yield assessment is highly relevant for the realisation of PV parks. It serves to determine the subsequent performance of the system and provides the various stakeholders with valuable information about their (possible) project. For project developers, it provides information about the yield potential of a site or land area. Banks and investors use it to decide whether the financing of the project or an investment is profitable or not. However, the electricity yield obtained is not the only decisive factor for the success of the park, which can sometimes lead to illusive profit prospects.

The expectations of lenders or owners regarding the yield of their plant are regularly disappointed. Whether a project will be successful in the long term depends not only on the yield of the plant. The investment costs (capex) and the operating costs (opex), as well as later dismantling costs, also contribute to the overall success of the solar park. Set in relation to the total lifetime, they determine the levelised cost of energy (LCOE) of the system. The lower the LCOE, the higher the economic efficiency of the system. It is therefore important to find the optimal balance between these determining factors.

Only a holistic and integrated approach enables low LCOE in the long term

Nevertheless, plants are still predominantly planned "unintegrated": project development focuses on the highest possible output from the available land – because it increases the sale price of the project rights.

The procurement of components and construction is carried out according to the premise of keeping investment costs as low as possible or obtaining the best Partial shading from vegetation can increase the risk of hotspots forming on modules. possible payment terms. They account for most of the total costs of a PV system – their influence on the LCOE is correspondingly large. Unfortunately, quality, service concept and maintenance effort are not always at the forefront of the decision.

Rarely does the approval, planning and design phase consider the subsequent operational management and its costs. However, even though the operating costs for photovoltaics (to be estimated at about 1.5-2.5% of the total costs per annum) are by far the lowest of all renewable energy sources, these costs can cumulate to a substantial amount, especially, due to previously unforeseen effects from development, procurement and construction that could have been avoided. They can have a significant impact on the LCOE and have a lasting negative effect on the economic viability of the PV system.

Obtain O&M expertise at an early stage

Certain impacts on the LCOE from O&M costs can be identified at various core stages of project development and execution by experienced O&M professionals. If you do not have an integrated team at hand, relevant know-how can be obtained from external service providers. Occasions for cooperation include:

Did you know?

With costs between €0.03-0.055/kWh (US\$0.03-0.062/ kWh), ground-mounted PV systems of 1MWp and larger can produce by far the cheapest electricity of all renewable energies in Germany, according to the Fraunhofer Institute for Solar Energy Systems ISE. Although the information is from 2021 and it can be assumed that the costs will rise in the near future due to the current high demand and continuing inflation - PV investments are still attractive as a viable investment in a sustainable energy supply. Site analysis. A PV site analysis involves the recording of all relevant information about a PV site and the route, which are necessary for project development, plant design, construction and subsequent operation. If necessary, it is supported by the creation of an exact digital elevation model of the surroundings using drone technology or by an analysis of the ground conditions. Among other things, they determine the preconditions for construction and already provide certain framework conditions that must be considered in the further course and can have an impact on economic viability. Ditches or hedges, for example, can have an impact on the accessibility for technicians or the accessibility for greenkeeping; nearby wind turbines or buildings can also provide additional shading. In an in-depth site analysis, these risks and their effects are highlighted.

Early exchange with the relevant

authorities. Not all risks of a site can be derived from a site analysis. For example, environmental authorities may impose strict regulations on the construction and operation of solar parks in certain areas or set high requirements for the creation and maintenance of compensation areas. This can cause costs that are not apparent at first glance, but later have an impact on operating costs. An early check and active exchange with authorities can not only serve to influence later concepts but can also lead to refraining from a project at an early stage in case of unsolvable challenges.

Review of the yield assessment. As

a basis for investment and financing decisions, a yield assessment must above all show a realistic picture of the expected result. If relevant risks or general conditions are underestimated, expectations may not be met in the end. Experience and performance indicators from operational management help to provide a picture of the developed plant which is as realistic as possible. It can therefore be helpful to have the results of the yield assessment neutrally reviewed by a specialist with many years of O&M experience.

Review of the system design. Today, software tools for creating PV plant designs and yield simulation software offer the possibility to quickly, easily and flexibly determine the optimal

Case study: Vegetation maintenance as a risk factor for LCOE

The following example shows that seemingly small challenges can lead to a significant increase in LCOE. In this case study, the lower edge of the modules of the ground-mounted system is at a relatively low level of 60cm, meaning that invasive and fast-growing vegetation gradually shades the lower module rows quickly. This aspect is not considered in the yield report as the basis for financing the system, but – as determined by greentech's operational management – leads to a long-term yield loss of 4% on average per year.

In terms of operating costs, this is accompanied by an increased need for green maintenance to keep the vegetation flat and, above all, to keep the lower rows of the modules permanently free from shading. Partial shading also increases the risk of hotspots forming on the modules, which can lead to shorter inspection intervals in the long term and, as the system ages, to higher repair costs.

In addition, the rack system installed has diagonal braces, which means that it is not possible to work efficiently with larger equipment underneath the tables. This leads to greater manual effort and correspondingly high costs. In addition, the mown greenery must be disposed of outside the site due to planning requirements. The authorities generally prohibit mowing between March and August due to the protection of species of ground-nesting birds. Permanent grazing with sheep is also not permitted for this reason. In this particular case, an individual solution was found in consultation with the environmental authority, which allowed an earlier grass cut under the supervision of an ornithologist.

In the long term, these non-negotiable framework conditions result in 15% higher O&M costs, an 8% increase in LCOE and a failing financing model for the plant.

How could things have gone better?

In this case, the O&M experience and perspective could have provided informative and solution-finding support from the very beginning.

Early contact and exchange with the environmental authority could have made the existing animal welfare measures and green maintenance conditions that later resulted more transparent at the beginning of the project development phase. In this way, it would have been possible to participate in the development of the ecological concept for the facility at an early stage and thus contribute to solving the problem at an early stage. It would have been conceivable, for example, to use slow-growing plant species to keep the operating costs as low as possible through less mowing activities per year. If this had not been possible, at least the prevailing environmental regulations of the authorities and the mowing ban could have been identified and communicated early on as a risk and significant influencing factor on the LCOE.

In this case, changes in the plant design and yield calculation might have been more obvious, leading to a more realistic picture of the plant's yield, LCOE and economic profit. For example, a different design might cause less shading, or a different substructure of the modules might allow better implementation of green maintenance at lower cost.

At the very least, the yield assessment could have anticipated the shading of the lower module rows due to the mowing ban and made the long-term effects on the yield transparent, leading to an appropriate price for the project rights.

system design for the land and the local conditions with the best possible yield prospects. Among other things, different row spacings and tilts of the module rows can be precisely simulated and their effects on the yield determined. The use of different inverter and module products also has an impact on the yield. Here it is important to choose the models that offer the best solution in terms of price and quality for the given conditions. Once this has been done, it is essential to have an experienced O&M specialist look over the design from the point of view of its effects on later operational management. For example, it may be that the use of low-maintenance inverters is more expensive to purchase, but experience has

shown that this can significantly reduce maintenance costs later on. In this case, it is important to provide the necessary cost transparency for both options to be able to make the right decision for the project regarding the LCOE.

Other ways to incorporate suggestions from O&M during the development and design phase include a review of the plant IT regarding remote monitoring and control. It is important to implement a reliable, secure and least complex system from the very beginning, which is less prone to faults and does not have to be rebuilt soon after the start of the operating phase. If, for example, the monitoring's remote access to the components of the plant goes over several routers with different access rights, this makes the monitoring process more difficult and can mean a considerable amount of extra time per day. This also increases the likelihood of failures of the system and costs of operation management accordingly.

The technical input from operations management can also be useful when developing a concept for plant security. For example, to protect against theft, plants are usually secured with a fence to prevent unauthorised access. However, wire mesh fences need to be regularly repaired or maintained as they are repeatedly damaged by wildlife or heavy weather. Pole mats fences may be more expensive to purchase, but they are also more stable and less likely to need repairs later. This is especially relevant to consider for systems with sheep grazing. Often this type of stable fencing is also sufficient to obtain the required insurance cover for the facility. Other high level security technology with high maintenance requirements can then be avoided. In any case, it is necessary to look closely at which combination of security measures in construction and

operation makes sense and are sufficient to protect the facility efficiently, to obtain the required insurance cover and to contribute to a low LCOE in the long term.

Thinking outside the box promotes low LCOE, high plant quality

Only the creation of transparency about the risks of all project phases enables a realistic picture of the economic potential of a photovoltaic system. It is important to identify and analyse the existing LCOErelevant aspects as early as possible and to determine their scope for each project phase. This should be done with an interdisciplinary approach from a common perspective, because from "inside the box" many risks do not appear as such at first or are possibly underestimated in their significance and scope.

Experience from O&M can help to find solutions for certain challenges at an early stage and even eliminate them altogether as risks for high LCOE. For other risks, suitable options for action must be thought up so that subsequent operating costs and the impact on LCOE are as low as possible. If no solutions for relevant risks can be thought of or implemented, the sales price can be adjusted or in the worst case the project can be stopped early to avoid high planning efforts and unnecessary costs.

A great added value of this interdisciplinary look "outside the box" is certainly also the sensitisation of the individual disciplines to LCOE-relevant aspects in the PV value chain. The findings not only enable new best practice approaches in project development, but also ensure reliably and economically operating plants and satisfied operators and investors in the long term.

Author

Jörn Carstensen joined greentech in 2014 as business development manager and has played a key role in shaping the company's



growth path. In addition to entering several European markets, he built up the engineering and technical advisory division. Today, as managing partner, Jörn is responsible for the energy services unit of greentech, which covers O&M, asset management as well as engineering and technical advisory.





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Challenges of PV soiling in desert climates

Soiling | Presenting findings on the exposure of PV panels to the harsh environment of the Arabian Desert, a team from the Qatar Environment & Energy Research Institute details the multiple mitigation approaches to solar soiling.

n 2016, the Paris Agreement acknowledged the need to restrict the maximum global average temperature rise to 1.5°C. However, the current policies to limit global greenhouse gas emissions due to the burning of fossil fuels are still insufficient to maintain the temperature increase below 2°C. Therefore, the decarbonisation of energy systems is currently the only available option to achieve this target. Towards such a goal, we are now welcoming the new terawatt era of photovoltaic (PV) solar energy.

In fact, the world's cumulative installed



Daily Soiling Rate (%/day) Soiling Loss % 40 20 0 -20 2 months 6 months 2 3 4 5 6 7 8 9 10 11 12 1 Month



solar PV capacity grew by 22% to reach 940GW by the end of 2021, representing a 56% share of all renewable energies [1]. By May 2022, the installed capacity surpassed the milestone of 1TW, led mainly by the deployment of large utility-scale solar plants. The state of Qatar, like the other Middle East and North Africa (MENA) countries, has a large potential for deployment of solar energy production due to the very high solar irradiations with the lowest levelised cost of electricity (LCOE), becoming an emerging PV market [2-4]. The average annual global horizontal solar irradiation goes up to 2286 kWh m⁻² with an associated annual PV electricity production potential of 2100 kWh/ kWp for c-Si modules [5]. Solar tender results provide testimony for the growing competitiveness of solar technology around the world, with new record-low solar tariffs registered in 2021 with the top four lowest bids in desert areas [1].

In 2008, the state of Qatar launched the Qatar National Vision 2030, setting a national target of 20% renewable energy by 2030 and a 10GW target for solar energy, and aimed at increasing PV adoption as part of the global transition towards a net zero carbon emissions. Qatar has a clear commitment to the implementation of PV solar plants in the country as proven by the inauguration in October 2022 of one of the largest PV plants in the world, Al-Kharsaah, which has a capacity of 800MWp and represents 10% of the country's demand. Two more projects starting in 2023 in Ras-Laffan and Mesaieed will account for 875MWp and will be finished by the end of 2024.

However, soiling of solar collectors has been recognised as the main issue and the biggest detriment for solar energy systems operating in the MENA region, which results in significant losses of solar power generation and an increase of associated

redit: QEERI.



(a) The 15 sites of QEERI's National Dust and PV soiling monitoring Network. (b) Photos of the Dust IQ, PM and meteorological sensors installed over the state of Qatar.

operational and maintenance (O&M) costs [2]. For instance, soiling is estimated to have reduced global solar power production by at least 4% [2], causing a conservative global revenue loss of more than €7 billion (US\$7.3 billion) by 2023 [2].

PV soiling is a multidimensional and dynamic phenomenon, influenced by site characteristics, weather conditions, surface material and dust particle physical and chemical properties [6-9]. The first step to address soiling adequately is monitoring, as soiling mitigation must be tailored to the specific conditions of each PV system, as no universally valid strategy is possible to date. While posteriori solutions do exist, such as PV module cleaning, key questions would be how, when and where should the modules be cleaned. Thus, a priori solution to the soiling issue would be an accurate understanding of the regional dust characteristics to improve the decision-making process for the selection of the best location for a PV plant and/or the best PV technologies to be employed.

In 2011, the government of Qatar recommended creating a solar energy test station to assess the effect of local climate conditions on PV systems. This aimed to study whether the high temperature, humidity and dust could cause PV reliability risks, which had to be quantified and mitigated prior to the large-scale development of PV plants. In 2012, the Outdoor Test Facility (OTF, **Figure 1a**) was opened at Qatar Science & Technology Park [10] and is currently operated by Qatar Environment & Energy Research Institute (QEERI).

The OTF is a 35,000m² outdoor site

with various plug and play PV testing that includes more than 85 PV systems from 35 PV manufacturers, 30 PV module test benches, seven tracker HSAT systems, vertical bifacial stands and robotic cleaning. The extreme environmental conditions at OTF (high irradiation, temperature, albedo, soiling, humidity leading to cementation, coastal marine aerosols, etc.) are unique and help to evaluate the performance of different solar technologies and devices and determine how to maximise their energy production and reliability. Since 2013, QEERI has started developing a unique regional and worldwide expertise on PV soiling in desert climates, both from experimental and modelling/forecasting point of view, thanks to OTF unique bench tests [10,11].

At the OTF, the average soiling rate (decrease in daily energy yield due to soiling) for fixed-tilt PV modules is 0.49%/ day (Fig.1b), or 13% in an average month without rain or cleaning (Fig.1c). The daily soiling rate was found to be higher in winter due to more frequent overnight dew. Because soiling has a critical impact on PV energy yield in desert climates, a variety of test stands are available at the OTF to study the effects of cleaning frequency, PV cell technology and mounting (fixed tilt versus tracking). Since 2018, OTF houses the Solar Consortium that put together companies, authorities and QEERI to study solar technologies in desert climates by means of a group research project as well as by confidential testing for individual members [10,11].

PV soiling monitoring

Establishment of a National Network for Dust and PV-Soiling Monitoring

The soiling effect on PV power production has a large spatial and temporal variability, both at large and short scales. Soiling may even considerably vary within the radius of a solar power plant and



ARC GIS geographical mapping of the field measured Soiling Ratio (SR%) in 2021. (b-e) Associated spatial distribution of the dominating chemical elements in dust particles, namely Silicon, Magnesium, Sodium, and chlorine, respectively. ArcGIS 10.8.1 software package developed by Environmental Systems Research Institute (ESRI) was used in this mapping for the creation of the basic GIS environment. The Qatar map image was first captured from Google Earth. A database on the GIS application to convert the image to digital format (called Digitising process) was performed. We have then aligned the map photo with an existing Geographical reference by coordinating Longitude and Latitude using a geo-referencing toolbox. could present large differences in different locations of a country such as Qatar, due to the specific environmental and meteorological conditions.

