

LONG LIVE THE KING

Charting solar's route to the power market's throne p.14



MARKET WATCH

Inside Japan's 160GW solar aim, p.21



SYSTEM INTEGRATION

Hurdling hydrogen's technical barriers, p.38

PLANT PERFORMANCE


Assessing the newest technologies in O&M, p.48



STORAGE & SMART POWER

Long duration energy storage technologies in focus, p.75

Delivering true value | Higher power, lower LCOE

A large, rectangular solar panel array is the central focus of the advertisement. It is composed of many smaller, square solar cells arranged in a grid pattern. The array is tilted slightly to the right. The background of the entire advertisement is a scenic landscape featuring snow-capped mountains, a valley with green and brown hills, and a herd of sheep grazing in a field in the foreground. The sky is blue with some white clouds.

**Shaping the future.
Once again.**

Hi-MO 5

**Published by****Solar Media Ltd.**

123 Buckingham Palace Road
London, SW1W 9SH, UK
Tel: +44 (0) 207 871 0122
www.pv-tech.org

Publisher

David Owen

Editorial**Editor in chief:**

Liam Stoker

Senior news editor:

Mark Osborne

Reporters:

Alice Grundy, Andy Colthorpe, Jules Scully,
Edith Hancock, Molly Lempriere, Carrie Xiao

Design & production**Design and production manager:**

Sarah-Jane Lee

Production:

Daniel Brown

Advertising**Sales director:**

David Evans

Account managers:

Graham Davie, Lili Zhu, Will Swan

Marketing executive:

Caroline Marques

Printed by

Buxton Press Ltd., Derbyshire

PV Tech Power Volume 26, 2021
ISSN: 2057-438X

While every effort has been made to ensure the accuracy of the contents of this supplement, the publisher will accept no responsibility for any errors, or opinion expressed, or omissions, or for any loss or damage, consequential or otherwise, suffered as a result of any material here published.

The entire contents of this publication are protected by copyright, full details of which are available from the publisher. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, mechanical, photocopying, recording or otherwise – without the prior permission of the copyright owner.

Brands of Solar Media:

Photovoltaics

SOLAR
POWER
PORTAL

PVTECH

SOLAR
ENERGY
EVENTS

PVTECH PRO

Energy
Storage

CURRENT[±]

Introduction



Welcome to volume 26 of PV Tech Power, the first to be published in what we hope will be more a more promising year than last. Thankfully, all of the early signs are that it will be.

Just as this edition of the journal was heading to press, BloombergNEF published its latest Global PV Outlook, painting a picture of good health for an industry that looks set for a big year. Solar markets across the globe are primed to catch up on any lost progress in 2020 and sizeable installation figures are anticipated by the year's end. For the first time, more than 200GW of solar could be deployed in a single year.

Solar is well and truly living up to its status as the newly crowned king of electricity markets, bestowed upon it by the International Energy Agency at the end of last year. This edition's cover feature explores how solar has earned that title, examining the technological, financial and regulatory progress made to date, and the trajectory that awaits solar this decade.

As it transpires, few obstacles remain in solar's path and any faltering performance in 2020 can be attributed almost solely to the significant impact of COVID-19. India's solar sector was particularly affected but, as Bridge to India's Vinay Rustagi tells us (p.34), the market is ready to rebound and could install as much as 13.5GW of solar PV this year.

One of the major stories to emerge in the opening months of 2021 has done so from Vietnam, a market that defied all expectations and installed a whopping 9GW of solar last

year, more than two-thirds of which was installed in December alone as the country's feed-in tariff regime drew to a close. Edgar Gunther writes for this issue (p.30) to explore the repercussions of that support scheme's success, and how the country intends to follow it up.

But deployment is just one area under the microscope in PV Tech Power volume 26. We also examine what's new in operations and maintenance, where new technologies and contract structures are emerging to suit solar's new demands (p.48), and how Big Data – and more specifically the industry's handling of it – continues to be a missed opportunity.

Meanwhile, leading our Storage & Smart Power section in this edition is a special focus feature on long-duration energy storage technologies, profiling the significant role they look set to play in the modern power system.

Solar may have earned its status as the eminent source of global renewables, but it will not be able to solve the energy transition alone. New technologies, be they of the energy storage variety, O&M or advancements of its own kind, will be vital to ensuring solar's role as the chief source of renewable power is maintained.

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

Liam Stoker

Editor in chief
Solar Media

Contents

50



21

08-13 NEWS

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

14-19 COVER STORY

- 14-19 **Here comes the Sun King**
How has solar earned its title as the new king of electricity markets, and what's next for the technology?

21-36 MARKET WATCH

- 21-25 **Decarbonising Japan: Challenges and opportunities for large-scale solar PV**
Uncovering the scale of solar opportunity in Japan
- 26-28 **Inside Asia's floating solar dominance**
What can other markets learn about FPV in Asia
- 30-32 **Unravelling the past, present and future of solar policy in Vietnam**
What follows the hugely successful FIT1 and FIT2 schemes
- 34-36 **Familiar uncertainties as India charts new solar territory**
Bridge to India's Vinay Rustagi discusses how India will respond to faltering year in 2020



66

38-41 SYSTEM INTEGRATION

- 38-41 **Going H2: The challenges and benefits of integrating solar and hydrogen**
Behind the scenes at solar-hydrogen facilities

42-53 PLANT PERFORMANCE

- 42-43 **Bifacial, trackers and AI: Lessons from the real world**
How are new technologies driving gains?
- 48-51 **Data cleaning – How a growing, ageing solar fleet is changing O&M**
New technologies and approaches in a richly competitive field
- 52-53 **Data disarray: Why solar is not fulfilling its potential**
By Katie Applebaum, Clir Renewables



26



Building a Fully Connected, Intelligent World

AI BOOST

Optimal Electricity Cost & Active Safety

Up to 30% More Energy by PV Optimizers

Higher Self-consumption with ESS Energy Optimizers

AI Powered Active Arcing Protection, No Worries

One-Fits-All Solution, Easier Business



FusionSolar App



SUN2000-450W-P



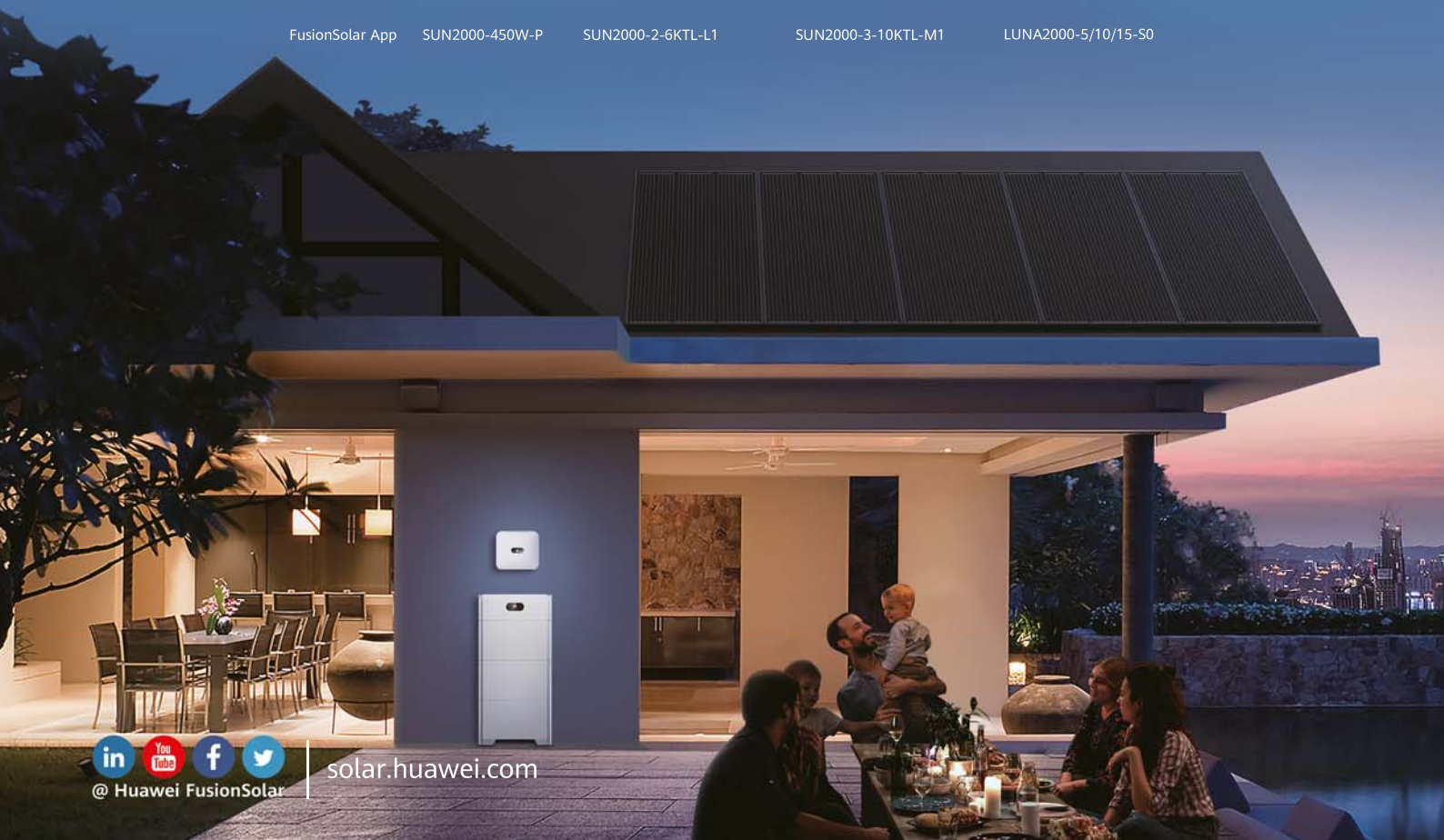
SUN2000-2-6KTL-L1



SUN2000-3-10KTL-M1



LUNA2000-5/10/15-50



85



45



75



59

55-60 DESIGN & BUILD

- 55-58 **Project Briefing** Taking floating solar to new terrains
How are novel anchors increasing the adoption of FPV
- 59-60 **Making 'construction 4.0' work for solar**
Greencells take us inside the use of Augmented Reality

62-69 FINANCIAL, LEGAL, PROFESSIONAL

- 62-65 **Corporate renewable energy sourcing: driving global decarbonisation efforts**
By Dr. Mercè Labordena and Milena Koot of SolarPower Europe
- 66-69 **Making solar more representative**
The benefits of adding diversity to your decision making teams



52

75-89 STORAGE & SMART POWER

LONG-DURATION IN FOCUS SPECIAL FEATURE:

- 75-76 **'Longer-duration storage' and its role in the future of energy**
By Florian Mayr and Dr Fabio Oldenburg of Apricum
- 77 **Vanadium flow batteries for a zero-emissions energy system**
By Ed Porter of Invinity Energy Systems
- 78 **Why Zinc should be a star player in long-duration energy storage**
By Ron MacDonald at Zinc8
- 80-84 **Piecing together the 'jigsaw of value' in UK energy storage**
New flexibility markets taking hold in the UK
- 85-89 **Software: The driving force putting batteries at the heart of the energy transition**
The pivotal role software is playing in enabling energy storage

REGULARS

- 03 **Introduction**
- 45 **Products**
- 90 **Advertisers index**



SERAPHIM SIV SERIES HALF-CELL MODULE

Small Changes, Big Accomplishments.

540W maximum power output | **21.1%** maximum module efficiency



Seraphim's new **SIV** series half-cell module provides a perfectly balanced solution for large ground-mounted plants. With MBB cell, smaller cell gap, and high-density encapsulation, higher output is guaranteed and micro-crack is minimized, which significantly reduces LCOE and save BoS cost.

SHIFTING • THE FUTURE

www.seraphim-energy.com | info@seraphim-energy.com

EUROPE

France

French solar industry braces for historic feed-in tariff cuts

French solar asset owners may face months of months of cuts and legal battles as the government seeks to retroactively cut feed-in tariffs for older PV power plants. The proposed cuts will affect hundreds of contracts signed from 2006-2010 on projects with more than 250kWp capacity benefitting from "excessive" remuneration, according to the Ministry of Ecological Transition. The government hopes to save roughly €4 billion (US\$3.30 billion) by 2030, to support the development of new projects. Trade body Enerplan was among the signatories of a joint statement in November 2020 warning the proposed cuts could create "economic catastrophe". Project owners, utilities and financiers backed the statement by Solidarité Renouvelables, a new organisation representing owners of more than 80% of project capacity that will be affected.

Market growth

'Landmark moment' in Europe as renewable electricity surpasses fossil fuels for first time

Europe saw its "greenest electricity year on record" in 2020, with renewables generating 38% of electricity, a report from think tanks Agora Energiewende and Ember states. 'The European Power Sector in 2020', found that 20% electricity was generated by wind and solar plants, while coal generation fell to just 13% last year, compared with 26% five years ago. Europe's solar market grew by 11% during 2020, adding 18.7GW of installations with Germany, The Netherlands, Spain, Poland and France leading growth.

'Resilient' European solar market posts double-digit growth in 2020

Europe's solar market grew by 11%, adding 18.7GW of installations – making 2020 the strongest growth year for solar in the continent since 2011, according to SolarPower Europe. The association's EU Market Outlook for Solar Power shows that Germany added the most capacity this year, with 4.8GW, taking its total installed solar up to 54.6GW. The Netherlands came second, with 2.8GW of additions, an increase of 23% on 2019, driven by commercial rooftop installations. Last year's winner Spain dropped to third in 2020, with 2.6GW of new solar installations, mostly from power purchase agreement-based systems.

Financing

Spain's auction 'a step in the right direction' as industry calls for more energy storage support

The results of Spain's first renewables auction since 2017 last month were welcomed by the country's solar sector, but calls have been made for tenders to support smaller-scale projects and encourage bids with energy storage. PV bidders picked up 2,036MW of capacity, with 998MW awarded for wind projects. The capacity for PV bidders was divided into 66 lots, secured by 27 companies with an average lot capacity of 30MW. Rafael Benjumea, president of UNEF, said the auction model was proven a "successful formula" for both project volumes and prices for consumers. However, UNEF is calling for a future auction to have 20% of allocated capacity specifically for installations smaller than 10MW as well as another auction for projects with storage.

European PPAs to hit 10GW capacity this year

Power purchase agreements (PPAs) in Europe could exceed 10GW of renewables capacity this year as deals ramped up despite COVID-19 slowdown. According to a new market outlook report published by renewables software firm Pexapark this week, more than 1GW of renewable energy was contracted into PPAs in December alone. Solar PPAs led the European renewables market in 2020, accounting for 46% of the 8.9GW renewable capacity contracted to offtakers across the continent. More than half (56%) of deals were made with corporate offtakers in Europe last year. Although Spain led PPA deals last year, Europe's emerging markets are also entering the fray. Renewables group BayWa r.e. signed a 10-year PPA with construction company HiedelbergCement on 28 January for what it claims is Poland's first subsidy-free solar park.

M&A

Macquarie's Green Investment Group reveals 8GW-strong solar development arm Cero Generation

Australia's Macquarie Green Investment Group (GIG) has launched Cero Generation, set to be among the biggest solar developers in Europe. The new company has a 8GW portfolio, consolidating the investment companies' existing sites under the new brand. This includes sites across the UK, Italy, Spain, Poland, France and the Netherlands, and makes it one of the largest solar development companies in Europe according to GIG. "It's a full service business within the solar space," Edward Northam, head of GIG for the UK and Europe told PV Tech. "It'll take projects from origination, through development, and construction and into operations. And it will just cover the whole sort of landscape of the solar market."

Floating Solar

Two offshore floating solar projects to take to the seas

Two floating solar projects off the coast of Norway and the Canary Islands are set to explore how the technology performs in challenging sea conditions. A consortium including Ocean Sun and Fred Olsen Renewables announced in January it will develop the 250kWp floating PV unit off the coast of Gran Canaria, which the partners say is the sunniest part of Europe. The pilot has a duration of 30 months and a €4 million budget, which has been provided under the European Union's Horizon 2020 research and innovation programme. Other partners in the consortium include engineering firm Innosea, the Technological Institute of the Canary Islands and the Oceanic Platform of the Canary Islands. That same month, oil and gas major Equinor revealed plans for a new floating PV pilot project to be built off the coast of Norway this summer in partnership with engineering company Moss Maritime.



A previous floating solar test system installed by Ocean Sun off the coast of Norway .

Credit: Ocean Sun

AMERICAS

Policy

US announces US\$45m in funding for solar and integration projects

The US Department of Energy (DOE) announced it will set aside US\$45 million to develop technology that will enable businesses to bring “large quantities of solar” onto the grid. The DOE will allocate the funding for research in two key areas: systems integration and hardware. Around US\$14 million will be reserved for R&D designed to increase the amount of solar PV hardware such as panels being made in the US. Companies could receive grants of up to US\$3 million for project development if their application is approved by the DOE. More than half of the funding (US\$25 million) will go towards the formation of a consortium to encourage “industry-wide collaboration” on developing technologies that enable both utility-scale and smaller distributed energy systems to connect to the grid.



Credit: NextEra Energy

The US\$45 million funding is to support bringing “large quantities of solar” onto the grid.

Canada hits out at ‘unwarranted’ US tariffs on solar products

Canada has requested consultations with the US on the latter’s “unwarranted” tariffs on imports of crystalline silicon PV cells. A statement from Canadian trade minister Mary Ng said that since their introduction in early 2018, the tariffs have caused Canada’s exports of solar products to the US to decline by as much as 82%. She said the tariffs “clearly violate” the provisions and spirit of the US-Mexico-Canada Agreement (USMCA), which entered into force last year and replaced the North American Free Trade Agreement.

New York announces 23 large-scale PV projects as part of governor’s clean energy drive

New York state will this year contract for 23 large-scale solar farms and one hydroelectric facility with a combined capacity of more than 2.2GW, as Governor Andrew Cuomo outlines efforts to spur on private investment in clean energy and drive job creation. These 24 projects will generate more than US\$2.9 billion of investment and create 3,400 jobs across the state, it was announced in the governor’s 2021 State of the State address, which also included commitments to construct a ‘green energy transmission superhighway’ to transport clean energy.

Jobs

US clean energy sector ends 2020 with 12% of pre-pandemic workforce unemployed

The US clean energy industry ended last year with the fewest number of workers since 2015, as impacts of the coronavirus pandemic mean 12% of the sector’s workforce is unemployed.

Despite the addition of around 16,900 jobs in December, 2020 marked the first year the clean energy industry saw a decline in jobs compared to the previous year, according to the latest analysis of federal unemployment filings prepared for E2, E4TheFuture and the American Council on Renewable Energy (ACORE) by BW Research Partnership.

PPAs

Amazon and Total help boost renewable corporate PPA growth as volumes jump 18%

Corporations bought 18% more clean energy last year compared with 2019, according to new research, with tech giant Amazon and oil and gas group Total leading the global energy transition. Tech companies, oil and gas groups and automakers bought 23.7GW of renewable energy through long-term agreements last year, up from 20.1GW in 2019 and close to double the 13.6GW purchased in 2018, a report from BloombergNEF has found.

Utility-scale solar

Record 15.4GW of utility-scale solar to come online in the US this year, EIA says

A record amount of utility-scale PV capacity is expected to be connected to the grid in the US this year, with Texas accounting for more than a quarter of solar additions, according to new data from the US Energy Information Administration (EIA). Developers and plant owners forecast 15.4GW of new utility-scale PV coming online in 2021, surpassing last year’s nearly 12GW figure. This will see solar account for the largest share of new capacity at 39%, followed by wind at 31%. In total, 39.7GW of new electricity generating capacity is slated to start operating this year.

Terra-Gen and Mortenson to build ‘world’s largest’ solar-plus-storage project

Renewable energy developer Terra-Gen has partnered with construction firm Mortenson to build what they claim is the world’s largest standalone solar-plus-storage project to date. Called the Edwards & Sanborn energy project, it consists of 1,118MW of solar and 2,165MWh of energy storage in Kern County, which has become California’s unofficial large-scale solar capital due to the number of projects being built there. Terra-Gen’s project will supply energy for “all hours of demand”, according to Brian Gorda, the company’s vice president of engineering.

MIDDLE EAST & AFRICA

Energy transition

Non-hydro renewables generation to remain below 10% in Africa by 2030

The amount of non-hydro renewables in Africa is likely to remain below 10% in 2030, according to a study from the University of Oxford, which used machine learning to analyse more than 2,500 planned projects and their chances of being commissioned. The research found that while electricity generation is likely to double over the next decade, fossil fuels will continue to dominate. Philipp Trotter, co-author of the study, said decisionmakers “need to act quickly” to stop Africa becoming locked into a carbon-intensive energy future. “Immediate re-directions of development finance from fossil fuels to renewables are an important lever to increase experience with solar and wind energy projects across the continent in the short term, creating critical learning curve effects.”

UAE

UAE solar capacity to increase fourfold by end of 2025 thanks to 'robust' development pipeline

The United Arab Emirates (UAE) can reach its renewable energy targets thanks to a "robust" development pipeline of solar projects, new research from Rystad Energy suggests. Installed solar PV is expected to increase fourfold from now to the end of 2025, increasing from its 2.1GW level to reach 8.5GW, when it will represent around 94% of the country's renewables capacity. The UAE is aiming to increase the contribution of clean energy in its energy mix to 50% by 2050, a target that Rystad said is "well within reach", due to low power purchase agreement prices secured for projects and the "resilience and determination" shown by the country's renewables sector amid COVID-19. Four solar parks are expected to drive the country's PV growth: the Al Dhafra (2GW), Abu Dhabi PV3 (1.5GW), and the fourth (950MW) and fifth (900MW) phases of the Mohammad bin Rashid Al Maktoum (MBR) facility.



The 800MW third phase of the Mohammed bin Rashid Al Maktoum solar park in Dubai was inaugurated last November.

Finance

EDF, JinkoPower and partners close financing for 2GW solar project in Abu Dhabi

Construction work on the 2GW Al Dhafra solar project in Abu Dhabi is set to begin as the consortium behind the development has reached financial closing, with around US\$1 billion provided by seven international lenders. Abu Dhabi National Energy Company (TAQA) will own 40% of the project, while the remaining partners – Masdar, EDF Renewables and JinkoPower – will have a 20% stake each. Located 35km south of Abu Dhabi city, Al Dhafra will feature 4 million solar panels and supply power to Emirates Water and Electricity Company when operational in 2022. According to TAQA, the plant will deploy "the latest in crystalline, bifacial solar technology".

Daystar Power secures US\$38m for west African expansion

African off-grid solar electricity supplier Daystar Power has raised US\$38 million to expand its operations across the continent. The Series B funding round will be used to help the company accelerate its regional expansion in Nigeria, Ghana, Côte d'Ivoire, Senegal and Togo. The firm oversees 23MW of installed solar capacity across the continent, and said it hopes to expand to 100MW. "African businesses are realising that solar power – stand-alone or in tandem with a second power source – is a superior energy alternative to the often-unreliable grid or too expensive, polluting diesel generators," said Daystar chief executive Jasper Graf von Hardenberg.

Israel

EDF Renewables and Masdar to collaborate on Israeli solar projects

EDF Renewables Israel, a subsidiary of French utility EDF, and Abu Dhabi-based solar developer Masdar have agreed to work together on renewable energy installations in Israel. The pair will collaborate on existing parks as well as new projects announced by the government of Israel, which last year unveiled a plan to deploy up to 15GW of solar by 2030. Mohamed Jameel Al Ramahi, chief executive of Masdar, said that Israel and the UAE have "embarked on a new era of co-operation on renewable energy" which will help both to reach their energy targets.

Floating solar

Study finds potential for colocating floating solar with hydropower in Africa

Hydropower plants across Africa could double their capacity if just 1% of their reservoirs are used to install floating solar projects, new research suggests. The large-scale roll-out of floating solar at hydropower reservoirs in the continent could reduce water evaporation, help to satisfy future energy needs and increase resilience to climate change without redesigning existing infrastructure, according to the study. Titled 'Assessment of floating solar photovoltaics potential in existing hydropower reservoirs in Africa', the research says floating photovoltaics can complement hydropower production during increasingly frequent dry periods in Africa, while hydropower provides a more flexible operation to intermittent PV output.

ASIA-PACIFIC

India

EDF and Total JV secures US\$165m for 450MWp Indian solar park

A JV between Total and EDF Renewables has secured US\$165 million to finance the construction of a 450MWp solar project in India. Eden Renewables India has closed financing for its SECI III solar PV project from DBS Bank, Standard Chartered and the Singaporean branch of Sumitomo Mitsui. The project is under construction in Rajasthan, northern India, and is due to be completed in the first half of this year.



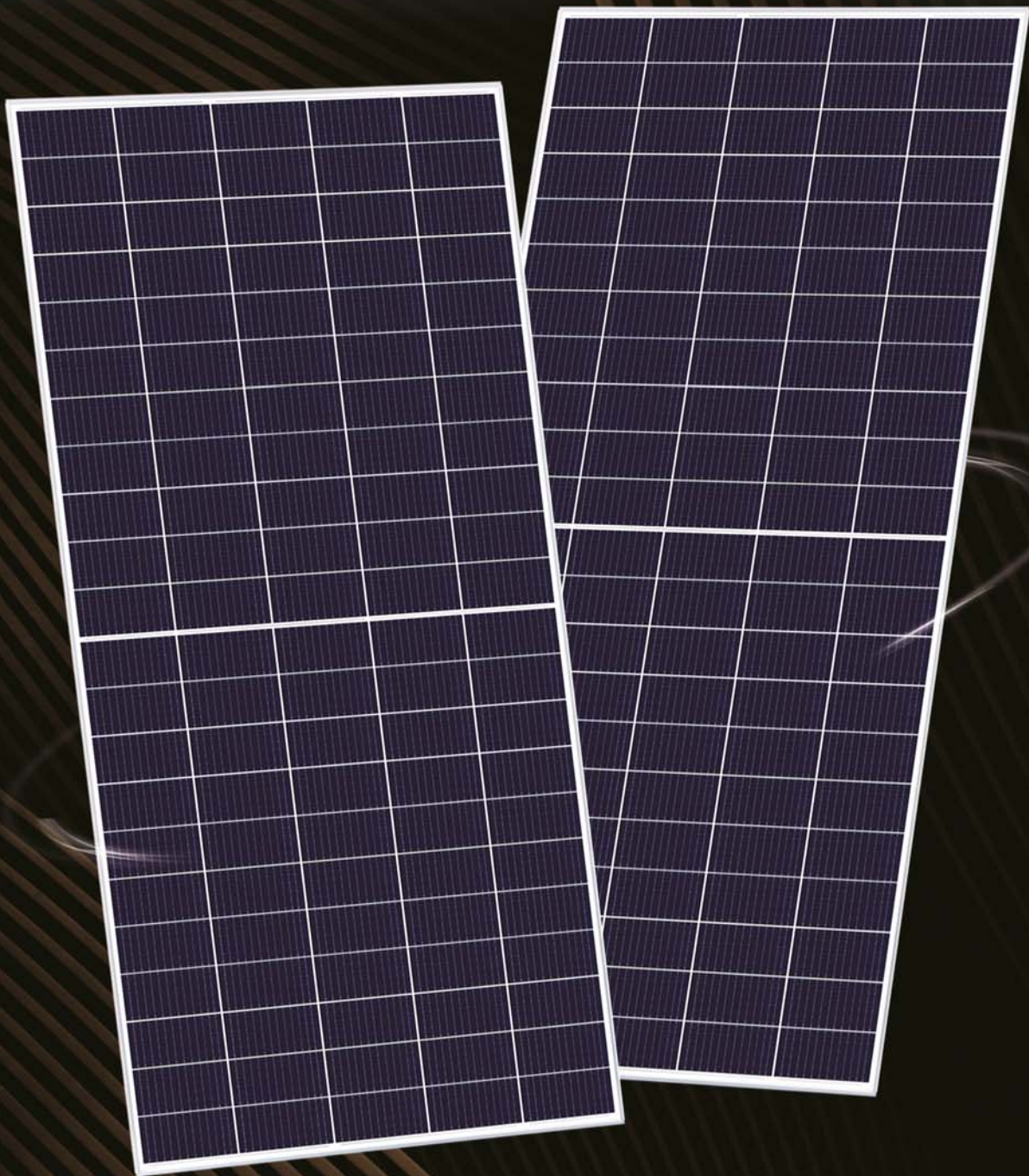
Total's Eden's Bap solar farm also in India.



risen
solar technology



550Wp PV module



www.risenenergy.com

India

IEA: India's solar power generation could rival coal by 2040

India's solar energy output could match coal-fired power within 20 years, but the country's clean energy sector may need US\$1.4 trillion in additional funding to ensure a "sustainable growth path" according to a report from the International Energy Agency (IEA). Falling renewable energy costs and India's ambitious targets could see the country host 450GW of renewable capacity by the end of the decade it continued.

Malaysia

116MWp ib vogt solar farm begins construction following financial close

Senior debt financing has been secured for the 116MWp Coara Marang solar farm being developed by Germany-headquartered ib vogt and Malaysian solar firm Coara Solar. It comes in the form of a senior debt facility from Malayan Banking Berhad, with the project having also signed a 21-year PPA with Malaysian electricity utility Tenaga Nasional Berhad.