In the quest for soiling monitoring with high accuracy and reliability, QEERI has set the objective of developing a dynamic Dust Atlas mapping for Qatar to help in assessing the actual country's PV potential, in collaboration with the Qatar Meteorological Department (QMD). Thus, high-quality monitoring stations consisting of 15 Dust IQ sensors and 15 meteorological stations containing air temperature, relative humidity, wind speed and wind direction and pressure, in addition to PM 1, 2.5 and albedometer stations have been deployed at 15 geographical sites selected across Qatar, providing minutes-resolution averages of transmitted data to QEERI servers. All the stations comply with IEC 61724-1 standard [12]. Some sites were additionally equipped with Mars dust sensors [13].

Figure 2 shows the 15 sites of the QEERI National Dust and PV-Soiling Monitoring Network. Photos of the Dust IQ and Mars sensors along with meteorological and PM sensors are shown within the map. All locations were selected to provide a comprehensive coverage of the country, creating a dense network in which the distances between stations are kept under 30km. Thus, a combination of solar, meteorological, environmental and soiling values is used to provide a complete ground calibrated real-time mapping of PV resources, with a high spatial and temporal resolution throughout the country.

Field measurement and PV soiling mapping

PV plant performance can be significantly impacted by module soiling. However, when and where to clean the modules? To answer this question, there is a need for accurate measurements of the soiling on PV modules. Associated with our ongoing efforts in solar forecasting, QEERI is currently developing an operational model to map the soiling appearance in the country and characterise it seasonality and geographically. The ultimate objective is to offer an optimised cleaning schedule and the most efficient method (dry versus wet cleaning) and thus maximise the return on investment on solar power plants.

Field measurements of soiling results are shown in **Figure 3** in 15 locations spread over the state of Qatar, along with the dominating chemical elements



Image of the tilted (a) monofacial soiled and clean modules, (b) bifacial clean and soiled, and (c) vertically mounted East-West oriented modules. Soiling is evident in the tilted modules, but not in vertical modules. d) Difference between the monofacial soiled and clean and the bifacial soiled and clean. (e) Normalized power and mean difference for the vertical bifacial modules clean and soiled.

contained in the dust particles. The chemical composition of the dust is of primary importance as not all dusts impact the light attenuation in the same manner. For instance, organic carbon is found to shade light 30 times higher than mineral dust, and elemental carbon (graphite and C_{60}) is over 200 times worse. Moreover, for the same amount of dust, fine particles have a more dramatic effect on light attenuation because of their higher cross-sectional area to volume ratio, that's why the chemical composition of the dust particles and their shape are critical on the light scattering and absorption properties.

PV soiling mitigation Robot cleaning

The first MW-scale PV projects in the Arabian Desert were exclusively manually cleaned before brush trolley tractor and manual cleaning Nomadd and Sol-Bright robots were launched, followed by introducing widespread robot cleaning trials with the demonstration of reliability issues [14]. Since 2020, 100-1,000MW PV plants were ~100% cleaned by robots, however many questions remain pending, e.g. the efficiency of these robots in terms of dust removal; cleaning frequency; cleaning uniformity; which type of robots to select; their economics (opex); the impact of weather condition on the process's efficiency; and more importantly, do cleaning robots abrade modules' antireflection (AR) coatings, and how might this cleaning process impact PV performance and reliability?[15,16]

QEERI, in collaboration with the Solar Consortium, is leading the largest realworld robot abrasion test globally to study PV module coating abrasion caused by machine cleaning. A commercial automatic PV cleaning machine ("robot") was installed at the OTF. It is installed on a 50m-long rack with daily and weekly cleaning schedules for different sections. The modules and/or samples are characterised at QEERI. The comprehensive and challenging project studies different types of PV modules, anti-reflecting coating (ARC) and robot technologies. This study will answer key questions such as the rate of ARC abrasion by dry robot cleaning, variation of abrasion between different modules, cleaning frequency versus abrasion and soiling loss and effects of moving shadow.

Bifacial PV modules

A highly interesting soiling mitigation approach in desert environments is the extended use of bifacial PV modules that we are currently experiencing. Bifacial crystalline silicon PV modules can produce additional output energy in comparison to traditional (monofacial) PV modules. This is achieved because both sides of the bifacial PV module, front and rear, can absorb and use solar radiation received by the front side and the light reflected from the ground and surroundings, which reach the rear side of the module.

In this context, the rear side of the bifacial module experiences little or no soiling compared to the front side. The high albedo of desert sand (exceeding





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(a) PV performance ratio as a function of deposited aerosol mass. (b) Deposited aerosol mass as a function of ambient relative humidity. (c) Developed ML results of Daily Soiling Ratio w/r to the period of the year.

40% in Qatar) in combination with the high levels of solar irradiation, make bifacial modules a very promising alternative technology compared to monofacial for soiling mitigation in a desert environment. It has been proven that bifacial PV modules in combination with one-axis trackers lead to the lowest LCOE [17], becoming the preferred PV configuration in desert climates and especially in the MENA region with the lowest bids as witnessed in the last years.

Furthermore, bifacial PV modules also allow for new and innovative concepts in PV system integration such as the vertically mounted east-west facing bifacial PV installations that benefit from very low soling rates and cleaning cost [18, 19] acting as a passive mitigation approach for soiling [20, 21]. The reduction in the O&M and cleaning cost and the increase in specific energy yield per kW and especially between cleaning cycles make this configuration a promising alternative for soiling mitigation in desert climates.

Figure 5 shows an example of a lower effect on energy yield for bifacial modules and low soiling accumulation on vertical PV installations at OTF (**figures 5a, b, c**). For tilted modules, soiling losses increased with time up to 60% and 45% for monofacial and bifacial modules, respectively, showing the lower effect on energy yield for bifacial (**Figure 5d**). No significant soiling losses were observed for the vertical module with values <1.5%. On average, vertical module yield is ~10% higher than conventional monofacial tilted module and during the summer, vertical module also strongly outperforms bifacial tilted module. Vertical installation of bifacial modules presents a great opportunity for soiling mitigation and reduction of cleaning costs [22,23].

PV soiling Forecasting

Additional strategies related to soiling mitigation are to forecast PV performance ratio reduction over several days ahead to permit optimising cleaning schedules. This might be achieved through tracking algorithms developed by machine learning (ML) in combination with meteorological factors. Multi-year monthly soiling maps over Qatar using a frequency map were hence developed.

Figure 6a shows the PV performance ratio as a function of deposited aerosol mass at OTF, and the deposited aerosol mass as a function of ambient relative humidity (RH) [24,25]. RH was found to be the critical point above which the deposition/cementation increases exponentially. An empirical model was developed and showed a high correlation between PV soiling loss and the sigmoid function of particulate matter PM10 & RH (Figure 6b). Furthermore, we have used ML to learn the best mapping functions to relate changes in meteorological and environmental conditions with the resulting soiling effect on PV modules. Our input to train the model are historical time series of different meteorological and environmental parameters (temperature, relative humidity, wind speed and direction and PM concentrations) collected in the same OTF location where the soiling effect on PV modules was measured.

We already successfully tested the use of linear and non-linear ML algorithms such as multi-variate linear regression, extreme gradient boosted threes, and artificial neural networks to learn the dependency between the amount of daily soiling and weather and PM conditions. **Figure 6c** shows an example of the drop in performance ratio measured in the period between January and March 2021.

By taking Qatar as a reference, the local daily loss in performance due to soiling is estimated to be an average of 0.4% per day, matching perfectly the field-measured values and attesting to the efficiency of this developed ML model.

We thus demonstrated that ML is a reliable method to derive the relationship between weather and environmental factors and to predict the corresponding soiling effect.

Conclusions

The light-collecting surfaces of solar power systems cover areas of more than 3,000 km2 worldwide, with PV modules accounting for the majority, and a new terawatt age is definitely established. Due to its large impact on the maintenance and economics of solar energy plants, especially in desert climates, there is growing interest in soiling mitigation, with the publication rate on the topic increasing exponentially since 2008. Currently, there is no 'one solution fits all' to the problem of soiling due to its sitespecific and seasonal variability. Yet the soiling problem is far from being solved, there are multiple mitigation approaches that have demonstrated their effectiveness, including robotic cleaning, module configuration (HSAT, Bifacial, etc.) and forecasting.

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For future PV plant projects in Qatar, we believe that the first soiling mitigation plan is the appropriate choice for the PV site location. QEERI is continually providing a dynamic geographical and seasonal mapping of the chemical and physical properties of dust over the state of Qatar. This is resulting in developing a land suitability index and soiling-risk map for future PV installations. These accumulated experimental data serve as a trusted input to improve our forecasting model for a cleaning optimisation schedule.

Subsequently, the effect of environmental parameters on the dust interaction with the PV surface is also being investigated towards the appropriate development of the most efficient cleaning method (dry/wet, robotic, coatings, etc.). With this developed knowledge, QEERI may address a number of issues for PV deployment companies, including corrosion, maintenance needs and best location selection.

Finally, by learning lessons from the exposure of PV panels to the harsh environment of this region, Qatar has a unique opportunity to develop mitigation strategies that will benefit other arid regions of the GCC and the desert environment at large. A constant and continual effort on advanced soiling research is thus necessary.

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'Everything is becoming more efficient': new floating PV construction methods take hold

Floating solar | As the floating solar sector becomes more mature, larger projects are being deployed in a range of water bodies, presenting a host of construction challenges. Jonathan Touriño Jacobo talks to project developers about how the latest technology is driving growth.



U (FPV) was a technology barely present around the globe, only starting to boom in the past five years, mainly in Asia. But Europe has been increasing installations, factoring in the region's necessity to accelerate renewables deployment. FPV could still be considered a nascent technology that has yet to reach its full potential, including the development of big projects (of GW-scale) and offshore FPV that is mainly in a research and development (R&D) phase.

In less than a decade the technology has been evolving and improving through trial and error, with the anchoring and mooring systems at the centrepiece of it. However, as with most new technologies, there is a need to create standards, to ensure the companies involved in floating solar do not wander in different directions. Setting best practice recommendations could help accelerate the improvement of projects.

DNV's recommended practice

While only a few years ago most floating solar projects were smaller in scale, we now see a rapid increase in project sizes and GW-scale projects are expected to be feasible within a few years. "Suppliers are getting more and more professionalised. The economy, the whole supply chain, manufacturing, installation, everything is becoming more efficient, which drives cost down and makes it easier to scale to larger projects," says Tore Hordvik, business lead of floating wind and solar at quality assurance company DNV.

The company has been working on implementing a recommended practice (DNV-RP-0584) for FPV projects, which was launched in 2021 and provides a comprehensive set of requirements, recommendations and guidelines throughout the entire lifespan of an FPV plant. "What we've seen is that especially technology developers, Anchoring and mooring need to be optimised as projects increase in size. those that make the floaters but also the anchoring and mooring system, have been very active in trying to get their technology verified according to this recommended practice," adds Hordvik.

A lack of guidelines or standards to build towards would have made it complicated for an owner, an investor, an insurance company or a government body to determine the quality of a project and what it should be, as even that was not defined, says Hordvik. Moreover, the recommended practice helped give an overview of what the standard for FPV should look like. This led developers of floaters, anchoring and mooring systems to work towards having their technology verified in accordance with DNV's document.

It is still a work in progress and for that reason DNV recently launched two joint industry projects with more than 20 industry partners, "where the goal is to go one step further to actually define to make the design standard, not just a recommended practice", says Hordvik, adding that this will allow projects to be certified according to DNV's design standard.

With a technology that is still nascent, errors and failures might continue to happen, and when it does, they are a great tool to learn and improve project construction and technology. "If we are able to bring the experience from past failures back into improved procedures and guidelines, as we are doing now together with the industry, then we get something out of these incidents," says Hordvik.

An important step to be considered while in the design phase is the operations and maintenance (O&M) of a project once completed and how workers will be able to walk around the modules while making sure there is access to the floating platform if reaching it by boat, says Hordvik, adding: "The lifecycle phases from design, to manufacture, to installation and to operation needs to go hand in hand."

FPV becomes more complex

As the applications of mooring and anchoring for floating solar projects have become more diversified, solutions have become more complex, says Tia Qin, regional director at Sungrow FPV. "At the start of the floating solar development [five years ago], the most normal mooring or anchoring rope we would use was made of steel chain. But due to the diversity of the application scenarios we started to recommend mooring ropes with materials containing some polyester elastic ropes," says Qin, adding that it gives better adaptability depending on the different project's conditions.

German developer BayWa r.e. usually works with the same trusted suppliers without "locking" itself to a single provider or subcontractor for a specific item, says Michele Tagliapietra, head of product management floating PV at BayWa r.e. In the case of floating solar it works with Zimmermann PV-Stahlbau to better optimise the technology, reduce the cost, improve the stability and make it fit for harsher environments, says Tagliapietra, adding that one of the improvements the company has brought to its more recent projects are bigger boats which can host more modules.

"An example of a new development that we're actually looking into for the projects that we're going to install from now on is a new floating sub-structure for the transformer station. We are adopting an improved concept to optimise the cost and improve buoyancy," adds Tagliapietra.

However, as projects are getting bigger, the technology does not necessarily need to be so different from smaller projects, but it mainly requires optimising the anchoring and mooring. "Apart from the higher loads that you can have on your mooring, the bigger the size the more you can optimise and reduce the costs," says Tagliapietra, adding that bigger projects do not necessarily imply a longer installation time.

One of the first FPV projects that BayWa r.e. built, in Weperpolder, the Netherlands, took one month to construct and has a capacity of 2MW, while its biggest floating solar project currently, Sellingen, also in the Netherlands, took two months and has 41.4MW of installed capacity. "It's not a linear relation between installation time and cost. For Sellingen, with a bigger installation platform, an optimised assembly process and more people involved we managed to significantly reduce the installation time and, although not in a directly proportional way, also reduce installation costs," says Tagliapietra. He adds that money can be saved by reducing the time spent on site, the mobilisation cost and finding the right time window and weather conditions to install the project.

One aspect to take into consideration though with bigger projects is to be cautious with the anchoring and mooring loads as they will be larger and thus have larger wind areas, according to Hordvik. His solution would be to make a lot of lines instead of big anchoring and mooring systems for larger projects. "The anchoring and mooring are key when it comes to bigger structures."

Another aspect aside from construction techniques and technology that developers are looking into is the environmental impact of floating solar projects. Due to the technology still being recent, knowledge around the effects of an FPV plant on water in the long term is still scarce and many companies are looking into it.

In the case of Portuguese utility EDP Produção it has even looked into reducing its carbon footprint at some of its latest projects in Portugal, such is the case in its 5MW FPV plant in Alqueva, by mixing the plastic used for the floaters – usually made of high-density polythene HDPE – with cork. "We reached a percentage of 30% of cork in this manufacturing process of the floaters," says Paulo Pinto, director of innovation at EDP, adding that it is looking into implementing this use of cork and CO2 reduction in future projects.

Meanwhile, BayWa r.e. is working on studying the environmental impact of floating solar plants by performing research activities in operational projects in the Netherlands to understand how water bodies react after installing the FPV. "So far, the results are quite positive with no detectable negative impact on the water quality, water composition, water temperatures and species which are in the water," says Tagliapietra.

Many developers asked Sungrow FPV about the potential to hybridise their projects (either with hydro, wind or energy storage) but mostly with hydropower, says Qin.

The Alqueva floating solar project built by EDP is hybrid, as it was connected to the hydro plant in the dam and also includes a battery storage of 1MW/2MWh, according to Pinto. Portugal's latest solar auction held this year and focused on FPV had recordlow negative bids posted, while showing the potential of hybridising renewable assets with different technologies.

Another common concern among developers working with Sungrow FPV is the lifetime of the floating platform and its reliability, which is due to it being a nascent technology and with the floating body being able to resist different working conditions for 25 years, according to Qin.

Unfortunately, the technological improvements made in the past years have not resulted in a decrease in the levelised cost of energy (LCOE), mainly due to the structure and the materials, says Qin.

For BayWa r.e., bigger projects, technology improvements and economies of scale on the other hand can reduce the cost per kWp of floating solar projects, adds Tagliapietra, but in the end the increased price of the materials, coupled with higher inflation, have a negative effect on overall system costs. "They are basically counteracting the technological improvements that we had made to optimise the costs and the layout."

Impact of diverse water bodies

The way the floating structure is moored and anchored will vary depending on the water body. This is a primordial aspect to take into consideration before starting a project as most floaters are flexible in that aspect and can be used at more water bodies, according to Hordvik. "The anchoring and mooring system needs to be tailored and optimised for each project." Both the wave height and wind speed are "The risk picture is much more connected to the location of your project rather than the size"

factors that will impact the selection of the anchoring and mooring.

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According to Pinto, it is not the same to have an FPV in a dam, for example, where the water levels will fluctuate a lot more, as in sandpits. "The risk picture is much more connected to the location of your project rather than the size," says Hordvik.

According to Tagliapietra, bathymetry – which is the measurement of water depth – is the parameter of the water body that affects the design and construction of the mooring system the most. "What really changes is how you anchor them and how you hook the mooring lines. If you have a specific type of clay, sand or rock on the water bottom it changes a lot the types of anchors you need to use," says Tagliapietra, adding that depending on the type of anchor you have, the way you install the system can change a lot.

While working on the development of the anchoring solutions, BayWa r.e. is not only looking at the technological aspect of them but also at new installation techniques to make them more efficient as it aims to find a solution for each specific water body.

Qin says that the acidity of the water also needs to be taken into consideration, and in the case of salty water, for example, how the anti-corrosion will affect a floating platform in the next 25 years. To remedy that issue, in waters with high levels of acidity, Qin says Sungrow FPV has changed the mooring ropes from steel chain material to polymer ones.

Early days for offshore FPV

As for the next big step in terms of FPV, offshore floating solar projects are still in the R&D phase at the moment with a couple of pilot projects on water already, according to Hordvik. These are both located in the Netherlands and developed by Oceans of Energy and Solar Duck. A few more projects are in detailed design stage.

Testing and development are currently underway with numerical simulations in computers to see how reinforced the structures need to be and what kind of anchoring and mooring solutions can be used to make offshore floating solar work, added Hordvik. "What is very interesting about offshore floating solar is that a lot of the big players are really looking into this because they see the potential for co-location with offshore wind."

Due to the distance needed between each wind turbine, that empty space could be used to add floating solar and thus increase the installed capacity of these projects. Countries like the Netherlands have started to require documenting the use of the area needed to build an offshore wind project, says Hordvik, adding "that's partly why these kind of big offshore wind players are so interested in floating solar. Actually you significantly increase your capacity of a wind farm by putting floating solar in between, because there are so large areas."

The other advantage of co-locating the project would help reduce the cost

Many offshore floating solar projects are still in the R&D phase but there's significant potential to co-locate with offshore wind.

of having offshore FPV, by sharing the infrastructure and power offtake, according to Hordvik. Moreover, offshore FPV as a standalone at the moment would be expensive because of the necessity to make the structures much more robust than the ones found in sheltered lakes, for example. "We believe that co-location with offshore wind can be kind of our first commercial stepping stone for offshore floating solar," said Hordvik, adding that as a standalone offshore FPV would require subsidies to be commercially viable.

If so far Asia has been the main driver of floating solar in terms of capacity installed or even in the development of the technology, Europe is setting itself ahead with offshore FPV and its R&D. For Hordvik this can be explained by the fact that most of the big offshore wind developers are located in Europe and have been key in funding the research for offshore floating solar.

As the research and potential for offshore floating continue to be improved, floating solar as a whole is poised to see accelerated growth as more countries seek to increase their renewables capacity and need to facilitate locations for the installation of solar PV. "It's a smart technology and we have already done a lot of the initial testing. Now we are ready to scale that and improve," says Hordvik, adding that more and more people are opening their eyes to the potential of floating solar.

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Project briefing

Overcoming logistical challenges to build Europe's largest solar project

Project name: Francisco Pizarro Location: Extremadura, Spain Capacity: 590MWp Energisation date: August 2021 Developer: Iberdrola

Perhaps one of the most promising regions for the development of solar PV is the Iberian Peninsula. Famed for its stunning scenery and scorching weather, Spain is one of the most prominent countries currently ramping up renewable energy generation in the form of solar.

Spanish multinational electric utility giant lberdrola has created something not only unique to Spain, but also to the wider European continent: Europe's largest solar PV plant.

Situated in the central-western region of Extremadura, the 'Francisco Pizarro' project, named after the renowned Spanish conquistador, has a generation capacity of 590MWp and came into operation in August 2022. The plant has nearly 1.5 million PV modules installed.

The project was developed via an investment of ± 261 million (± 300 million) and created various green jobs for the local area as well as an opportunity to scale the renewable energy generation industry. It also provided a basis to decarbonise various businesses and their operations.

During the construction phase of the project, it was reported that Francisco Pizarro created more than 1,500 jobs during peak construction periods. As indicated, this provided a solid foundation for the creation of green jobs in the local area and additionally prepped the population for an influx of renewable projects across Spain.

The Francisco Pizarro project also overtook the installed capacity of Iberdrola's former largest solar plant in Spain, the 500MW Núñez de Balboa, for which the company was ordered by a Spanish court earlier this year to return part of the land for the solar plant after disputes with one of the three landowners.

The development process

With the sheer size of the Francisco Pizarro site and previous difficulties in developing a solar farm of such scale, it was predicted the



project would prove to be a challenge to develop. Perhaps the most difficult obstacle, according to Iberdrola, was the process of securing the vast amount of land in order to create the megaproject.

The project occupies an area of approximately 1,300 hectares and the energy generated is extracted from the project and transported to the Almaraz 400kV substation by a 31km 400kV overhead line.

"Land was a challenge for us," a spokesperson from Iberdrola says. "It was difficult to secure sufficient land for the development of the project and validate land for a plant of almost 600MW. To achieve this, we combined owned and leased land."

According to law firm Mariscal & Abogados, there are five steps in developing a solar project in Spain. This includes securing land rights, requesting access points and network connection, depositing the guarantees, preparing environmental studies and lastly obtaining permits and licenses.

Iberdrola was additionally keen to highlight the creation of green jobs throughout the construction phase of the project. "During the construction of the plant more than 1,500 people have been employed, 60% of them local workforce," Iberdrola stated.

"It is also important to note that construction, given the size of the plant, was divided into three zones that were built independently by three different contractors (Eiffage, Elmya and UTE PizarroAbengoa/ The plant features PV modules from Trina Solar and JA Solar. FCC). This reduces risks and enables better management of the works and distribution of supplies."

The amount of renewable energy being provided via the project could be monumental for local industry and the wider Spanish green economy. More importantly, the solar can be used to decarbonise vast areas of Extremadura.

Like much of Europe, Spain has targeted net zero emissions by 2050 via a culmination of renewable technologies. Central to this will be solar energy and the associated projects needed to stimulate growth for the country's green economy.

According to McKinsey Sustainability, "although Spain's emissions have been declining over the past 15 years, since 2013 the rate of decline has lowered to approximately 2MtCO2e per year. This rate needs to be four times as fast if Spain is to reach its 2030 decarbonisation goals, and five times as fast after that to reach net zero by 2050." According to this analysis, the use of utility-scale solar projects could be a crucial aspect in achieving decarbonisation and net zero targets.

Three primary technologies

As indicated by Iberdrola, there are three primary technologies that are spearheading the Francisco Pizarro megaproject. These are JA Solar mono PERC72S10, Trina polycrystalline PE15H and the INGECON SUN 1640TL.

The JA Solar mono PERC72S10 is a

bifacial half-cell double glass module and provides several notable advantages including less shading, lower resistive loss and better mechanical loading tolerance, according to JA Solar.

Working alongside the JA solar module is the Trina Polycrystalline PE15H, a 340W module with 144 half-cells from Trina Solar. The technology is said to offer increased efficiency by resisting losses due to current or shading.

The final technology that has been implemented into the Francisco Pizarro project is the INGECON SUN 1640TL. This is a string inverter with an efficiency rate of around 98%, nominal voltage of around 450VAC and a maximum output power of 1640kW. This technology was provided by Ingeteam.

Supply and construction challenges

As often associated with large-scale solar projects, various issues and challenges were

faced throughout the development of the Francisco Pizarro project.

As referenced earlier, securing enough land for the project had been a challenge for Iberdrola with the 600MW project requiring around 1,300 hectares of space to be constructed. On top of this, land to develop the overhead line was required. These factors led to several concerns which could have both delayed the construction phase of the project or, more drastically, could have led to the cancellation of the project altogether.

Another crucial challenge lberdrola faced was associated with environmental aspects. "We have taken measures to integrate the plant into the environment from the design stage and boost biodiversity. Specific measures have been taken at the site to improve forest, wildlife habitats, such as the creation of a controlled reproduction centre for rabbit breeding, the installation of nesting boxes or bird feeding protection areas," the Iberdrola spokesperson says.

Ensuring the natural environment and local wildlife are not impacted by the project is fundamental in securing planning approval. Because of this, biodiversity has become an increasingly important aspect to consider when developing renewable projects, particularly solar PV farms which can take up vast amounts of space. By coordinating the creation of various biodiversity "hubs" for the project, wildlife and the ecosystem will be able to both adapt and thrive from the solar installation.

Another important factor that proved a challenge for Iberdrola was the logistics operations required throughout.

"One of the challenges included the complexity of the construction due to its dimensions as well as supply challenges with the construction process requiring more than 4,000 containers to be unloaded



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for main supplies. This with along with the need for 26,500 tonnes of steel for the solar trackers," the Iberdrola spokesperson says.

With these issues, it poses an important question regarding decarbonisation – how green are these supply chains? Creating greener solutions for supply chains could allow for future projects of this size to be created with a lower carbon footprint.

Perhaps one of the more unusual challenges with the solar project comes in the form of archaeology. In line with plans to preserve both the natural and cultural heritage of the solar plant location, during the constriction process, several startling discoveries were uncovered.

"The biggest challenge has been to reconcile the archaeological finds made during the construction phase. This has required the redesign of the engineering of the affected areas, in parallel with the execution of the works. The archaeological finds continued throughout the civil phase of the project, so that they have coexisted for most of the duration of the project," says the lberdrola spokesperson.

During the execution of the project, Iberdrola guaranteed at all times the preservation of the natural environment and the archaeological remains discovered thanks to prospecting work. Specifically, some 20 rock formations with rock art and three archaeological sites were located.

Following the discovery, Iberdrola said that all the necessary measures were taken for the control, excavation and safeguarding of these remains by the company.

Revenue certainty via PPAs

Iberdrola has guaranteed the viability of the Francisco Pizarro project by signing longterm power purchase agreements (PPAs) with companies in different sectors.

One was pharmaceutical company Bayer, with Iberdrola supplying 100% renewable electricity to cover the entire electricity procurement of nine Bayer sites in Spain, including three factories, five research and development centres and the company's headquarters for Iberia.

At the time, Laura Dieguez, director of communications, corporate public affairs and sustainability at Bayer, said: "Measures such as these help us to further Bayer's commitment to sustainability by taking concrete steps to reduce our environmental impact. Working with experts such as lberdrola makes this commitment effective almost immediately, while we contribute to develop the infrastructure Europe needs to build a greener and more environmentally friendly future."

Alongside Bayer, Iberdrola signed PPAs to supply renewable electricity from the plant to Danone and PepsiCo to cover the energy needs of their centres in Spain.

"Long-term contracts PPAs provide visibility and certainty about the revenues that the plant will receive. This concept is key to the investment decision. Each PPA contract is adapted to the conditions agreed between customer and supplier and is reflected in an agreement for a quantity of energy at an agreed price and term," says the Iberdrola spokesperson.

"These PPA contracts, together with our portfolio of retail customers and wholesale market sales, structure a balanced mix of secured routes to market with a long-term vision that speeds up the execution of projects."

The agreement reached with Danone will guarantee the long-term green supply of electricity to all the food company's Spanish production plants and its natural water sources as well as its logistics centres and offices. Danone España's suppliers, Graham Packaging and Salvesen Logística, have also joined the alliance, showcasing how the solar project is able to drive decarbonisation and renewable energy into the heart of Spanish supply chains.

An advocate for the natural environment

As revealed previously, the Francisco Pizarro project has incorporated a range of different measures to boost the natural environment and its ecosystem alongside the cultural heritage of the region.

"Independently of the environmental monitoring plan that is carried out during

The project site has grazing sheep and nesting boxes for different species of birds and bats. the construction phase, the following environmental measures can be highlighted," the Iberdrola spokesperson says.

"This includes the introduction of sheep husbandry, the installation of nesting boxes for different species of birds and bats, the construction of shelters for reptiles, radio monitoring of steppe birds and the creation of ponds for storks.

"Along with this, we incorporated agricultural management of land to favour steppe birds, forestry compensation and reforestation, improvements to certain habitats of community interest, construction of rabbit pits and rabbit breeding centres and participated in the Spanish Ornithological Society's campaign to monitor steppe birds in Extremadura."

Solar farms can cause multiple issues for birds. Not only can certain areas disrupt both breeding grounds and places to search for food, but it is noted that solar panels can often look like water, ponds and lakes, and thus could have drastic impacts on local bird populations.

Perhaps more pressing is the impact the installation could have on local ground wildlife such as sheep and rabbits. Particularly for rabbits, their breeding grounds can be disrupted via the project and thus lberdrola has taken specific measures to ensure there will be minimal impact on the local population.

In addition, the introduction of sheep husbandry can help promote further industrial needs. The basis of this allows the sheep to graze and occupy the land in which the plant sits, helping to cater for both farming and renewable energy generation.

With this project currently the biggest solar PV project to be operational in Europe, it is a triumph of its time. However, with the rapid scaling of solar farms around the continent, this project could soon be overtaken. This is a promising move and development as this will continue to spur greater growth in the solar market and help develop a sustainable and renewable society across Europe.