Floating solar

Chenya Energy eyes floating PV growth after completing 181MWp offshore project

Chenya Energy is planning to further expand its floating PV (FPV) portfolio following the completion of the world's largest offshore solar plant, a 181MWp project off the west coast of Taiwan. The Taiwanese company currently has 68MW of FPV under development and will mainly focus on floating projects to grow its solar portfolio and help the country reach its target of 20GW of installed PV by 2025.

Masdar creates JV to drive development of 145MW Indonesian floating solar project

Abu Dhabi-based Masdar has formed a JV to bring forward a 145MWac floating PV park at a reservoir in West Java, Indonesia. The renewables developer has partnered with PT PJBI, a subsidiary of Indonesia's state electricity company PT PLN, for the Cirata project, with construction work due to start in early 2021.

China

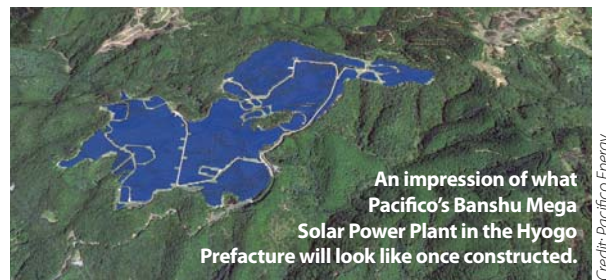
China's path to carbon neutrality could see country reach 4.2TW of solar by 2050

A massive renewables scale up by China to help it achieve its recently announced carbon neutrality pledge could see the country reach 4.2TW of solar capacity by 2050, a study from BloombergNEF says. The research organisation predicts that solar and wind could account for as much as 74% of China's generation capacity, requiring an investment of US\$6.4 trillion over the next 30 years.

Japan

Pacifico Energy breaks ground on new Hyogo Prefecture solar plant

Japanese solar developer Pacifico Energy has started building a 77MW solar power plant in Hyogo Prefecture. Pacifico has hired construction company Sharp Energy Solutions to build the plant on the site of a former golf course, which is expected to come online in 2023. Once complete, it will generate around 93 million kWhs of electricity per year. The project was financed by MUFG Bank.



An impression of what Pacifico's Banshu Mega Solar Power Plant in the Hyogo Prefecture will look like once constructed.

Credit: Pacifico Energy

Vena Energy buys 162MW Japanese solar project

Singapore-headquartered renewable energy producer Vena Energy has acquired a 162MW solar PV project in Japan from Spanish developer X-ELIO. Vena has broken ground on the Amateras Shirorishi Solar project in Japan's Miyagi Prefecture, which is expected to produce up to 175,000MWh of energy per year once completed.

Vietnam

Sharp Energy Solutions completes 50MW solar project in Vietnam

Sharp Energy Solutions has finalised its latest PV project in Vietnam, taking its total installed solar capacity in the country to 340MWdc. Located in Binh Dinh province, the 50MWdc installation will have a power generation capacity of 82,506MWh/year. Development of the project was carried out alongside Viet Nam Viet Renewable Energy Joint Stock Company, which will oversee operations, as well as NSN Construction and Engineering, the co-owner of the facility.



Sharp Energy Solutions's latest 50MW installation will take it total installed capacity to 340MW in Vietnam.

Credit: Sharp Energy Solutions

UPSTREAM

Polysilicon

Rivals GCL-Poly and LONGi sign major polysilicon pact

The solar industry's two largest enterprises, GCL and LONGi have signed a major polysilicon supply deal, the first time the rivals have entered into a major business deal together. Major polysilicon producer GCL-Poly Energy Holdings is set to supply all of LONGi's seven monocrystalline ingot/wafer subsidiaries with a total of 91,400MT of polysilicon from March 2021 through to the end of 2023. Current average market prices of high-grade polysilicon have reached nearly US\$14.0/kg, more than double prices seen in 2019. At current prices the supply deal would cost LONGi approximately RMB7.328 billion (US\$1.13 billion). In a separate financial statement, GCL-Poly said that the polysilicon procurement agreement with LONGi's subsidiaries would include the supply of its Fluidized Bed Reactor (FBR) 'Granular' polysilicon, without stating any specific quantities.

Partnerships

JinkoSolar strengthens partnership with Tongwei

Major 'Solar Module Super League' (SMSL) member JinkoSolar has extended its supply chain cooperation with major polysilicon and merchant solar cell manufacturer Tongwei Group, with Tongwei gaining extra gigawatts of mono wafers from JinkoSolar. JinkoSolar is to invest in a planned 45,000MT polysilicon expansion by Tongwei, while Tongwei will invest in a 15GW monocrystalline wafer plant planned by JinkoSolar. JinkoSolar will hold a 35% equity share in the polysilicon plant expansion, securing further polysilicon supplies for wafer production expansions, while Tongwei will have a 30% shareholding in the wafer plant, securing with a total of around 6.5GW of mono-wafer products for three years (2021-2023) for its merchant solar cell business.

Xinte Energy planning 200,000MT 'green' polysilicon complex in Inner Mongolia

Major China-based polysilicon producer Xinte Energy is planning the world's single largest polysilicon production complex. The facility, slated for development near the city of Baotou, Inner Mongolia, would produce 200,000MT of polysilicon per annum. Xinte Energy's existing major hub for polysilicon production is an 80,000MT facility in Urumqi, Xinjiang. The plans, which have yet to go through site selection and approval with the Baotou Municipal Government, include an initial polysilicon plant with an annual capacity of 100,000MT, requiring an investment of RMB8.0 billion (US\$1.24 billion).

Cells

JinkoSolar cell capacity to jump to 30GW this year as world's largest facility to accelerate deployment

JinkoSolar has recently started construction of a 20GW large-scale solar cell manufacturing base in Chuxiong, Yunnan Province, China, which, once complete, will become the world's largest single cell production plant. The new base will increase Jinko's in-house solar cell capacity to more than 30GW by the end of 2021. That capacity will be enough to propel Jinko to become the third-largest solar cell manufacturer in the world, following Tongwei (40GW) and Aiko (32GW). Phase I of the Chuxiong facility, which will have a cell production capacity of 10GW, is scheduled to be commissioned by April 2021. It will enable Jinko to double production of its Tiger Pro series module this year, the company states.

LONGi planning new 15GW solar cell plant to be operational in 2022

'Solar Module Super League' (SMSL) member LONGi Group is

The new 15GW facility is slated to become operational in 2022.

planning to build a new 15GW monocrystalline solar cell plant in Jinghe New City, Xixian New District, Shaanxi Province, China to become operational in 2022. LONGi said that the project would cost around RMB8.0 billion (US\$1.23 billion) but would not have a material financial impact on operating income on the company in 2021. The latest project would take in-house solar cell production to around 45GW in 2022. The SMSL member's previous cell expansions targeted an in-house cell capacity of 30GW in 2022, up from 27.5GW targeted production in 2021.

JA Solar takes solar cell capacity plans at Yangzhou plant to 10GW

'Solar Module Super League' (SMSL) member JA Solar has updated its capacity expansion plans for its solar cell and module assembly plant in the Yangzhou Economic and Technological Development Zone (ETDZ). The manufacturer has approved plans to invest in taking solar cell capacity to 10GW, up from previous plans to build a 6GW solar cell facility alongside a 6GW module assembly plant. JA Solar said that the plans included a two-phase approach. The first phase would be a 6GW solar cell and a 6GW module assembly plant, with a total planned investment of around RMB6 billion (US\$926 million). The second phase would include a 4GW solar cell expansion with an investment of around RMB4 billion (US\$617 million).

Modules

Panasonic ending in-house heterojunction cell and module production

Panasonic has announced plans to withdraw from manufacturing heterojunction (HJT) cells and modules with the closure of its manufacturing plants in Malaysia and Shimane Prefecture, Japan. The company said that the plant closures would occur during its fiscal 2022, ending in March 2020, noting that production of its HJT cells and modules would continue with subcontracting production to its manufacturing partners. However, Panasonic had already transferred a 90% stake in its plant in Malaysia to China-based PV manufacturer GS-Solar as part of wider collaboration on HJT production expansion and R&D. However, the deal fell through and Panasonic had sought to find another partner without success. As part of plan, Panasonic said it would also be reducing its R&D functions and headcount at its Nishikinohama factory in Kaizuka City, Osaka. The company did not say how many jobs would be lost or the cost of the shutdowns.

GCL-SI cancels original plans for 2.5GW 'shingled' module assembly plant

'Solar Module Super League' (SMSL) member GCL System Integration Technology Co (GCL-SI) has cancelled plans to build a 2.5GW 'Shingled' (cell) module assembly plant in Funing, Hebei Province, China and will instead shift the project to its recently started 60GW module manufacturing hub in Hefei. The SMSL member had recently raised the funding for the Funing plant, said to cost around RMB1.070 million (US\$165.2 million). However, the recent ground-breaking of the Hefei module assembly hub has meant GCL-SI will build the dedicated shingle module assembly plant at the new hub, reducing capital expenditure requirements while allowing the company to benefit from higher levels of module assembly scale.



Credit: LONGi Solar

Here comes the Sun King

Future forecasts | Having been hailed as the new king of electricity markets, Liam Stoker charts solar's journey up until this point, explores how it has earned the crown and poses the question: what next for PV?



Credit: Adrian Cartwright/PlanetIllustration

Having jostled for the title for some time, the International Energy Agency made headlines late last year when it crowned solar PV as the new “king of electricity markets” worldwide, ahead of wind, hydropower and all other generation technologies. Citing drastic reductions in price over the last decade in particular, the IEA – which is reasonably famed for having underestimated solar PV’s potential in the past – projected that solar would smash deployment records in each year from 2022 onwards, becoming the eminent source of power in Europe by 2025.

That projection came within the IEA’s World Energy Outlook report for 2020, wherein all of the association’s models projected that renewables would grow rapidly over the coming decade. Solar, however, was said to be at the centre of that growth, a mixture of maturing technologies and supportive policies opening up ultra-cheap access to capital and, in turn, cheaper routes to market. Solar is now consistently cheaper than new gas and coal in numerous markets, with the IEA concluding solar to be offering “some of the cheapest electricity ever seen”.

While hydropower remains the largest single source of renewable power, solar will be the main driver of growth in the coming years, the IEA states. Under the association’s ‘Stated Policies’ or STEPS model, wherein the impact of existing policy frameworks is modelled, solar generation output is expected to hit 4,813TWh per year by 2040. The ‘Sustainable Development Scenario’ or SDS, models how a radical, Sustainable Development Goals (SDG)-compliant energy market may look, and that places solar PV output at a significant 8,135TWh within the same time frame.

While the IEA models are not designed to be projections or forecasts as such, solar PV would be worthy of its crown should the asset class deliver the kind of growth modelled by the association. “If governments and investors step up their clean energy efforts in line with our Sustainable Development Scenario, the growth of both solar and wind would be even more spectacular – and hugely encouraging for overcoming the world’s climate challenge,” Faith Birol, executive

director at the IEA, said at the time of the 2020 Outlook’s release.

Solar’s path to the throne has been carefully plotted, and indeed the technology looks all but set to ascend to the throne. But what are the steps needed, from a technological, regulatory and financial perspective, to grasp that mantle?

Technology driving change

If solar PV is to truly become the king of new power generation, it will owe its crown to consecutive years of technology price reductions. More efficient panels and emergent technologies have dragged LCOEs down to such an extent that newbuild solar is already cheaper

“If governments and investors step up their clean energy efforts in line with our Sustainable Development Scenario, the growth of both solar and wind would be even more spectacular.”

than coal and gas in markets such as Spain, Italy, India and 16 US states. By 2030, that will be true in more than 15 established markets, analysis by consultancy WoodMac claims.

Large-area wafers and modules, bifaciality and trackers are contributing to that more cost-effective power generation, but a host of other technologies could yet drive costs down even further. Heterojunction and TOPCon solar cells are widely anticipated to boost efficiencies even further – JinkoSolar having established a new record conversion efficiency of 24.9% for its N-type TOPCon monocrystalline solar cell earlier this year.

But these technologies are still some years away from commercialisation and, as a result, should not be included in any prospective roadmap to industry dominance for solar PV, at least not for the time being. WoodMac asserted that it had not factored such novel technologies into its analysis, stating they could yet provide even further cost upside. Jenny Chase, head of solar at research organisation BloombergNEF, says that while these maturations or evolutions in technology “might knock another

cent per watt off” the cost of generating power, much of the heavy lifting has already been achieved by industry standard modules.

Considerable importance will therefore be placed on existing technologies and, critically, ensuring they are in abundant supply. Thankfully solar appears ready to cater for this shift in demand. Most industries spent 2020 navigating the impact of COVID-19 – solar PV has, of course, been no exception to that – but last year also bore witness to a significant gear-shift for upstream solar manufacturing. Leading solar cell and module manufacturers announced major commitments to capacity expansions which, combined, point to the solar industry having ample supply for any sizeable leap in demand and deployment.

There had been some concern over the availability of materials and components towards the end of 2020. Polysilicon supply, stymied by incidents at production facilities in China, had caused price spikes as demand continued to soar. Likewise, demand for solar-grade glass in China sent prices soaring to such an extent several manufacturers lobbied the government to intervene. While prices are likely to remain high – BloombergNEF expects average selling prices (ASPs) for polysilicon to stabilise at around US\$12/kg this year, around double the ASP noted by some providers at the start of 2020 – there will be no shortage of supply. Modules will, too, be abundant enough to cater for demand throughout the 2020s, even if larger-format modules are to come at a premium cost. Indeed, PV Tech analysis of announced capacity expansions highlights an estimated joint capacity from the nine largest module manufacturers of 250.5GW by the end of 2021, with not insignificant quantities of that capacity earmarked for larger-area modules.

There are also renewed efforts to establish a manufacturing base in Europe to cater for any additional demand in the region, efforts which have received backing from the European Commission. In late February, trade association Solar Power Europe partnered with innovation engine EIT InnoEnergy to launch the European Solar Initiative, a drive to revive Europe’s PV manufacturing industry and capture the 20GW of added annual solar demand that’s set to emerge on

◀ Solar has been crowned the “new king of electricity markets”, but what has earned it that crown?

PV plant revamping – why now's the time to hit refresh on your asset

Tommaso Landi, FIMER's Global Product Manager for Commercial & Industrial Solutions

Over the past decade, the growth of PV solar installations across the world has increased dramatically. According to a report by the International Energy Agency (IEA), global PV solar capacity increased 18-fold between 2010 and 2020, with a similar report from the International Renewable Energy Agency (IRENA) showing a nearly 80% drop in PV solar installation cost within most countries.

This means that PV projects installed at the beginning of this long period of growth have now been in operation for ten years or more. As a result, we are now anticipating a dramatic growth in revamping initiatives, with PV inverter replacement sitting on top of most frequent interventions. Last year, IHS Markit predicted that the solar inverter replacement market would increase by around 40% during 2020, primarily in Europe due to early adoption of solar in all market segments – from residential to utility – particularly throughout Germany, Spain, Italy, France and the UK.

As such, asset managers are seeking to protect PV owners' investments by preserving performance while taking advantage of the latest developments in inverter technology. This therefore makes PV plant revamping a means of financial risk mitigation. There are three core drivers of inverter replacement, all based on a common underlying goal - preserving the investment by securing energy production and ultimately revenues from plant operation.

- **Risk mitigation** - first, there are asset managers who deal with a well-performing PV plant. As the plant ages, replacing all or part of the installed inverters – let's call it preventive replacement - helps to mitigate the risk of a sudden, unforeseeable performance downturn.
- **Underperformance correction** - second, asset managers may be faced with an underperforming PV plant which is undermining the objectives of their business plan. A corrective replacement can be performed to take plant's performance ratio back to target figures.
- **Rapid replacement** - third, PV inverters can fail or show such severe underperformance as to be virtually unproductive. This calls for rapid inverter replacement as the asset is burning cash fast, thus seriously jeopardizing the projected return on investment.

All three scenarios have a key advantage in common: a new inverter carries new features and overall improvements – not least providing an up-to-date and more flexible piece of digital equipment – which future-proofs the asset and enables an easier and broader interoperability of devices across the whole plant.

However, plant revamping does come with challenges. A PV plant is the result of a fine interplay between optimum PV panel arrangement and best inverter selection, which includes the kind of inverter, its power size, mechanical size and overall set of specifications. Consequently, asset managers may easily face sizable extra costs due to any plant design deviations incurred upon inverter replacement. This is the most critical challenge of any revamping intervention – ensuring any change from the original design keeps intervention costs down.

In a market where once active suppliers of inverters are no longer there and inverter's features – from DC-side specs to communication and control equipment – evolved dramatically over time, revamping calls for solutions to this ultimate challenge, ensuring simplicity and cost-effectiveness through inverter flexibility.

A brand-new inverter, perfect for revamping projects

The quest for flexibility in a revamping project puts a bright spotlight on PV inverters.

Ideally, everything should stay unchanged during a project apart from the inverters being replaced. Carrying out the intervention during planned production shutdowns would then prevent extra downtime, closing the loop of a flawless revamp.

New PV inverter solutions are now available that can overcome the flexibility

challenge, making revamping a relatively straightforward process.

FIMER's latest range of string inverters – the PVS-10/33-TL product family for commercial and industrial projects – offers unique DC-side flexibility for any revamping applications and full back-compatibility with its predecessors – the PVI-10/12.5-TL and TRIO-20/27.6-TL – as well as other vendors' products. This allows for a straightforward one-to-one inverter replacement as the new products flexibly fit into the overall electrical arrangement, while matching existing inverter-to-inverter and inverter-to-user communication interfaces.

Designed to cater for the increasing demand for flexibility in commercial and industrial solar projects, the new range extends FIMER's existing string inverter portfolio to offer a host of additional performance features and address any kind of application, setting plant designers free of any constraints. Available in outputs from 10 kW to 33 kW, the PVI-10/33-TL offers all that eventually makes a difference: power-dense, highly-flexible products sporting a complete set of communication and control options, from wireless communication to Ethernet and RS485 interfaces, all hinged upon the convenience of a TCP-IP architecture and complemented by the user-friendliness of FIMER's Installer for Solar Inverters mobile application.

PVS-10/33-TL is designed for simplicity and flexibility. It fits anywhere and can be easily installed in both new or existing plants, to ensure lower installation and maintenance costs.

A future-proof solution

Not only does PVS-10/33-TL make revamping fast and easy, it also embraces new technologies by translating today's market trends into usable features.

For example, to respond to demand for ever-increasing PV module currents, as in the case of bifacial modules, the range has been designed to accommodate up to 26A input channels on the 20, 30 and 33kW power sizes. Another major advantage is the inclusion of an integrated Dynamic Feed-In Control algorithm, which delivers on controlling the amount of energy fed into the grid with the least expenditure in additional balance-of-system devices. The PVS-10/33-TL only requires the installation of an inexpensive external meter to get Dynamic Feed-In Control up and running.

From a communication and control angle, an entirely TCP/IP-based architecture allows for the most cost-efficient networking throughout the plant as well as off-the-shelf, readily available replacements.

The new inverters also feature current monitoring on each string and a maximum input voltage of 1100 Vdc, allowing for longer strings as well as the ability to operate across wider temperature ranges.

For ease of operation and cost saving, the fuse-free design removes the need for on-site interventions and component replacement, as fuse faults occur. This also avoids inconvenient plant downtimes due to blown fuses.

Wherever needed, the new PVS-10/33-TL also offers integrated PID (Potential-Induced Degradation) recovery to maximise plant's performance ratio over time as well as an Arc-Fault Detection System for all those applications requiring some extra-safety arrangements on fire prevention.

Conclusion

With Fatih Birol, executive director at the IEA, stating that "I see solar becoming the new king of the world's electricity markets", demand for solar power will continue increasing over the years to come. To ensure PV solar players make the most of this opportunity, inverter technology needs to adapt to an evolving scenario and ensure two pillars will continue supporting the business of all key actors - operational simplicity and design flexibility.



FIMER

Find your flex



The new PVS-10/33-TL gives you complete flexibility.

Forget constraints. Choose it for new and existing installations. DC-side specifications work for any plant design and advanced communication ensures it's easy to add new technology, while keeping costs low.

Available now in six power sizes.

Stronger. Better. FIMER

fimer.com



the continent this decade. Diego Pavia, CEO at EIT InnoEnergy, said the mixture of policy, low cost capital and historic success of technology development in Europe made for “fertile ground for a rebirth of European PV”. To date, the most notable manufacturer to outline serious new plans to manufacture solar panels in Europe is Meyer Burger.

Modules are, however, just a single piece of the broader puzzle. For solar to reach its potential the entire supply chain must travel the same path. There is now a broad consensus within the industry that more collaborative efforts, such as the Trina Solar-led Open Innovation Ecological Alliance, are vital to the success of the collective. “The entire PV industrial chain should work together to attain the common goal, encourage more interactions and collaborative innovation involving upstream and downstream enterprises, so as to reduce LCOE and to make the PV power generation applications more economical,” Dennis She, senior vice president at LONGi Solar, says, also pointing to the need for more standardisation within product lines. In February 2021, eight of the world’s leading tracker manufacturers said they had approved products for use in new large-area modules, following inverter manufacturers who had committed to releasing compatible products this year. James Wu, vice president at inverter manufacturer Sungrow, says the company has committed a “massive R&D task force” in order to “push the boundaries of innovation” and develop a suite of products for use by “the whole industry”.

Technology will play a considerable role in elevating solar to become the eminent source of power globally, and has arguably already pushed the asset class into a dominant position. The key now is its ability to beat all comers on a cost basis, which solar is doing with growing ease.

Cost competitive power the world over

Solar is emerging as the king of new power markets principally because it is offering cheaper power than ever before, delivering at the lowest price in auctions, tenders, and even on wholesale markets.

The most recent IEA analysis of levelised cost of electricity (LCOE), released at the end of last year, produced a median price for solar generation of US\$56/MWh, with lows of US\$34/MWh recorded globally. Chase concurs with the low end of those figures, stating that if a new build project in Spain is offering €35/MWh (US\$42.5/MWh) for a power purchase agreement (PPA), then “you’ll probably get take up”.

Those projections are also being borne out in the field. France’s most recent tender for large-scale projects, the ninth such auction it has launched, attracted average bids of €53.83/MWh

(US\$65.83/MWh). A recent auction in India for 6.4GW of capacity in Andhra Pradesh attracted a lowest bid of US\$33.9/MWh. The most recent Spanish renewables auction, which awarded 2GW of capacity contracts to solar, attracted an average winning for solar of €24.4/MWh

(US\$29.5/MWh), however the lowest bid – tabled by developer Ignis – came in at just €14.8/MWh (US\$18/MWh). But even that figure was not low enough to limbo beneath prices recorded in Spain’s neighbour to the west. The €11.14/MWh (US\$13.12/MWh) recorded in last year’s auction surpassed the Portuguese government’s – and many in the industry’s – wildest expectations, creating anticipation for what might be delivered in the country’s third auction later this year.

Fortunately for solar, there is no looming shortage of auctions in which to demonstrate this LCOE prowess either. Analysis by WoodMac published earlier this year stated there to be 45GW of renewables auctions planned in 2021 in Europe alone. 6GW of that figure is earmarked just for solar, while a further 22GW of technology-neutral auctions will see solar compete against other technologies. If the asset class’ performance in tenders to date is anything to go by, it’ll be a brave generator to fancy its chances against solar PV.

Costs have fallen to such an extent already that it begs the question, how low can solar go? Jenny Chase is of the opinion that LCOEs will continue to fall, albeit not as drastically as they might have done until now. Having witnessed the cost of technology tumble

in the past decade, developers are now having to squeeze pips elsewhere. While increases in module efficiency will of course be welcomed, larger-format modules provide benefits to the Balance of System (BOS) cost and bifaciality can boost yields anywhere from 5 – 10% (see p.42), the cost of hardware is no longer the “main driver” for cost declines, Chase adds.

Instead the focus has been drawn to soft costs, but these have proven more stubborn to come down. “The issue here is a lot of these soft costs are quite value based, they’re literally a matter of finding the right paperwork and waiting until you get the get the permission, and then you can sell that paperwork for whatever you like. The price you can put it at is the cost of building a solar plant, but it’s also based on how much you can sell the power for,” Chase explains.

The key to bringing soft costs down further will be scale. The cost of site design, obtaining planning permissions and all the other necessary paper and office-based tasks cost less for each megawatt deployed, spreading that portion of the CapEx across a wider base. The industry is too becoming better at navigating the rigours of project design, and the scales at which some multinational developers are operating at can only deliver significant economies of scale benefits.

CapEx figures on the whole will continue to fall. BloombergNEF expects the cost of developing a typical, 100MW utility-scale solar system to fall from around US\$0.58c/Wdc this year to around US\$0.49c/Wdc in 2025. The rate may be steadier than previous collapses, but tangible all the same.

A problem that may be all the harder to solve is, however, further up the chain.

“the role of policy now is no longer making sure solar gets paid an above market price, it’s making sure solar can sell power at all and that it is actually possible to build a solar project.”

Fixing the grid

Having hurdled the cost barrier so competently, the last true obstacle to solar’s dominance is somewhat out of its hands. National grids, many of them

€11.14/MWh

**(US\$13.12/MWh)
Record low auction price
attracted in Portugal in
August 2020**

reliant on decades-old infrastructure, are poorly suited to a modern electricity system and, as a result, congested. Sungrow's James Wu highlights grid instability, alongside PV clipping losses and the desire for lower LCOEs, as one of the few remaining "difficult nuts to crack" for the industry. The inverter manufacturer believes the solution to grid challenges is to embrace more solar-plus-storage solutions.

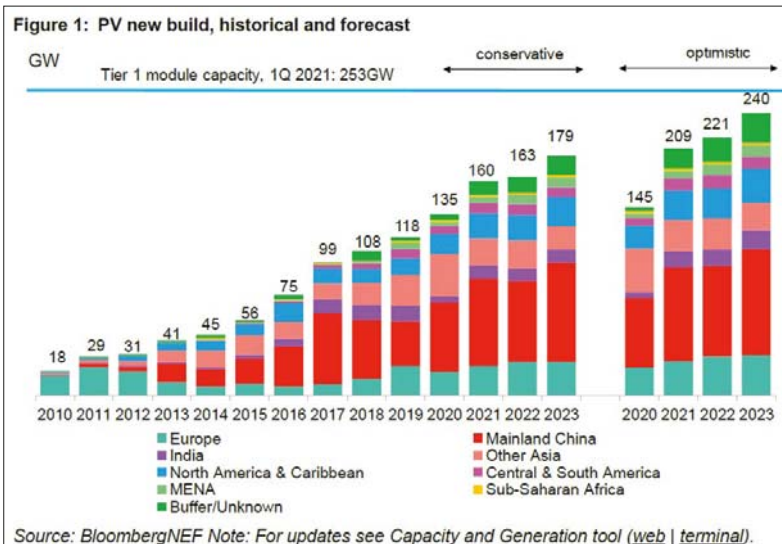
But they still require a grid connection agreement, which in some jurisdictions are not necessarily worth their weight in gold, but certainly cost bullion-esque fees. Chase says that in Spain – a nation where grid congestion is particularly problematic – fees could reach as much as €200,000 per megawatt for the connection and site approval. Grid connection fees in the UK have also been described as "astronomical" by developers.

There are various ways of smoothing the grid connection process (as discussed in *PV Tech Power Volume 25*), but there is little escaping the fact that without costly investment, either through hardware (pylons and cables) or software (flexibility systems leveraging smarter power), further growth of solar power will be stymied by the grid.

The IEA's World Energy Outlook 2020 narrowed on in the issue, arguing that electricity networks have a "central part to play" in unlocking flexibility from power plants, that flexibility being the "cornerstone" of modern power. The prevailing issue is, according to the IEA, that transmission system operator revenues tumbled in 2020 amidst the COVID-19 pandemic and could take some time to recover. With the IEA forecasting that as much as US\$460 billion worth of grid investments would be needed worldwide by 2030, the problems facing the grid take on an enormous scale. BloombergNEF's Power Grid Long-Term Outlook 2021 argues that power grid investments will need to top US\$636 billion by 2050 to replace existing infrastructure, serve new power demand and support greater renewables penetration.

Aside from investment, policy could also play a key enabling role in easing grid concerns and pathing the way for more solar to come onstream. While solar

BloombergNEF's solar install forecasts for 2021 - 2023



policy support is most commonly considered as subsidies or fiscal incentives, the policy demands of solar PV have evolved just as much as the technology itself. Now, it's about clearing the way, and not so much about identifying what can help solar, but about removing what can stop it.

"Policy is still hugely important because in a lot of places in the world, there is a high degree of central planning. Even in places where there is not a high degree of central planning, you often find big utilities and government and state-owned enterprises having control over who accesses the grid. So I would say the role of policy now is no longer making sure solar gets paid an above market price, it's making sure solar can sell power at all, and that it is actually possible to build a solar project," Chase says.