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PPA aggregation increasing offtaker pool for project developers

PPAs | While renewables procurement is more challenging for SMEs with smaller power demands and less energy sector expertise, PPA aggregations offer a solution. Meghan McIntyre of Schneider Electric explores the deal structures for such aggregations and how project developers can benefit from them.

Since COP26, power markets across Europe have faced unprecedented levels of volatility with profound impacts on businesses and consumers. As world leaders gathered for COP27, it was clear that the energy transition must now consider how volatility can be mitigated to protect the economy whilst still reducing emissions. This means finding solutions that reduce our reliance on fossil-fueled power resources while increasing the capacity of cost-competitive renewable energy.

One avenue is power purchase agreements (PPAs), an energy contract between an offtaker (a utility or corporate buyer) and a renewable generator for an agreed volume, price, and delivery structure. While the nuances of PPA contracts can vary, these instruments are credited with providing both parties with long-term stability, as offtakers can forecast their energy costs while generators gain a long-term financing guarantee.

Demand for PPAs is rapidly growing. As greater importance is placed on emission reporting and reduction, renewablepowered operations are delivering an impactful result. Furthermore, following the recent announcement that the RE100 criteria has been revised to require purchasing of renewable electricity generated from a site less than 15 years old, it is expected that PPA demand will continue to increase. This in turn is likely to encourage further developer investment into new renewable projects to capture growing demand.

SME challenges and aggregation solutions

To date, the demand for corporate PPAs has been led by large corporations with large electricity loads. Although there is willingness to source renewable power among smaller actors, renewable procurement is more challenging for small and medium-sized enterprises (SMEs) with smaller power demands and less energy sector expertise. Challenges include their relatively low energy consumption, their credit rating and the need for an internal skillset to complete complex tender negotiations.

To reach climate targets, there must be greater inclusion of SMEs to realize the full potential of PPAs and the energy transition. One solution is an aggregate PPA in A diversified set of energy buyers can helps democratise and increase demand for renewables projects. which sponsoring corporations group their suppliers into a buyer consortium to meet the volume demand required from a developer's perspective. This allows individual SMEs to increase their buying power and holds the potential to reduce emissions throughout a sponsor company's supply chain.

There are two main deal structures for aggregate PPAs. In one, a buyer acts as the anchor tenant for the PPA, offtaking the largest volume while other consortium members offtake a smaller amount of energy generated. In the second, companies enter an agreement on equal terms without a lead buyer. These deals can be negotiated separately or may be negotiated together under a joint venture.

Potential for supply chains

While larger companies may already have the energy volume needed to enter a PPA as the sole buyer, the growing emphasis on Scope 3 emissions reduction is encouraging corporations to exercise their size and influence to decarbonise their supply chain by acting as an anchor tenant during PPA negotiations and by offtaking a larger share of energy generated. This structure supports SME buyers to meet the volume required by generators to finance a new renewable project.

An anchor tenant aggregate PPA often follows a three-tiered approach, consisting of one large buyer, several mediumto-large buyers, and many smaller sized corporates. For the medium-to-large corporates, an aggregate PPA helps diversify their energy mix to reduce risk, whilst smaller companies are provided with a route to entry. The effect of having a lead energy offtaker which bears the bulk financial and volume risk allows smaller companies with potentially poor credit to access the benefits of a long-term PPA.

Aside from decarbonisation, an aggregate PPA consisting of buyers within the same supply chain can also support SME suppliers during periods of energy market volatility. The current energy crisis has increased the operational costs of companies in all sectors, with many struggling to afford increased rates. By utilising the buying power of a consortium, an aggregate PPA allows SME suppliers to secure renewable energy at a fixed price, offsetting price volatility and stabilising operations to avoid disruption. If this potential is realized by larger corporations, the combination of operational and sustainable strategies is likely to drive emission reduction as a high priority.

Consortium aggregate PPA

Alternatively, a consortium of businesses, without an anchor tenant, can bundle their energy demand and enter an aggregate PPA together. Here, corporate offtakers unify to achieve similar goals: aggregate their energy offtake, benefit from economies of scale and optimise their combined offtaker profile.

One example is the first pan-European, aggregated virtual PPA taken between four separate companies without an anchor buyer: Philips, Heineken, Nouryon and Signify. The ten-year, 330GWh/year agreement will avoid 230,000 tons of emissions annually. By entering a virtual contract structure, the consortium supports the deployment of new renewable energy despite geographical and grid constraints. Schneider Electric was proud to advise the consortium companies on this deal.

Challenges

Despite the benefits, an aggregated PPA introduces challenges uncommon in a single offtaker PPA. A consortium of energy buyers in either model may introduce conflicting motivations, priorities and timelines that can slow down the decision-making process. It may also lead to a need for compromises that some cohort members will find unsatisfactory. Developers will also require aligned expectations, which can be difficult to achieve. Consortium offtakers should be prepared for conflict and work together to reach alignment before going to market which will increase the likelihood of a successful tendering negotiation.

"By spreading risk across a consortium made up of members from different industries, aggregate PPAs also become a better solution for developers"

> When forming a consortium, members must consider not only whether they are suitable from a developer perspective, but also for each other. Alternatively, the consortium can nominate one buyer to manage the tender process and represent the best interests of all corporates. Due to the complexity of a PPA tender, this responsibility often rests with the largest or most mature corporate, which is more likely to have the skill set to lead these discussions. Although complex, the benefits of the consortium model for smaller companies still outweigh the challenges.

Benefits for developers

For developers, the benefits of aggregation are akin to a standard PPA whereby a long-term power contract provides bankability that allows them to secure debt financing. In addition, a diversified set of energy buyers helps to democratise and increase demand for renewable projects, ultimately encouraging further investment. Although some developers may continue to prefer PPAs with a sole offtaker due to their relative simplicity, other developers have expressed a strong desire to enter aggregated negotiations to help SMEs enter the PPA market.

However, feedback from a developer focus group on the Zeigo platform highlighted several challenges. Namely, most developers do not have the legal resources to engage in different contracts for all corporates under an aggregated deal. In these cases, compromise on the buyer side may be required as developers may need a consortium to agree to a one-size-fits-all legal agreement. Developers are also looking for a uniform contract duration, with all members in a consortium agreeing to a single start and end date for the contracts.

A second area of consideration is credit. Although a consortium is likely to produce a favourable credit rating, one developer shared how funding structure is a key determinant of how likely a developer is to engage in an aggregate PPA. This will influence their appetite for risk and willingness to engage with consortium members with bad credit.

Finally, a developer shared that they perceive less risk when consortiums are made of corporates from a range of industries, as market downturns will not affect the entire group to the same extent. However, this may complicate the desire for a uniform legal contract.

What's the outlook?

Although there can be significant challenges to signing an aggregate PPA, and PPA prices will continue to be subject to volatile non-commodity factors, the benefits aggregation can provide is leading to increasing interest among sponsor companies. Although many of the benefits of an aggregate PPA are felt by SMEs, larger members are incentivised by reducing emissions in their supply chain to meet their own Scope 3 goals. Plus, all consortium members can benefit from price security through the duration of the contract, which can help to stabilise costs during a period of economic instability.

Nevertheless, aggregate PPAs are still in their infancy and very complex. However, as more aggregate PPAs are signed, learning by doing will reduce their challenges and accelerate their adoption. By spreading risk across a consortium made up of members from different industries, aggregate PPAs also become a better solution for developers. The efforts being made in this space make aggregate PPAs ripe for growth.

Author

Meghan McIntyre is an experienced energy analyst at Schneider Electric with expertise in energy markets and the low carbon transition. Che helde an MSe in surt



tion. She holds an MSc in sustainable resource economics from University College London and has professional experience in private and public sector roles.

An IRA deep dive: how significant is it and what uncertainties remain?

Legislation | The largest climate package in US history promises to turbocharge the country's solar sector, but considerable uncertainty remains around the impact the Inflation Reduction Act will have and how it will be enforced by authorities, writes Sean Rai-Roche.

Variable Var

PV Tech Power has conducted a deep dive into the IRA, examining precisely what provisions are contained within the act, its potential to scale up US solar manufacturing, its likely impact on US deployment and what legal and regulatory hurdles remain. Through conversations with industry bodies, US developers, analysts, policymakers and lawyers, we hope to provide you with an exhaustive assessment of the potential of the IRA to support the US' decarbonisation as well as an exploration of any uncertainties and barriers that might remain.

Despite the tremendous work of renewable stakeholders in the US, the country is still far behind much of the Western world when it comes to decarbonising its economy. It gets just over 20% of its power from renewables sources, according to World Bank data, is lagging behind Europe in the adoption of electric vehicles (EVs), needs a massive injection of investment into its failing grid system and has much work to do when it comes to just transition.

That said, the IRA has the potential to address several of these fronts and, if exploited properly, could turbocharge the US' downstream sector at the same time as facilitating a rapid buildout of the country's upstream PV manufacturing base. The US has increasingly, and with strong wording, expressed its desire to onshore solar production – the theme of this issue of *PV Tech Power* – and reduce its reliance on Chinese imports, echoing sentiments found in India, Europe and elsewhere.

Brief history of the IRA

After gaining power, President Joe Biden tried to enact various different policy packages aimed at supporting the US' renewables sector. First, was his US\$2 trillion Build Back Better agenda that would have delivered considerable certainty for both the downstream and upstream sectors. That got scuppered by obstructive Democratic senator Joe Machin, who occupies the party's right, alongside Arizona senator Kyrsten Sinema, who effectively stonewalled the bill's passage.

Initially expected to pass as early as November 2021, by July no progress had been made and many thought the hope for a favourable policy package for solar was dead in the water. But then, later that month, Manchin and Senate majority leader Chuck Schumer announced a shock breakthrough in negotiations, much to the surprise of political pundits and the solar sector.

Manchin U-turned and said he would support a bill that would "ensure our country invests in the energy security and climate change solutions we need to remain a global superpower through innovation rather than elimination" in a statement issued on 27 July 2022.

Dubbed the Inflation Reduction Act, the bill passed both chambers of the US Congress before heading to Biden's desk to be signed into law on 17 August. Setting aside US\$369 billion for decarbonisation efforts, the act was described by Biden as "the biggest step forward on climate ever".

Incentives contained within the IRA

As part of the IRA, the US' investment tax credit (ITC) increased from 26% to 30% for a period of ten years and, crucially, is now transferable to other taxpayers. From 2031, the ITC will be phased down, with precise details on this forthcoming.

Previously excluded from accessing the ITC, standalone energy storage systems are now able to receive the 30% credit. The storage tax credit will allow existing solar and wind projects to be retrofitted with batteries without the need for any major grid connection changes, which remains the key bottleneck for new builds.

The IRA will also enable solar developers and manufacturers to make investments with the backing of a ten-year policy certainty, Christopher Seiple, vice chairman of energy transition and power and renewables practice at research firm Wood Mackenzie, previously told *PV Tech*. "The renewables industry, solar included, has never had a period in its future where it had policy certainty for ten-plus years."

On top of this, a production tax credit (PTC) has been made available to solar projects under the IRA. If projects meet 'prevailing wage requirements' (more on this shortly) set out under the IRA, then it will bag a tax credit of US\$0.025/kWh for the first ten years of its lifespan. If it doesn't meet those requirements, this is reduced to just US\$0.003/kWh. The PTC will rise in line with inflation.

"While solar now qualifies for the PTC, projects coming online in 2023 may primarily use the ITC if it is too late to change project financials," says Pol Lezcano, BloombergNEF's lead analyst for North American solar. "After 2024, we expect most utility-scale solar installations to opt for PTC given their low upfront capex and high generation potential. Only projects in diminished capacity factor areas are expected to keep using ITC."

Adders key to maximising IRA benefits

While lucrative, the ITC being set at 30% for ten years is just the beginning of benefits able to be accessed under the IRA. On top of that 30% credit, developers can also



access three other adders that provide an additional 10% credit, including ones for paying "prevailing wages" and having apprenticeship schemes, one for sourcing domestic content and one for "energy communities".

Developers can access an additional 10% tax credit by paying workers prevailing wages and ensuring they are part of an electrical apprenticeship programme. This has been designed not only to benefit local populations and ensure a fair wage is paid but also to grow the US solar workforce. These tax credits will begin to apply to projects over 1MW in 2023.

If contractors or subcontractors employ more than four workers to perform construction, alterations or repairs, then they must employ at least one qualified apprentice. Breaking these rules could result in a US\$5,000 fine for each worker being underpaid, or even up to US\$10,000 if the US Department of Labor deems this to be intentional.

Next is the domestic content adder. If PV projects receiving the ITC source their hardware from companies manufacturing in the US, they can access an additional 10% credit. All steel used in solar projects wishing to access this credit must be manufactured in the US. For goods with longer and more opaque supply chains, such as modules, inverters and balance of system equipment, 40% needs to be US-made, with this percentage set to rise moving forwards.

The industry has called for greater clarity on this (and we will get into how developers should approach the domestic content adder later on) but it is important to note that certain products may be imported if the quality of US-made alternatives is not up to scratch or would push up project costs by more than 25%.

Thirdly, there is the project siting and "environmental communities" adder. Under this adder, projects located in former "energy communities" can earn the additional credit. The IRA defines energy communities as brownfield sites or locations that have been linked with fossil fuels. This adder was designed to ensure those communities historically reliant on coal are included in the energy transition and are reskilled to focus on clean energy instead.

Manufacturing credits critical to upstream buildout

Under the IRA, companies will receive solar manufacturing tax credits, similar to the Solar Energy Manufacturing for America Act, as proposed by Georgia senator Jon Ossoff, which will be critical to building out the country's upstream PV sector. Under the system, the US government will support domestic solar manufacturing, offering incentives for each unit of polysilicon, solar wafers, cells and modules produced within the US.

The solar manufacturing tax credits are as follows:

- Modules would receive US\$0.07, multiplied by the capacity of the module (on a per direct current watt basis)
- Thin-film or crystalline PV cells would get US\$0.04, multiplied by the cell's capacity (on a per direct current watt basis)
- Wafers would secure US\$12 per square metre
- Polymeric backsheets would receive US\$0.40 per square metre
- Solar-grade polysilicon would get US\$3
 per kilogramme

There is also a separate manufacturing tax credit for inverter manufacturers given the importance of the systems to a plethora of key technologies. For inverter manufacturers, the credit applies per watt of alternating current (AC). They are as follows:

- Central inverter: US\$0.0025/W
- Utility inverter: US\$0.015/W
- Commercial inverters: US\$0.02/W

- Residential inverters: US\$0.065/W
- Microinverters: US\$0.11/W

Additionally, torque tubes used in racking will get US\$0.87/kg, while structural fasteners will receive US\$2.28/kg.

IRA's impact on the US' clean energy industry

The impact of the IRA is going to be felt across the US' (and indeed the world's) clean energy sector, but the biggest impact will not be felt until the end of 2023 and moving into 2024, most industry analysts agree. This is because it will take time to scale up the US manufacturing sector and current module constraints that have plagued the US' solar sector for the past two years are set to persist in the short term.

After that point, however, deployment in the US is set to skyrocket. "The impact of the IRA on deployments is gigantic," says Sylvia Leyva Martinez, Wood Mackenzie's senior analyst for North American utilityscale solar.

"We estimate that the IRA will increase utility-scale developments by 83% (200GW) over the next ten years compared to a scenario without the tax credit extension," she tells *PV Tech*. "This is driven mainly by the added certainty of having a ten-year extension of the ITC (at least), but also the expansion to PTC and transferability options."

BNEF expects the IRA to boost solar build by 63GW and storage by 20GW/78GWh between 2022 and 2030. Broken down by sector, it is predicting the additional deployment because of the IRA tax credit extensions (and high power prices) to be distributed pretty evenly between 2022 and 2030 across utilityscale (49GW more build, a 22% increase compared with previous forecast), residential (10GW more build, 18% increase) and commercial (4.8GW more build, 20% increase), according to Lezcano.

Moreover, the combination of domestic content adders and advanced manufacturing production tax credits are expected not only to develop the US solar supply chain, but mitigate the impact of potential changes in trade policy, such as the ones experienced since 2021, Leyva Martinez says.

Trade association the American Council of Renewable Energy (ACORE) laid it out for *PV Tech Power* in financial terms. "We project that investments in renewable generation and enabling technologies will accelerate from the current US\$50-US\$60 billion annually to US\$90-US\$100 billion annually, which is more in line with our national climate goals," said its president and CEO Gregory Wetstone.

Wetstone said, however, that achieving the US' long-term emission reduction targets "will require additional steps beyond the pivotal gains we will see from incentives".

One of the main objectives of the IRA was to onshore more PV production to the US and analysts are predicting a significant buildout of the country's module

"If the government allows the transfer of tax credits to be a little cumbersome, they could radically change the project finance dynamics"

production capacity by 2030. Since the announcement of the IRA alone, around 20GW of new module capacity has been announced, according to BNEF.

A recent analysis by the Solar Energy Industries Association revealed that the passage of the IRA will accelerate the buildout of large-scale manufacturing facilities, likely to commence as soon as next year. The trade body predicts the US will have over 10GW of module manufacturing capacity by 2024, and over 30GW of capacity by 2025.

But Lezcano reminds us that forecasting module manufacturing capacity is extremely difficult due to the "too many unknowns", including if "you believe the construction timelines and capex shared by the manufacturer". Readers should be wary of forecasts that do not bake in contingencies and unforeseen economic shocks. There is also still a great deal of uncertainty regarding certain aspects of the IRA, as previously mentioned, which may temper manufacturing forecasts.

Significant uncertainties remain

These legal uncertainties are regarding precisely how the IRA will be implemented by US authorities. "In general, the entire implementation of the IRA remains uncertain," noted Leyva Martinez, adding big question marks were hanging over the exact requirements to access adders, such as how to qualify for the energy community adders and the details on how transferability will work.

"I think the tax credit transferability is the most important aspect that needs clarification. If the government allows the transfer of tax credits to be a little cumbersome, they could radically change the project finance dynamics in the US and remove the main bottleneck, which is tax equity," Lezcano noted.

Carl Fleming, partner at law firm McDermott Will & Emery, renewable energy lawyer and former White House energy advisor, has been working on several IRA-related cases for clients. He says cases can generally be grouped into three buckets: transactions that can happen now with no more clarity needed, transactions that can occur now but may need to wait for funding and those that are transactable at all.

For example, Fleming says he was working on a couple of deals relating to energy communities where the requirements were clear enough to be certain support could be accessed. But in other areas, things are less clear. He called the domestic content adder "the most transformative aspect of the IRA" but said it was "too vague" in its current form, urging the Internal Revenue Service (IRS) to clarify the rules and simplify the wording.

The IRS initiated a consultation period that ended on 4 November, which Fleming said would likely help clear up some of the uncertainty, adding that the IRS had historically been "receptive to commercial feedback". Given the sheer volume of comments, Fleming said it would be remarkable if any added clarity was provided before the end of Q1 2023.

For now, companies should be making preparations by getting financing commitments and contingent funding ready for when clarity comes, Fleming advised. Otherwise, they risk playing catch-up on early movers when more information is provided, with this risk compounded by the increased strain on the IRS as a result of massively increased requests.

While the IRA is a significant boon for the US solar sector, it is by no means the complete solution. Added clarity and guidance on its provisions need to be provided soon in order to maximise the benefits it is expected to bring in 2023 and onwards. It has previously been described as the "best chance the US has" and a "game changer" for the country's solar sector, and all stakeholders will need to work together to bring this about.

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74 NEWS

The latest news from the world of energy storage.

- 76-77 Three V2G/V2X projects getting around major challenges of consumer vehicle space Cameron Murray talks to three companies taking a practical approach to scaling their vehicle-to-grid and vehicle-to-building offerings.
- 78-80 Second life energy storage firms position themselves ahead of EV battery boom Using batteries from electric vehicles in energy storage systems can provide a potentially lowcost way to sidestep supply chain bottlenecks, writes Cameron Murray.

81-83 Southeast Asia's emerging energy storage opportunities

Amid an uptick in energy storage investment in Southeast Asia, Andy Colthorpe speaks with the companies working to gain a foothold in the region.

84-88 European energy strategy must reconcile the need for flexibility

By Julian Jansen and Lars Stephan of Fluence.



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Introduction



Welcome to the latest edition of 'Storage & Smart Power', brought to you each quarter by the team at *Energy-Storage.news*.

What a year it's been. I think it's fair to say we never returned to the pre-pandemic normality we'd promised ourselves, and three years on, it's still not clear what the "new normal" was that people spoke about in COVID-19's early days.

Instead, unpredictable and turbulent global and national political happenings have been replaced by other unpredictable and turbulent happenings. Some of them good, some of them not-so-good and their impact on the clean energy industry has been equally difficult to predict.

In the corner marked 'good things,' we see the US passing of the Inflation Reduction Act (IRA) and the expected uplift it will bring to energy storage deployments while supporting domestic value chain development.

We've seen some major projects announced and going online around the world, from the completion of a 196MWh project in England which is Europe's biggest BESS to date, to the commissioning of the world's first flow battery in the hundred-megawatt class, in China.

Investment activity in the sector is livelier than it has ever been, and this could be the year we saw the first contracts signed that signal the coming dawn of the long-duration energy storage age.

Yet 2022 has of course had its share of bad news too. Supply chain constraints continue to be a source of headaches for the industry, felt most keenly in battery cells but seen elsewhere with some projects stalled due to lack of available transformers, for example.

There have also been a couple of high-profile safety incidents or performance issues at some of the world's newest and highest profile battery storage projects, which harms confidence in the industry.

Perhaps the biggest disappointment was COP27, which took place almost completely away from the focus of the world's media, in stark contrast to the seemingly buoyant mood around the previous edition. The agreement to form a Loss and Damage fund for climate-vulnerable countries was reached, but this seems to have been the only real consensus decision to emerge.

Even so, the clean energy industry is an optimistic one, based on effecting positive change. In response to perhaps the biggest bad news story of this year – Russia's invasion of Ukraine – the European Union is attempting to seize the opportunity to decarbonise while decoupling from Russian fuel imports.

However, REPowerEU, the EU's strategy, went big on renewables while including only passing mention of energy storage. In a contributed article to this edition, Julian Jansen and Lars Stephan of Fluence outline a set of policy proposals that Europe could use to ensure energy storage and other flexibility technologies get a fair chance to contribute to its energy transition (p.84).

It's certainly been an interesting year for technologies. We've seen synergies between the electric vehicle and energy storage revolutions for some time, with the most obvious example being the shared reliance on lithium batteries.

In a special two-part feature article (p.76), *Energy-Storage. news* writer Cameron Murray focuses on two further areas of synergy: the repurposing of used EV batteries as second life BESS, and how vehicle-to-X companies are creating business models to bypass early consumer reluctance.

Finally, it's always encouraging to see new markets emerge around the world and in my feature article this time out I speak with companies looking to help create a sustainable energy storage market for Southeast Asia (p.81).

With all of that in mind, I think it's fair to say 2022 has been challenging for many, but perhaps one that we might look back on positively as a turning point, in years to come.

Andy Colthorpe Solar Media



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BloombergNEF upgrades global deployment forecasts

Recent policy developments in the US and European Union (EU) represent a considerable uplift to the prospects for global energy storage deployment, according to Bloomberg-NEF.

In issuing its latest analysis of the sector, the firm has forecast that by the end of 2030, cumulative installations worldwide will reach 411GW and 1,194GWh. That's considerably higher than BloombergNEF predicted in November 2021, when its forecast stood at 358GW/1,028GWh of cumulative installs by the end of the decade.

Even at that time, the analysis group highlighted that it expected the 2020s to be "the energy storage decade" and its most recent forecasts appear to strongly reinforce that message.

Canada introduces 30% refundable investment tax credits for energy storage

Canada's government will introduce tax incentives for clean energy technologies, including solar PV, battery storage, and hydrogen. Announced as part of Canada's Fall Economic Statement 2022, the move has already been welcomed by renewable energy, energy storage and manufacturing trade groups.

The government proposes to introduce a refundable tax credit equivalent to 30% of the cost of capital investment into electricity generation systems, stationary electricity storage systems, low-carbon heat equipment and industrial zero-emissions vehicles and related charging or refueling equipment. Projects that do not meet requirements on local labour conditions will get a 10% reduction in the minimum tax credit rate

Ontario targets 2,500MW energy storage procurements

The government of Ontario, Canada, has ordered the procurement of at least 1,500MW and up to 2,500MW of energy storage.

The government looks to ensure electricity supply is sufficient and reliable as demand is forecast to increase significantly over the next few years as the province's population grows.

While Ontario operates on a surplus of electricity resources and has been forecast to be able to do so until at least 2025, according to modelling by the Ontario Independent Electricity System Operator after that date the margins become thinner.

A total 4,000MW of new electricity supply will be procured, and within that sits the energy storage target, alongside a planned 1,500MW of new natural gas generation.

BlackRock buys US battery storage developer Jupiter Power

BlackRock has acquired US battery energy storage developer Jupiter Power. The largest asset management firm in the world, with around US\$10 trillion under management, has agreed to buy Jupiter through its BlackRock Alternatives arm.

The selling parties are EnCap's EnCap Energy Transition Fund I (EETF I) and co-investors Yorktown Partners and Mercuria Energy. The transaction should close in late 2022 and will see Jupiter become part of a fund managed by BlackRock's Diversified Infrastructure business.

Founded in 2017, Jupiter only started commissioning battery storage projects last year but has quickly built up a 11,000MW development pipeline including 655MWh of operational projects in the ERCOT, Texas market, making it the largest player there. It also has 340MWh of projects in or 'near' construction including its first in California.

US\$1 billion financing closed for world's largest solar-plus-storage project

Developer Terra-Gen has closed US\$969 million in project financing for the second phase of Edwards Sanborn Solar-plus-Storage facility in California, which will bring it to 3,291MWh of energy storage capacity.

The \$959 million financing comprises a US\$460 million construction and term loan facility and a US\$96 million construction and revolving letter of credit facility, led by BNP Paribas, CoBank, ING, and Nomura Securities, as well as a US\$403 million tax equity bridge facility from U.S. Bank.



A portion of Terra-Gen's Edwards Sanborn project. The Edwards Sanborn Solar-plus-Storage facility in Kern County will total 755MW of solar PV alongside the battery energy storage when the second phase comes online over Q3 and Q4 2022 and Q3 2023. It combines both stand-alone battery storage and batteries which charge from the PV. The first phase came online late last year

Fluence building 250MW 'Grid Booster' battery storage system for German TSO

Fluence will deploy a 250MW/250MWh 'Grid Booster' battery energy storage system for transmission system operator (TSO) TransnetBW, one of two such projects planned in Germany.

The BESS, called a Netzbooster in German, will be built in the state of Badden-Wurttemberg. It is set to be completed in 2025.

The Grid Booster will be built as a strategic network node along a transmission line and operated to inject or absorb power into the line in a way that mimics transmission flow lines. This will allow TransnetBW to forego installing extra transmission infrastructure lines, which would be more costly, have a larger footprint, and take longer to do.

It will allow the existing transmission infrastructure to be operated more efficiently by, for example, lowering the need for preventive redispatch measures and conventional network reinforcements and operating costs.



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Three V2G/V2X projects getting around major challenges of consumer vehicle space

V2G | Electric vehicles are batteries on wheels, and often with quite large batteries too. Bidirectional charging means vehicle-to-grid and vehicle-to-building are technologically feasible, but barriers to adoption include manufacturer warranties and customer acquisition. Cameron Murray meets three companies taking a practical approach to scaling their V2X propositions.

Pehicle-to-grid (V2G) or vehicle-toeverything (V2X) technology has the potential to massively boost the amount of flexible capacity on the grid or behind-the-meter, considering the number of EVs set to arrive on roads in the coming years. The 623,000 EVs sold in the US in 2021 equates to at least 25GWh of potential energy storage, based on an average battery size of 40kWh (which is growing).

But major challenges to scaling up the technology, which combines EV batteries, bidirectional charging and smart software, exist in the consumer vehicle space. In this article, we interview three companies launching V2G/V2X projects in the US and Canada that provide alternative use cases not beset by those challenges.

SWTCH: 'EV charging with added value'

Canada-based SWTCH provides bespoke EV charging infrastructure solutions in the consumer space, including V2G technology, but CEO Carter Li is sceptical of how far the technology can be used on a daily basis.

"It's not every day that a user thinks 'I want to discharge my energy today'. End-users' main focus is on charging their vehicle and might participate in V2G if there is a way to make money off that once in a while, so we offer EV charging with the potential for revenue and valueadds rather than a straight V2G service. End-users worry about how much their range will be reduced by daily participation," he tells PV Tech Power.

SWTCH recently partnered with condo developer Tridel and e-bike and EV car share company Kite Mobility to install Canada's first multi-residential V2G EV



Highland provides turnkey bus electrification with V2G wrapped into the service.

'mage: Highland Electric Fleets.

charger at a residential block in Toronto.

The pilot will allow the building to draw energy from EVs during demand response programmes which Li says occur in the order of 5-20 times a year, and will allow SWTCH to get around one of the main challenges with consumer EV V2G/X.

Li explains: "The project answers the challenge of making sure that the vehicles are actually plugged in when they're needed. If the building operator violates the demand response contract with the utility, they get a massive fine."

"We're using shared mobility vehicles that people book with a reservation system. So we can make sure that the vehicle is not reservable in the period when the curtailment event is going to occur. So, it's an interesting example of creating a reliable use case in a setting where it is not normally reliable, because they are end-consumers."

Li adds that backup power is another potential low-hanging fruit use case for V2G technology.

For now, he says that it only makes sense to discharge from a consumer EV during the sporadic demand response periods throughout the year: "The return of participating on a daily basis through peak shaving etc does not increase dramatically on top of those 5-20 most lucrative demand response periods in the year. And it also means you have to think more about battery degradation."

The move towards more frequent discharge events which are more lucrative than peak shaving, like frequency response and voltage regulation, would need more data points around how they affect battery life cycles, and perhaps an improvement in battery chemistry itself, he says.

The Mobility House: 'Vehicle-tobuilding resiliency'

As discussed previously by *Energy-Storage*. *news*, buses are a great use case for V2G and V2X. A project in the city of Oakland in California, US, will see stored energy from AC Transit's electric buses provide backup power to the West Oakland Branch of the Oakland Public Library.