This could come out of closer collaboration between developers, grid operators and policymakers, and efforts are afoot to facilitate these discussions through trade bodies such as Eurelectric. Governments will play a vital role in rescinding some of that red tape, however, especially in nations with ambitious climate targets on the line. "There needs to be collaboration, and sometimes policymakers do need to take the lead and say, Look, I know this is not trivial, but you can't just ban solar, which is of course the easiest thing for the grid to do," Chase says.

Terawatts and beyond

Having wrestled control of the throne, solar is showing no signs of abdicating it any time soon. After a COVID-19-led blip in 2020, solar deployments look set to

surge back into the ascendancy this year, BloombergNEF forecasting that as much as 209GW could be installed. Quite how much exactly is installed – the research organisation's range is sizeable at 160 – 209GW – will depend on actual activity in selected markets, most notably China which could install anywhere from 65 – 75GW as it shifts gear in pursuit of an ambitious net zero target, to developers' collective ability to hurdle those remaining grid barriers.

Solar will also be more diverse geographically, with no fewer than 20 so-called 'gigawatt markets', where more than 1GW of solar is installed, in 2021. Old hands such as China and the US are to be joined by relative newcomers such as Poland. Installs will keep on coming, too. BloombergNEF's optimistic figures place installs at 221GW in 2022 and 240GW in 2023. Having passed the 500GW installed capacity threshold in 2018, it is widely anticipated to pass the terawatt mark either later this year or early next, depending on movements in notable markets. There is every indication that solar PV won't have to wait long for its next terawatt either, with the IEA's SDS and Net Zero 2050 models forecasting this to happen by 2026 at the latest.

Solar's rise has been meteoric, but it has been no overnight success story. The hundreds of gigawatts deployed this year and the terawatts that go on to be deployed over the next decade will owe everything to the kilowatts and megawatts deployed in years previous, charting the course. Solar may be the new king of electricity, the world's eminent source of renewable power but, in reality, this is merely the end of the beginning.

US\$460 BILLION

Grid investments needed by 2030 to support the renewables transition, according to the IEA

**SNEC 15th (2021) International Photovoltaic Power Generation
and Smart Energy Exhibition & Conference**

2021 | **June 3-5**
Shanghai · China

*Venue: Shanghai New International Expo
Center (SNIEC)*



SNEC Homepage

© Asian Photovoltaic Industry Association / Shanghai New Energy Industry Association

© Show Management: Follow Me Int'l Exhibition (Shanghai), Inc.

Add: RM905-907 No 425 Yishan Rd, Xuhui District, Shanghai 200235, PRC

Tel: +86-21-33685117 / 33683167

© For exhibition: info@snec.org.cn

For conference: office@snec.org.cn

Decarbonising Japan: Challenges and opportunities for large-scale solar PV

Japan | Andy Colthorpe takes a look at what's happening and what's expected to happen in the Japanese large-scale PV market, with data and analysis courtesy of RTS Corporation and interviews with Vena Energy Japan, Sonnedix Japan and Baywa Japan.



Credit: Vena Energy Japan

United Nations Secretary-General António Guterres said in November 2020 that the “science is clear”: failure to reduce greenhouse gas (GHG) emissions by 2030 by half and achieving net-zero emissions by 2050 worldwide will be catastrophic. The COVID-19 crisis will “pale in comparison to what the climate crisis holds in store,” Guterres said.

Speaking five years after the Paris Agreement, when a landmark consensus had been reached, the Secretary-General highlighted that the European Union, along with the United Kingdom, Japan and the Republic of Korea and more than 110 other countries had pledged to achieve carbon neutrality by 2050 and China by 2060. Since then, US President Joe Biden has brought his country back into the Paris Agreement too.

Japan's Prime Minister Yoshihide Suga made that pledge in October, like Biden making climate action one of his first big moves after taking office. Japan has

embraced solar energy in the recent and not-so-recent past, initially in the 1970s following the OPEC oil price shock and then again from 2012, following the earthquake and tsunami that hit East Japan in March 2011.

The introduction of the feed-in tariff (FIT) in 2012 for solar PV at all scales with prices set originally in excess of ¥40 (US\$0.38) per kW began a solar ‘gold rush’: according to government statistics, a total of 74.3GW of solar was approved under the regime, of which 68% (50.2GW) has been commissioned. The vast majority of projects below 2MW capacity approved have been built and connected to the grid already, for instance 97% of projects under 10kW — generally residential — have been built and between 70% and 80% of all projects between 10kW to 2MW capacity have been commissioned.

However, for PV plants of 2MW or more, 21.9GW of projects have been approved and only 42% commissioned (9.2GW).

Vena Energy Japan's 35MW Ono plant in Fukushima Prefecture demonstrates the ‘uniqueness’ of developing large-scale solar in Japan.

Tokyo-headquartered industry analysis firm RTS Corporation believes that much of the remaining 12.7GW is under development, but it is unclear what will definitely be built. So what are some of the challenges still facing large-scale solar PV developers today?

Winning over local stakeholders

It can take a lot of time to develop projects in Japan, Tomomichi Kageyama, representative director at Sonnedix Japan, says. European PV developer Sonnedix has more than 1GW of operational assets worldwide and opened its offices in Tokyo in 2013. It now has 250MW in operation in Japan. Kageyama says this is due to rapid development in 2020: at the end of 2019, Sonnedix Japan only had 56MW in operation.

Progress last year was partly down to a new strategy of acquiring projects under development. From the early stages, projects took longer than the company had expected, Kageyama says, with a “long, long journey” to obtain permitting.

“In Japan, local development matters are very challenging. In large-scale infrastructure projects overseas, mostly those projects are supported by the national government of each country,” Tetsuya Oura, president and representative director for Baywa Japan says.

Oura developed and financed projects in various industries in Japan and internationally before joining Baywa a couple of years ago. Each country has fundamental risks, he says, but generally speaking there tends to be strong backing from central government for large projects.

“In Japan, the local stakeholders and private entities, they are very strong, they have strong rights. So in that sense, we need to get their consensus.”

Baywa was a relative latecomer to Japan,



Credit: Baywa Japan.

arriving in 2015. It commissioned and sold its first large-scale PV project in the country last year, an 11.9MW, 24 hectare solar park in Kyushu, southern Japan. This was quickly followed up by a 35MW larger project (pictured) as part of an initial 100MW pipeline.

Market evolving to meet unique circumstances

Singapore-headquartered Vena Energy is active in eight countries across the Asia-Pacific renewable energy market. The independent power producer (IPP) has commissioned 450MW of large-scale PV since opening its Japan offices in 2013, doing everything from development to construction and operation of assets.

"Japan is quite unique in terms of site acquisition and permitting and construction," Juan Mas Valor, country head for Vena Energy Japan says. "I've never seen the kind of constructions that we are doing here in Japan. Japan is a mountainous country and the flat areas are rice fields that we are not allowed to use. So we need to focus on [finding the right] areas," Mas Valor says.

Juan Mas Valor has worked in Japan since 2013 and before that built PV plants in America and Europe. The Japanese market has evolved and matured, he says, with costs reduced significantly with scale, experience and competitiveness.

There has also been an "evolution of the players" too, Mas Valor says, from an industry "of a few pioneers" in 2013. Early on there weren't many very large or institutional players involved but more and more have joined.

Policy has also evolved. The government has launched auctions for large-scale solar

in place of the feed-in tariff. Vena Energy Japan won the biggest contract awarded in the most recent auction with a 68MW plant.

Unlike recent auctions in other countries, they have not been heavily oversubscribed. The government has set ceiling prices and had some success in lowering costs. Analysis firm RTS Corporation noted that the average winning bid price was ¥11.34 in the November tender, held for systems with 250kW capacity or more.

"The last auction was in the range of ¥11 and we will see this going down. Solar is going to be the most competitive technology, so naturally the country will adopt more and more this clean technology because on top it is also cost-effective," Juan Mas Valor says.

At the beginning the incentive of the high FiT was needed to attract both local and international investment. Japan did a very good job with that and "now the machine is working," Mas Valor says.

Nonetheless, the auctions have presented challenges. Not just the ceiling prices or the price competition, but also in the requirement to secure grid connections and suitable land before participating in auctions, which are for projects of 250kW capacity or more. Projects over 30MW need to show progress in the environmental impact assessment process. A deposit needs to be placed before the auction and another placed after winning. All of these things could be barriers to companies taking part, Juan Mas Valor says.

Neither Sonnedix Japan and Baywa Japan have entered the auctions, with Sonnedix's Kageyama saying that the

Baywa Japan sold the 35MWp Isohara solar project in Kita-Ibaraki City to a venture set up by Osaka Gas and the Development Bank of Japan (DBJ).

company has not ruled out investing time and money in the tenders but that finding land and meeting other criteria "is not easy".

The projects Sonnedix Japan acquired in 2020 are all high FiT-level projects awarded in past years. That type of project still represents a "meaningful investment" for the company, Kageyama says, and a number of development assets Sonnedix is working to acquire are also high tariff projects.

Tetsuya Oura confirmed that Baywa is also still working on a pipeline of FiT projects. The auction scheme itself will soon be phased out, with the replacement regime, called the feed-in premium, still a work in progress. There is also expected to be a greater tendency towards corporate power purchase agreements (PPAs) and even PPAs signed directly with local authorities.

All of our interviewees are enthusiastic about the idea of signing long-term corporate PPAs. Equally, PPAs with local authorities could be a good option, they say, although this will require further regulatory reform.

150GW by 2030

Ahead of the 2050 carbon neutral target, the country is expected to introduce a higher interim renewable energy target for 2030 than the 22% - 24% goal currently in place. Environment Minister Shinjiro Koizumi said last year that it could be upped to 40% in the next national Strategic Energy Plan and while onshore and offshore wind will start contributing a higher proportion than the minimal or non-existent amount they do now, solar PV looks likely to continue to dominate.

RTS Corporation says that around 8GW of solar was deployed in Japan in 2020, with cumulative installs at all scales coming in at around 70GW. In fact, the analysis firm pointed out in a webinar last year that the 2030 PV capacity target in existing national renewable energy goals, about 64GW, was surpassed at some point between 2019 and 2020.

A more ambitious new target that RTS believes is achievable and would contribute meaningfully to full decarbonisation or carbon neutrality would be 150GW by 2030. From the company's modelling of the market, even a business-as-usual scenario would see Japan achieve around 130GW by 2030 and under an 'accelerated scenario' could go to 160GW.

Minister of Economy, Trade and Industry

Hiroshi Kajiyama said last year that the country will work to maximise renewable energy and nuclear and in future will support new options like hydrogen. There is also an expectation that some regulations on land use and permitting will be relaxed, allowing development of solar and wind on abandoned agricultural land and some National Parks.

"There's so many ways to increase capacity for renewables, especially for solar," Sonnedix Japan's Tomomichi Kageyama says. "In recent years, the government didn't look like they are clearly facilitating renewables. In the last few years, they've made many changes in FIT law and also [introduced] some regulations against solar because they have concerns that too much increased investment for solar and an increase in subsidies would be too much [of a] burden for the population [to pay]."

Juan Mas Valor says that Vena Energy Japan's portfolio of projects with FIT contracts is expected to be finalised and "many projects are under construction now already". Being able to develop new projects is going to be important, he says.

"We want to continue helping Japan to reach the targets of zero carbon. So the focus is to continue developing new projects. Already METI is talking about new business models, for example, with FIP structure. We are here for the long term — we are here to continue supporting Japan in the aspect of renewable energy, so we need to continue developing projects."

The feed-in premium is expected to be a contract structure that will pay a certain top-up on prices that generators can get from the wholesale market or from PPAs, rather than a high fixed rate for kilowatts installed that a feed-in tariff is. Mas Valor says that with "a lot of discussions" underway, the industry is getting "more and more information of how it will end up". While it isn't therefore exactly clear what the policy will look like, Vena Energy Japan will be "happy to continue developing projects with these [new] schemes," he says.

Support doesn't have to mean direct subsidies, it can also mean changing or updating rules and regulations to enable positive changes. Sonnedix Japan's Kageyama says that the rigidity of the FIT scheme structure prevents companies for example from changing modules installed at a site for newer, larger components with greater yield and efficiency.

"In a FIT scheme, we cannot increase the

capacity [of a solar plant]. Because if we increase the capacity of the higher tariff site, we will get more benefit. But a lot of technology has improved." The capacity of electricity that a single PV module can produce has changed a lot since the FIT launched more than eight and a half years ago. Even the wholesale price for power from the expanded portion of capacity would be enough of an incentive to "repower" or "upgrade" plants in this way.

Resolving the grid capacity issue

The lack of available grid capacity is a big technical and development challenge for large-scale solar developers in Japan. For Sonnedix Japan it's the main challenge when it comes to finding new projects and Kageyama says that again, changing regulations around that could help.

"It's been said that there's actually ample capacity already, but in case of emergencies, quite a big amount of capacity is unused. There is also the capacity needed for nuclear plants which are not operating now (since Fukushima most of Japan's fleet of nuclear plants have been shuttered) but they need capacity for that."

Baywa Japan's Tetsuya Oura says that most of Japan's 11 regional grid operators — who are also Japan's regional monopoly utility providers — do at least show how much grid capacity is available on maps. However each utility uses different methodologies to calculate capacities. He says it is positive that the government is leading initiatives to improve transparency and the situation could be resolved by cooperation between policymakers, utilities and the renewables industry.

Vena Energy's Juan Mas Valor agrees that there are a "lot of constraints on the grid" that "block the possibility of developing more projects". He too is aware that METI is working to change that situation, including the cancellation of FIT contracts for planned solar projects that look unlikely to proceed but for which grid capacity has been reserved. In the last year or so "several countermeasures" have been discussed to try to solve the problem, but it will take some time to see the impact.

Vena Energy is also already installing bifacial modules at projects in Japan, which again can improve generation. Sonnedix Japan and Baywa haven't used bifacial modules at their projects in the country yet, but both are actively looking at the technology for future projects. Baywa Japan's chief operating officer, Jean-Francois Rebeille, says that a project where

they will be used hasn't been "firmed up yet," but it is "definitely on the table for some configurations that we have".

"The size, and the module type is quite dynamic, we always look for the latest, best choice in terms of performance and cost trade-off. The assumption you make when you start the project, and then the actual panels that you end up selecting and buying and installing can be quite different. The development cycle can take a couple of years. We pick the best technology at the time that we have to place an order, and that can include bifacial — we use those on a global basis as well."

Rebeille said that Baywa is also keen to investigate opportunities for floating solar: "Japan has already done a number of things in floating PV. There's still bodies of water out there that are available. Whether for standalone development or related to an industrial site that might have a pond or some kind of reservoir associated with their activity. Size-wise, we're not talking about 'Megasolar', tens of megawatts type of configurations, although there could be some fairly good sized projects."

Battery storage's role in the future

Battery storage is likely to play a greater role in the future. There aren't market opportunities for batteries to provide frequency regulation and other ancillary services yet, although Baywa's Jean-Francois Rebeille believes this will change, depending on what grid operators require. He also sees hybrid renewables and storage projects as a "holistic" answer to many of the challenges of growing the renewable contribution to the energy mix, whether solar or wind.

"There's going to be more and more discussion around, you're putting in renewables, but can you store the energy when you're not using it or so you can release it when you need it? It's still early stages: a lot of things need to happen in Japan to accelerate that transformation. But for us, we're convinced that storage is going to be part of what we are going to have to offer."

Sonnex Japan's Tomomichi Kageyama says that energy storage "could be a driver for the next phase" of large-scale solar in Japan. At the moment, battery storage costs are still considered quite high and the only part of the country that has mandated any form of storage for renewables is the northern island of Hokkaido, which has a congested grid and only limited interconnection with the rest of the country.

***Exhibit & Participate in
Japan's Largest*
PV Industry Show!***

Held inside World Smart Energy Week 2021

14th Int'l Photovoltaic Power Generation Expo

PV EXPO 2021

Mar. 3 [Wed] – 5 [Fri], 2021
Tokyo Big Sight, Japan

Organised by: Reed Exhibitions Japan Ltd.

*Largest in reference to the exhibitor number and the net exhibit space of trade shows with the same concept.



<https://www.pvexpo.jp/en-gb.html>



Organised by



Organiser: Reed Exhibitions Japan Ltd. PV EXPO Show Management

TEL: +81-3-3349-8576 E-mail: pv@reedexpo.co.jp Web: www.pvexpo.jp/en/

A division of Reed Business Registered in England, Number 678540



Sonnedit Japan acquired this 55.6MW project in December 2020. The plant is under a feed-in tariff which expires in 2037.

Credit: Sonnedix Japan.

"We have to think about the investment, we need to make sure that investment has good return," Kageyama says. Storage costs are not that "reasonable or cheap" yet and mandatory requirements for storage do not make investment more profitable. However, he says, Sonnedix Japan also expects — and hopes — to be installing energy storage in Japan.

Vena Energy is building a 150MW battery project in South Australia which, Juan Mas Valor says, the Japan team will be watching closely. The business case for storage is already present in Australia, he says, with greater immediate need for ancillary grid services. Japan too, will get to that point soon as the penetration of renewables goes up.

Baywa's Jean-François Rebeille says that curtailment of renewables could become a bigger issue that energy storage could resolve too. "We'll have to see what the picture is in terms of curtailment. That's where it can mean storage gives you the ability to store energy and return it to the grid at the right time. Curtailment can be quite a significant factor to consider."

Commitment for the long-term

Solar will need to play a major role in Japan's carbon neutrality goals. Prime Minister Yoshihide Suga and other government ministers have also acknowledged, as has been the case with the EU and the Biden-Harris Administration in the US, the low-carbon transition as a major driver of economic activity. All of our interviewees are in Japan to do business long-term and want to continue contributing to those goals, engage with local communities, open local offices and train local staff.

"Not only government initiatives, but also the ambitions of the corporate sector, are the keys," Baywa's Tetsuya Oura says.

"We are now observing more and more firms showing the willingness to be green and to join the RE100. More and more companies have contacted us to discuss the possibility of our support in their renewable energy shift. There are many companies willing to increase the renewable energy usage but they are not familiar with the development or construction of the project itself. In that sense, they will outsource the development of innovative projects to 'outsiders' like ourselves. That

is a core part of our future activities we're thinking about."

Jean-François Rebeille says that Baywa is convinced that Japan's government, corporates and other stakeholders realise solar needs to play a big part in the national energy transition. Increasing the national renewable energy target to 40% will count on offshore wind starting to contribute, but this is a "heavy, long-term effort," while deploying solar is relatively quick and cheap. People are now carefully monitoring, he says, how the different stakeholders will approach questions such as access to land, competitive costs and the design of appropriate corporate PPA structures.

"Vena Energy came here to Japan in 2013, to stay for a long time. We are a long-term player. We have proved this with the large amount of projects that we have managed to develop, build and operate," Juan Mas Valor says.

"Last thing but not least, we always believe in supporting the local communities. Wherever we go and build projects, we ensure that we go to the communities and if they need something, we are helping them."

Inside Asia's floating solar dominance

Floating solar | Asia is expected to dominate floating solar's growth over the next four years with up to 70% of global installations of floating PV to take place in the continent. But what are the key drivers behind this surging demand, and what can other continents learn from it? Jules Scully investigates

Faced with ambitious climate targets and rising electricity demand, some governments across Asia have thrown their weight behind efforts to support the development of floating solar projects, recognising its potential in high-density areas that lack suitable space for ground-mounted PV.

As high demand for available land pushes up rent and purchase prices, inland water bodies such as reservoirs, lakes and flooded coal mines located close to urban areas are being exploited to house large-scale floating PV (FPV) plants that dwarf the size of comparable installations in other continents.

Feed-in tariffs (FITs) as well as tenders and auctions for floating solar capacity have helped drive growth of the sector, while early adaptation of the technology and successful pilot projects have given first movers the knowledge to scale-up installations and deploy advanced floating structures in areas prone to extreme weather.

Markets such as Japan and South Korea are now able to benefit from more than ten years of floating solar experience, according to Frank Haugwitz, senior advisor at renewable energy consulting firm Apricum. "Once the proof of concept was established, it undoubtedly helped to scale-up floating PV in the following years, particularly in China, which started to deploy megawatt-class floating solar systems as early as 2015," he says.

"Additionally, Asia is a fairly dynamic region with some countries experiencing high single or even double-digit annual electricity growth rates. Given that these countries have inland water bodies that are often in the vicinity of load centres, the need for long distance power transmission and associated curtailment issues are eliminated. Because of this on-site consumption, floating PV made a



A 20MW floating power plant at an irrigation reservoir in Guangxi, China.

Credit: Sungrow

compelling case for many project developers," Haugwitz adds.

As with ground-mounted solar, China is the world leader in terms of FPV installed capacity, with a host of 100MW-plus projects that are often developed in coal mining subsidence areas. Last April, Hangzhou Fengling Electricity Science Technology completed the second phase of its 320MW Cixi plant, making it the world's largest floating solar installation.

According to figures from IHS Markit, China's installed floating PV base is estimated to be double the size of the next largest 11 countries in terms of installed base greater than 5MW. The research firm says China maintained its ranking as the largest market for floating PV for the third year in a row in 2019, despite a slide in installs due to the general decline of the country's solar market and the removal of the Top Runner policy.

That policy saw China's National Energy Agency issue a tender in 2016 for the installation of 1GWp of FPV in coal mine subsidence areas, mainly in

Anhui Province, and another 400MWp in Shandong Province.

Floating PV mounting supplier Sungrow was among the beneficiaries, as more than 400MW of the projects planned by the Chinese government from 2016 to 2017 in these coal mine subsidence areas feature the company's floating system. "These floating power plants not only make full use of these waters, but also promote the local

"Although the national conditions of each country are not the same, each country will have some abandoned waters with very low utilisation value,"

employment and economic development," says Kane Wang, manager of Sungrow Floating's system solution department.

Wang believes this example of supporting the development of large-



An image of the planned 41MW project that Q CELLS is developing at the Hapcheon Dam in South Korea.

scale floating solar in coal areas could be copied in other markets. "Although the national conditions of each country are not the same, each country will have some abandoned waters with very low utilisation value," he says. "We believe that governments of all countries can learn from China's experience and focus on planning these abandoned waters with low utilisation value as floating PV power plants, so as to develop clean energy while making full use of water resources, saving land, driving economic development and employment. This is a choice that every smart and responsible government will make."

IHS Markit says both Sungrow and Ciel et Terre dominate the global market of FPV mounting suppliers, with the companies together accounting for 70% of the total completed or under-construction installations. Sungrow Floating is said to have the largest installed base due to its strong market share in China and other Asian countries, and as of December 2020, its cumulative installed capacity exceeds 1.1GW.

Sungrow has formed a dedicated research and development team to tackle issues such as product reliability under harsh environmental conditions, the impact floating projects have on water bodies and the construction of anchoring technology in areas with large fluctuations in water levels.

Environmental challenges

Despite the potential benefits of developing floating PV – including reduced water evaporation, higher land use efficiency and increased energy yield thanks to the cooling effect of water – there have been calls for additional research into the environmental impact of such installations to allow the technology to take off.

A report from the World Bank and Solar Energy Research Institute of Singa-

pore (SERIS) says that for most countries hoping to develop a well-functioning FPV segment, unique aspects of permitting and licensing need to be addressed through cooperation between both energy and water authorities.

In South Korea, tests carried out at a dam where Q CELLS is looking to develop a 41MW floating plant found that the installation "will have no negative environmental impact", the company says. Currently under construction at the Hapcheon Dam in the south of the country, the project has seen Q CELLS carry out environmental stability tests to ensure that it would have no adverse impact on the dam or its ecological balance.

"Scientific consensus – as a result of monitoring tests conducted on four separate occasions by the Korea Environment Institute (KEI) – showed that the water quality is unaffected and that there is no significant difference between the water area covered by the power plant and the uncovered water area," says Ian Clover, manager of corporate communications at Q CELLS.

As well as the land scarcity, Clover believes that some Asian markets' success in floating solar is partly thanks to knowledge of waterways that ensures there is already a good base level of engineering expertise. He says: "Similar to how in Europe it is the Netherlands that has already made great strides in floating solar thanks to its history of managing and manipulating its water,

there is similar expertise in Asian countries, where communities have long relied on local bodies of water for generations. It is an extension of that relationship, in many places."

Q CELLS won the rights to develop the Hapcheon Dam floating solar project last year from

K-water (the Korea Water Resources Institute). It will feature the company's Q.PEAK DUO Poseidon modules and have a design inspired by the plum blossom, the symbolic flower of the local area.

While Q CELLS recognises that there are "some additional costs" associated with the installation process of a floating solar plant, it is looking to take advantage of up to 10% higher power generation compared to land-based PV as a result of the cooling effect of the water and the lack of shading.

South Korea's floating PV market

has been boosted by the country's Renewable Portfolio Standards policy that requires power producers with an installed generation capacity greater than 500MW to mandatorily supply a certain amount of renewable energy. To meet their targets, these operators purchase Renewable Energy Certificates (REC), with a different weighting applied to various renewable technologies.

"In the case of floating PV, a time and a half REC can be granted," Clover says. "This means, for example, that if 1,000kWh electricity is produced at a floating PV site, it will receive a REC to the value of 1,500 kWh. In this way, floating PV offers distinct and attractive advantages in terms of return on investment."

South Korea will be the location of the world's largest floating project, which will be developed inside the country's Saemangeum seawall, feature around 5.25 million solar panels and have a capacity of 2.1GW when fully operational in 2025.

As Q CELLS makes progress with the Hapcheon project, Clover believes adding floating solar to dams "makes sense", as reservoirs created by them are "generally large, open bodies of water with good road access and pre-existing infrastructure".

Colocation with hydropower

The potential for co-locating FPV with existing hydropower plants in Southeast Asia was revealed in research last year from the Institute for Energy Economics & Financial Analysis (IEEFA), which suggests the region's floating solar potential is at least 24GW. In Indonesia, the think tank says there are "many excellent opportunities" to install floating solar on existing dams/reservoirs, thanks in part to its considerable number of inland water bodies. Citing government data, IEEFA says the country has 231 big dams, 3,489 weirs and 4,311 reservoirs.

Renewables developer Masdar is currently progressing with plans to develop Indonesia's first large-scale floating solar project, which will be built at the Cirata reservoir in West Java and have a capacity of 145MWac. The Abu Dhabi-based company recently formed a joint venture with PT PJB, a subsidiary of Indonesia's state electricity company PT PLN, to drive development of the plant.

After signing a power purchase agreement for the facility early last year,

24GW
Southeast Asia's
floating solar
potential,
according to
IEEFA

Taiwan's record-breaking offshore PV project

Last November saw Taiwanese solar developer and operator Chenya Energy complete the world's largest offshore floating PV project.

The 181MWp facility, called 'Lunwei East No. 1 and No. 2 Photovoltaic Power Station', is located on the west coast of Taiwan, in the country's most densely populated county, and took just over 16 months to construct.

Modules are fixed to a mooring frame and floats that are supported by concrete anchors, with the installation sitting on the seabed during low tide and floating when the tide rises.

Despite concerns from financiers surrounding the construction schedule (which could have affected the feed-in tariff for the project) and the potential danger of earthquakes and typhoons, Chenya was able to secure TWD7.2 billion (US\$240 million) in financing from seven banks for the facility last year.

Surrounded by the ocean and with a high population density, Taiwan presents challenges for solar developers looking for suitable land for large-scale projects, a Chenya Energy spokesperson told *PV Tech Power*.

With the country looking to achieve 20GW of installed PV by 2025, the company has welcomed government efforts to back renewables deployment. "The government has provided sound supportive measures for the development of floating solar photovoltaics, which include land inventory, establishing multiple sources of funds, promoting banks to finance solar photovoltaic establishment and promoting the talent development of solar photovoltaic industry," the spokesperson says.

Completion of the project came months after Chenya Energy was acquired by Japanese trading giant Marubeni. At the time, Marubeni said the acquisition would allow it to gain expertise in the floating solar market, an area it plans to expand on in Taiwan and other regions.



The 181MWp project from Chenya Energy Project was completed last November

Masdar is benefiting from PT PJB's local knowledge, as the partners work on achieving financial close, with construction expected to begin the first half of 2021. "PJB is playing a significant role in bringing the project to closing, particularly on the permitting work stream, on land-related matters and other crucial local activities," says Ahmed Al Awadhi, director of business development and investment at Masdar Clean Energy.

Set to be built on 4% of the Cirata Reservoir's water surface, the project will feature around 350,000 solar panels arranged into multiple islands anchored to the bottom of the reservoir using mooring lines. It will be connected to the 150kV Cirata switchyard, located approximately 4km away from the power plant.

According to Al Awadhi, Masdar is aiming to expand its business in other Southeast Asian markets through the

creation of other joint ventures: "Partnerships lie at the heart of our business and investment philosophy," he says.

"Masdar is keen to apply [floating PV] wherever possible, and we believe that, particularly in Southeast Asia, floating PV makes sense, given land constraints, where traditional solar projects could compete with other usages, such as agriculture. We see floating PV as being attractive in countries such as Indonesia, Vietnam, the Philippines, Thailand and Malaysia."

Policies to support FPV growth

The World Bank/SERIS report says that while few countries have provided financial incentives specifically for FPV, most markets that have preferential FiTs for solar typically also include floating PV. This is the case in countries such as Japan, Malaysia and Vietnam. Taiwan,

meanwhile, has a FiT policy that favours floating installations over ground-mounted solar.