The California Energy Commissionfunded project aims to demonstrate the value of bidirectional EV charging to create a 'vehicle-to-building (V2B) resilience hub'.

Germany-headquartered firm The Mobility House will provide its Charge-Pilot software to optimise the charge and discharge of the bus batteries when parked at the library and manage their powering of the building. The project will be up and running by mid-2023 and will run for two years.

Sarah Woogen, The Mobility House's Head of USA Operations & Analytics, tells PV Tech Power that the bus batteries will allow the library to act as a safe space for the Oakland community during public safety power shutoffs (PSPSs) and rolling blackouts, with a recently upgraded HVAC and air filtration system.

Extra use cases through V2G could happen too, even within the project's two-year timeline, Woogen added: "It could, depending on the timeline. V2G can be a little more complicated to set up initially because it requires additional permitting and interconnection, but all the hardware is there."

"The chargers are Rule 21 compliant which means they can export into California's grid under certain programmes being developed."

The Mobility House focuses on fleet vehicles like transit, school or commercial fleets. Woogen explains why these can be good use cases for V2X/V2G.

"You might have a lower barrier to entry because you don't have to sign up each individual vehicle. Within the fleet space, a lot is happening with school buses since a lot of them are already bidirectionally capable, as that was part of the requirements for certain funding schemes over the last few years."

"They also have large batteries and have a lot of downtime, notably during those peaks at 5 pm when all the kids are already back from school."

The Oakland project, on the other hand, uses public transit buses instead and while these are at an earlier stage of V2G/ V2X adoption than school buses, Woogen expects this to grow in the coming years. "Public transit is not talked about as often but we're going to prove that out with projects like these. Though they run a lot more than school buses, they have enough dwell time that they could provide V2G/V2X. And their batteries are even larger, 1.5-2x bigger than school buses', so there are opportunities for these fleets to be making revenues this way," she adds.

Highland Electric Fleets: 'Electric school buses as energy assets'

Massachusetts-based Highland Electric Fleets is one of those companies capitalising on school buses' unique potential for V2G/X. The firm offers school bus electrification solutions under an annual mileage payment, into which it wraps V2G functionality, for which it currently works with aggregation partners to manage.

"School bus lives are predictable and so can be used as energy assets for the grid really effectively," explains Sean Leach, the firm's director of technology and platform management.

"And the grid's need is highest in summer when the buses are doing nothing most of the time. We can have the bus participate in those grid programmes which then keeps the contract cost with the end-user as low as possible."

The main V2G use case of Highland's fleet of electric buses is to provide energy to the grid for peak events. This is where grid operators will specify in advance a specific time period of the day, which normally comes well after the school home run, in which it wants the firm to discharge the bus batteries.

The firm has had its electric buses active in commercial V2G for two years during which it has discharged around 10MWh back to the grid, Leach said. A project in Beverly, Massachusetts, with two Proterra Powered battery system-enabled school buses accounts for the bulk of this.

Those vehicles participated in 32 grid events over this past summer, providing power to grid operator National Grid, with the discharges typically requested 24 hours in advance.

Another project launched in August saw four new electric buses join the South Burlington (Vermont) school district which will provide power to utility Green Mountain Power (GMP).

Asked if the summertime period offered the potential to expand the variety of use cases beyond scheduled grid events, i.e., to value-stack, Leach says:



SWTCH provides EV charging solutions with V2G as an optional value-add, but CEO Carter Li is sceptical of how far it can go in the consumer space.

"We still tend to just react to those peak events. However, with Green Mountain Power we'll be able to react to much narrower window events, i.e., unexpected peaks. Sometimes you only get a 10- or 15-minute signal, and we can react to that."

"For the future, there's the potential for frequency regulation. While we're not participating in any of those markets yet, there will be an opportunity for that at some point. Resiliency is another thing that we're looking at, which could be using bus batteries in the event of a grid outage."

Interestingly, that is exactly the use case of The Mobility House's project covered in the previous section.

The main challenge and slowdown with getting these programmes rolled out is that utilities are still trying to figure out how to pay people for the power coming back to the grid, Leach said, adding: "But all of them recognise the value of these EVs as essentially giant mobile batteries that they can call on for support."

Discussing battery degradation from V2G/X and how that affects battery warranties, Leach says that OEMs are in general not too worried.

"As long as you stay inside the warranty's specific maximum throughput of a pack, be it driving or V2G/X, they're okay with it. The discharges required for V2G are not as strenuous as an actual drive with a bus full of kids on a hot day going up and down hills."

In October, Highland and the Montgomery County Public Schools district in Maryland announced a four-year deal for Highland to provide 326 electric buses, which will all be V2G-enabled and equate to 65MWh of energy storage. The company today has around 20MWh of energy storage capacity available through around 100 V2G-enabled buses on the road.

Second life energy storage firms position themselves ahead of EV battery boom

Reuse | Batteries from electric vehicles can find a 'second life' in energy storage systems, making more use of these valuable devices, and offering a potentially low-cost way to sidestep supply chain bottlenecks. Cameron Murray meets some of the companies harnessing used automotive batteries to play a part in the energy transition even without wheels.

he shortage of lithium-ion battery cells continues to hamper the stationary energy storage system (ESS) industry, and the mismatch in supply and demand does not look like going away anytime soon. That means the value proposition of repurposing used electric vehicle (EV) batteries into ESS units is as clear as day.

In this article we interview four companies doing this; BatteryLoop (Sweden), Octave (Belgium), Evyon (Norway) and Moment Energy (Canada), while touching on others that have previously spoken to PV Tech Power.

Big volumes of second life EV batteries are expected to become available for this starting from 2025 and with up to 227GWh hitting the market by 2030, according to McKinsey, the potential is huge. That figure would exceed the expected demand for utility-scale lithium-ion ESS by that point.

But the deployment of such second-life systems is at a very nascent stage, and the majority of operational systems use relatively new battery cells rather than ones with a few years of EV activity behind them.

While overall global cumulative battery energy storage deployments are somewhere in the low double-digit gigawatts (GW), operational second-life systems outside of China probably only total a few hundred megawatts (MW) at the very most, based on the number and scale of announced projects.

Supply of battery modules

As mentioned, most battery modules which are in today's operational second life ESS units are relatively unused. These include battery modules from test vehicles, manufacturing process breakage which means the battery is not suitable for an EV but fine for ESS, and cases of oversupply. But the portion of systems which are made up of actual second life modules is growing.

In the case of newer batteries, second life ESS companies can offer similar 10-year warranties to regular ESS ones. For used batteries bespoke warranty or service agreements may need to be formulated, although sophisticated monitoring and control algorithms can mean similar warranties to first life are possible.

Companies can buy modules directly from OEMs, and Renault, Nissan and Mercedes-Benz seem to be leaders in selling to second-life solution companies. Batteries can also be bought from battery recyclers' marketplaces but it's a highly illiquid market with obscure pricing dynamics for now.

"There is a trade-off in terms of remaining lifetime of the batteries and the purchase price: a battery module with a lower state of health is cheaper but will have to be replaced more often," says Maxime Snick, co-founder and general manager of Octave.

Because of the variability in battery module size, companies need to have a fairly flexible architecture platform to design new systems when a new module type comes in with enough volumes to build a new product - a system typically needs a homogeneous set of modules.

BatteryLoop has secured used batteries from electric trucks and built an architecture around that while another firm, Germanybased Tricera, has built systems using electric forklift batteries.

Customers and use cases

With the size of the systems that these companies offer generally in the few hundreds of kWh, their main deployments to-date have been in the commercial and industrial (C&I) segment. All four mentioned a focus on deploying systems to optimise



BatteryLoop's energy storage system. PV and EV charging as well as the obvious behind-the-meter C&I use cases like peak shaving.

Both Nordic firms cited commercial real estate owners and developers as typical end-users, with Evyon's chief commercial officer (COO) Ralph Groen adding that construction sites are now a big opportunity too. A requirement by 2025 in Norway for emissions-free construction in major cities means big demand for on-site chargers for electrical machinery and vehicles, and the company sells its units to firms building those charging solutions.

Moment Energy's main projects to-date have been at a scuba resort, a few off-grid residential deployments and upcoming off-grid projects with the respective departments of defence in the US, Canada and New Zealand.

All four companies are moving into the grid-connected or grid-scale market in different ways.

Utility Ottawa Hydro intends to purchase 480kWh of Moment's systems for the firm to deploy in different neighbourhoods to prevent the grid being overwhelmed by an increase in EV charging loads.

Bergström says BatteryLoop is starting to focus on working with energy companies

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or big industrial sites to provide frequency services, energy trading and grid support. "There's increasingly more and more

"There's increasingly more and more renewable energy in the generation mix so there's more opportunities here," he says.

Groen mentioned arbitrage/energy trading as another use case of its systems while Snick says that Octave has put some of its systems into a virtual power plant (VPP) which provides flexibility services to the grid operator.

Drivers of demand

The demand drivers for energy storage more broadly will be well-known to readers of PV Tech Power and other Solar Media titles. An increasing demand for flexibility services and load shifting of intermittent renewable energy grows on the utility-scale side, and a desire to reduce electricity bills through peak shaving and optimise selfgeneration or EV charging on the C&I and residential end.

For second life ESS solutions specifically, sustainability is a big one. Groen says that it is becoming more and more of a driver for C&I customers and project proposals are now scored on their supply chain circularity, from 1-10.

Bergström similarly says that second life battery systems help real estate owners get more points in assessments for Leadership Energy and Environmental Design (LEED), a certification for how environmentally friendly a building is, which can then open up green financing opportunities.

The costs of second life ESS solutions are also more-or-less at parity with first life ones. "The same for NMC batteries, a bit higher when it comes to LFP," adds Bergström.

Design and software provider to fully integrated manufacturer

It being a relatively new market, these companies vary greatly in what parts of the process they do in-house versus contracting out, but all take charge of the module procurement and design of the ESS unit. Octave's first battery system installation, at a waste incinerator site.

Nissan's LEAF

of the leaders

third-party

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in working with

second life ESS

electric vehicle. The firm is one Moment Energy claims to be the biggest player doing second life ESS solutions in North America and has its own 15,000 square foot facility that tests modules and assembles them into enclosures (including any initial disassembly).

"We're fully vertically integrated. The only thing we outsource is sheet metal bending of the frames and enclosures," CEO Edward Chiang says.

BatteryLoop meanwhile outsources the production of its units but does the installation and system integration with adjacent technologies (PV, EV charging etc) as well as grid connection. Octave and UK-based Connected Energy subcontract out their production and system integration.

CEO Rasmus Bergström explains BatteryLoop's approach: "We are software people, and it becomes more complicated with unions if we have our own blue-collar employees. We prefer to steer production, which takes place in Sweden and to a lesser extent Germany."

There's also variability in the extent to which the companies develop their own battery management systems (BMS) and energy management systems (EMS) to wrap around the offer of their physical product.

Despite being the smallest outfit interviewed for this report, Octave has developed both in-house BMS and EMS platforms and is putting a lot of effort into developing sophisticated models for combining its ESS with on-site EV charging.

Moment Energy, the only one to have its own manufacturing facility, has its own BMS but does not provide an EMS. Octave and Connected Energy offer microgrid controls to integrate their ESS with other power loads/sources.

Chiang: "We will work with any EMS platform. It's a crowded market already so we chose not to focus on that."

Connected Energy CEO Matthew Lumsden described its bespoke BMS as its 'secret sauce', Evyon uses a master BMS from a 'leading European provider' while



BatteryLoop buys its modules with attached BMS, on top of which it builds a multi-string and battery controller.

Outsourcing of production should not come as a surprise, considering the world's largest battery energy storage system (BESS) technology provider Fluence also uses third-party manufacturing to build its modular product.

Money raised and deployment targets

Moment Energy has a project pipeline of over 20MWh projects but, like BatteryLoop, could deploy 100MWh based on its battery volumes if it had enough manufacturing capacity, Chiang says. It has raised US\$9 million in seed funding and an additional US\$7-15 million in funding is on its way by the end of the year.

Evyon has raised over €10 million to-date and has secured access to 40MWh of battery modules for delivery to customers during 2023, Groen says. Octave for its part is targeting 7MWh of deployments over the next 12 months.

Bergström wouldn't disclose Battery-Loop's near-term deployment targets, only saying that the order book is 10 times larger than a year ago. The company is part of big recycling firm Stena.

Major challenges

So, what are the challenges for these companies? As with 'first life' BESS solution companies, supply chain and scaling are the main things that come up.

"Our main challenge right now is just being able to scale up manufacturing fast enough, and getting the UL 1974 certification, which is just a matter of time," Chiang says.

"My headache on the supply chain is the ingoing material for electrical cabinets and general components," Bergström says. "I have the battery volumes to deploy 100MW today, but I don't have the capacity in terms of the size of my company."

Snick similarly says that it is the supply of the surrounding electronic equipment needed for an enclosure that is the bottleneck, not the battery modules themselves.

All to play for as a huge opportunity looms

The second life market looks set to boom in the coming years as EV uptake grows. But it is still taking shape so it will be fascinating to see what roles OEMs, battery recycling firms and system integrators carve out for themselves in the space.

Southeast Asia's emerging energy storage opportunities

Southeast Asia | There has been an uptick in energy storage investment in Southeast Asia, a region still largely powered by coal and experiencing high growth in population and energy demand. Andy Colthorpe speaks with companies working to establish a framework of opportunities in the region.



Imost all Southeast Asian countries have experienced a doubling of their GDP since the turn of the millennium and seen their energy demand increase by around 3% every year in that time, according to the International Energy Agency (IEA).

The IEA's 2022 Southeast Asia Energy Outlook reported that under stated policies by the ten countries in the ASEAN region, three-quarters of that increasing demand will be met with fossil fuels, leading to a 35% increase in CO2 emissions.

However, with six of those countries now committed to a future net zero target date, renewable energy buildout is set to accelerate. In a scenario where global warming is restricted to "well below 2°C" within the aims of the Paris Agreement, Southeast Asia countries must deploy around 21GW of renewable energy each year to 2030 and about a quarter of cars sold must be electric vehicles (EVs).

Under that Sustainable Development Scenario (SDS), wind and solar PV reach an 18% share of generation by 2030 and 44% by 2050. To integrate these higher shares at lowest cost and balance the system flexibly, that could equate to a need for about 45GW of energy storage.

'Very big need for energy storage systems'

"For all of these countries, we see that there is going to be a very big need for energy storage systems," Frederic Carron, VP for the Middle East and Asia region at Wärtsilä Energy.

"Most people have a feeling that yes, energy storage is going to be part of the solution, but they don't know exactly what benefit it is going to provide in terms of emission reduction, plus also in terms of overall system cost benefit."

Wärtsilä has delivered a number of projects in the region, including Singapore's first-ever pilot grid-scale battery energy storage system (BESS) and several large-scale projects in the Philippines, building on the company's existing presence as a provider of flexible engine power plant solutions. The Philippines' first large-scale solar-plus-storage hybrid (pictured), was commissioned this year. Wärtsilä is also among the international players to have been awarded projects in Taiwan, not one of the ASEAN countries, but often included in considerations of the Southeast Asia region.

In studies of its own, Wärtsilä modelled the power systems of three key ASEAN countries, the Philippines, Vietnam and Indonesia. Wärtsilä inputs the targeted net zero date as well as the current power generation portfolio in place for a territory in its power system studies.

"The software helps you understand what the optimal power generation assets are to be added to the system by 2050, to at the same time reach the decarbonisation target, plus also at the lowest power system cost," Carron says.

For example, Luzon, the largest and most populous island of the Philippines, would only reach 26% renewable energy by 2030 and 34% by 2040, under a national Power Development Plan. That's far short of the 35% and 50% called for by the Philippines' National Renewable Energy Program 2020-2040. As well as faster buildout of renewable energy, Luzon will need about 6GW of energy storage, according to Wärtsilä's study.

Similarly, the central Indonesian island of Sulawesi, home to the 7% of the country's power demand but about 41% of its power generation capacity – mainly from coal – will need about 20.9GW of renewable energy to meet a government mandate for 51.6% of total electricity generation to come from renewables by 2030. Wärtsilä found that about 14GW of energy storage will likely be needed in Sulawesi.

While Indonesia has set a 2060 net zero target date and the Philippines is yet to introduce one, Vietnam is aiming for 2050. The country has already gone beyond the 20% renewable energy threshold, largely thanks to a solar feed-in tariff that drove about 15GW of instalments from 2020, equivalent to about three years of typical solar deployment for the whole ASEAN region.

Wärtsilä said in its power system study that Vietnam needs about 7GW of balancing capacity that could be provided by flexible engine power plants by 2030, and about 1GW of energy storage by 2035.

"Because each country has different access, for instance, to natural resources, to fuels, they are starting from different points. But what's interesting to see is in all the three cases, and we can even extrapolate to most of the countries in the world, the path to net zero is always going to be the same," Frederic Carron says, starting with the addition of renewable energy and continuing with the addition of flexibility resources like energy storage, with some reliance on gas or other fuels for balancing in-between.

So how has the market progressed so far? There has been a real "uptick in investments" in the past couple of years, George Garbandic, principal consultant and energy storage lead for DNV in the APAC region, says.

DNV entered the region about eight years ago as an "exploratory presence" and focused on market-making activities. An unknown field at the time, the market lacked investment funds, developers and off-takers making a concerted effort to get into energy storage.

"The real uptick in investments into BESS projects, I'm talking about real commercial projects with solid financial fundamentals, came about three to four years ago and in the last two years, it is going exponentially up," Garabandic says.

It's still not at the same sort of level seen in the US, in Europe, or even in Australia nearby, but year-to-year growth in the market has been "like crazy", he says. Those countries include Vietnam, Thailand, Taiwan, Philippines, Singapore, Malaysia and Indonesia. That growth is distributed quite equally throughout the region, although each country comes from a very different starting point.

Many countries in the region are now realising that decarbonisation goals can't be achieved just by installing more renewable energy capacity, Narsingh Chaudhary, executive VP and managing director for the Asia-Pacific region with Black & Veatch, says.

About two-thirds of power generation in the wider Asian continent comes from coal, but the economics of energy are changing rapidly. The price of coal in Vietnam for example has risen from about US\$50/MT in Jul 2020 to over US\$400/MT, while following the country's fast buildout of solar, many renewable power plants risk curtailment and generated energy being wasted.

What's missing?

The main market barriers are similar to what was first seen in now more mature energy storage markets – battery storage is a relatively new technology that was never factored in when it came to grid or energy capacity planning in the past.

DNV's George Garabandic says that Hokkaido in Japan, and California or Hawaii in the US are good examples of territories that have introduced energy resource planning that values the role of storage. In Hokkaido, Japan's northern island, new solar PV or wind plants must be developed with a set portion of energy storage per installed megawatt of renewables. The grid was reaching a plateau of hosting capacity for new renewable energy projects, leading regulators to create a framework that would enable more by leveraging energy storage.

"We still need a unifying and a firm grid interconnect norm, which is valid for every single large utility-scale renewable project in Vietnam, in Thailand, in Taiwan, in any one of these countries that has reached the limit for hosting capacity of renewables," Garabandic says.

"Once this is available, then potential investors will look at these new interconnect norms, that will encompass some level of dispatchability of renewables, and based on these norms, they will provide the necessary storage capability within their renewable parks and maintain compliance."

Institutional investors still not ready

A year and a half ago, at the Solar and Storage Finance Asia conference hosted by our publisher Solar Media, Alexander Lenz, CEO of Aquila Capital's APAC business said the industry should be proactive in offering input to regulators and other stakeholders in the region.

With grids in ASEAN countries dispersed around many islands and less interconnected than other parts of the world, energy storage presents an excellent opportunity to keep networks stable while integrating higher shares of solar PV and wind.

However, as Lenz said at the time, under the current regulatory environment energy storage can't generate the revenue streams to give investors certainty, and grid operators in the region need to understand how different storage applications and technologies can benefit their networks.

Aquila Capital invests in sustainable infrastructure including renewable energy on behalf of institutional investors.

"We wish we could say that the permitting and regulatory environment for renewables has massively shifted in the last 12 months, but unfortunately, we are still facing many of the same headwinds we did in ASEAN a year ago – namely a challenging permitting, regulatory and policy environment and now with the added macroeconomic pressures of rising material costs, inflation and supply chain challenges," Alexander Lenz said when approached for comment.

But despite those challenges, Lenz says he has "no doubt" battery storage will be critical to balance the load across grids and handle the intermittency of renew-



A Wärtsilä BESS project in the Philippines, completed last year. Image: Wärtsilä Energy.

able generation and is hopeful this will be the case in the ASEAN region too.

"With a surer picture of the boundary conditions around any investment or project in ASEAN, we would be more than happy to take on the required risk to build the needed battery energy storage capacity across the region," Lenz says.

Versatile technology dictates learning curve

Of course, as mentioned earlier by George Garabandic and seen in the timeline below, there has been growing energy storage activity in the region, despite this reluctance from Aquila Capital and presumably other investors.

In the Philippines, major power generation companies like SMC Global Power are building out large-scale battery storage plants at their thermal generation sites. Batteries can deliver ancillary services, which SMC and other generators are contracted to provide, faster and more precisely than thermal power plants, and they can do it without the associated emissions.

Garabandic says those power companies are in a sort of arms race with each other to increase operational efficiency of their fleets.

"They know that the battery technology is a lot more efficient way to conduct the business of ancillary services. So, it's not about selling the technology to them as a holy grail, it's about the race between themselves to make their assets be more efficient, and to get the edge over the competition."

Whereas in Thailand, Southeast Asia's biggest solar-plus-storage plant to date is being constructed with a 45MW/136.24MWh BESS. In the case of Thailand and Indonesia, neither country has energy markets, so the objective of renewable energy is not to participate in energy markets.

"Asking independent energy producers to do ancillary services in Thailand is not reasonable because they have no such thing as a tariff for ancillary services. However, in their case, the use case for energy storage is in the line of expanding the hosting capacity of the grid for renewables."

It speaks to the versatility of the technology that different countries around Southeast Asia present different market structures all unified by a common thread of aiming to increase efficiency of delivery, improve energy

Key recent Southeast Asia market developments, as reported by Energy-Storage.news:

October 2020: **Singapore's first grid-scale BESS commissioning** announced. Wärtsilä supplied a 2.4MW/2.4MWh BESS in a project supported by the EMA and utility company SP Group. The system participates in the wholesale market, helping to integrate solar onto the grid and reduce peak demand.

November 2021: **Supply contract for Southeast Asia's then-largest BESS** awarded to Sungrow. The solar PV inverter manufacturer is supplying 49MW of solar inverters and 45MW/136.24MWh BESS to renewable energy independent power producer (IPP) Super Energy for a solar-plus-storage project in Thailand.

February 2022: First large-scale solar-plus-storage project in Philippines is online, with AC Energy (ACEN), a subsidiary of holding company Ayala Group, inaugurating the 40MW/60MWh BESS pilot at a 120MW solar PV plant. ACEN said the system, in the municipality of Alaminos, Laguna, will be used by the company to evaluate more opportunities to add battery storage to its portfolio.

March 2022: **5MW BESS pilot project in Indonesia** launched by state-owned utility PLN. A Memorandum of Understanding (MoU) was signed with another state-owned group, Indonesia Battery Corporation. The pilot is aligned with PLN's strategy to reduce consumption and use of diesel at its generation sites, the company says.

May 2022: **Taiwan needs 5GW of energy storage by 2025 and 9GW by 2030** to meet renewable energy goals, says Nelson Chang, chairman of Taiwan Cement Corporation (TCC). Speaking at an AGM, Chang discussed how energy storage was an increasingly important pillar of TCC's business strategy as the cement group adjusted to a decarbonising world.

TCC acquired energy storage integrator NHOA from ENGIE in 2018 and has awarded NHOA more than 400MWh of contracts for BESS projects at TCC facilities on Taiwan.

June 2022: **Philippines solar-plus-storage project with 4,500MWh BESS proposed**. Infrastructure group Prime Infra, owned by billionaire Enrique K Razon, is developing a project which would combine between 2,500MW and 3,500MW of PV with 4,000MWh to 4,500MWh of batteries, described as a "model of dependable renewable energy" by the company.

Q2 2022: Philippines power company SMC Global Power reached the halfway point in its 1,000MW/1,000MWh rollout of BESS at its thermal power plant sites around the country. According to local news outlets, Ramon Ang, president of SMC parent company San Miguel Corporation, said 500MWh had been deployed, and 700MWh expected by the end of this year.

July 2022: **100MW/100MWh BESS project deal in Taiwan** signed by Fluence. The company's third and largest deal in Taiwan so far, targeted completion date is mid-2023.

"Taiwan has become one of the most active energy storage markets in the Asia Pacific region. The growth momentum of the energy ecosystem is driven by a clear target and objectives for renewable energy and net zero emission set by the local government," Fluence SVP and APAC region president Jan Teichmann says.

Q4 2022, **Region's biggest BESS** scheduled for commissioning as this edition went to press, Q4 2022. Singapore engineering services group Sembcorp is delivering the 200MW/200MWh project on Jurong Island, an energy and industrial park in the nation state.

The project resulted from Accelerating Energy Storage Access for Singapore (ACCESS), a programme launched in 2018 by the Singapore Electricity Market Authority (EMA).

access and add renewable energy capacity, with energy storage as a means to get there.

Black & Veatch's Narsingh Chaudhary highlights the potential for microgrids around Indonesia's and the Philippines' many islands, powered by a combination of solar PV and batteries with some diesel for backup.

Corporates with production facilities in the region too are seeing battery storage microgrids, typically with rooftop solar, as a means to meet their sustainability goals and gain long-term control over energy costs.

However, markets with scalable energy storage opportunities across the region can only come about if regulators embrace it. Black & Veatch is currently working as owner's engineer on a developer's bid to build a gigawatt-scale solar-plus-storage facility in the Philippines. While regulations in Southeast Asia are not actively holding the industry back, they are also not proactively encouraging it either, Chaudhary says.

So, is it a question of policymakers and regulators in ASEAN countries looking to more mature markets for answers? Unfortunately, says DNV's George Garabandic, that's unlikely.

"Learning from others is wishful thinking, but this is not something that we can generalise in the region. Often, I end up seeing that various jurisdictions prefer to reinvent the wheel themselves," Garabandic says.

European energy strategy must reconcile the need for flexibility

Policy & regulation | Energy storage is among a number of key technologies which can bring much-needed flexibility to electricity networks and therefore to energy markets. With Europe at an unprecedented crossroads in its energy system planning, now is the time to factor in that critical flexibility, argue Julian Jansen and Lars Stephan of Fluence.



ver the last 12 months, we have witnessed an unprecedented crisis in the European energy markets. This was caused, among others, by the war in Ukraine, the growing effects of climate change, and the unavailability of the French nuclear fleet. Europe's response to those challenges is an even faster acceleration of renewable buildout in Europe.

As we rediscover the meaning of security of supply, it is time to better understand the value of flexibility as a critical enabler of the energy transition. European policy makers need to strengthen the role of flexibility technologies, including energy storage, in future Energy Market Design.

A perfect storm

In many ways, European power markets have faced a perfect storm in 2022. Towards the end of 2021, gas prices and corresponding electricity prices came under stress because of tightening gas supplies in Europe. After the start Anti-war protestors photographed in Glasgow, Scotland, as Russia's invasion began, February 2022.

of the war in Ukraine, gas prices came under constant upwards stress driven by the uncertainty around international sanctions and Russian willingness to continue supplying Europe with gas, followed by reductions of gas volumes and, finally, the sabotage of the Nord Stream pipelines.

The European energy crisis of 2022 is not only about gas shortages, but also

about a persistent heat wave during the summer. High temperatures and droughts resulted in reduced production of conventional power plants, which were lacking cooling water, and decreasing water levels at hydro plants and reservoirs around Europe.

Several Covid-related delays of maintenance schedules at French nuclear plants and unexpected maintenance challenges at some reactors contributed to a historic low in electricity generated from the French nuclear fleet. This turned France from one of the biggest exporters of electricity to one of Europe's largest importers of electricity, further increasing the stress on European power markets.

All of the above factors led to higher

gas and electricity bills for households and businesses, bringing the social dimension of energy markets into the focus of European policy makers, and raising questions about the competitiveness of European industries and businesses.

Europe's reaction to the energy crisis

The REPowerEU Plan, published in May by the European Commission, aims to increase the target of energy generated from renewable sources to 45% by 2030, up from 40% compared to last year's targets. This would bring Europe's renewable energy generation to 1,236GW by 2030, including the installation of 320GW of new solar PV by 2025. By the middle of

The value of flexibility in the European Power System

Flexibility in the energy system is necessary to balance generation and demand in various time periods, from seconds to minutes, from hours to days and even weeks. Today, fast-ramping peaking plants, typically gas-powered Open Combustion Cycle Generators (OCCG) are often, and wrongly seen as the sole flexible asset class.

Peaking plants are defined as power generation assets that produce electricity during peak demand periods, typically evening hours, and are differentiated from base-load capacity that operates continuously. Peaking plants only operate for a limited number of hours per day or even month, doing so at a low asset capital cost and a high marginal cost due to their low efficiency. Electricity generated from these assets is typically the most expensive in the market. Their price-setting nature coupled with high gas prices caused directly drove high electricity prices currently observed in Europe.

Today's reliance and focus on gas-based peaking plants risks a carbon lock-in of generation-emitting assets and import dependency on natural gas. Gas plants cannot shift or reuse renewable electricity in a cost-effective manner. Using hydrogen as a storage medium – first using renewable electricity to produce hydrogen and to re-electrify hydrogen in H2-capable gas plants – is inefficient, not technologically mature, and not optimal for short-term flexibility needed in the current phase of the energy transition.

However, fast-ramping peaking capacity derived from various flexible technologies will be critical in the future as a corner-stone for the integration of large amounts of volatile renewable energy.

Today, surplus renewable generation (meaning renewable generation above the instantaneous load) must be stored and shifted from periods where production is higher than demand into periods where renewable generation is not sufficient to supply the full load. This can be achieved with a range of low-carbon flexibility technologies, including energy storage or demand response. However, today's reality is that instead much renewable energy is instead being curtailed, thus wasted.