Alongside FiTs, the other two other main policies that support floating solar deployment in Asia are auctions and deployment targets. Thailand has a target of 2.7GW spread over 16 projects to be realised by 2037. However, auctions conducted in China and India have triggered a "far greater response", says Frank Haugwitz of Apricum, with India releasing a series of floating PV tenders between 2018 and early 2020 amounting to more than 2GW.

"In general, auctions signalled government support, raised awareness among market stakeholders, triggered technological advancements and led to significant cost reductions in a relatively short period of time," adds Haugwitz.

Tenders and auctions are expected to be the main drivers to help the adoption of floating PV in many Asian countries, according to IHS Markit, which expects the continent to account for more than 70% of all FPV installations in the next four years. Given their experience of the technology, FPV players operating in Asia have the potential to export their knowledge to other markets looking to make use of available water bodies to build FPV capacity to meet clean energy targets.

Benefits could also be transferred in terms of project financing. Minh Khoi Le, a research analyst at Rystad Energy, says that the "relatively unproven" nature of FPV has led to hesitation from banks and investment funds. "As mega-size floating PV plants are commissioned, the sample size gets bigger, lessons learnt lead to better, safer technologies, financing institutes can be more accepting of floating PV," he says. "It just so happens that these Asian regions are quite hurricane-prone, which can make them be the perfect testbed for floating PV."

Despite the progress made in many Asian countries, floating PV is estimated to make up less than 1% of total global installed solar capacity. But as larger floating solar project sizes allow for economies of scale that yield lower installation costs, progress made by pioneers in Asia can pave the way for other markets to follow. ■

Turn to page 55 for a Project Briefing from a 20MW FPV system installed in Guangxi, China.

inter solar

connecting solar business

The World's Leading Exhibition Series
for the Solar Industry

INTERSOLAR EVENTS 2021

www.intersolar-events.com



JUNE 14–16, 2021, DUBAI, UAE

www.intersolar.ae

JULY 14–16, 2021, LONG BEACH, USA

www.intersolar.us

JULY 21–23, 2021, MUNICH, GERMANY

www.intersolar.de

SEPTEMBER 7–9, 2021, MEXICO CITY, MEXICO

www.intersolar.mx

OCTOBER 18–20, 2021, SÃO PAULO, BRAZIL

www.intersolar.net.br

DECEMBER 14–16, 2021, MUMBAI, INDIA

www.intersolar.in

INTERSOLAR SUMMITS WORLDWIDE

www.intersolar-summit.com

FOLLOW US



Unravelling the past, present and future of solar policy in Vietnam

Vietnam | Vietnam experienced enormous growth in solar deployments in 2020, with as much as 9GW being installed as the successful FIT policy drew to a close. Edgar Gunther explores how that policy came to be so successful, and what the future holds for solar PV in Vietnam.



Credit: Jinko Solar

Vietnam's year-end solar installation figure of 9GW captured headlines in January 2021. But how did Vietnam grow its cumulative solar installations from a 2018 base of 106MWp, according to International Renewable Energy Agency (IRENA) Renewable Capacity Statistics, to year end 2020 cumulative PV capacity of over 19.4GWp?

In a word, policy. The uncapped solar Feed-in Tariff (FIT) incentive policies to be more specific.

The original FIT1

On 11 April 2017, Vietnam's Prime Minister approved Decision No: 11 /2017/QĐ-TTg on support mechanisms for the development of solar power projects in Vietnam, launch-

ing the original FIT policy. The Solar FIT program required utility company Vietnam Electricity (EVN) to purchase electricity from grid-connected solar projects over a period of 20 years at 2,086 Vietnamese Dong (VND) per kWh, excluding VAT, Value Added Tax, equivalent to US\$0.0935 per kWh based on the State Bank of Vietnam exchange rate at the time and therefore subject to exchange rate risk.

The Power Purchase Agreement (PPA) follows a template issued by the Vietnam Ministry of Industry and Trade (MOIT). To qualify, on-grid solar projects were required to use solar cells with greater than 16% efficiency or modules with greater than 15% efficiency and achieve Commercial Operation Date (COD) by 30 June 2019.

Solar installs throughout 2020 took Vietnam's cumulative capacity to more than 19.4GW.

On-grid solar projects, typically ground mounted, also required approval for inclusion into the Power Development Master Plan, while rooftop solar projects did not. Solar projects below 50MWp needed approval from MOIT, and solar projects 50MWp or greater in capacity required Prime Ministerial approval for inclusion into the Power Development Master Plan.

Vietnam's original FIT policy created a solar ground mount boom with 2019 installations of about 5.317GWp from a cumulative 2018 solar base of 106MWp, making Vietnam the solar PV leader of ASEAN.

However, the solar ground mount boom also created high voltage grid congestion in Ninh Thuan and Binh Thuan Provinces, leading to solar project curtailments that are still being mitigated, worked through, and resolved today.

FIT2 takes to the rooftops

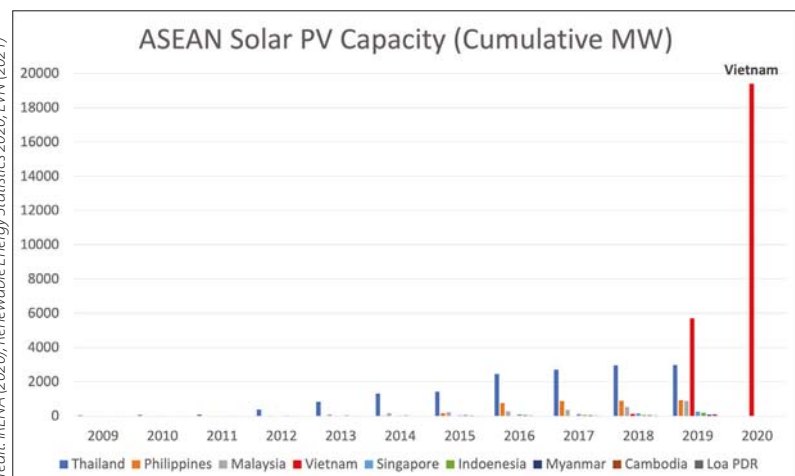
After the expiration of the original FIT policy (FIT1) on 30 June 2019, Vietnam digested its solar growth and considered new incentive policies, with a focus this time on rooftop solar to generate electricity where it is needed without concerns of grid congestion.

During the initial wave of COVID-19 in Vietnam, the Prime Minister issued Decision No. 13/2020/QĐ-TTg on the mechanism for encouraging the development of solar power on 6 April 2020, setting the policy framework for Vietnam's tremendous rooftop solar market.

Dubbed 'FIT2', the new incentive policy paid VND1,943 per kWh (US\$0.0838 per kWh), based on the State Bank of Vietnam exchange rate at the time, over a period of 20 years with COD achieved by year end 31 December 2020. The FIT2 rates for ground mount and floating solar projects were US\$0.0709/ kWh and US\$0.0769/kWh respectively with the same term and COD deadline.

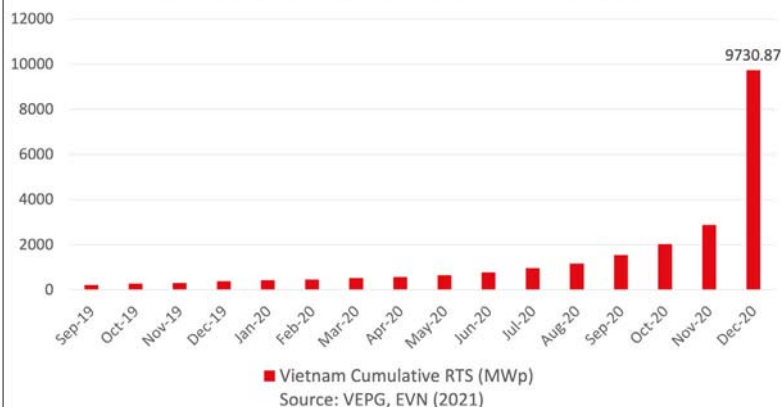
Initial FIT2 expectations were for an extension of the FIT1 rate of VND2,086

Cumulative solar capacity of ASEAN nations



Credit: IRENA (2020), Renewable Energy Statistics 2020, EVN (2021)

Vietnam Rooftop Solar PV Installations



Credit: VEPG, EVN (2021)

per kWh (US\$0.0935/kWh) for rooftop solar. However, FIT2 did provide a special FIT1 extension for certain grid-connected solar projects in Ninh Thuan Province not exceeding 2000MW in capacity that were already included in the Power Development Master Plan and would achieve COD by 31 December 2020.

An important ingredient of the FIT2 policy included clarity on corporate PPAs for rooftop solar systems enabling electricity transactions between a rooftop solar developer and a private company.

Vietnam's 2020 rooftop solar boom has seen further revisions upward, with an additional 148MWp added to the total 9.731GWp over the past month as the state-owned EVN reviewed the data per the latest Viet Nam Energy Partnership Group (VEPG) report.

Throughout 2020 rooftop solar installations in Vietnam grew by a significant 2,474%, rising from a 2019 base of 378MWp to 9.731GWp, spread across 105,212 systems. Per the above chart, Vietnam rooftop solar installations grew steadily in H1 2020 despite the pandemic and a nationwide lockdown period imposed in the country. Rooftop solar growth continued to accelerate throughout Q3 2020, and cumulative Vietnam rooftop solar reached an impressive 2.876GWp by the end of November 2020, with monthly installations of some 851MWp.

While most forecasted a few GWp range of rooftop solar installations in the last month, December 2020 saw Vietnam rooftop solar installations skyrocket by 6.855GWp, dominated by the commercial and industrial (C&I) segment with 5.792GWp and 392.6MWp each respectively. Per *TuoiTre Online*, in the final three days of December 2020 before the FIT2 policy expired, Vietnam added 19,209 PV systems, equivalent to about 4.4419 GWp

of capacity, according to the revised figures. All these systems required EVN third party testing for grid connection and executed PPAs with EVN to participate in FIT2.

Furthermore, a 31 December 2020 notice from the MOIT revealed cumulative PV capacity to have reached 16.449GWp (13.160 GWac) by year end, implying another 1.549GWp of ground mount and floating solar projects to have also achieved COD under FIT2 in 2020.

But 38 solar projects, or 2.888GWac, did not qualify for FIT2. Perhaps some of these did not meet the rooftop solar requirements. MOIT clarified the rooftop solar definition back in September after a number of agricultural rooftops were built for the sole purpose of installing solar. The late year surge may have included these structures modified by constructing walls in order to qualify for the FIT2. These projects appear to be included in the 19.4GWp 2020 cumulative PV capacity number from Vietnamese news sources, citing EVN.

While FIT1 and its successor have driven solar to new heights in Vietnam, the country has been crafting more focused policies to incentivise renewables for the past few years.

The solar auction program

Solar auctions have been proposed in Vietnam for the direct sale of electricity to EVN, transitioning solar farms away from blunt feed-in tariff policy mechanisms. FITs have led to concentrated development of solar farms in Vietnam's highest solar resource provinces, Ninh Thuan and Binh Thuan, stressing high voltage transmission line capacity and resulting in curtailment for many solar farms. Also, local Provincial People's Committee approval authority for solar projects below 50MWp in capacity resulted in numerous solar farms approved with capacities just below that mark.

Rooftop solar capacity in Vietnam exploded throughout 2020, but especially in December.

The initial Solar Auction Pilot Program, outlined in a 25 September 2020 (No: 7200/BCT-DL) MOIT Draft Decision, was expected to begin in 2020 and continue through May 2021 as a transition phase to the launch of a national solar auction program. While total capacity for the pilot program is capped at 1GWp, only 60% of the participating projects' total capacity will be selected to ensure a competitive process, and a single investor cannot exceed 20% of the total selected capacity. Pilot Program participants are limited to ground mount or floating solar farm projects already included in the Power Development Master Plan and not eligible for FIT2.

Projects bidding the lowest tariff price and meeting all other program criteria will be selected to sign a PPA with EVN until the above capacity constraints are reached. However, the proposed solar project tariff must not exceed the FIT2 tariff rates for ground mount and floating solar projects. MOIT has proposed that the model PPA for FIT2 apply to the Pilot Program with the same 20-year PPA term from project COD. PPAs will again be paid in VND and subject to VND to USD exchange rate fluctuation.

Additional project requirements for the Pilot Program include the ability of the EVN grid infrastructure to absorb the project's proposed capacity, a proposed COD by 30 June 2022, and approval by the local Provincial People's Committee for participation in the Pilot Program. The project's tariff as determined by the bidding process would be reduced 5% for each quarter of delay failing to achieve the 30 June 2022 date.

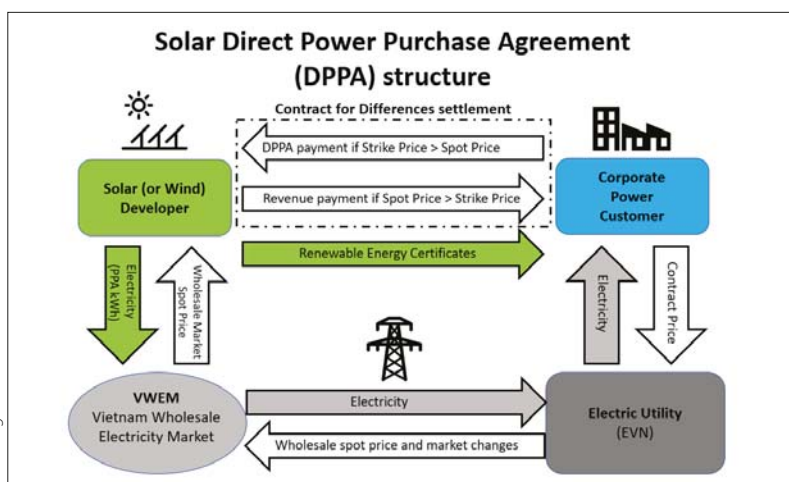
More recently, on 21 January 2021, the Electricity and Renewable Energy Authority of Vietnam (EREA) Draft Decision (No. 20/BC-DL) focuses upon investor selection criteria and eligibility requirements for the national solar auction program.

Of course, any of the Draft Decisions are subject to further MOIT review, consultation, and the Vietnam Prime Minister's final approval and signature.

The direct PPA route

Additionally, Vietnam has proposed a renewable, virtual Direct Power Purchase Agreement (DPPA) program allowing factories and businesses to meet prospective 100% renewable energy goals from private firms through a financial arrangement.

Also known as a synthetic DPPA, a corporate customer (offtaker) enters into a DPPA with a solar project developer to purchase off-site renewable electricity at an agreed



upon quantity, strike price, and contract term. In return, the corporate customer also obtains the Renewable Energy Certificates (RECs) generated by the contracted electricity. Otherwise, the corporate customer continues to purchase power normally through their energy provider or utility, EVN in this case, whose energy mix includes the solar project.

The solar project developer sells the project's electricity to the utility via the Vietnam Wholesale Electricity Market (VWEM) at the spot price. The DPPA contract is settled between the corporate customer and the solar project developer through a Contract for Differences (CfD). If the spot price is less than the strike price, the corporate customer pays the solar project developer the difference; and vice versa, the solar project developer pays the corporate customer the difference if the spot price is higher than the strike price.

The DPPA revenue stream enables the solar project developer to finance the project and provides the corporate customer a hedge from rising electricity prices. But as with other contracts with EVN, solar project developers are concerned about curtailment, termination, and force majeure event risks, according to Baker McKenzie Vietnam.

This innovative policy mechanism has been developed by the MOIT and Electricity Regulatory Authority of Vietnam (ERAV) with the support of the United States Agency for International Development.

Last January, MOIT issued Proposal No. 544/TTr-BCT and Draft Decision on the approval of a pilot program for the direct power purchase agreement (DPPA) mechanism between renewable energy power generation companies and power consumers. The proposed pilot for off-site renewable energy projects was sized between 400MW and 1000MW and established

certain criteria for project developers and corporate customers to participate.

Project developers need to register for the DPPA Pilot Program, have an on-grid installed system capacity greater than 30MW, be included in the Power Development Master Plan with zero or low risk of grid congestion, and have sufficient financial and technical capability and experience in renewable energy project development and operations.

Corporate customers also need to register for the DPPA Pilot Program, purchase electricity at 22kV or higher voltage level, have sufficient financial and technical capability with priority given to corporate customers having international commitments regarding the environment, climate change, and sustainable development.

Multinational brands and foreign direct investors are strong advocates for the DPPA program to meet sustainability goals and power their complex supply chains with renewable energy. According to Nikkei Asia, Nike and H&M joined 29 fashion brands in a letter to Vietnamese Prime Minister Nguyen Xuan Phuc last December urging the country to approve DPPAs between corporate customers and renewable energy project developers.

A DPPA Pilot Program was expected last year but may yet debut in 2021 as technical and legal issues are resolved before the introduction. A new draft or final mechanism is required to kickstart the DPPA Pilot Program. However, an extensive legal roadmap remains to be navigated, including legal amendments for the VWEM and DPPA mechanisms, conversion of the National Load Dispatch Center (NLDC) into an Independent System Operator, and amendments to Electricity Law and Pricing Law possibly stretching the implementation into 2022 and beyond.

DPPAs have been proposed to help factories and businesses meet renewable energy targets.

Future FIT prospects, self-consumption, and floating solar

Prospects for the extension of the rooftop solar FIT policy have now dimmed, and EVN has stated new PPAs for rooftop solar power would stop with the expiration of the FIT2 policy. Thus far, a new decision on solar FIT policy has not even been drafted.

In my opinion, a regional FIT for northern and north central Vietnam would promote solar PV in areas that have lagged behind others in installations. In addition, a new FIT could incentivise solar and wind plus storage to address peak power demand in Vietnam from 5:30-6:30pm.

Released on 2 October 2020, Resolution No.140/NQ-CP Promulgating the Government's Action Programme for implementing Resolution no. 55-NQ/TW dated 11/02/2020 of Politburo regarding orientations of the Vietnamese National Energy Development Strategy until 2030, with a vision till 2045, provides insights on solar and renewable strategic priorities. In particular, the following goals are outlined:

- Study to develop, propose incentive mechanisms for developing RE-based electricity for self-consumption (with priority for rooftop solar power).
- Study to develop, propose incentive mechanisms for developing floating solar power.

Development of an "Incentive mechanism for development of distributed solar power projects for self-consumption" is targeted for the 2020-2022 timeframe.

According to *TuoiTre Online*, EVN has already expressed concerns regarding excess solar generation on weekends and holidays. Even during weekdays, EVN has observed the duck curve phenomenon between 10:00am and 2:00pm from excess solar electricity generation impacting the grid power system. By contrast, peak power demand in Vietnam from 5:30-6:30pm cannot be addressed by solar.

The NLDC (A0), still an EVN subsidiary, said renewable energy including solar and wind could not be fully utilised during low load hours, weekends, or over the Tet (Vietnamese Lunar New Year) holiday week. Sure enough, some industrial rooftop solar systems were instructed by A0 to curtail their output over this year's Tet holiday week.

Author

Edgar Gunther is a partner with Syntegra Solar and works at the Vietnam EPC joint venture company, Tona Syntegra Solar JSC.



PV MODULETECH CONFERENCE

9-11 March 2021

Going into its fourth year, **PV ModuleTech** focuses on all aspects of PV modules, including manufacturing, module design, inspection and bankability.

- Hear from the CTOs of the global Leaders in PV module manufacturers
- Understand the panel formats & trends for 600 Watt+ modules
- Exclusive update from Finlay Colville with the latest financial and technical metrics benchmarking the top PV module manufacturers
- Understand key metrics behind module quality, reliability & bankability
- Hear from the key stakeholders in GW module supply, certification, testing & factory auditing
- Determine impact of module technology advances on site yield, monitoring & return-on-investments
- Find out which module suppliers are key to unlocking new end-market growth in utility-scale solar

“**Irma Pienaar, Scatec Solar**
Great networking and technology “deep dive” showing the face of future PV.

“**Nikhil Nahar, SolarSquare Energy**
The event was focussed, speakers were great, conference was organised very well and topics were relevant.

“**Christophe Inglin, Energetix**
This event helps me evaluate the substance behind many manufacturers marketing claims.

SPONSORS AND EXHIBITORS ALREADY CONFIRMED:

GOLD SPONSORS

Jinko Solar

LONGI

Q CELLS
Engineered in Germany

risen
solar technology



SERAPHIM

Sunport Power

Trina solar

SILVER SPONSOR

PVEL

BRONZE SPONSORS

Phono Solar



To get involved either as a speaker, partner or attendee please email: pvmoduletech@solarmedia.co.uk

moduletech.solarenergyevents.com

Familiar uncertainties as India charts new solar territory



Credit: Total Eren

India | After a challenging year, India's solar sector stands primed for something of a rebound. But a host of familiar issues, from the perilous state of DISCOMs to regulatory uncertainty, run the risk of stymying future growth. Vinay Rustagi, managing director at consultancy Bridge to India, talks to *PV Tech Power* about the future prospects for Indian solar.

With high levels of irradiance, a deep desire to decarbonise and a lofty deployment target championed by a newly elected Prime Minister, India emerged in the mid-2010s as one of the hottest solar markets in the world. But fast forward five years and there's almost a sense of missed opportunity.

Of the 100GW of solar PV Narendra Modi pledged to see built in India by 2022, the general consensus is the country will actually see around two-thirds of that figure built. Despite the target almost certain to be missed, it has not dampened enthusiasm for renewables from within Modi's government. That 100GW ambition has been superseded by a new target, for 450GW of renewables – 300GW of it solar – to be operational by the end of this decade. Such deployment

would see India become a global renewables powerhouse. Recent analysis of that target by the Institute of Energy Economics and Financial Analysis (IEEFA) found that around US\$500 billion of investment would be needed for India to hit target – US\$300 billion for generation, US\$150 billion for transmission and distribution initiatives and a further US\$50 billion for grid stabilising technologies such as energy storage.

But for that to happen, India will have to overcome numerous issues which have served to stymie solar installations in the country and dent investor confidence. Distribution companies, or DISCOMs, continue to be plagued by financial difficulties and government efforts to find a more permanent solution have so far failed. As a result, power producers in the country face delayed payments.

A 120MWp project completed by Total Eren in India.

Investors have been further dissuaded by attempts to renegotiate, or in some cases entirely renege on, power purchase agreements. While this is nothing new, that the practice continues has created a sense of trepidation. In February 2021, India's federal government stepped in to mediate after the state of Gujarat sought to scrap the results of a tender for a 700MW solar project struck previously and relaunch the tender, citing the fact that tariff prices had fallen considerably since the previous award.

Equally, there remains considerable scrutiny over the country's domestic solar manufacturing landscape, with the Modi government's 'Make in India' pledge established to push the use of domestic wares wherever possible. Safeguard duties on imported modules had been in place since 2018, but were extended

for a further year last summer, lasting until 29 July 2021 at least. An additional basic customs duty (BCD) – said to be at 20% initially, rising to 40% – has also been proposed, and was once said to be introduced alongside the safeguard duty. But, despite assertions that the BCD was to come into place last summer, the date for its implementation came and went, and the Indian government has yet to provide any further details, at least publicly, about its introduction. A surprise increase of the import tax attached to solar inverters, included within the country's recent budget, has further moved the goalposts for developers, and created yet more uncertainty at a time when installations have stalled.

COVID-19 also presented India with fresh challenges throughout 2020. Developers struggled to mobilise labour and supply chain issues were also felt throughout India, leading to dwindling deployment. In Q3 2020, just 853MW of solar generation was installed in India, according to Bridge to India analysis, less than half the 1,743MW of solar installed in the corresponding period in 2019. The impact of the pandemic was felt more strongly in Q2 2020, when just 351MW was installed.

And yet, as Vinay Rustagi, managing director at consultancy Bridge to India says, investors have continued to flock to the country, and India remains at the forefront of any discussion surrounding solar's leading markets.

PV Tech Power: India faced a challenging 2020, as did most markets, with delays caused by COVID and regulatory uncertainty clouding development. What's the current status of the Indian solar market?

Vinay Rustagi: As a matter of fact, the last two to three years have been a pretty challenging time for the industry. There are several factors including unsigned PPAs, delayed payments from power purchasers, extra costs, to rising module and metal prices contributing to tough times. Coming on back of this, COVID has obviously not helped. The main challenges that the sector faces are, firstly, that power demand in India has been lukewarm and has not grown as rapidly as expected. That has restricted demand for renewable power.

There are around 19,000MW of projects with completed auctions but unsigned power purchase agreements. This has been a major concern for the sector.

Secondly, distribution utilities, typically state government owned, are in a perilous

"At the same time, quite remarkably, India is managing to attract huge investment into the sector."

financial condition. Their performance has been deteriorating over time for many reasons including political interference in tariff determination and poor network efficiency. In COVID times, they've not been able to pass on cost rises to customers and their own payment collections from customers have also suffered badly. As a result, payment delays to IPPs have been increasing sharply and are now at all time high levels. Then there are some distribution companies looking to get out of some contracts.

In addition, the government has imposed duties on modules to support domestic manufacturing. In the latest budget, duties on inverters have also been hiked and developers have to bear the extra costs. While there is a regulatory mechanism for them to pass on some of these extra costs back to the offtakers, the mechanism does not work very well and saddles developers with high working capital requirements as well as reduced profitability.

Despite all this, the market remains very competitive and tariffs continue to come down. In 2020, capacity addition for the solar sector was at a five-year low, but 2021 should be a much better year. We are expecting 13.5GW of solar capacity additions – 11GW utility scale and 2.5GW rooftop solar – which should be highly welcome. It would help ease some of the challenges faced by the sector in the last two years. All eyes are on the government, in terms of what kind of distribution sector reforms are introduced, hopefully to make things easier for the market.

And what would be the kind of ideal scenario for those reforms?

Just to give you an idea of the numbers, total outstanding amount to power

purchasers is more than US\$30 billion, and total estimated losses of distribution companies, in FY 2021, would be around US\$80 to \$90 billion. It's therefore a massive problem.

The worrying thing, in my view, is that this is not a new problem. This has been a problem in the Indian power sector for as long as I can remember, going back perhaps to 30 years or more. In the past, the government has always tried to fix it by some kind of financial band-aid, which has kept the clock ticking for another five or seven years. What is different now is that size of the problem has become much bigger. The ability of government at the central or state level, in terms of their own fiscal constraints, to keep injecting more money is limited now. It seems implausible that another bailout package could be provided by the government.

We are now at the point where a long term, permanent fix is needed. The government has proposed various measures including, for example, cutting transmission and distribution losses from around 22% to 15% or less, tariff rationalisation and resetting, privatisation etc. But there is a lot of resistance from state governments, and the reform process is stalled in our view. More recently, the government has thrown another idea to open distribution sector to private players. So, consumers can choose from their existing DISCOM or other providers who would get access to the distribution network. It is a bit like what happens in the UK for example, where you can choose your [electricity] provider.

But we have also seen some warning signs that the government is backtracking on reforms in the face of opposition from consumer groups and states. For example, now privatisation is off the table and tariff rationalisation is also looking tricky. It remains to be seen if the government has the political will to go through the process.

Ultimately, it doesn't really matter which approach the government takes, there will be a lot of hard painful choices for them to make. It would mean tariffs going up for customers, distribution businesses will have to become much more efficient and private sector would be allowed entry into the distribution business. The regulatory system will have to evolve, necessitating a long period of adjustment. The timing, however, is still not clear.

13.5GW
BRIDGE TO INDIA'S FORECAST
FOR SOLAR DEPLOYMENT
IN 2021

Is that uncertainty impacting the appetite of new entrants or existing players in investing in India's solar market?

The answer to that is yes and no at the same time. It is having an impact in the sense that there is a staggering number of tenders which have been completed, projects have been awarded to developers but PPAs have still not been signed. Something like this is obviously draining market confidence. Everybody knows that the distribution companies are in a financial mess, and they are concerned about offtake risk. That is why central government owned companies like SECI [Solar Energy Corporation of India] and [power utility] NTPC are playing the role of intermediary procurers. There is heightened risk aversion and awareness of contract renegotiation and delayed payment risks.

At the same time, quite remarkably, India is managing to attract huge investment into the sector. The large market size, transparent auction process and 100% FDI are attracting leading sovereign wealth funds, private equity funds, international utilities like EDF, Engie, Sembcorp to the sector.

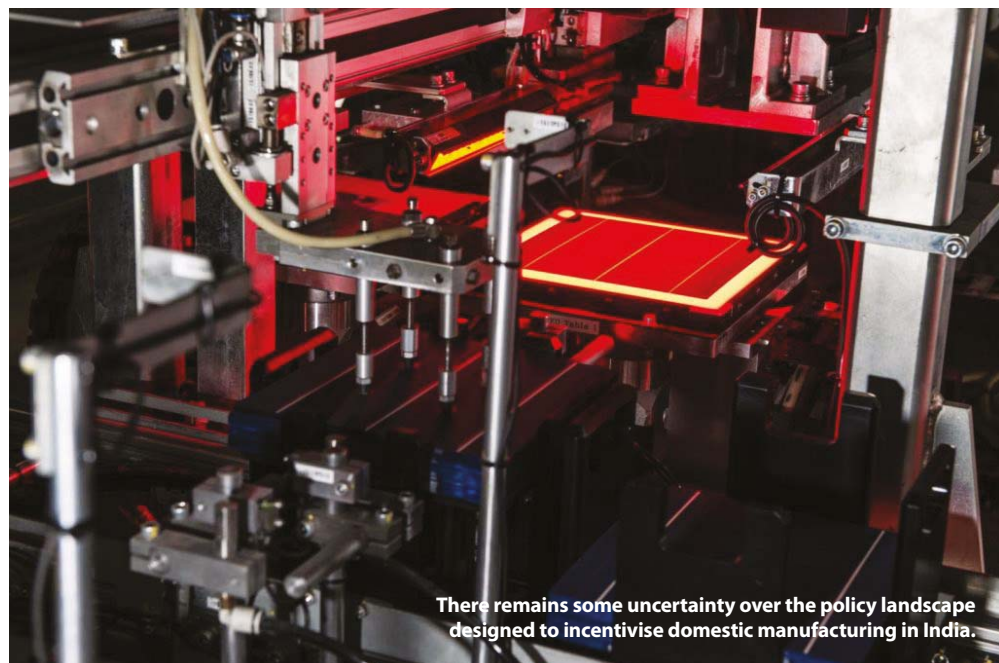
Somewhat surprisingly, investment appetite has actually increased after COVID. We believe that partly it is down to reduction in interest rates all over the world. Cost of capital has come down and the amount of available investment opportunities has declined. Investors are also looking to jump on the energy transition bandwagon.

Is it perhaps leading to some kind of consolidation in the market, so you have the same few big names that are taking leading roles and most tenders?

It is something which has already been happening in India for some time. Aggressive bidding, increasing project sizes and various operational and financial challenges are naturally pointing to market consolidation. But we also continue to see many new players entering the market because raising capital for the renewable sector has seemingly been surprisingly easy. The industry is still relatively fragmented. High demand for assets is tending to push tariffs down.

65GW

BRIDGE TO INDIA'S FORECAST FOR TOTAL INDIAN SOLAR CAPACITY BY 2022, SHORT OF MODI'S 100GW AMBITION



There remains some uncertainty over the policy landscape designed to incentivise domestic manufacturing in India.

Credit: Vikram Solar

There is this overhanging target of 100GW of solar by 2022. What's the lay of the land there?

The solar sector has a two-year development cycle. So, we have a very good visibility of likely progress by 2022. At the end of 2020, India had total installed capacity of about 40GW including rooftop solar. We expect 13.5GW addition this year and another 12GW in 2022. So, we'll end up somewhere around 65GW by the end of 2022.

What is the next step for Indian solar in that regard? Is there going to be any kind of further government push on solar?

The government is already looking ahead to 2030 with a capacity target of 300GW for solar and 450GW for all renewables.

On the manufacturing side, we have obviously seen this push towards domestic manufacturing. We've yet to receive clarity on the basic customs duty on modules, is there still an appetite for that?

This is a really hard problem for the entire sector. The Indian government has supported 'Make in India' in very strong language and backed it up with multiple policy support measures over many years. But the government seems torn between cheaper solar power and domestic manufacturing. Manufacturers are saying we need duty protection and without

duties, there will be no Make in India. On the other hand, the developers and investors are saying that any push towards Make in India with duties would increase cost of solar power and reduce demand.

Safeguard duty was implemented initially for two years, and then extended for one year. The government has been talking about a basic customs duty over the next eight or nine months now. But the duty is yet to be announced and we just don't know anything about the level or timeline for the duty. Lack of long-term visibility is a big deterrent for investors.

Meanwhile, the government has announced a production linked incentive (PLI) worth about US\$650 million for Indian cell and module manufacturers. There are various project schemes contingent upon using only India-made cells and modules. Essentially, the government seems unsure yet it is throwing everything including demand support, financial subsidies and tariff barriers at Make in India. The overall policy is in a bit of a flux. Because of lack of a clear roadmap, progress remains pitiful and we believe that a large part of the optimism is misplaced. A lack of visibility over duties is also obviously a major risk for project developers.

Vinay Rustagi

Vinay is managing director at consultancy firm Bridge to India. He has six years of specialist renewable advisory experience and more than 16 years of experience in financing energy and infrastructure projects across India and Europe.



Photovoltaics in the fast lane: Intersolar Europe 2021 presents trends and developments in the solar industry



The European photovoltaics market is booming. According to the industry association SolarPower Europe, the European Union (EU) saw an eleven percent increase in photovoltaic (PV) capacity in 2020, meaning that even with the coronavirus pandemic, the European solar market experienced record growth. 2020 marked the industry's second best year, topped only by 2011. Germany was the front-runner, having installed 4.8 GW of new capacity. Overall, installed PV capacity in Europe grew to 137.2 GW by the end of 2020. The EU Market Outlook for Solar Power 2020-2024 forecasts that solar systems with a capacity of 22.4 GW (an increase of 23 percent) will be installed in 2021. But growth is not limited to new installations.

PV production in Europe is experiencing a renaissance

PV production in Europe is also on the rise: Product innovations and optimizations, rising demand and sinking production costs are enabling solar companies to bring photovoltaic production back to Europe. This trend is further boosted by the research and mechanical engineering expertise represented on the continent as well as by problems with global supply chains stemming from the coronavirus pandemic. Swiss-based company Meyer Burger is building module production facilities Saxony and Saxony-Anhalt, which is helping to revive a region that used to be Germany's solar valley.

Cells and modules – Constant competition for more efficiency

Innovations are driving the development and production of more powerful and cost-effective solar cells and modules. Heterojunction technology (HJT) represents an important step toward even greater efficiency; this technology earned REC Solar EMEA GmbH the Intersolar Award in 2020.

Under the motto “Creating the new energy world,” The smarter E Europe covers a comprehensive range of topics relating to the new energy world and presents cross-sector energy solutions and technologies. This makes it Europe's largest platform for the energy industry. Intersolar, the world's leading exhibition for the solar industry, will take place along with The smarter E Europe at Messe München from July 21–23, 2021. The smarter E Europe includes three other energy exhibitions – ees Europe, Power2Drive Europe and EM-Power Europe.

Bifacial modules, which make use of solar radiation on the backsheet and lead to higher solar power yields, are also growing in popularity. When combined with single-axis tracking systems in free-standing installations, they have enormous potential to reduce electricity generation costs.

Inverters – Smart all-rounders

Inverters are no longer limited to their core task of converting direct current into alternating current. These smart all-rounders are also used to analyze and control solar arrays and solar batteries as well as power-to-heat and smart home solutions. They include interfaces for digital communication and are connected to energy management systems which incorporate electric vehicles and make smart charging possible. For more information, please visit www.intersolar.de and www.thesmartere.de.

ees Europe, the continent's largest and most international exhibition for batteries and energy storage systems

ees Europe has been held annually at Messe München exhibition center in Munich, Germany since 2014. Under the motto “Innovating energy storage,” the event brings together manufacturers, distributors, project developers, system integrators, professional users and suppliers of innovative battery technologies and sustainable solutions for storing renewable energies such as hydrogen and Power-to-Gas applications. The accompanying ees Europe Conference highlights and consolidates current industry issues.

Power2Drive Europe, the international exhibition for charging infrastructure and e-mobility

Under the motto “Charging the future of mobility,” Power2Drive Europe focuses on solutions and technologies for clean transportation. It offers manufacturers, suppliers, distributors and start-ups in this growing industry a professional meeting point to present new developments and business models. Interactivity will be the name of the game when experts, key players and pioneers shaping the mobility of the future gather in Munich at the Power2Drive Europe Conference.

EM-Power Europe, the international exhibition for energy management and integrated energy solutions

EM-Power Europe is the international exhibition for energy management and integrated energy solutions. It focuses on the efficient distribution and use of electricity and heat generated from renewable sources of energy, smart energy management, and sector coupling in buildings and districts. Other key topics are smart grids and microgrids, grid infrastructure, energy services and operator models. 2021 will also see the premiere of a dedicated EM-Power Europe Conference, which will take up specialist topics from the exhibition.

Going H2: The challenges and benefits of integrating solar and hydrogen

Hydrogen | With green hydrogen from renewables at the core of a number of decarbonisation strategies globally, the first large-scale projects face a number of challenges integrating into the energy system. Molly Lempriere explores the barriers to developing large-scale green hydrogen, the technologies easing interaction and the benefits of hydrogen for grid balancing and storage.

Green hydrogen has become key to many international decarbonisation plans in recent years, as the cost of renewable energy continues to fall and people look for alternatives to gas for difficult to decarbonise sectors. But challenges remain with integrating the gas and the nascent technology around it into the energy system.

In a report on the technology published in December 2020 Francesco La Camera, director-general of the International Renewable Energy Agency (IRENA), said renewable or green hydrogen could become a game changer helping to decarbonise economies globally. "Cost-competitive green hydrogen can help us build a resilient energy system that thrives on modern technologies and embraces innovative solutions fit for the 21st century," he said.

But as large scale projects begin to emerge, challenges with economics, efficient grid connections and the surrounding networks still present hurdles, despite the flexibility of the fuel.

Grid constraints and new networks

As electricity systems transition from large centralised generation to more distributed renewable energy sources, many have been pushed to their limits. This has led to grid constraints, often meaning expensive network upgrades are required, as well as connections for renewable energy projects often being oversubscribed.

For example, in June 2020 the Spanish government passed a new law to ease grid connections in a move designed to boost the renewable energy sector. It estimated that there had been up to 430GW of grid access applications filed in the country in the 16 months leading up to the law, creating a backlog exacerbated by international companies buying connections with no intention to develop. The new law – which includes a five-step process that companies must complete or lose their connection – could facilitate a €90 billion boost to green

investment over the next ten years.

Spain's grid connection challenges mirror those seen around the world, but are particularly stark given the maturity of the solar market in the country. This same maturity, and positive permitting framework, has allowed it to become one of the front runners in green hydrogen development, with companies including Iberdrola announcing large-scale projects such as its Puertollano (Ciudad Real) plant, which will combine a 100 MW solar plant, a 20 MWh lithium-ion battery system and one of the largest electrolytic hydrogen production systems in the world at 20MW.

The same grid connection challenges faced by pure play renewable energy projects are true of green hydrogen projects, with additional complexity coming from the multiple pathways within large scale developments. Depending on the project, generation from multiple sites, consumption, storage and power exporting may all be factors to be taken into account when integrating it with the wider system.

Energy majors ENGIE and Total announced in January 2021 that they are developing what will be France's largest green hydrogen development. The 100MW Masshylia project will consist of an expansive solar photovoltaic installation and a 40MW electrolyser that will produce five tonnes of green hydrogen per day. The

hydrogen will be used at Total's La Mede biorefinery, helping to avoid 15,000 tonnes of CO2 emissions per year.

Despite the hydrogen element not playing into the grid directly, the solar photovoltaic sites – which will be located at the La Mede site and around the region given the scale of installation needed – will need to use both existing and new grid networks, presenting a challenge to ENGIE.

Olivier Machet, SVP of business development at ENGIE's hydrogen business unit explains that firstly a direct connection with a specific PV farm near the electrolyser is needed, before additional connections with other farms in the region are considered. They will utilise the grid network already in place in the region for this, while relying entirely on the solar generation at part of the project.

"We will need to specifically develop a new electricity line for this project, because we are going to need certain power," says Machet. "And this will take time because you need to build a new line and so on. So it can be an issue, but it's worth it to have this specific project with its additional solar renewable generation, when compared to other projects we can see today developed in France and other countries in Europe or anywhere. It's very specific."

Many large-scale projects thus far have been located near to industrial off-takers, which provides easier electricity grid access in addition to the proximity and ease of direct offtake agreements.

In Australia, Austrom Hydrogen is developing a 3,600MW combined solar and battery storage site that will fuel green hydrogen production in the Callide area of Queensland. The site was chosen in particular because of its proximity to existing power infrastructure, as well as strong irradiation in the area.

By constructing the solar array in the Callide area, the company can use a mix of existing and new infrastructure to get

In the Castilla-La Mancha region that Iberdrola is developing its Puertollano plant, it will develop three further photovoltaic projects, including one at Cuenca (pictured) with an installed capacity of 150 MW.



the green electricity to the hydrolyser with minimal line loss. Additionally, the site's proximity to Gladstone Port eases export of the hydrogen.

It is clear that in order for a large-scale green hydrogen project to be financially viable, ease of grid connection is essential. Given the high demands on power networks, projects will generally require some level of network development, but choosing locations where there is existing robust grid capacity can ease the integration of the multitude of elements required for a green hydrogen project.

Securing the green premium

Whilst the construction of a new segment of grid undoubtedly adds cost and complexity to the project, renewable hydrogen projects come with numerous benefits, bolstering the business case for such projects.

Machet says: "We could have taken electricity from the grid, and it could have been simpler. But our objective is to have an innovative project and to ensure that the electricity price will not be exposed to electricity market price nor to the guarantee of origin price volatility."

It is therefore key that while green hydrogen remains more expensive than its blue and grey cousins, its environmental credentials remain key selling points. Research from the International Energy Agency suggests that a kilogram of green hydrogen, which contains about 33.3kWh of power, costs €3.50 to €5, or between €0.10/kWh and 0.15/kWh. In comparison grey hydrogen comes in at just €1.5/kg or €0.045/kWh, indicating a clear price advantage.

As Machet says though, the added value of a green product must be taken into consideration within the cost equation. This may help green hydrogen production going forwards, with organisations opting to pay a premium in order to decarbonise.

"Costs for producing green hydrogen have fallen 50% since 2015 and could be reduced by an additional 30% by 2025 due to the benefits of increased scale and more standardized manufacturing, among other factors," said Simon Blakey, IHS Markit senior advisor for Global Gas. This can be aided by using dedicated renewables as a feedstock he continued, together with economies of scale with the average size of project by 2023 expected to be 100MW, ten times the size of today's projects.

ENGIE's La Mede project will hope to benefit from the reduced cost of solar PV – which has fallen by 80% in the last ten years – as well as the economies of scale

Both on and off-grid solutions

Even outside of mains grid connection, hydrogen offers an interesting option for renewable energy systems. In 2017, Enel hailed the success of what it said was the world's first emissions free "plug-and-play" commercial-sized micro-grid powered by solar PV together with hydrogen and lithium storage.

The Hybrid Energy Storage System (HyESS) comprises a 125kWp solar PV installation along with a 450kWh hydrogen storage system and 132kWh of lithium storage, installed in the Antofagasta region of Chile. Together these elements are able to provide green energy 24 hours a day, and can run completely independently of the grid.

While the facility can work both on-grid and off-grid, it highlights the ability for green hydrogen to enable green electricity, both day and night, in almost any location. With green hydrogen's potential for longer duration storage than lithium-ion, it can complement off-grid clean energy solutions, easily integrated into renewable energy systems in remote locations.



Enel's "plug-and-play" commercial-sized micro-grid powered by solar PV together with hydrogen and lithium storage.

from a project as large as 100MW and the support of pursuing a green option. In order to ensure the seamless integration of the numerous elements to secure the success of the project, software development will be key. Machet says that the company needed to develop specific tools to ensure the security of the hydrogen delivery, making sure all the elements of the project will be integrated. "We will develop specific tools to ensure the traceability of the production because we want to be compliant with the future Renewable Energy Directive (RED II)," he says. "Therefore, we need to ensure that the electrons are traced, through the entire chain from PV farm to the production of hydrogen."

The company has developed a digital piloting system to tackle this, which is capable of managing the continuous supply of hydrogen with real-time management of solar electricity production. This is central to the project's green credentials and to the stability of the generation, allowing each part of the system to work together to ensure the continuous flow of hydrogen to the biorefinery.

For other green hydrogen projects being developed, being connected to the grid in such a way that the renewable energy generated is seamlessly managed whether it be powering the electrolyser or feeding into the grid will be essential.

A new path to flexibility?

Generating green hydrogen through surplus renewable energy may present some grid connection challenges, but it also offers a wealth of benefits for the grid. By capturing surplus solar electricity generated during periods of high irradiation for example, green hydrogen can both limit curtailment and provide energy storage.

Because of this, ensuring access to the grid will remain of high importance for new hydrogen projects. "We need to plan for this on the basis that green hydrogen electrolysis can provide a flexible demand source that can be used to help alleviate grid constraints in areas of high renewable energy deployment," Grace Millman, energy analyst at UK-based trade body Regen, says.

Thus far, this remains largely theoretical, but a number of companies are working towards commercialisation. For example, Mitsubishi Power launched in 2020 two integrated green hydrogen solutions, with so-called 'Hydaptive' and 'Hystore' packages. Hydaptive is designed to provide flexibility to the grid by offering a near-instantaneous power balancing resource. A hydrogen plant and a natural gas fuelled gas turbine power plant are integrated together with electrolysis to produce green hydrogen and onsite storage. Three projects around the US were



SOLARSOLUTIONS INTERNATIONAL

PV ■ STORAGE ■ INNOVATIONS

**THE LARGEST SOLAR ENERGY TRADE
SHOW IN NORTHWEST EUROPE**

28/29/30 SEPTEMBER 2021

**EXPO HAARLEMMERMEER
THE NETHERLANDS**

B2B ONLY

**NEW
DATE!**

www.solarsolutions.nl

launched using the technology, to explore the ability for green hydrogen to increase the flexibility of grids.

One of these projects is taking place at a 600MW site operated by asset operator Danskammer Energy in Newburgh, New York, announced in September 2020. Danskammer's CEO William Reid said at the time they were committed to helping New York meet its climate targets, selecting Mitsubishi's technology to "ready our facility to be a hydrogen-based zero-carbon power generator."

"By partnering with Mitsubishi Power for integrated green hydrogen generation and storage technologies, we hope to provide leadership in developing short- and long-duration energy storage infrastructure in New York State," he said.

Integrating renewables and green hydrogen onto national grids is widely expected to be mutually beneficial, with a report from UK-based energy consultancy Aurora in June 2020 suggesting that in the UK, using such a system could reduce the need for alternative flexibility services in winter months and increase revenues for clean power generators by around £3 billion per year by 2050.

Utilising green hydrogen can therefore add another string to the bow of renewable energy sources, but policy changes will be needed to maximise this opportunity, with little or no policy framework for green hydrogen connected to the electricity grids in many countries.

Hurdling policy barriers

In the UK, power to gas – as electrolysis to create green hydrogen would be considered – is not formally recognised by the electricity industry or government as a form of energy storage according to the European Union Horizon 2020 research

and innovation programme-funded HyLaw project. While authorities are looking to establish a legal status for the technology to facilitate storage options, it remains a barrier to grid connected green hydrogen projects.

Therefore despite the "huge amount of interest in green hydrogen electrolysis at the moment", explains Regen's Millman, projects are still only at an innovation level. "Our research has identified 19 operational green hydrogen innovation projects across the UK, with a further 21 in the pipeline," she says. "Most of these are small scale (0.5 - 5MW), focusing on areas like transport and industrial processes."

HyLaw highlights similar challenges throughout much of the EU, with a lack of legislation currently acting as a barrier to grid integration in countries including Spain, France and Italy. Globally, policy changes can work to increase the potential of green hydrogen flexibility services, with research from IRENA arguing that: "Policy makers should aim to provide a platform to monetise the flexibility offered by electrolyzers, while also allowing revenue stacking from all services provided by the electrolyser."

Already we are seeing this legislation come through, with increasing support for green hydrogen through government initiatives such as the European Union launching its hydrogen strategy in 2020 that targets 40GW of electrolyzers by 2030. The likes of Australia, Chile, Japan, New Zealand and others have also launched national hydrogen strategies.

In terms of providing storage and flexibility services, green hydrogen may still be held back due to competition from battery energy storage. Currently, surplus renewable generation can be stored in lithium-ion battery cells with 80% to 90%

of that used to charge, also available to discharge. But green hydrogen has a much lower efficiency level, with approximately 40% to 50% of the electricity used by the electrolyser for hydrogen production available for use when discharging.

Whilst this is expected to improve, with a strong focus on the development of electrolyzers currently, this is still a consideration for renewable energy projects assessing which storage option to pursue.

There are other advantages, such as the duration of the storage of hydrogen – offering the possibility of energy storage that lasts through seasons (see p.75) - but it is a consideration when looking to maximise surplus renewables. Unlike industrial green hydrogen projects like ENGIE's La Mede or Austrom's Callide project, should generators wish to develop green hydrogen for use in the wider grid, the barriers go further than grid constraints and will require further policy support.

New technology, familiar challenges

Challenges around system integration remain for large-scale green hydrogen, but many are not particularly different from those large-scale renewable energy projects face. With supportive policy coming into play, this should largely be addressed as nations build out a framework for the fuel.

The advantages of green hydrogen are clear, and with the cost of the technology set to come down dramatically over the coming years, more projects are likely to come to the fore. In particular, we could see green hydrogen playing a role in flexibility as well as decarbonising industry. "The hydrogen value chain is complex with multiple distribution channels, markets, and competitors," adds Regen's Millman. "This is good news in terms of the opportunity to develop an exciting new industry, but it does mean that policy makers need to tread very carefully when thinking about market-building policy interventions."

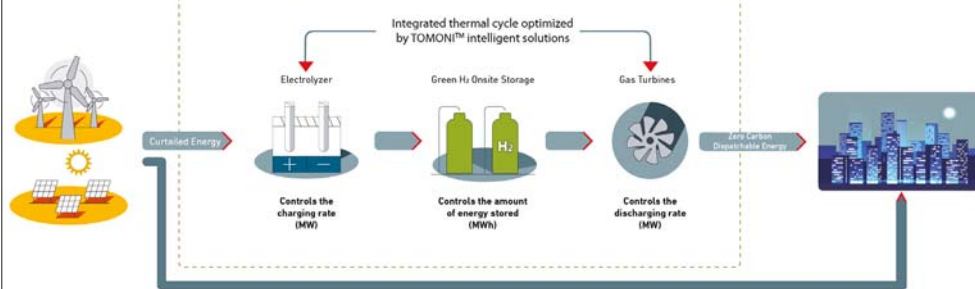
"There needs to be a whole value chain approach to hydrogen, which is underpinned by the development of consumer markets, as well as investment in production, storage, and distribution infrastructure, which will require support and planning."

As such, governments should look to establish firm policy around green hydrogen that allows it to integrate into the electricity sector, in particular the storage and flexibility spaces, in order to truly capitalise on the development of this green giant.

Mitsubishi Hyadaptive solution utilises curtailed renewable energy to create green hydrogen, which can subsequently meet grid demand.



HYDAPTIVE™ STANDARD FLEXIBILITY PACKAGE



The Hyadaptive™ package accelerates the path toward 100% carbon-free power generation

- ▶ Technology adapts as the grid needs larger amounts of energy storage
- ▶ Standard packages reduce the cost and complexity of decarbonization
- ▶ Integrated technology adds flexibility to existing dispatchable power generation

Bifacial, trackers and AI: Lessons from the real world



Technology | Bifaciality and trackers have become almost synonymous with modern plant design, but modelling gains in a real-world environment is notoriously difficult. Liam Stoker reports from a panel at the Solar Finance & Investment Europe conference which explored how new technologies are driving yield upside

Credit: Nextracker

The combination of bifacial panels with trackers has been perhaps the technological advancement of note in the solar sector for years, but there remains some uncertainty over its real-world efficacy. Producing substantial gains in the lab or in a test site with ideal conditions is one thing, but doing so consistently in the field is another task altogether.

A panel debate at the Solar Finance & Investment Europe conference, organised by PV Tech Power publisher Solar Media, brought together a host of experts in the field to shine a light on how these technologies are performing in tandem, and how accurate modelling continues to be a thorn in the side of asset developers.

Lightsource BP has been using bifacial panels since 2018 and to date has installed around 500MW of bifacial solar in what the company's technical director

Chris Buckland describes as a "pretty wild ride". The gains Lightsource BP has recorded from bifacial sites vary from the 10% recorded on a fixed-tilt site in the UK which features a design specifically upscaled for bifaciality, to the ~5% recorded on a project in Spain which features trackers and surroundings conducive for a strong albedo affect.

Evidently, and entirely predictably, bifacial yields differ site by site, and need comprehensive modelling to determine the ideal system size, modules selected and combination of technologies. In some

Bifacial panels attached to Nextracker's Gemini tracker product.

"There are lots of moving parts, keeping people on their feet... keeping abreast of this has become a full-time job in itself."

cases, particularly on sites closer to the equator where the module can track the sun almost perfectly, the yield gain from the rear side of the panel could be negligible. "The amount of sunlight you can get from the rear side of the panel versus the cost of adding an additional module actually brings that discussion right back to what's the main motivator," Buckland said of those circumstances.

But, as the industry is increasingly becoming accustomed to, modelling bifacial gains is far from precise, made all the more complicated by the rapidly-maturing technologies at hand. Bifacial panels are, simply, not what they used to be, Buckland said, pointing towards the fact that now the industry can expect half-cut large-area modules that have bifaciality as standard. And these modules are set to change again over the coming quarters as even larger products come off

manufacturing lines in China and enter the industry. "There are lots of moving parts keeping people on their feet... keeping abreast of this has become a full-time job in itself," Buckland said.

Not all modules are created equal

The job becomes all the harder when bifacial modules themselves are not all created equal. Jörg Althaus, global solar segment leader for solar at testing provider TÜV Rheinland, noted that while the level of bifaciality in modules can vary from between 60% - 90% in the lab, there can be differences of between 2 - 5% per module. The introduction of N-Type modules – the anticipated 'next step' along many product roadmaps – could see the advent of bifaciality beyond 90%, a further potential gamechanger for the asset class.

In real world performance, a 15% change in bifaciality may only provide an increase in yield of 2%, but in the world of sharpened pencils and strict performance targets, such a change can be critical.

Those sharpened pencils are placing more importance on further metrics. While the albedo of a site can contribute as much as 50% to the bifacial yield, panel conditions such as operational temperature can, in turn, affect performance and yield. Buckland said this has prompted further analysis of the materials used, with Lightsource BP having determined that glass-glass bifacial panels operate at a different temperature compared to glass-glass monofacial modules, a change that hasn't yet been noted in modelling software.

Industry-standard modelling and design software is, Buckland said, struggling to keep up. "It's a very, very difficult task, and a lot of processing power is needed... it's almost become a lookup table," he added, a nod towards the computer science method of retrieving a specific value from memory as opposed to running a more complex computation.

Whether its conditions underneath the panel, ambient temperatures, the electrical design of a system or, in truth, any one of a number of other contributing factors, there does not appear to be an easily replicable way of modelling bifacial gains. The technology almost juxtaposes itself against calls from within the industry for greater standardisation. "There's a lot of opportunity to optimise and take the upside of bifacial," Buckland said, adding: "but there's also some

practical discussions needed and it's not necessarily going to be the benefit you had anticipated."

Even standardisation is posing something of an issue to bifaciality performance it would seem. Althaus said he had seen some sites using bifacial panels that had been disrupted by industry-standard, copy-and-paste O&M contracts. Given the detailed thinking that can go into deciding the substrate below the panel – Lightsource BP has a host of preferred grasses and vegetation which offer better albedo effects than others – a more bespoke O&M offering that takes into account that potential reflection is required.

This also extends to trackers, with difficulties arising from clearing the grass beneath what is essentially moving electrical infrastructure. Funnily enough the panel concluded that perhaps the most ideal solution to this problem is relatively simplistic compared to the tech involved; grazing sheep.

Site intelligence more artificial

Once the confines of science-fiction, artificial intelligence (AI) is now being adopted by industries en masse and solar is no different. As the panel discussed, AI has so far offered demonstrable value in predictive maintenance and weather forecasting. PV Hardware CTO Ivan Arkipoff said the use of AI for predictive maintenance had come into its own since string inverters began to eat into central's

"We're always talking about performance, but if the site is not available you will experience the greater loss."

market share. Given there now stood to be far more components on a single site than ever before, it was even more important to ensure a robust supply of replacement parts, and what better way for that to happen than to predict a part's failure before it has happened. "We're always talking about performance, but if the site is not available you will experience the greater loss," he said.

But weather forecasting is a new area for solar and AI. Buckland provided the example of an operational solar array Lightsource BP has in Texas, sited within an area frequented by strong winds and

hail storms. As larger modules come on stream – those in excess of 2.4 metres in length – the effect of wind on structural stability and integrity grows significantly, and stands to become even more prominent as tracker layouts progress from 1P to 2P. Storms stand to be even more damaging than before.

Challenges presented by weather conditions – brought into new light following recent events in both Texas, where a severe winter storm nearly crashed the state's grid, and in Spain, which received record snowfall in January 2021 – pose numerous challenges to asset operators, ones which AI can pose solutions to.

Tracker control is imperative in such situations, especially when deciding what the best course of preventative action to take is. In a severe hail storm, for instance, do you face your modules into the wind to preserve or your system, but face more direct hail strikes, or tilt away from the hail to take your chances with high wind speeds and the potentially devastating stress around clamping points?

AI is helping to educate such decisions by linking tracker controls with weather services, using APIs from weather predictors with the aim of getting detailed, advance forecasts 30 minutes before conditions change. Lightsource BP is looking to pilot this approach in Texas before potentially retrofitting it on a global scale.