The concept of energy storage as flexibility tool is not new to European power markets. Existing pumpedhydro resources in Europe already function as low-carbon peaking capacity. They reduce overall energy cost by shifting renewable electricity from daytime periods with low wholesale market prices to periods with high wholesale prices. It is critical to define policy to accelerate the integration of a new generation of flexible and low-carbon peaking capacity to meet the demands of the future energy system.

The business case of energy-shifting (or arbitrage), thus providing low-carbon peaking capacity, is based on price differentials in wholesale markets. Additional energy consumption during low price periods moves clearing prices in wholesale markets only slightly (graph - A). Moving this electricity as additional supply into high price periods has a strong effect on dampening prices during those periods, as it replaces high-cost peaking plants (graph - B). As the lower clearing prices apply to all energy traded in each period, arbitrage operations of flexibility assets result in overall system optimization and lower the cost of electricity for all consumers. In the long term, high shares of volatile renewable generation will drive intra-day volatility further, with the effects of REPowerEU accelerating this development.



the decade, this would result in cumulative solar capacity surpassing electricity demand in several European countries.

The REPowerEU plan is widely received as an important step by energy industry stakeholders, but it has also left some important questions unanswered. Discussed between energy experts, but largely invisible to the general public, is the need to upgrade power networks and interconnectivity between markets in Europe. While pivotal, it is not only a huge investment challenge, but also hindered by slow planning cycles and resistance against new infrastructure.

The other major question is how to safely integrate the increasing shares of fluctuating renewable energy into the European power system and market, and aligning it with the load profiles of industry and consumers. Energy storage, demand response and other flexible technologies are ready to address the needs, but the need and their value remain underestimated.

In July 2022, the CEOs of several businesses and organisations with decades-long experience in building and supporting energy markets brought the above issues to the European Commission. The open letter that was co-signed by 28 companies, including major energy companies, technology suppliers (including Fluence), IPPs and associations calling on the European Commission to bolster the REPowerEU Plan with adequate targets and policy frameworks for the deployment of energy storage and other flexibility technologies.

To this end, battery-based energy storage is a quickly deployed, costeffective, and low-emissions solution with the potential to become a backbone of modern, resilient, and decarbonised energy systems. Other technologies, such as demand side response (DSR), the improved utilisation of existing storage potential of pumped hydroelectric and other energy storage technologies, as well as the interconnectivity between national electricity markets, are all critical to enabling the European energy transition.

Despite having access to this ready-todeploy and cost-effective technology, we continue to rely on high-emission natural gas-based generation for flexibility needs in European power markets, while the Europe-wide targets that would strategically scale up energy storage projects are yet to be developed and embedded in law.

The investment challenge for energy storage as clean peaking capacity

In Europe, industry experts see the REPowerEU Plan and the current higher energy prices as a major accelerator for energy storage. Market intelligence providers have roughly doubled their forecasts for the energy storage buildout until 2030 to above 80GW. member states to reduce energy bills for consumers.

In the medium- to long-term the European Commission is prioritising the accelerated build-out of renewable generation. To integrate higher levels of renewable energy into energy markets, regulators are working on a proposal to restructure European Electricity Market Design. The European Commission aims to



Despite positive outlook, the business case of flexible assets has limitations for investors. They are fully merchant, and the investment case depends on forecasted wholesale market volatility. Without longterm revenue security, such assets are less bankable. This reduces access to low-cost capital funding for developers and owners of flexibility assets. Reducing revenue risk for flexibility assets will attract broader investments, reducing the cost of and increasing availability of capital. Without such levels of investment, there will be insufficient flexibility to integrate the increasing amount of renewable energy in our power system.

Reducing investment risk and, thereby, revenue risk for assets in our electricity system is not a new mechanism. Renewable generation assets benefit from feed-in-tariffs, renewable obligations or Contracts-for-Difference (CfD). Similarly, many European member states have Capacity Markets, remunerating the buildout of reliable capacity in power markets. These schemes address and guarantee decarbonisation and security supply – which are central to European energy markets.

Creating Electricity Market Design fit for the energy transition

In response to the energy crisis, the European Commission has taken a number of steps to stabilise the cost of electricity in the short term, including the introduction of price caps (on some generation technologies) in wholesale markets and mechanisms to allow develop a merit-order mechanism, under which wholesale markets operate, ensuring the low cost of renewable electricity filters through to consumers.

Rethinking European Electricity Market Design also opens the opportunity to rethink the role of flexibility in electricity markets. Failing to prepare for the buildout of flexibility technologies and grid infrastructure to match the pace of the roll out of renewables will result in increased congestion on power grids, curtailment of renewable generation, continued CO2 emissions from the power sector, and higher costs to consumers. At the same time, flexibility assets create opportunity to increase the efficiency of our power system, and ultimately lower cost to consumers. The question we need to answer now is: how to incentivise investment into flexible assets to enable this?

Recognising the need for Flexibility as part of the Electricity Market

In October 2022, Fluence launched a policy whitepaper with dedicated proposals for the European Electricity Market Design, that would establish market mechanism around the need for flexibility. The proposals could help create a market environment with stronger investment certainty for flexibility assets to foster renewable integration and reduce emissions in the power sector.

- The policy proposal focusses on: 1) Reforming and decarbonising the
- capacity mechanism
- 2) Incentivising flexible and low-carbon peaking capacity

Decarbonising the Capacity Market

The Capacity Market or Capacity Mechanism (CM) is an integral part of European Electricity Market Design as a temporary measure to ensure the necessary means of resource adequacy in national electricity markets. Security of supply has become a critical area of focus during the current energy crisis.

As renewable penetration increases, CM design should prevent an unsustainable lock-in effect of carbon intensive thermal generation assets. Otherwise, Europe will fail to meet emission reduction targets. We therefore propose three key changes to the CM:

- 1) Decreasing the existing carbon cap over time
- 2) Linking CM payments to carbon intensity
- Providing longer contracts for new-build low-carbon assets The three proposed changes will

provide a clear path to owners and operators of existing CM assets as well as clear investment signals for new-build capacity to accelerate the decarbonisation of CM across Europe.

1) Decreasing the existing carbon emission limits in CM over time

In Article 22 (4), the current CM design includes a carbon emission limit, or carbon cap, for assets to participate in the CM. To achieve a phased decarbonisation of generation assets in CMs, the carbon emission cap should be progressively reduced in pre-defined time-steps and based on carbon limits for emissions per kWh electricity produced as well as annualised emissions.



The currently established approach to CO2 emissions limits will provide an incentive to keep higher emitting generators online as back-up generators reducing their operating hours in electricity markets. This ensures Europe makes appropriate use of existing carbongeneration capacity as back-up resource and provides a clear timeframe and revenue slope for legacy carbon-generators and their operators. At the same time, emission caps need to be lowered progressively to ensure a timely market exit of high-carbon emitting assets to enable market integration of new-build low-carbon assets.

2) Link capacity mechanism payments to carbon intensity

In addition to fixed carbon emission limits, CMs should include market-based mechanisms to incentivise low- carbon assets to enter and high-carbon assets to exit CMs. Therefore, we propose scalars for CM payments based on carbon intensity. Market insiders know such scalar systems for example from the Irish ancillary service market (DS3). The advantage is that instead of defining targets for certain technologies, like zero-carbon technologies, a scalar system, allows different technologies to compete based on their merit, in this case their carbon intensity.



De-rating of assets depending on certain characteristics, such as availability is a common theme in implementation of CM across Europe. A scalar based on carbon intensity is therefore in line with existing CM implementation.

CM payments could be structured as follows:

- a. 200% payments of CM clearing price to assets that emit zero carbon
- b. 100% payment of CM clearing price to assets that emit 75% of the maximum allowed carbon emissions
- c. 50% payment of CM clearing price to assets that emit the maximum allowed carbon emission

3) Provide longer contracts for new-build low-carbon assets

Multi-year contracts awarded to new low-carbon assets in CM, would incentivise a faster build out. Providing revenue certainty increases low-interest rate capital availability to those projects. We propose offering CM assets, which emit a maximum of 10% of the carbon emission limit for the respective year, with longterm contracts of at least 15 years.

Providing long-term contracts for certain assets is a CM design mechanism already implemented in various member states. Basing long duration contracts on carbon intensity is therefore in line with existing mechanism and targeted at the decarbonisation of the CM.

Building flexible and low-carbon peaking capacity

We further propose two key changes to the Electricity Market Design that will enable flexibility options via a market mechanism to balance generation and demand on the grid, reducing curtailment of renewables and replacing peaking capacity with low-carbon peaking capacity. These options include:

- 1) Mandatory Renewable + Storage auctions
- 2) Contract for Difference (CfD) for flexibility and curtailment prevention

1) Mandatory Renewable + Storage auctions

The balancing of generation and demand in renewable-driven power systems can take place at various locations in the grid: connection with load, with generation, or via standalone assets. The future energy system will require an optimised mix of flexibility options across all locations.

The combination of flexibility options, such as energy storage with renewable generation assets, creates socio-economic benefits in the power system that are currently not accurately captured and rewarded. These include:

- Higher utilisation of grid connections, resulting in lower requirements for grid reinforcement
- Higher grid utilisation, resulting in lower grid fees
- Reduction of renewable curtailment
- Increased investments in renew-

able assets by reducing exposure to negative or low-price periods (renewable cannibalisation effect)

- Acting as dispatchable assets, feeding electricity to the grid when the residual load (load minus renewable generation) is highest
- Energy storage adding capability to provide system services and other grid benefits such as active voltage and reactive power management, frequency regulation and inertia services, and short-circuit contributions

While some of these benefits are remunerated, others such as prevention of renewable curtailment or increasing transmission utilisation are not incentivised in most markets. Creating policy and market mechanisms to reward hybrid assets for their contributions would require complex Market Design and renumeration mechanisms.

It would be more practical to encourage the installation of hybrid renewableplus-storage sites in member states via mandatory co-location auctions. These auctions could take different forms: as auctions for co-located assets; as minimum shares for co-located projects to be awarded in renewable auctions; or as standalone storage auctions, if operated as part of a renewable portfolio.

While not yet widely adopted in Europe, such auctions have proven successful, for example in Germany's Innovation Auctions. Member states should define how the hybridisation of renewable assets with storage could best be incentivised by:

- Adjusted/higher renumeration for power produced under auction mechanisms
- Faster access to grid connections
- Reduced cost for grid access and/or lower grid fees
- Other suitable mechanisms At the same time, member states could define operating guidelines for hybrid to ensure they provide additional,



non-remunerated benefits to the grid. This could include a requirement to cap solar peak feed-in; bans on exporting power to the grid from storage during periods of local grid congestion or negative wholesale market prices; or other guidelines to define grid-beneficial usage of hybrid assets.

It is important to clearly define such regulation to not disadvantage or prevent co-located assets from participating in other parts of the electricity market. It is imperative to take a market-driven approach that allows investors and asset owners to find the best locations and business cases for co-located assets.

2) Two-sided Contract for Difference (CfD) for flexibility and curtailment prevention

A novel approach to incentivise flexibility in European power markets is to create a dedicated market product. Similar to the Capacity Market, which procures a minimum share of flexible capacity for security of supply, a two sides CfD for Flexibility and Curtailment Prevention could secure sufficient levels of flexibility in power markets.

The proposed Contract for Difference (CfD) for Flexibility would provide longterm revenue certainty through a revenue floor for providing power during daily peak demand periods, while also capping revenues above a strike price threshold.

The revenue floor and strike price are to be defined based on a daily or weekly arbitrage spread or absolute revenue number in €/MWh of energy production or consumption shifted. Assets would operate on a merchant basis in the existing markets. The floor price guarantee or strike price would apply retroactively, in case flexibility assets fail to achieve revenues within the revenue band. The floor guarantee of an arbitrage spread offers a bankable baseline revenue reducing the cost of capital for projects. The cap is to be designed to prevent excessive profits for those assets. Still the cap should only apply to 80% of revenues above the cap, incentivising owners to optimise their flexibility assets above the strike price.

Participation in the flexibility CfD could be linked to a discharge obligation during a pre-defined price peak period, such as during the 4-hour evening price peak. The obligation to discharge power could also be defined in a more flexible way, as long as it is guaranteed that the assets can still participate in the relevant market, including ancillary service markets, such as FCR and aFFR, as well as Day-Ahead and Intraday Wholesale market.

Curtailment Prevention Mechanism

This flexibility CfD could include a curtailment prevention structure, where assets are awarded an additional premium (in €/ MWh), if they charge with electricity that would otherwise be curtailed. Here it will be important to define a methodology that ensures the tracking of otherwise curtailed energy, e.g. via notification by grid operators about renewable curtailment in specific gird areas. This would also add much needed transparency on renewable curtailment in Europe, which is missing in most markets. The curtailment prevention mechanism would provide an incentive to capture otherwise curtailed energy, which in various member states must be compensated via renewable support schemes. It would also provide a locational price signal. The structure would therefore result in additional socioeconomic benefits of reducing network reinforcement and increase the utilisation of existing grid infrastructure.

Auction design for Flexibility CfD

Contracts for a flexibility CfD could be awarded via auctions for existing and new assets with 10-20-year contracts. This would guarantee a market-based procurement of flexibility services. An auction mechanism would provide member states with a tool to control and incentivise



the amount of flexible peaking capacity required to be integrated in their electricity market. At the same time, assets could be built outside of the CfD structure as well, leaving potential investors the option to pursue fully merchant flexibility assets as well. This would mirror the mechanisms used to procure capacity via capacity auctions in several European markets today.

Technical requirements could additionally be defined in terms of carbon emissions allowed from those assets, including carbon intensity of electricity stored by energy storage assets. Further start-up and ramping requirements could be defined to ensure that such assets have the capability to support steep ramps required for the integration of volatile renewable assets.

An auction-based Market Design with a CfD structure can provide additional revenue certainty to investors without resulting in cost to electricity consumers or taxpayers. It will provide revenue certainty for investors, based on price levels that are reflective of the expected long-term price volatility in energy markets.

European energy strategy needs to address flexibility

Europe today stands at a crossroad. Based on the unprecedented challenge in our energy markets, we decided to accelerate renewable build out, which in time will result in a lower-emission, more resilient, and more affordable energy system for European citizens. Still, as we chart the course of a renewable based energy system, we need to pre-empt future challenges and already define solutions to the future challenges of our energy transition ahead of time. Defining the need for flexibility and creating market mechanisms for flexibility is a key part of Europe's future renewable powered energy system.

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working in the policy and regulatory space as well as business development with stakeholders including transmission system operators.

The UK's new landscape for utility & rooftop solar: Opportunities within a GW-plus annual market



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- The summit provided an opportunity to talk about the key challenges facing solar development and the opportunities for the future. Sue Kaner, ERM
- Excellent event, providing very useful insight into the significant potential of UK solar PV, set against the not insignificant challenges. Nick Kay, BayWa r.e.

The event was a bang up to date insight into the issues and successes of the UK Solar PV Generation Market. Speakers were all hands on knowledgeable and willing to share under the cover insights into their projects. Finlay was a fabulous host and I look forward to visiting next year. Nick Pascoe, Cowbridge Farm

The Summit was very informative and helpful to gauge the PV Industries' opinion on the current & future challenges. Presentations and speakers were to a high standard and delegates keen to participate. James Innes, Peridot Solar





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