But there are still challenges to this. There is not a commercial off the shelf solution, with Buckland having noted Lightsource BP is doing much of this itself, which has repercussions further down the chain. "AI is here to help, it does unfortunately however push us towards customizable solutions, and the more we customize the more difficult it becomes to do O&M, and the more difficult it becomes to standardize that across the globe. It's great to see the progress being made on AI, but what I would say is if we can get these products and capabilities out into the market rather than people such as ourselves having to develop our own, I think that would be better for the industry," he said. ■

Solar Finance & Investment Europe 2021 was held between 3 – 4 Feb 2021. More details can be found at financeeurope.solarenergyevents.com

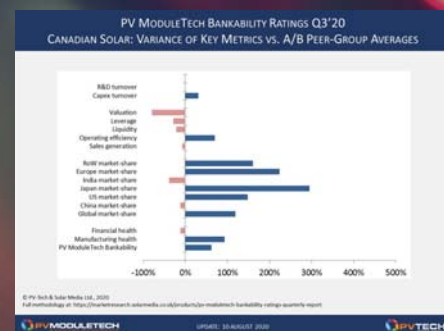
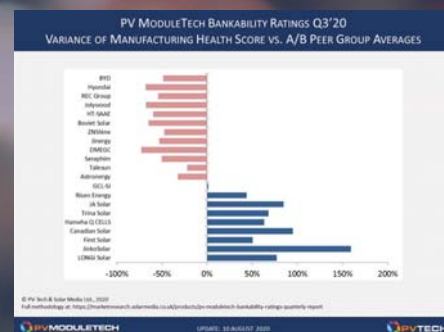
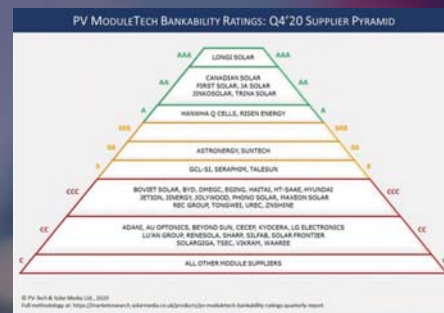


PVMODULETECH BANKABILITY RATINGS

The industry's most trusted PV module supplier bankability rankings – quarterly-updated analysis from PV Tech Research

The report provides everything you need to benchmark all your existing/potential suppliers against each other in terms of bankability, limit your supplier short-lists to only the most financially stable, risk-averse companies and help you avoid the near-bankrupt entities claiming to be “Tier 1 suppliers”.

- Unparalleled company data, analysis and forecasting for more than 50 of the major global module suppliers to the industry, refreshed each quarter
- Financial operations of each company - both public-listed and privately-held - in a clear, understandable format, all benchmarked to PV industry operating norms
- Technology and module shipment trends, updated quarterly, forecast to the end of current calendar years, including company in-house production by region, technology and capex/R&D
- A must-have for buyers of modules or anyone undertaking assessment of potential suppliers at the utility scale level.



We are offering **free introduction webinars** to companies interested in accessing the full range of services available – email marketresearch@solarmedia.co.uk to find out more

<https://bit.ly/2zdrKf>

Product reviews

Inverters | Growatt's MAX 1500V string inverter line offers lower BOS and LCOE costs

Product Outline: Growatt has launched a powerful 1500V string inverter for large scale solar plants. The MAX 1500V inverter aims to lower LCOE and achieve higher yields for clients. It is compatible with bifacial and high-power modules and its smart functions, such as smart I-V diagnosis, will make O&M easier and reduce costs.



Problem: PV asset owners are increasingly turning to string inverter technology for utility-scale projects in order to deliver improved energy yield, while reducing upfront BOS (Balance of System) costs and

significantly shortening installation and configuration lead times.

Solution: Growatt's MAX 185-253KTL3-X HV 1500V string inverter is designed for utility-scale solar power plants. It will reduce BOS costs, lower LCOE and maximize return on investment: it has an efficiency of 99.0%, is compatible with bifacial and 600W+ high power modules and is equipped with 15 independent maximum power point tracking (MPPT) inputs and a high DC/AC overloading ratio up to 2.0. Growatt's new generation of intelligent string inverters and Online Smart Service (OSS) cloud platform is designed to reduce costs associated with installation, configuration and maintenance.

Applications: Utility-scale PV power plants.

Platform: The MAX 185-253KTL3-X HV 1500V string inverter comes with up to 15 MPPTs and a fuse free design. The 15 independent MPPTs provide sufficient flexibility for the module configuration and enable the DC/AC overloading ratio to contribute to LCOE reduction. The fuse free design reduces BOS costs by eliminating the need for additional fuse boxes. Also provided is an optional anti-PID/night SVG/AFCI function and data storage of up to 25 years.

Availability: Currently available.

O&M | Hoymiles S-Miles Cloud Platform improves PV power plant operating analysis

Product Outline: Hoymiles Power Electronics has recently unveiled the all-new S-Miles Cloud Platform for real-time visualised monitoring of solar power generating equipment.

Problem: Simplifying and standardising data collection, PV power plant operators and asset owners could benefit from increased data accuracy and better map overall power generation status, reducing operating costs.

Solution: The S-Miles Cloud Platform is designed for real-time visualised monitoring of solar power generating equipment. Field equipment can be connected to the



S-Miles Cloud Platform. With IoT-supported data collection devices, the platform can track the output effectiveness of arrays, provide status updates on individual modules and notify of any malfunctions. Accessible as a mobile app or via a web browser, the S-Miles Cloud Platform offers a powerful and easy-to-use portal to effectively maintain solar power stations. Through the user-friendly installation process, integrating the platform into an existing array can be quick and simple.

Applications: All types of PV power plants.

Platform: The newly upgraded platform features a clean and simple dashboard interface which was designed with end-users in mind to allow for clearer visual data displays and additional options for in-depth analysis. The upgrade also includes a real-time progress tracking feature for hardware updates, which displays a progress bar and provides detailed explanations of any errors that occur. The Platform is also compatible with Hoymiles' newest and most advanced hardware offerings of the DTU-Pro, DTU-Lite and new Sub-1G version microinverters.

Availability: Currently available.

Inverters | Kehua's SPI250K-B-H 1500V string inverters match grid needs with solar plus storage

Product Outline: Kehua Tech's new generation of 1500V string inverter (SPI250K-B-H) is suitable for a 1500V big block design and 12 MPPT 30A applications with 1.5 times DC/AC ratio.

Problem: PV project developers and asset owners are increasingly demanding lower-LCOE, grid-friendliness, high-efficiencies and improved reliability of PV inverters. Demand requirements are rapidly expanding to include greater integration and optimisation with energy storage systems (ESS) that provide intelligent features to be more responsive to grid requirements.

Solution: The SPI250K-B-H string inverter series is said to reduce Balance of System (BOS) costs by 1% and increase the power



generated in a 100MW station by 1.5 million kilowatt-hours per year, when compared to those with a string system less than 200kW. The system supports night SVG to achieve a quick response to

reactive power within 30ms. When there is rated active power, it can output 48% of reactive power capacity, greatly reducing the cost of equipment, power loss and installation of power stations. The system supports PLC intelligent communication box to enable fast response and dispatching, and I-V curve scanning for timely detection of PV module abnormalities, reducing losses by more than 60%. Kehua has devel-

oped a mature PV+ESS inverter that meets grid-friendly requirements for HVRT & LVRT and is applicable to various grid construction and management projects.

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

Platform: The patented PID solution adopts decentralised suppression and repair of corresponding PV modules of the string inverter, enabling a round-the-clock operation with reliable voltage protection and repair through flexible settings and adjustments according to specific features of PV modules, thereby protecting PV modules and increasing the power generated.

Availability: Q3 2020, onwards.

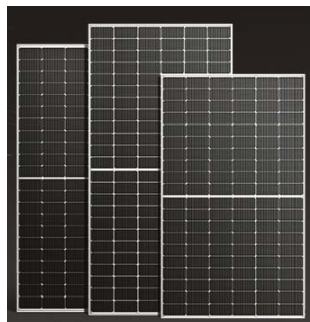
Product reviews

Modules LONGi Solar's 66C type Hi-MO 4m module offers compact design for global DG markets

Product Outline: LONGi Solar has launched its new 66C type Hi-MO 4m monofacial PV module (Hi-MO 4m) for the global distributed generation (DG) market.

Problem: With the shift to larger wafer/cell/module sizes to boost PV module output and reduce Levelised Cost of Electricity (LCOE) metrics for utility-scale markets, residential rooftop markets require smaller module sizes that provide the flexibility in installation design, limit weight and operate at voltages that better match PV inverters designed specifically for this market, while benefiting from higher performance output and yield.

Solution: The Hi-MO 4m module combines



the advantages of high efficiency, high energy yield and high reliability. Its size and weight are designed to match the requirements of DG system installations and application scenarios. For the residential market, the Hi-MO 4m 60C module (area of 1.82 m², weight of 19.5kg, width of 1.04m) is most suitable in terms of convenient installation due to its moderate size and weight. In some countries and regions, modules of larger size and weight can also be installed on residential roofs. LONGi therefore also provides 66C (22.0kg) and 72C (23.5kg) options. In terms of electrical matching, the

current at maximum power of the Hi-MO 4m module is lower than 11A, which is a match for the various brands of string inverters, power optimisers and micro inverters available worldwide. It not only makes full use of the design margin of the equipment, but also avoids the loss of power generation or mismatch caused by current limiting.

Applications: Global DG rooftop market.

Platform: The width of the module is standardised, while three different length options allow the Hi-MO 4m series to maximise the photovoltaic system's installation capacity in residential rooftops.

Availability: Currently available.

Modules Seraphim Solar S4 half-cell PERC series PV modules have 21.1% conversion efficiencies

Product Outline: Seraphim Solar has released its new generation of products, the S4 half-cell series PV modules. The new S4 half-cell series can achieve a maximum power output of up to 540W, with the maximum module efficiency reaching 21.1%, by integrating 182mm large silicon wafers with state-of-the-art technologies such as passivated emitter rear cell (PERC), multi-busbar (MBB), half-cut cells, and high-density packaging.

Problem: In 2020, newly rolled-out PV modules using large and varied sized wafer/cell configurations lead to a multitude of module dimensions and weights. This created confusion in the industry in selecting the optimal product for PV power plant



projects, whether monofacial or bifacial.

Solution: The new S4 series module integrates 182mm large-size silicon wafers of PERC, multi-busbar, half-cell, bifacial technologies and high-density encapsulation. The S4 bifacial series exhibits an efficiency increase of the module of up to 21.1%, and a maximum power output on the front side of 540W. It is compatible with existing packaging schemes, container sizes and logistics methods. The S4 bifacial series modules have the advantage of more power per unit area and reduced Balance of System (BOS) cost and can be effectively combined with mainstream 1p and 2p

mounting styles for single-axis trackers.

Applications: Utility-scale PV power plants and commercial and industrial applications.

Platform: The module is a 72-cell half-cut (144-cell) format using 182mm x 182mm large-area wafers with dimensions of 2,288mm x 1,134mm, weighing 28.5kg for monofacial and 32.5kg for bifacial. The bifacial module also has a 35mm thick anodized aluminum alloy frame to make it easy to assemble.

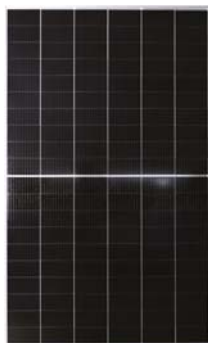
Availability: Both monofacial and bifacial modules will be put into mass production in the first quarter of 2021, with an expected annual capacity of 3GW.

Modules Suntech's Ultra X PV module series come in the 580-600W range with large-area 210mm mono-wafers

Product Outline: Suntech's 'Ultra X' PV module series adopts large format 210mm monocrystalline wafers and 1/3 cut Passivated Emitter Rear Cell (PERC), which increases the light receiving area by 80.5% compared with products of conventional formats, according to the company.

Problem: PV project developers and EPCs are seeking optimisation of PV power plants that spans PV module shipping, installation, performance and high yield coupled to long lifetime expectations that can exceed 30 years.

Solution: Suntech's Ultra X product series uses a non-destructive cutting technology which makes it possible to avoid the



damage of cutting surfaces, realising the optimal 1/3-cut design while effectively reducing current loss and the risk of hot spots. By virtue of the multi-busbar technology, the transverse propagation path of the current can be decreased by 50% and resistance loss can be reduced effectively, while realising the maximum power output and the reliability of the module. While ensuring the reliability of the welding process between cells, Suntech's upgraded high efficiency ribbon brings more second-time refraction of oblique light, which increases the power generation by 1.57% when the maximum power exceeds 600W+. Fully compatible with mainstream system designs, the module can match terminals better and save on EPC costs by more than

1.2%, saving the cost of land by 4% and BOS by 2.7%, ultimately achieving lower LCOE and higher return on investment for customers, according to the company.

Applications: Utility-scale PV power plants.

Platform: Suntech has a particularly optimised structure design and owns this exclusive patent. Compared to mainstream products of the same specification, the weight of the module is 26.9Kg, reduced by more than 1/5 suiting the transportation standard and reducing the labor cost of installation by 15%, according to Suntech.

Availability: Currently available.

A DIFFERENT TYPE OF WEBINAR

The new way to launch your PV products via the industry's preferred digital platform

Benefits include

- Access to the entire audience on the leading PV site
- Proven, popular format of both Product Review and TechTalk webinar
- Brand recognition via co-branded banners online and on PV Tech Newsletter in build up to webinar
- Ongoing exposure via recording of webinar and slides on PV Tech and your own website/social media channels.
- Product Review online and edited version in PV Tech Power journal
- Generation of sales leads
- PV Tech's expertise in marketing in both upstream and downstream – the team has 40 years collective experience in PV marketing

See examples of previous
TechTalk Product Series here:
www.pv-tech.org/on-demand-webinars/list

For more information and to register your interest in sponsoring your own
TechTalk Product Series webinar email marketing@solarmedia.co.uk

Data cleaning – How a growing, ageing solar fleet is changing O&M



O&M | As solar continues to proliferate and the very first large-scale arrays exceed 10 years of operational life, the value of operations and maintenance services is forecast to skyrocket. But as Edith Hancock writes, industry pressures such as new technologies and consolidation, are reshaping the industry.

Credit: Ecoppia.

Renewable energy prices have plunged to record lows over the past year, and while that is good news for the end consumer and multinational developers who can benefit from economies of scale, it has left asset owners with far less room for error on their balance sheets.

Operations and maintenance (O&M) has become a hugely competitive part of the wider solar market as a result. While some companies see rich prospects for O&M as the global solar fleet ages, a report from research firm Wood Mackenzie published in June 2020 suggests that this itself will present numerous challenges to O&M, and

will be further compounded by project auctions placing increased pressure on costs as developers look to save on project OpEx.

The research group forecasts that assets running into premature failures will rise from ~4.2GWdc this year to 36GWdc by 2025 as more solar plants pass 10 years of operational life. Solar power systems nearing inverter end of life, meanwhile, currently account for 5% of the global PV market, according to the report, but this number could grow to 16% - or 227GWdc of solar power generation globally within the next five years.

Still, there is plenty of optimism around

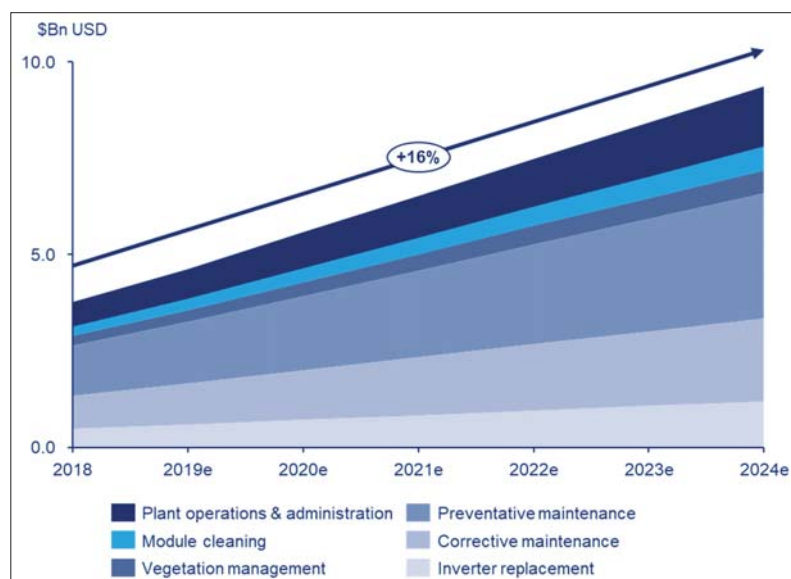
Ecoppia's automated panel cleaning robots whilst docked.

the O&M sector's growth as governments worldwide commit to more renewables installations to meet net zero targets in the first half of the 21st century. Wood Mackenzie's June 2020 report predicted that the O&M market could be worth US\$9.4 billion by 2025. Although the Asia Pacific market is expected to hold the bulk of this value at US\$4.1 billion, Europe is expected to be an "especially important" area for inverter repowering, with more than 16GWdc of systems currently over ten years old, Daniel Liu, Wood Mackenzie's principal analyst, says. By 2025, he says, that number will grow to 100GWdc.

Liu believes that aging solar systems are an "opportunity for repowering activities, while new projects can take advantage of advanced analytics." But with pressure on margins from more solar coming on to the grid and lower auction prices, O&M providers need to come up with smart, low-risk solutions in a tight budget.

Robots and drones

The COVID-19 pandemic and subsequent restrictions on movement shook the O&M sector, which relies heavily on cohesion in the supply chain and the transportation of new equipment from the manufacturer to the asset owner. They must also think more frugally about the time staff spent on site, with crews working in fewer numbers, or even refraining from sending any unless absolutely necessary. O&M providers have been working with new automation



The solar O&M market is expected to be worth up to US\$9.4 billion by 2025.

LARGE SCALE SOLAR EU

HOST SPONSOR



13-14 | APR
2021
VIRTUAL

Use code
PVTECH20 for
20% off when you
register online

WINNING BUSINESS IN A NEW ERA OF EUROPEAN SOLAR

// It was very interesting the topics and the format and also the networking sessions.
PEDRO AMARAL JORGE, APREN

It was my first Large scale solar online event. I found it very useful and certainly good to still gain knowledge of the new trends and activities. //

MICHELE APPENDINO, SOLAR VENTURES

Brought to you through our best-in-class platform (used by the Olympics), **Large Scale Solar 2021** will bring you the latest information about how to win business as economies emerge from the pandemic.

The cost of solar has dropped precipitously by 89% in the last decade, Solar Power Europe is forecasting an additional 30GW of solar by 2022, building on the 18.7 GW of solar which was deployed in 2020. Make no mistake, the 2020s will be the solar decade.

Large Scale Solar EU taps into that opportunity by bringing the European and UK solar industry directly to your screen. Speakers will cover 9 key topics enabling the transition and all will be at the top of their game. Seize the opportunity in April.

THINK VIRTUAL EVENTS LACK THE SURPRISE OF FACE-TO-FACE? OURS DON'T! WE'RE PACKING YOUR AGENDA WITH THE OPPORTUNITY TO MAKE NEW CONTACTS



SPEED NETWORKING

Fast, furious and fun, these 4-minute groupings 4-person bring you the feel of the serendipitous meeting at a coffee break when you bump into someone who can help your project move forward...



TALK BUSINESS AT YOUR OWN PRIVATE 1-2-1 MEETING

We do the hard work for you by gathering the movers and shakers of the European solar industry into one place. All you have to do is show up.



SOLVE PROBLEMS DURING OUR TOPIC BASED ROUND TABLES

Structured networking groups designed to form strategies around some of the bigger challenges faced by the industry or take part in our ever-popular country showcase sessions and meet new partners.



FIND SOLUTIONS AT OUR EXCLUSIVE EXHIBITION

Meet Silicon Module Super League players, top tier EPCs, inverter and tracker manufacturers, law firms, technical advisors, logistics companies, financiers, and other experts ready to enable your business.

REGISTER HERE: ss.solarenergyevents.com/tickets

tools to bring more value to their clients long before 2020, but the pandemic has brought its value into sharp focus. Finally, finer margins in the sector as a result of lowering tariff rates at auctions and cheaper energy prices has highlighted the disadvantage of carrying out work manually. A recent survey by Wood Mackenzie found that reducing costs in the business operation was one of the key motivations for solar asset managers to automate their O&M services.

As such, companies that were able to capitalise on the emergence of robot cleaning technologies early made huge gains in their respective markets. Clean Solar Solutions, based in the UK, was borne from founder Steve Williams' window cleaning service in 2013, after one client asked if he could also take care of their rooftop panels. Within three months, he secured a national contract with British Gas Solar and went on to publish a health and safety manual for panel cleaning as there was "no information" available at the time. The company purchased its first robotic cleaning device in 2017, and now oversees the cleaning of between 1.8 and 1.9 million panels globally, with offices in Ireland and Australia.

Williams tells *PV Tech Power* that introducing robots and reducing on-site staff levels was central to sustaining the business as the national, and global, solar fleet expanded since 2013. Now, Clean Solar Solutions is looking for ways to refine their offering.

But, he says, robot development is really still "first generation" and can be unreliable. "They're not overly user friendly, have sharp edges, and are heavy and cumbersome, so the robots themselves will be developed massively over the next years. Hundreds of patents are pending for solar panel robots all over the world." One development Williams has his eyes on are those with "bigger and wider brushes, so we can increase our cleaning capacity with one pass," but speed and data acquisition are also important, especially in the field of fault detection.

"Thermal imaging can be integrated into the robots as well and pick up some faults for clients. There should be a way of fitting barcode scanners onto the panels as well, so that you can scan each as you clean, and that information could be collated on the robot. At the end of the job it would spin you out an excel file which would highlight where each panel is sat and when there is a weakness in that area they know which

ones are playing up. You would be able to spot trends across the plant as you go along."

Aerial monitoring of solar power systems has proved popular in this space as drone technology has become more sophisticated. Aline Kirsten Vidal de Oliveira and Ricardo Rüther, researchers at the Federal University of Santa Catarina, and Mohammadreza Aghae of the Fraunhofer Institute for Solar Energy systems, published a report in June 2020 exploring the efficacy of aerial inspections of solar sites using mechanisms such as drones. The widespread adoption of such devices, they said, had increased the availability of controlling and route planning software, which has in turn added to the automation of aerial inspection.

One independent power producer harnessing this new technology is Enerparc, which partnered with data and analytics company Sitemark to use its "Fuse" platform and drone technology to carry out site inspections. The company said last July it would fly drones fitted with high-resolution visual cameras and thermographic sensors over more than 1GW of its own solar assets worldwide.

The data collected from such sensors is invaluable in making O&M as efficient as possible.

Solar's new data era

Although it accounts for nearly 15% of O&M costs, Wood Mackenzie's report points out that fewer than 1% of solar systems experience premature inverter failures, representing a generous margin

"Once you've mapped out every single component and you see how they all hang together you can then play with component level maintenance, and condition-based maintenance."

for providers who can harness data well. The report believes the rate of failure will only grow as the market matures.

O&M has broadened to mean far more than cleaning and vegetation management, although there is some dispute over where to draw the line on its definition. Declan O'Halloran, the managing director of asset management group Quintas

Energy, says his company "never gets involved" with O&M, but does instead provide a layer of management that helps people measure the performance of their assets and contractors on any given solar plant. "We never send anybody to site to fix anything," he says, "but we do send people for site inspections, for modelling and drone inspection." It's a service that O&M providers are increasingly certain need to be a part of their playbook.

Israeli robotic solar panel cleaning business Ecoppia launched an initial public offering (IPO) after securing more than US\$82.5 million through a public tender phase at the end of 2020, with investors valuing the company at US\$300 million. This is on top of a US\$40 million investment from US investor CIM Group, which acquired US\$40 million of shares in Ecoppia, and with US\$20 million of investment ploughed directly into the company. Now listed on the Tel Aviv Stock Exchange, chief executive Jean Scemama, says the company is readying itself for expansion into new markets, and developing a more intelligent form of data collection that would turn its cleaning robots into module performance analysts.

The robots Ecoppia use already collect a small amount of data on the more than 16GW of energy generation plants in its client portfolio, and they are all managed by a cloud-based solar panel cleaning solution, something Scemama believes gives the company a competitive advantage for this specific ambition. "The system is already quite smart," he says, but there is more value to be found in creating a system that makes a judgement call on the data it gathers.

"Adding on analysing the data we already gather from the system and providing alerts and insight for the site owners is the next stage. The more data we're going to have, the more precise the prediction will be. We therefore plan on adding multiple additional sensors on the site, including drones. Eventually our aim is to recommend to the site owner: 'in this block and in this row, in this panel, you have an issue. Our recommendation is to replace it and this is your ROI'. That's a significant value we plan on bringing to our customers."

Established asset managers are using the information they have to hand to create their own smart solutions and predictive maintenance systems. Quintas Energy has started using a system called Parklife, which gathers all available information about a solar power system to

module-level to create a digital twin, which can then be used to predict when specific components are due to be replaced. O'Halloran says the company is "obnoxious" in its conviction over their necessity to a plant's performance.

"Once you've mapped out every single component and you see how they all hang together you can then play with component level maintenance, and condition-based maintenance," he says. "That's when you're able to tell the operator on-site the condition of every component for the next period of time, say three, six or eight weeks."

As crucial as collecting data is to broadening the services an O&M provider can offer, there is still a significant skill gap that needs to be closed in order to turn that into reliably actionable insights.

Changing relationship between asset owners and contractors

In a bid to take greater control of the solar projects they manage, some asset owners have decided to invest in building their own teams rather than outsourcing to contractors, whose software Obton's technical director Robin Hirschl says often "does not deliver" what it promises. The company is to double the size of its technical team this year in a bid to streamline the maintenance of its own solar portfolio.

Obton, which manages some 800 PV projects globally with an overall capacity of 982MWp, is among Europe's largest solar asset owners. Hirschl, who had previously spent the last decade running his own O&M and facility management company, joined Obton as the company's technical director in 2019, overseeing a team of 15 people. The company has decided to bring more technical expertise in-house as profit margins are increasingly squeezed by falling feed-in tariff rates.

"Back in the days when we had feed-in tariffs of €30-€40 it was a lot easier to pay money to O&M providers," he says, but warns that as more, cheaper clean energy comes onto the grid, "asset owners need to think very carefully about what is really required. How do we control what our contractors are really doing? How do we organise the interface to our lenders, which is also something that has been completely neglected in recent years and why we as an owner need to ramp up our team."

While Obton still uses local contractors for preventative maintenance and day-to-day asset management, the newly-

bolstered team will work to consolidate the data from developers on its 800 plants into one system which will provide a more automated approach to maximising the portfolio's effectiveness. Hirschl says ideal candidates will be working in "one-person teams" to coordinate directly with technical suppliers, and the company is looking for engineers with a background in EPC, technical service or at a technical asset management company.

Hirschl is recruiting more people into his team over the course of this year with a view to building their own overarching intelligent system that "helps us identify which systems are running well and which are not...is this due to causes we can't influence like grid issues or due to non-performing local contractors? That's one of our main concerns at the moment."

Meanwhile, Germany-headquartered Enerparc has already been on a recruitment drive to bolster its technical team over the past 18 months. Chief operating officer Stefan Müller says the challenge is to find data analysts "with an engineering mind" in order to ensure the information they can gather on their systems can be applied to optimise a plant's efficiency. In addition to incorporating drone technology into its asset management, Sitemark is also collaborating with Enerparc to build up its in-house capabilities in order to perform its own drone inspections over the years to come.

A consolidating but critical market

As the sector has become increasingly competitive, some big players in the industry have decided to sell off their O&M arms, while others buy up their teams and capabilities to create ventures of their own.

US residential solar software company Omnidian also acquired its O&M business partner PV Pros in March 2020, and went on to raise US\$15 million series A funding to expand its monitoring business nationwide. Canadian private equity group Clairvest created NovaSource last year, snapping up two separate O&M businesses to do so. Having acquired SunPower's O&M business in May, the group then bought the maintenance arm of US module manufacturer First Solar in August, which had seen the division's margins contract over the past year.

Speaking to analysts after the results disclosure, chief executive Mark Widmar said in order "to justify incremental capital investment in O&M, the financial returns would need to exceed those available

from further investment in our module business." NovaSource's acquisition offer was "compelling", he said.

At the start of 2021 Texas-based energy firm Consolidated Asset Management Services (CAMS) acquired developer Belectric's US solar operations and maintenance (O&M) business, after Belectric had managed to meet its target of managing 3GW of capacity for its clients and was ranked in the top five O&M service providers in the market globally by Bloomberg-NEF. Explaining the decision to acquire the solar group's O&M business, CAMS COO Greg Bobrow said that CAMS' clients are "increasingly focused on the transition of energy generation towards renewable sources."

"CAMS always looks for ways to support an improved environment while at the same time providing cost savings and creating value for our customers. We at CAMS look forward to a growing market-ing presence in the solar energy space."

Smaller businesses with a legacy of O&M provision have taken note. Clean Solar Solutions' Williams says he is "having conversations" about a potential acquisition from a larger player, but couldn't say more. The chief executive of robotic cleaning specialist Ecoppia also says he is "not ruling out" acquiring a company with expertise in AI software as it aims to dominate the global market.

Although falling energy prices and the gradual reduction of government subsidies has placed increased pressure on asset managers' margins, O'Halloran argues it also ensures the need for strong O&M providers. Businesses that can keep up will reap the benefits of Wood Mackenzie's projected US\$9.4 billion value. "The most valuable thing we can do, especially in the Spanish market where solar farms are already viable, is to help owners use data and control rooms for real-time control to take on merchant risk," he says.

The managing director firmly believes that capacity will outstrip the ability of the PPA market to buy all subsidy-free energy well into the future, forcing rates down. "When that happens, the demand for control rooms for daily and hourly monitoring measurement verification and the provision of that data to the trading team whose job it is to find in the merchant market will create not just an additional demand for data, but additional liabilities for data providers who get it wrong. That's when everybody starts taking their job very seriously!" ■

Data disarray: Why solar is not fulfilling its potential

Big Data | Given the significant wealth of data available from an energy generation asset today, it's perhaps easy to overlook the availability and value from around the asset as well. Katie Applebaum, business development manager at Clir Renewables, explains why this 'data disarray' is preventing solar assets from reaching their full potential.



Credit: Huawei

Solar projects across the world are underperforming. In some cases, projects miss production budgets by more than 10%. Despite these startling figures, the underlying assumption that solar projects are doing 'just fine' persists within the industry.

While new solar capacity is being installed at a rapid rate, asset owners are continuing to realise much lower returns than if a project met its full potential. Addressing the disparity between the solar industry's potential and its current performance is key to furthering the technology's rise as a globally preferred generation type.

Renewable energy is typically considered difficult to assess for project losses due to the intermittency of resource. Energy production fluctuates in line with the strength of wind or solar irradiance, and this can overshadow the impact of small but consistent technical issues. However, even if these technical problems do not progress into more extreme damages, these quiet losses can ultimately build up and significantly impact revenue over the project's lifetime.

Solar is particularly prone to small but significant project losses due to the

Data from multiple sources can be valuable from an asset performance perspective.

passive nature of the technology. In wind projects, small electrical or mechanical issues are taken very seriously as many defects, particularly those present in rotating components, can result in catastrophic failure if ignored. On the other hand, solar assets tend toward less dramatic breakdowns, reducing pressure on the operator to promptly attend to issues.

Solar PV components can suffer from a range of technical issues, many of which may not necessarily result in downtime but will instead impact energy production - for example, tracker misalignment



A chart showing the fluctuation of inverter temperatures on an operational solar system over time.

can result in reduced power generation at specific times of day. An additional, subtle cause of underperformance is poor electrical health – inclusive of voltage, signals, and temperatures.

There are also physical influences on-site that can hinder the performance of solar panels. For example, the growth of vegetation nearby, hot-spot failures, and severe weather can reduce performance over time without the owner realising their assets are actively being damaged. These failures are not picked up directly by faults or statuses in the SCADA system and so can often be mistaken for simple fluctuations in resource.

Often, solar underperformance does not come down to a single point of failure but is caused by the interaction of the environment, electrical health, and component errors across the PV module or array more widely. This means that understanding the root of the issue and the actions required to solving it demands analysis of multiple data sources.

Multiple data sources

To identify, quantify, and ultimately fix solar underperformance at a project level, owners must analyse data across the entire system in that project in the context of data from the surrounding environment. Not only does this mean gathering multiple data streams, but it also means gathering data that has been recorded in different formats or “languages” – a discrepancy that is common due to differing formatting preferences between OEMs. In order to enable accurate comparisons of performance, these disparate data streams must first be “translated” into a uniform dataset.

In practice, this disparity has resulted in a concerning degree of inattention when it comes to realising the benefits of data analytics. When owners dedicate in-house resources to assess project or portfolio data, the many hours of collating, translating, and finally analysing data from all asset types and sources can often exceed the potential gains in returns that optimisation can bring.

Without the technology or resources to effectively translate, integrate and analyse this data quickly, owners are left in the dark as to whether their asset is performing as it should be.

This has the potential to impact project financing, as while a reluctance to address the data challenges behind performance inefficiencies exists, owners are unable to reduce uncertainty around the forecasted energy output of their sites. With unnecessary performance losses accumulating, there remains a concern that potential investors cannot have full confidence in projected gains from solar projects.

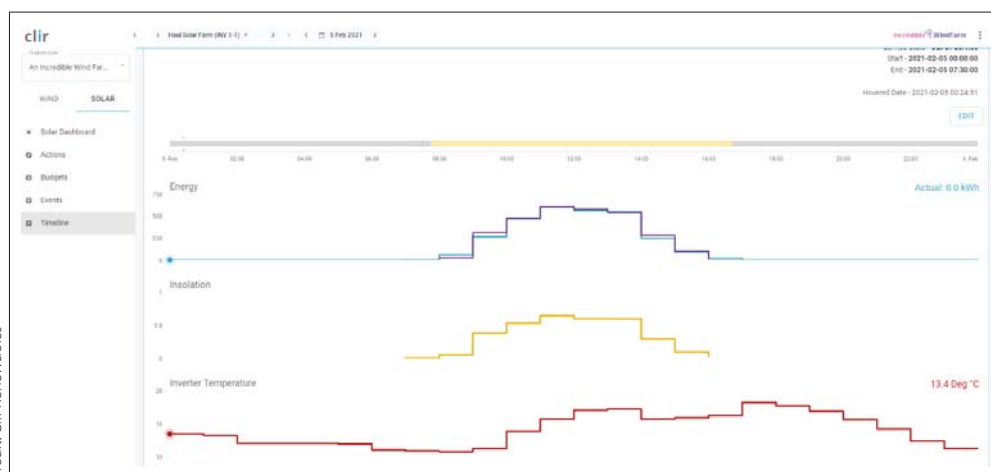
Clir is working with a number of owners and operators to pull data from projects into a common model for analysis and generation of optimisation insights. This includes consideration of:

- Current and historical meteorological data,
- Surrounding forestry and vegetation,
- Operational and grid activities,
- Device-specific SCADA data from the individual asset.

Once all this data is translated into the common data model, we use machine learning to compare assets on a like-for-like basis. From this analysis, we can pinpoint not only instances of underperformance but the root causes, providing owners with the information needed to increase energy production, target O&M activities and validate financial decisions around the asset.

It is important to note that while asset owners are limited to comparing performance across the sites or assets in their portfolio, we are able to accurately benchmark their assets across their full portfolio of solar farms onboarded. With the use of data analytic techniques such as machine learning, the platform gets “smarter” the more data it ingests, enabling more rapid identification of underperformance and likely causes based on an ever-increasing bank of global solar PV module, array, and portfolio data.

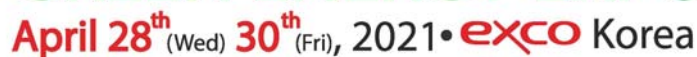
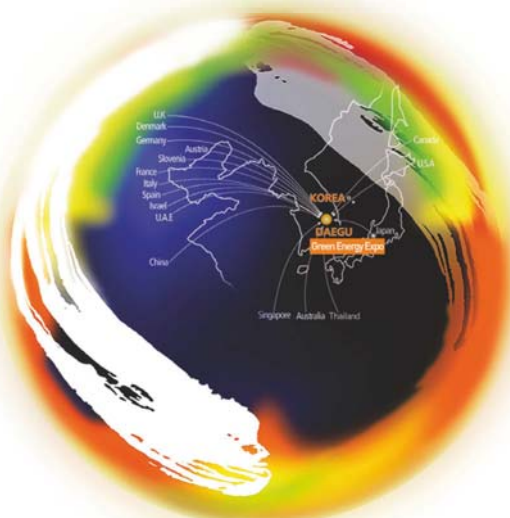
The outlook for solar power is optimistic, and once owners harness the latest technology to monitor, assess, and optimise their assets – regardless of manufacturer – they will be able to unlock the full potential of the technology as an energy and revenue generator.



An example of the analysis undertaken on a site-by-site basis, indicating performance and inverter temperature in a single view.

The collage consists of 12 individual photographs arranged in a grid-like fashion, showcasing the 2015 Korea Energy Efficiency Exposition. The images depict various exhibition booths and large crowds of visitors. Key elements include:

- Booths and Exhibitors:** Several booths are clearly visible, including Hanwha Q CELLS (top left), Risen solar technology (middle left), Hyundai (middle right), Longi Solar (bottom left), Akcom (bottom middle), Suntech (bottom right), and PVM (bottom right).
- Crowds:** Multiple photographs show large groups of people, including men and women, walking through the exhibition hall and gathered around the booths.
- Exhibition Hall:** The background of many photos shows the vast, high-ceilinged exhibition hall with its industrial structure and lighting.
- Signage and Displays:** Various signs, banners, and digital displays are visible, some featuring logos and text in both Korean and English.



Sponsored by

Platinum  HANWHA Q CELLS  HYUNDAI ENERGY SOLUTIONS  SHINSUNG E&G

Gold  SUNGROW  KOGAS  KEPCO

Silver  HUAWEI  HAEZOOM

Bronze  JINKO SOLAR  SINENG  RISEN SOLAR  BAYWA r.e.

- 1 Korea's representative and most professional PV B2B exhibition
- 2 The one & only PV show in Korea sponsored by Global players
- 3 The only exhibition in Korea that is a member of Global Solar Alliance
- 4 The only event organized by major assoc's in Korea
- 5 Korea's largest international conference, education and export consultation meeting will be held simultaneously



Book your prescence (Feb 12, 2021)

For further inquiries

Tel +82 536015371
E-mail renew@exco.co.kr

Project Briefing:



TAKING FLOATING SOLAR TO NEW TERRAINS

Project name: Guping Reservoir Floating PV (FPV) project

Location: Qintang district, Guigang city, Guangxi Zhuang Autonomous Region, China

Capacity: 20MW

Energisation date: December 2019

Investment value: RMB70 million (US\$10.8 million)

The adoption of floating solar is accelerating the world over, and Asia has taken a leading position in the adoption of FPV (see page 26). With the aid of subsidy support, technological advances and ever-growing comfort with the technology class, FPV is being taken to ever newer and more hard-to-reach bodies of water.

Located in the southeastern part of Guangxi Zhuang Autonomous Region, China, Guigang city is an important gateway leading to the ocean for the southwestern part of China. Lying on the middle reaches of Xijiang River, it is also the first major inland river port in western China.

Floating on that body of water is an FPV

install that boasts a raft of unique features and novel technological approaches. The 20MW Guping reservoir FPV plant is located in Qintang District, Guigang City, Guangxi Province. Built over an irrigation reservoir, the total power production capacity generated over its expected 25-year life span is forecasted to exceed 470 million kWh, averaging at over 19 million kWh annually.

Construction of the FPV system kicked off in October 2019. The plant was contracted by Sungrow and connected to grid at the end of December of the same year. The total project investment exceeded RMB70 million (US\$10.8 million).

Compared to power plants of 50MW or 100MW, the 20MW Guping Reservoir FPV is not among the largest floating solar installations in China, where FPV project sizes continue to grow. What makes this project stand out, however, is the unique technologies used in its development and the picturesque surroundings it finds itself in, the basin itself surrounded by mountains and rivers. Furthermore, the formation of the reservoir, and the deployment

techniques used to float solar atop it, set it apart from others.

Building on the Karst

It is not easy to build a FPV plant in such a scenic spot. Among the issues to be considered are local ecology protection and adaption to special geomorphological features.

The Guping Reservoir FPV site features Karst landforms, bodies of water formed by the dissolution of soluble rocks – typically limestone or gypsum – which can eventually give way, posing unique issues to overcome. China's Karst landforms are concentrated in Guangxi, Guizhou and Yunnan provinces, but are most widely found in Guangxi province. This creation of Karst landforms makes elements of developing infrastructure projects, including solar PV, particularly difficult. "Underneath the reservoir is a Karst landscape, piled with easily eroded rocks, making it impossible to drive piles. The cost of driving piles is also very high," says Kane Wang, system solution manager at Sungrow Floating Solar, the Sungrow division dedicated to FPV.

The 20MW Guping Reservoir Floating PV project was completed in December 2019.



Credit: Sungrow



The project's design combines rods and floats which hold the modules in place.

Credit: Sungrow.

Based on the underwater geological survey report and local conditions, Sungrow applied its new generation of floating system in this project. Instead of using more traditional floating products, the company developed a plan combining floating bodies and rods. The output of a single super-large floating square, designed with special deadweight anchors, can reach up to 7MW.

"The anchoring system is the key factor at play for the safe and smooth operation of this FPV system. To this end we've introduced a scheme combining rods and floating bodies. In the north-south direction, a kind of galvanized Al Mg alloy rod is used as the connecting piece.

"The pull force at a single anchoring point can reach up to 25KN. For a traditional floating array, due to the use of HDPE materials, the maximum tensile force of the anchor point is only about 15KN. Generally speaking, the less anchorage points, the less anchoring costs. The high strength at the anchorage points is effective in avoiding accidents which are often triggered by insufficient pull force," Wang says.

The HDPE material referenced by Wang is a food-grade, durable and weather-resistant material independently developed by Sungrow in the company's advanced floating body materials research laboratory. Both acid and alkali-resistant, the material is said to be performing very well in harsh environments, such as cold or hot conditions, and capable of meeting the 25-year design life requirement that comes as standard with operational solar projects today.

In addition, the possible impact on the ecology of the body of water and its surroundings has also remained a consideration in Sungrow's design of floating solar installations. These installs feature low water surface coverage, higher light transmission and better oxygen dissolution which, in short, makes for a lesser impact on the quality of water sitting beneath the panels. This is in comparison to alternative floating system solutions which can allow for more than 45% of the water's surface to be directly covered by solar arrays.

"Our products can ventilate and cool down the PV modules very well, [which] is quite effective in increasing the output of

electric energy production capacity. Our R&D efforts were also directed at enhancing electric energy production capacity and delivering environment-friendly products," says Wang.

Wang points to research from third-party institutions in the Netherlands and Singapore – two other markets where floating solar's rise has been particularly prominent – have found that floating PV systems with open structures can provide a higher heat loss coefficient by allowing wind to pass beneath the modules. Proper system design, therefore, allows for more heat convection between the modules and the water surface.

Construction, operation and maintenance

Sungrow's system has been easy to install and operates efficiently, contributing towards an accelerated construction process. It took just over two months from the construction start in October to grid connection at the end of December 2019, a rapid deployment for a floating solar project of this size.



EU PVSEC 2021

38th European Photovoltaic Solar Energy
Conference and Exhibition

**THE
INNOVATION
PLATFORM
FOR THE
GLOBAL
PV SOLAR
SECTOR**

**06 - 10
SEPTEMBER
2021**

**LISBON
PORTUGAL**

We are proud to
present the
EU PVSEC 2021
General Chair
Prof. João M Serra
from the
University of Lisbon.

We are monitoring current
developments very carefully
and reserve the right to
change the concept if the
situation requires it.

Photo by Daoudi Aissa on Unsplash

“The EU PVSEC 2021 is a
top reference event not only
for the latest developments
in scientific and technical
but also in financial, policy
and market insights related
to photovoltaics.”



João M Serra,
Professor,
Faculdade de
Ciências da
Universidade
de Lisboa.



www.photovoltaic-conference.com
www.photovoltaic-exhibition.com



Credit: Sungrow.

The design of special deadweight anchors used in the project.

Recognising the benefits, the local government also offered its support of this FPV project. As a novel mode of power generation, FPV is conducive to local green energy development, and local residents also benefited by taking part in plant construction, many receiving employment as a result.

"Most of the FPV installations are assembled at a construction platform onshore. Floating solar assembly is a repetitive operation, not a skill-demanding task. We hired local people to do that, which also increased their income," Wang says.

Aside from construction, the ongoing operation and maintenance – right the way through from part replacement to panel cleaning – constitutes a massive part of any given operating power plant. But floating solar O&M is proving much easier than their ground-mounted counterparts. According to Sungrow, most of the walkways required to clean the panels and conduct other O&M services were pre-installed within the project area at the build phase. As a result, workers can access each module through these channels, and the low module height makes for easier manual cleaning, with water used capable of being captured on-site. No additional treatment for the water, as it is collected via rainfall and stored simply for use in irrigation, is needed before it can be used for panel cleaning.

In addition, Wang says the air above the reservoir is much cleaner than the air surrounding it, meaning modules used in the installation continue to be much cleaner than those used in other projects, avoiding the potentially costly effects of air pollution. These modules do not need to be cleaned quite so often, thus the operation and maintenance costs are reduced.

An O&M technician inspecting the plant



Credit: Sungrow.



Credit: Sungrow.

Other project components have also been floated alongside the structure.

A replicable model?

Having customised the design of floating solar to be more suitable for the specific landscape and environment this project required, Sungrow is keen to take inspiration from it and develop further ideas for new FPV projects. The Guping Reservoir project is the first from Sungrow to be deployed on Karst waters, but it doesn't stand to be the company's last.

Since its grid connection at the end of December 2019, the plant has met operating expectations. "At present, the combination of power generation on water surface and water storage has been a widely accepted dual-benefit model in Southeast Asia. With the gradual promotion of FPV technology, more such FPV plants will be built in future on the Karst waters of Guangxi, China," Wang says.

As floating solar projects continue to be built, a developing, more technologically-advanced industry is being built around it and is, quite literally in this instance, charting new waters. Tech upgrades and novel approaches are allowing for FPV to be constructed in more areas than ever before.

Sungrow Floating Solar's stated aim is to continue FPV on that trajectory, given the significant benefits the generation class poses. "FPV uses no land resources and boasts high output of electric energy production capacity. With technology advancements, the reduced cost of annual electric energy production capacity supports wider FPV adoption. As more countries and regions are joining in, many African countries included, the global FPV markets at multiple regions are bound to grow tremendously," Wang says.

Making 'construction 4.0' work for solar

AI | Digital tools are increasingly used throughout all stages of construction projects. Greencells Group has adapted this principle for use on solar plant worksites - with an Augmented Reality support solution developed in-house.



Credit: Greencells

In terms of digitalisation, the construction sector is still being considered one of the least-developed industries, and solar construction is no exception. But change is underway - construction now sees a surge of new information technology emerging. Tools such as robotics, 3D printing and AI are being adapted to the sector, and some experts predict that 'Construction 4.0', blending traditional and new, digitised ways of working, will be a reality soon.

German developer-EPC Greencells Group has made tech and innovation a focus since its early beginnings. Searching to stay on top of the latest technological developments, Greencells has been among early adopters and forerunners of new technologies in this field. The in-house R&D team developed the company's own customisable mounting

structures and devised more efficient installation techniques for these. The O&M arm generates analytics for predictive and preventive maintenance services in-house, extracting and modelling data from operating plants. Innovation such as single-axis trackers and bifacial modules were speedily adopted and implemented for clients soon after their emergence on the market, at times introducing these new technologies as early movers, for example in projects in South East Asia.

Thanks to this company mindset and its dedicated R&D team, Greencells is now exploring a new playing field when it comes to bringing new technological concepts to the solar sector - Augmented Reality (AR).

"With our remote monitoring and predictive maintenance services, we employ the latest technology in opera-

The use of augmented reality tools can be used to serve various purposes on the site of a solar farm.

tions and maintenance, making the plants serviced by us run stable and generate higher yield by avoiding unnecessary downtime," says COO Patrick Clemens. Coming from a research background at module manufacturer Q CELLS, Clemens also holds the role of CTO. "So while we already employ state-of-the-art technology in aftercare, we realised that we could also push the cursor further in the actual building process of our plants and benefit from digital technology there. With the global scope of our projects, the need for technological support is steadily increasing."

AR soon caught the eye of the R&D team as a possible solution for new challenges. The working principle of Augmented Reality (AR) is to combine camera-captured, real-time images with computer-generated information. With the use of a vizor or other AR-compatible device, individuals using an AR solution can overlay information coming from a central database on the actual surface they see in front of them.

Troubleshooting in an instant

Andreas Gisch, head of R&D at Greencells, sees big potential in AR's ability to help when the gap between planning information and operational reality becomes apparent: "We can see many uses for AR from sharing of project documentation to running through checklists, hands-free working, or giving support for critical decision-making.

"But the starting point for us was really the idea of remote assistance for trouble shooting. Most projects run into situations where senior engineer advice is needed, and usually it is needed fast. Working on frequently changing, often remote sites but headquartered in Germany, we wanted to find a better way of supporting our teams and site managers, especially



Credit: Greencells

One of Greencells' on-site engineers using the AR device.

on sites more difficult to reach, usually outside Europe. The question was: How can we solve technical issues in real-time, without having to fly engineers out to the actual site or spending a lot of time sending mails or photo footage back and forth? AR seemed to solve many questions here."

In recent years, AR technology has become more affordable, making the use of AR tools more broadly accessible. Via its AR solution, Greencells can make senior engineer assistance available almost instantaneously. Remote worksites will be equipped with an AR vizor, and integrated in the vizor display is a camera which shows the exact perspective of the team member on site to the engineering colleague in the headquarters. Senior engineers can assess and assist in real-time, giving graphic and audio feedback via the vizor. Ultimately, this means instant troubleshooting, assuring smooth project progress and quality monitoring.

The first trial of the solution was at one of the Group's current worksites in Malaysia, the 43MWp Pekan plant, which is currently nearing the end of construction. At the outbreak of the COVID-19 pandemic, works at Pekan were in full swing, so having the solution there gave this test run an unexpected edge. With lockdown measures coming in as an unplanned challenge in the construction

of the actual plant, the trial soon turned into a communication lifeline.

"Malaysia closed its borders to foreigners in March and suspended works on construction sites for two months. After worksites were allowed to resume operations in May, we were able to give remote assistance to our colleagues on the worksite, making sure works could progress though we did not have the possibility to fly in engineers as scheduled. It was a tough but very realistic test for our solution, and we were glad to have it on site right at that point in time," says Gisch.

The next destination is Europe – the solution is currently being used in a new Greencells worksite in Hungary. Here, further usage will be explored, for example in quality management.

Holger Killian, head of quality management at Greencells, says: "During the lifecycle of our projects, quality management (QM) has different touchpoints with each site. We visit all sites on a regular basis, both securing our internal quality standards and supporting the construction teams with their questions.

"Within our team we rotate between the different sites, making sure that all projects are assessed by several quality managers which in turn gives us a shared panel view on all sites. The Coronavirus crisis and all the changes it brought in a way forced us to re-invent ourselves. Not only is travelling to sites by far not as easy as before the crisis and will stay disrupted for a certain time, we also began to see which types of visits could be dealt with remotely. What we have found is that AR can be very helpful for checks for which the time window to conduct them is very narrow within the construction process.

"A good example are cable trenches. Usually, the aim is to close the trenches as soon as possible to assure stability. While it is a simple check in itself, it is obviously vital to have it done before trenches are closed and should not bring construction work to a halt if the quality manager is still on the way to the site. AR is a very helpful tool here to do a quick and efficient remote check.

"The solution will make us more independent of travelling and less exposed to sudden changes in travel regulations. Timings are assured. But for sure, AR will not replace QM site visits completely. To be personally present is important and will remain part of our quality procedure. This is also true for

the final site visit with our clients and Technical Advisors. But where it makes sense, this solution will help us reduce costs and time, and give us the possibility to react very quickly when needed. And after all – less travelling also means less CO2 emissions, the ultimate goal of renewables."

Further usage is foreseen in O&M. Greencells currently manages an O&M portfolio of over 260MWp worldwide. The company's approach to O&M spans preventative, predictive and corrective maintenance. Analyses for preventive and predictive maintenance already leverage extensive data mining from running plants, with considerable manpower and technology employed in the German headquarters to steer these activities. The road ahead using AR promises to bring advantages here as well, especially when it comes to scheduled reviews or repairs of running plants. In this context, the new technology can also enable the company to work with local technicians for repair and replacement of defective components by guiding them remotely with support from an expert. This will help to intervene fast when needed and further increase plant availability.

"Using AR solutions is a big opportunity for us to be present globally while assuring our working standards, even in the most remote worksites. The rule of thumb would be – as long as there is an internet connection, we can give support on site in real-time despite distance or time difference," says Clemens. "This is very important for us as we want to deliver our high-quality results equally in all projects, no matter the geography. It will also help in promoting our efforts in employing local workforce in the countries we operate in. Depending on the region, finding technically trained personnel still remains a challenge. This is why we are looking into a scheme of giving local workforce specific technical training for skills required in the construction and maintenance of solar plants. Using our solution, we would be able to have senior technical staff conduct training sequences remotely from their desk in Germany."

What might have still sounded futuristic about a year ago now is a welcome tool to tackle current and future challenges for Greencells in their construction projects. Another example of technological acceleration rapidly changing the status quo. ■



PV CELLTECH

CONFERENCE

Online 2021

27-29 April 2021

Going into its sixth year, **PV CellTech** is a truly unique event attended by the world's top cell manufacturers, equipment and material suppliers, shaping the PV Technology Roadmap of the future

Join us to network with PV industry leaders.

“PV CellTech Online 2020 kept me up-to-date at a time where networking and exchange is more difficult than usual. The speakers are asked not to show generally available graphs (like the ITRPV) and instead are required to show their own achievements and to talk about their own activities. This makes the content very useful and unique.”
Pietro Altermatt, Principal Scientist, Trinasolar

“This conference is the most information dense annual event in the field of PV cell technology.”
**Akira Terakawa,
R&D Project Leader,
Panasonic Corporation**

To get involved either as a speaker, partner or attendee please email: pvcelltech@solarmedia.co.uk



GOLD

Previous sponsors included:

Aiko CELLS
made from the heart

Heraeus

JINERGY

**中来光电
JOLYWOOD**

Q CELLS
Engineered in Germany

MEYER BURGER

risen
solar technology

SCHUNK
Expect Solutions

SINGULUS

VON ARDENNE

SILVER

h.a.l.m.

SUPPORTING

**ISRA
VISION
GP solar**

PVEL

sgl carbon

celltech.solarenergyevents.com

Corporate renewable energy sourcing: driving global decarbonisation efforts

PPAs | Companies are purchasing solar, wind, and other forms of renewable energy more than ever before. The power purchase agreement (PPA) market in Europe has grown to a cumulative capacity of over 12GW, with a record 4GW signed in 2020. Corporate climate commitments are opening doors for investment in renewable energy, and continued price declines are convincing companies to sign new contracts. Is the European market ready to fulfil its potential? By Dr. Mercè Labordena, senior policy advisor at SolarPower Europe, and Milena Koot, communications advisor at SolarPower Europe

Credit: Solarcentury

In 2020, corporate PPA announcements in Europe broke records despite the COVID-19 pandemic, with solar accounting for almost half of all PPA capacity contracted, which is significantly more than in previous years, demonstrating the rapid growth in the popularity of solar corporate PPAs in Europe. This article explores the corporate appetite for renewables, how their demand might outpace supply, and what we should do about this as a sector and in policy. More technically, we will look at how PPAs have evolved over time and the variety of contracts now on offer. We will also consider how PPAs have been streamlined; for example, through the EFET template contract. Overall, this article finds that the corporate appetite for renewable PPAs is insatiable at the moment, and with the right policy support and market mechanisms to help meet this demand, renewable PPAs can spearhead decarbonisation efforts around the world.

Corporate climate commitments are opening doors for massive renewable energy development. More than 280

companies across the globe are now part of the RE100, which is committed to reaching a 100% renewable electricity supply. The overall electricity demand of RE100 companies equals more than Australia's total electricity demand, and these companies are increasingly reliant on PPAs to meet their procurement goals.¹

PPAs account for a quarter of the renewable power sourced by RE100 companies worldwide, and companies are benefiting from long-term price stability and the ease of investing in new renewable energy capacity. The popularity of PPAs has led to an impressive growth in global markets. According to BloombergNEF (BNEF), in 2020 alone corporations purchased a record of 23.7GW of renewable energy, up from 20.1GW in 2019. This growth is especially impressive given the context of the pandemic and a global recession.

Global growth

To date, the United States market leads on the numbers of PPA deals and capacity contracted. Last year, companies

Corporate power purchase agreements are on the rise, with a record 4GW signed last year.

announced 11.9GW of corporate PPAs in the US. While the amount of renewable energy that was signed last year was less than in 2019, the country was not only deeply impacted by the pandemic, but companies also faced uncertainty on national energy policy before the presidential election.

Europe has also experienced significant growth in PPA activity. Last year companies signed a record 4GW of corporate PPAs in Europe, contributing to the over 12GW contracted since the European corporate PPA market started around 2014. Latin America continues as an emerging market with 1.5GW of corporate PPAs announced last year.²

Asia-Pacific markets have more challenging conditions for PPAs but signed a record 2.9GW in 2020. One notable outcome was Taiwanese corporations signing 1.25GW of PPAs in total. A new policy is on the way in Taiwan that means companies using over 5MW annual load of electricity are obliged to use clean power. This, and the large number of manufactur-

ENERGY TXEN

EXHIBITION • TRAINING • NETWORKING

IN PARTNERSHIP WITH



**CLEAN
ENERGY
COUNCIL**

A NEW FREE-TO-ATTEND
EVENT IN SYDNEY
SHOWCASING THE LATEST
CLEAN ENERGY INNOVATION
& TECHNOLOGIES

13-14
JULY 2021
ICC
SYDNEY

FREE-TO-
ATTEND
VISIT
ENERGYNEXT
.COM.AU

Organised by:



Reed Exhibitions

Co-located with:



**AUSTRALIAN
CLEAN ENERGY
SUMMIT 2021**

ers who are facing pressure to green their industry due to decarbonisation targets, mean that renewables look well positioned to flourish in this market.

Besides Taiwan's positive PPA developments, South Korea is widely predicted to be the next big player in the Asian PPA market. At the beginning of 2021, the Electric Utility Act was revised, and a green tariff program and PPA mechanism have been put in place. Companies in South Korea are also feeling mounting pressures due to decarbonisation demands.

Global markets are growing along with the decarbonisation ambition of many corporates. Despite the global pandemic, corporate clean energy purchasing was up 18% in 2020, which is a record figure considering the otherwise poor economic trends over the year. BloombergNEF's H1 2020 European Corporate PPA Price Survey reports that at 23.7GW, corporations purchased more clean energy in 2020, than ever before. The figures are up from 20.1GW in 2019 and 13.6GW in 2018. The online retail company Amazon leads the race for the largest clean energy buyer in 2020, announcing 35 PPAs with a total amount of 5.1GW. More than half of the off-site PPA energy purchased by Amazon came from solar. Likewise, the top 10 global corporate clean energy buyers signed close to three times more solar PPAs in terms of capacity, compared to wind PPAs.

What's driving demand?

Decreasing costs of renewable energy are further driving corporate demand to sign PPAs across Europe. The BloombergNEF Survey shows PPA prices generally declining across the EU, with significant regional variation, as PPA prices will depend on many factors, including technology, contract structure, and term length.

For all the reasons above, near-term corporate demand for clean energy may outpace supply. Policies are needed to remove barriers to PPAs and to encourage solar deployment to match demand with supply in a timely manner. According to BloombergNEF, the shortfall of clean electricity demand from the RE100 signatories would be approximately 224TWh by 2030, if they want to reach their 100% renewable energy targets. To put this in context, the electricity demand of the signatories of RE100 equals approximately 315TWh. Demand for renewable energy is growing faster than developers can supply. Policymakers must accommodate this

demand with the right policies and strive to correctly implement regulations already in place.

SolarPower Europe is working to enable a more suitable policy framework for PPAs. To achieve this, SolarPower Europe co-founded the RE-Source Platform with WindEurope, RE100, and WBCSD. The RE-Source Platform is a European alliance of stakeholders representing clean energy buyers and suppliers for corporate renewable energy sourcing. The Platform pools resources and coordinates activities to promote a better framework for corporate renewable energy sourcing at EU and national level. The Platform works to remove barriers to PPAs. For example, to improve the traceability of green electric-

BloombergNEF's H1 2020 European Corporate PPA Price Survey reports that at 23.7GW, corporations purchased more clean energy in 2020, than ever before

ity for corporate consumers. Companies aiming for 100% clean electricity supply need to track the original source of their electrons and prove that the electricity they consume comes from a renewable source.

Guarantees of origin (GOs) provide this tracing of green electricity, and are key to a cost-effective and clean energy transition. For this reason, RE-Source advocates for the removal of barriers to GOs and to allow all renewable electricity generators to receive GOs for the green electricity they produce. If policies are aligned with EU and national climate and energy targets, and a wide range of corporate sourcing business models are made available without barriers across Europe, there is no reason corporate PPAs will not accelerate decarbonisation targets.

To help enable supply to meet demand, RE-Source members signed a joint declaration to EU policymakers to achieve the following four objectives:

- 1) remove regulatory and administrative barriers to corporate renewable sourcing so the success of some EU countries can be replicated more broadly;
- 2) provide corporates with clarity and certainty of long-term ownership of GOs from contracted supplies;
- 3) encourage cross-border renewable energy transactions to maximise oppor-

tunities to deploy the most cost-effective renewable energy solutions, and;

- 4) enable a wide variety of procurement models and market products, from on- and off-site solutions to multi-corporate renewable PPAs to minimise risks and maximise participation.

These calls are substantiated by the RE100 Progress and Insights Annual Report launched in December 2020, which also highlights the issues surrounding PPA development.

To further support corporates on their sourcing journey, RE-Source provides the Renewable Energy Buyers Toolkit, an open-source toolkit developed to provide information, raise awareness, and help companies enter the market for corporate sourcing. The Introduction to Corporate Sourcing of Renewable Electricity in Europe introduces the different types of PPAs available to European companies.

Virtual over physical

To date, most contracts in Europe have been signed for physical PPAs, which provide physical energy delivery. Virtual PPAs are an alternative contract structure recently growing in popularity. Virtual PPAs are financial contracts that do not include physical energy delivery; rather, the price for the underlying electricity is settled through a contract-for-difference (CfD) structure.

In Europe, companies may also seek to sign a cross-border PPA to access renewable energy outside their given market. Companies will need to carefully consider the type of PPA that is right for them according to their unique risk profile and needs. For example, corporations that use significant amounts of baseload power in a single location – like data centres – might prefer a physical PPA, while companies consuming lower amounts of electricity across multiple locations might find virtual PPAs a better fit.

The RE-Source Platform also offers a template contract to adapt to the current demands and interests of renewable energy stakeholders looking for long-term procurement today. The standard contract, developed by EFET jointly with RE-Source, allows for both physical and virtual PPAs, and helps bring down transaction costs and facilitate the negotiation process. Despite being standardised, the EFET template contract is also flexible and ready for adjustments depending on the nuanced needs or setting of a specific agreement. Despite having been operation since 1999,

the EFET had a new template released in 2019 to adapt to the current demands and interests of renewable energy stakeholders looking for long-term procurement today. The goal of the EFET is to offer standardised solutions for typical factors in wholesale transactions anywhere in European energy markets; for example, aspects of contracting or data exchange. As the EFET template is gaining traction with utilities, the template will provide a faster and more streamlined method for PPA contract closure. The agreement is translated into multiple EU languages to ease its uptake across Europe.

The RE-Source Platform also promotes successful national models for corporate procurement. Spain provides an excellent current example. European solar PPA prices are the lowest in Spain at €35.6/MWh,³ leading to rapidly expanded market activity. Last year, companies announced contracts to purchase more than 1.3GW of clean energy in Spain, with solar power accounting for more than 1GW of that total, making it the largest European solar PPA market. In addition, the energy company Total acquired 3.3GW of solar projects in Spain and has contracted the

output of around 3GW to power their own European industrial operations. The boom in Spain has been driven by a combination of favourable solar economics and accessible solar resources and land, with investors and off-takers from across Europe contributing to signing new deals. Less sunny regions are also attracting attention to solar PPAs. BayWa r.e. and HeidelbergCement, one of the world's leading building construction materials companies, signed Poland's first solar corporate PPA this year. This is great news since it proves that subsidy-free solar is attractive and competitive, even in a country further north than sunny Spain.

In conclusion, the European PPA market has the possibility of fulfilling its potential, with interest from corporates growing, and guidance on best practices being avidly exchanged on platforms like RE-Source. Different corporate sourcing models also mean that a PPA can be adapted to the needs of each individual customer, and developments like the EFET template contract can help to streamline the contractual process. The corporate appetite for renewable PPAs is ever growing, and with the right policy arrange-

ments, renewable PPAs in Europe, and around the world, will be key to achieving decarbonisation targets. ■

References

- ¹ www.there100.org/growing-renewable-power-companies-seizing-leadership-opportunities
- ² <https://about.bnef.com/blog/corporate-clean-energy-buying-grew-18-in-2020-despite-mountain-of-adversity/>
- ³ <https://pexapark.com/blog/european-ppa-market/>

Authors

Dr. Mercè Labordena is the senior policy advisor at SolarPower Europe for Solar Digitalisation, Finance and Corporate Sourcing of Renewable Energy. She oversees the activities of the RE-Source Platform, the European alliance of stakeholders representing energy buyers and suppliers for corporate renewable energy sourcing, where she coordinates with stakeholders and other associations the promotion of corporate sourcing of renewable energy in Europe. Mercè has a PhD in Climate Policy from ETH Zurich, and a Double Degree MSc in Renewable Energy, with a specialisation in Energy Innovation and Energy Engineering.

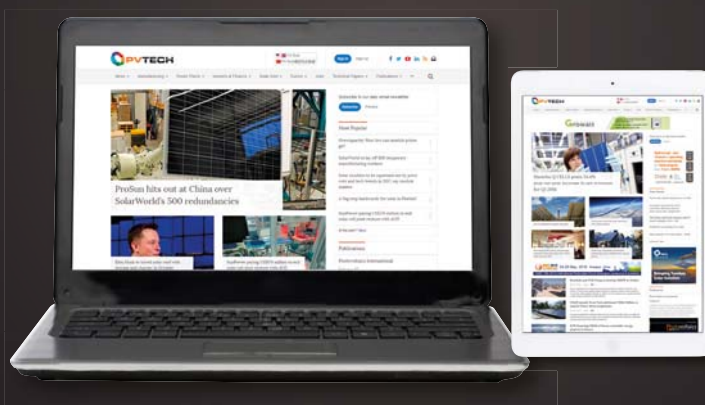


Milena Koot assists in providing external communications and maintaining the engaging digital presence of SolarPower Europe. This includes contributing to and supporting the execution of political communications campaigns around policy and industry.



The No.1 source for in-depth & up-to-the-minute news, blogs, technical papers, and reviews on the international solar PV supply chain covering:

Manufacturing | Technical innovations | Markets & Finance | Events



Sign-up for the PV Tech newsletters for the **biggest stories in PV** from around the world.

Subscribe for free: ➔ pv-tech.org/newsletter

Making solar more representative



CSR | As increased emphasis is placed on diversity society-wide, Alice Grundy takes a look at efforts from across the solar sector to increase diversity within its ranks.

Credit: Lightsource BP

It is perhaps surprising to very few to say that diversity has not always been a focus of the solar industry, having historically been largely made up of white men, as is the case for many sectors that by their very nature dabble in the also largely male engineering and finance industries.

However, whether this is still the case in the sector is not so clear cut, particularly as huge pushes for improvements to gender, race, sexuality, economic background and religious representation are made in society as a whole. Whilst many of these movements are largely

calling for wider societal reforms, private companies are not exempt from being held to higher standards. With solar helping the charge towards a better, carbon-free world, how much does the sector reflect this modern world it is attempting to build?

No industry has a perfect track record when it comes to diversity and the solar sector is no different. Whilst it does have its fair share of successes to be celebrated, it certainly isn't squeaky clean either. Several high-profile discrimination cases have made their way to the courts and if taken in isolation, could certainly paint

Encouraging more women in engineering should start in schools.

a very specific picture of solar and its attitudes towards certain underrepresented demographics.

In 2019, a class-action lawsuit was brought against US-based Momentum Solar on behalf of six black former employees, with this lawsuit alleging black workers were paid less, assigned "less desirable jobs" and in certain cases fired when complaining of discrimination to managers. This was heavily disputed by Momentum Solar at the time, with the company stating the claims had "no basis in law and fact".

It wasn't the only case to hit the



EXPO SOLAR
www.exposolar.org



GREEN NEW DEAL EXPO
www.greennewdealexpo.com



ESS EXPO
www.essexpo.co.kr

The 12th Korea's One & Only PV Show

SOLAR + ESS + GREEN NEW DEAL EXPO 2021

June 16(Wed.)-18(Fri.) 2021
KINTEX, SEOUL KOREA

EXPO SOLAR

- Since 2009, only exhibition specialized in photovoltaic energy in Korea
- Co-sponsored by local governments and associations to share the latest PV trends
- Related parallel exhibitions: Energy Storage System (ESS) and Green New Deal Expos
- Supporting global marketing and PR activities for participating brands and technologies
- Held at KINTEX, Korea's largest exhibition center within an hour drive from Seoul and Incheon International Airport

- Exhibiting Items: solar cells/panels (PV modules), inverter, components, monitoring solution, power system, production technologies, plant, repowering, BIPV

GREEN NEW DEAL EXPO

Exhibiting Items: New Renewable Energy, Green New Deal Convergence Industry, Smart Energy Platform, Hydrogen·Electric Vehicle Market, Low Carbon Dispersive Energy, Smart Green Industrial Complex

ESS EXPO

Exhibiting Items: Energy Storage System / Technology / Components & Devices, Control Engineering for Optimal Energy Consumption

**REGISTER FOR
FREE ENTRY!**



**RESERVE YOUR
BOOTH!**



Contact Us

International

Call. +82-70-5031-5319 | interexpo@infothe.com | www.exposolar.org

China

Call. +86-592-5092908 | eileen@honorgroups.com | www.honorgroups.com

headlines of alleged racism in the solar sector. A year prior a separate lawsuit was brought against Vivint Solar which stated that a black employee was subject to racist remarks, while further allegations claimed a cardboard fort had been constructed that was spray-painted with the words “white only”. In a statement released at the time of the claims, Vivint Solar’s chief executive David Bywater was quick to assure that the company has a “zero-tolerance policy for racial discrimination and harassment in the workplace”, with Vivint being built “on the strength of diversity”. One employee was dismissed as a result of the case.

Whilst these are perhaps the two most well-known alleged instances of discrimination in the solar sector, they are not the only ones to surface. In November 2019, allegations came to light against Tesla, with six former employees of its upstate New York solar cell and module factory filing racism and discrimination complaints with the US Equal Employment Opportunity Commission. And in January 2020, US-based solar installer Fidelity Home Energy – and its successor NorCal Home Systems – agreed to pay \$350,000 to a former employee and hire a consultant to resolve a discrimination lawsuit.

In the wake of these cases, the solar industry has stressed the need for greater diversity in its ranks, the aim being to perforate perceived glass ceilings and make the sector more representative. Indeed, many solar companies are now actively searching for diverse talent and recognising the benefits of this. Chief among these benefits is more nuanced decision making, with many different ideas and ways of thinking converging in one room resulting in better, more well-informed ideas.

“It creates an environment where the way you make decisions is richer,” Kareen Boutonnat, CEO of Lightsource BP International and Europe says, adding that “it creates a different perspective”. However, having many different people thinking in many different directions can also create challenges in return when it comes to managing these varying ideas. Whilst this can be difficult, Boutonnat says she’d “rather have the issue of managing that type of thinking outside of the box” than have the opposite issue of everyone in a team thinking the same way to the point of being able to finish each other’s sentences.

The benefits also vary depending on which demographic is looked at. When it comes to increasing the number of women in the sector specifically, Sonya Bedford, partner at UK solicitors Stephens Scown where she heads up the renewable energy team as well as being a non-executive director of energy trade body Regen, suggests that there are certain aspects where on average women perform better, stating “we’ve certainly seen better results when it comes to communication”. She adds that there are “a lot of very, very clever women” and that anyone regardless of gender should “be able to come forward and deliver the projects and be on the frontline of the energy revolution”.

This recognition of the benefits comes as many solar firms are celebrating the levels of diversity achieved within its staff, with Boutonnat describing the over 30 nationalities working in Lightsource BP’s London office as being “quite an achievement” and something that has created “who we are and a DNA that’s very rich as a result”. This is also true of other firms operating in the solar sector, such as investor NextEnergy Capital.

“It creates an environment where the way you make decisions is richer”

Giulia Guidi, head of ESG, describes the company as having a “very open and diverse culture” with around 22 different nationalities across around 190 employees.

However, the question as to whether the sector is as welcoming and easy to succeed in for women as it is for men is not easily answered. Guidi says that despite the solar sector being “vibrant and exciting”, there are times when she had to work harder as a woman, although this was largely in relation to learning to ask for support and “also the art of delegation”. The real challenge is in “managing your personal and professional lives in a balanced way,” Guidi says, adding this is true regardless of your gender.

Meanwhile, Elizabeth Akinkugbe, project team manager for construction operations at US solar and battery

storage firm Sunnova, says that it is “hard work and determination” that has opened many doors for her. When it comes to being a woman in the solar sector, she says that can be intimidating at times but that her parents raised her to “never limit myself or be afraid of what I can accomplish because of my gender or race”.

The convergence of engineering and finance

The experiences of women in the sector can vary depending on a number of things. Boutonnat explains that when compared to industries such as the tech industry – where her background lies – solar is “not a cutthroat environment”. In fact, renewables has been “refreshing”, with women being “very well represented in renewables”.

This is in spite of the fact solar has historically been saturated with white men, something which could be due to it being at its core a convergence of engineering and finance – with both these sectors being “generally more attractive to men” as Guidi says. Therefore as the industry came to be, those with experience in the necessary sectors moved over into solar, bringing with them similar levels of diversity.

The convergence of finance and engineering in the sector “has certainly played a role” in solar being historically male and white, according to Abigail Ross Hopper, president and CEO of the Solar Energy Industries Association (SEIA), while Bedford adds that there has been “less visible women who are doing the engineering side”, with this having never been seen as “roles that women were getting into”.

Visibility is an important factor in increasing diversity, allowing the younger generations to see examples of people like them in the jobs they aspire to one day have, showing it is something that can in fact be achieved. As Akinkugbe explains: “Highlighting the current women and their positions will bring more awareness of how many women are actually in this sector and how many are joining every day”.

A diverse sector for a modern agenda

So the times- are they a’changing? These things are perhaps a little hard to quantify in any truly meaningful way (short of rounding up every single employee in

the solar sector for one survey). When looking at the US specifically, research from the SEIA released in its 2019 US Solar Industry Diversity Study shows that despite some of the improvements cited above, there are still some aspects of the industry where there are not quite equal opportunities.

Its survey – which had responses from 377 solar firms and 398 employees – found that when it comes to the manager, director, president (MDP) level men are more likely to hold these positions than women, with 37% of men holding these positions comparing to 28% of women. When the MDP level is broken down to include only executive-level positions, the average firm reported its senior executives are in fact all white men. Among all senior executives reported by solar firms, 88% are white and 80% are men, the report found. Hopper says that when she joined the SEIA in 2017, she was “taken aback by the lack of representation in our industry” and has ever since then made diversity and inclusion “a top priority”.

Whilst the report found certain discrepancies showing a need for further diversity in the sector, it also found that when it comes to the LGBTQA+ community, the solar industry seems to have “generally adopted an inclusive and welcoming environment”. It detailed how 39% of LGBTQA+ people hold MDP-level positions, a figure higher than the overall percentage of respondents that hold those positions, and 61% hold mid-level positions.

Anecdotal evidence does seem to support the idea that some progress in increasing levels of diversity has certainly been made, suggesting that a combination of a greater awareness of the importance of having diverse teams within companies alongside initiatives outside of the sector itself – largely an increased focus on pushing science, technology, engineering and mathematics (STEM) subjects and careers in schools – has in part been responsible for this.

Giving the example of being one of only two women when she studied for her Masters degree six years ago, Bedford says this is something that is indeed changing and there now are “more women engineers coming through”. The industry is moving towards a “much more level playing field”, she continues, although with the caveat that it’s “still not balanced by a longshot”.

Improving diversity: Where to go from here

Whilst the improvements made are certainly something to be celebrated, it is also important for the industry to not rest on its laurels. There is always more to be done, with a number of ways to encourage greater diversity in the sector. Boutonnat suggests that one way to do this is doing more “early on in the process at schools” and spending more time speaking to and educating students.

This emphasis on schools and education is echoed by Guidi, who said that encouragement “starts from school and from us as individuals and families”.

“Diverse workers are out there and it’s on us to expand our hiring pool and find them”

with the first step to encouraging more women into the sector being to let young girls “try and explore different things, ensuring that they grow as they want to grow without prejudice”. Other ways to improve diversity include increasing awareness throughout the educational journey, with schools and universities needing to offer more courses on both solar and renewable energy as a whole.

However, measures such as education and internships are not the only solution, with Hopper warning against viewing internship programmes as a silver bullet despite claiming them to be useful for creating a pipeline of talent. She points to how it can be difficult to be ‘the first’ or ‘the only’ at a company, suggesting that to retain diverse talent is equally important to “think about a diverse worker’s experience at your company and how your culture can either contribute to or inhibit their success”.

Measures such as mentorship programmes also play a significant role in encouraging women both into the solar sector and into higher positions. Akinkugbe points to how she has a “great group of mentors” and is encouraged to enrol on any leadership courses or skill development classes she wants to take. “They allow me to try new things and sit in on some meetings that they believe will help me develop a stronger skill set and grow individually,” she says.

Meanwhile, sector-wide initiatives

such as the Entrepreneurial Women in Renewable Energy (EWIRE) mentoring programme – set up by UK-based trade body Regen – have been created to encourage women in the clean energy industry to progress their careers by matching them with both senior women and men across the sector.

According to the SEIA’s report, over half of women indicated that professional connections and networking are vital to their successful career navigation compared to only 30% of men.

Additionally, Bedford says that some of the best networking she’s experienced has come from women groups, with there being more of an “openness and willingness to talk about issues” without the “bravado that used to come in the solar industry”.

These measures should come alongside ones such as ensuring those that are hiring do so fairly, with Hopper detailing how unconscious bias training – with some employers discounting candidates because of unconscious bias about their race, gender, sexuality etc – is “critically important for anyone in a hiring or managerial position”.

It will be action across the industry, however, that results in higher levels of diversity. It is not the responsibility of one company or trade body to implement change that will create a truly diverse sector, although the benefits to the organisations leading the way when it comes to diversity in setting an example can’t be underestimated. It is, however, systematic change, such as that being called for throughout society, that will make the biggest difference in this journey.

Whilst this does seem like a tall order, there are clear signs from companies and trade bodies alike that the drive, willingness and ability to continue to diversify the workforce and create an industry that is better for its inclusivity is indeed present. There have been great steps forward, and while there is still more to do, the work ahead is perhaps not insurmountable. Mentorships, training and open minds will continue to boost the diversity and as a result create a richer and better sector. Most importantly, continuing to make diverse hires and listening to the voices of those underrepresented in the sector will be key. As Hopper explains: “Diverse workers are out there and it’s on us to expand our hiring pool and find them”.

ENERGY TAIWAN

27-29 OCT. 2021

📍 Taipei Nangang Exhibition Center, Hall 1

PV Taiwan

Wind Energy Taiwan

HFC Taiwan

Smart Storage Taiwan

2020 SHOW PREVIEW

130 Exhibitors

500 Booths

13,000 Visitors



14%

VISITORS



12%

BOOTHS



20%

MATCHMAKING

TAITRA Ms. Carol Chang

☎ +886-2-2725-5200 #2856

✉ energy@taitra.org.tw



**More information
please visit**

www.energytaiwan.com.tw

STORAGE & SMART POWER



85

- 73 NEWS**
The biggest stories from the world of energy storage
- 75 LONG-DURATION IN FOCUS SPECIAL FEATURE:**
'Longer-duration storage' and its role in the future of energy
Representatives from Apricum, Invinity Energy Systems and Zinc8 delve into the prospects and potential of long-duration energy storage technologies
- 80 Piecing together the 'jigsaw of value' in UK energy storage**
How has the UK overcome deployment barriers to become one of the leading markets for energy storage?
- 85 Software: The driving force putting batteries at the heart of the energy transition**
Andy Colthorpe examines the growing role software is playing in energy storage

Introduction



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

There's no such thing as business as usual in the energy storage industry. Every week something happens to change the way we think about the role of batteries, mechanical and thermal storage in the energy transition. Every month brings unexpected developments and milestones. And every quarter we publish this journal to help you make sense of it all.

Since the last edition, Moss Landing, the world's biggest battery storage project, came online, at 300MW / 1,200MWh and built at the site of a natural gas plant in California. So there's a milestone. Only a few days after we reported that Vistra Energy had powered up Moss Landing, Australian renewable energy fund CEP Energy revealed plans for a project four times bigger. That was an unexpected development.

There have been some other big announcements around the world and a lot has changed in just the last three months. Another emerging trend is the developing appetite for investment. System integrators and technology providers Fluence and Powin Energy have both netted more than US\$100 million each, in Fluence's case bringing its valuation over a billion dollars. We also reported just the other day that US project developer Key Capture Energy raised a similar amount to fuel activities in markets including Texas and New York.

The sector has not been immune either from the special purpose acquisition company (SPAC) phenomenon. Multiple companies have revealed their intent to use this type of vehicle to go into public ownership in the past months. Whatever your view on SPACs, it's an undeniable indicator of confidence in energy storage companies for potential growth, with the likes of Stem Inc and Eos Energy Storage moving to go listed on stock exchanges through the controversial model.

In this edition, we look at one of the major drivers behind both the growth in scale and scope of battery projects and the recognition of their value: software. Energy storage is perhaps the most versatile asset the electric grid has ever had, as one of our interviewees said, allowing for the push and pull of power and energy to balance the network. But without smart software to coordinate and control everything, we would be very lost indeed. I spoke to folks at Modo Energy, ION Energy and Wärtsilä about many of the different and amazing things software enables us to do with batteries.

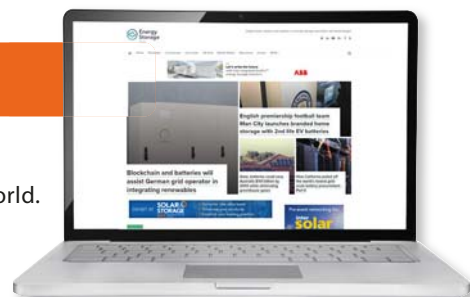
The UK has been one of the markets most receptive of and adaptive to lithium-ion battery storage: in this edition, Solar Media's Molly Lempriere brings you up to speed on how quickly the sector has grown in Britain and why it's set to continue growing, with around 14GW of projects at various stages of development, according to our in-house market research team. From ever-bigger projects to the roll-out of smart flexibility services that batteries excel at, Molly speaks to some of the pioneers, leading players and key stakeholders for a comprehensive update.

While lithium-ion batteries are at the forefront of new energy storage deployments, it's always good to think about what else the world needs to decarbonise, modernise and make electricity supply more resilient, cost-effective and accessible to all. In our special feature on long-duration energy storage, market experts at consultancy Apricum think about what gaps in the market exist today and when long-duration, 'longer-duration' and seasonal energy storage will become viable. Long-duration storage providers Invinity Energy Systems (vanadium flow) and Zinc8 (zinc-air) talk about the market opportunities their respective technologies can fill in an energy system fit for the future.

Andy Colthorpe
Solar Media

www.energy-storage.news

Visit the site and **subscribe free** to the **Energy-Storage.News newsletter** today. Technology with the capacity to change the world.



World's biggest battery storage project online in California

The world's largest battery energy storage system (BESS) went into operation in December in Monterey County, California, through retail electricity and power generation company Vistra. Phase 1 of Moss Landing Energy Storage Facility is connected to the power grid at the site of a natural gas power station owned by Vistra.

At 300MW / 1,200MWh, the BESS is considerably larger than the 250MW / 250MWh Gateway Energy Storage project brought online earlier in 2020 by LS Power, also in California. Phase 2 of Vistra's project will add another 100MW / 400MWh and is scheduled for completion by August this year. The company also claimed the site offers the potential to support up to 1,500MW / 6,000MWh of energy storage capacity, "should market and economic conditions support it".

Li-ion battery pack prices found below US\$100/kWh

BloombergNEF claims average lithium-ion battery pack average prices will be close to US\$100/kWh by 2023 after reporting some pack prices on the market at lower than US\$100/kWh for the first time.

BloombergNEF's Battery Price Survey predicts that pack prices for stationary storage and electric vehicles (EVs) will fall to US\$101/kWh within three years. Average pack prices have sat at around US\$137/kWh during 2020, 89% lower than in 2010 and nearly a fifth of their cost seven years ago.

This has come as a result of rising order sizes and EV sales growth, which has led battery manufacturers to benefit from economies of scale. The cost of cathode materials has also fallen substantially since the start of 2018, providing developers with more favourable profit margins.

State-owned utility announces 100MWh of battery storage in Ireland

Electricity Supply Board (ESB) has announced almost 100MWh of utility-scale battery storage projects, kicking off its pipeline of projects in the Republic of Ireland.



Credit: Lumicon Energy Storage

The state-owned energy company is to develop battery energy storage systems at two of its pre-existing sites, one on the east coast at Inchicore, Co Dublin and one on the west coast at Aghada, Co Cork. ESB will work with energy storage technology provider Fluence for both the 60MWh Dublin site and the 38MWh Cork site.

"Enabling technologies such as these fast-acting battery projects are crucial to support the grid and will facilitate ever more onshore wind, offshore wind and solar onto the electricity system in the coming decades," Paul Smith, head of Asset Development at ESB Generation and Trading, said.

Ireland's grid storage market only kicked off during 2020 but has already seen sizeable projects completed such as this 100MW system.

Construction of renewable-powered lithium-ion battery recycling plant begins

A lithium-ion battery recycling plant is under construction in Norway, focusing initially on electric vehicle (EV) batteries, but which will also be capable of processing batteries from stationary energy storage systems (ESS).

The plant will be capable of processing more than 8,000 tonnes of EV battery modules annually when it opens later this year and is being built by Hydrovolt, a joint venture (JV) formed between Norwegian materials processing company Hydro and Sweden-headquartered lithium battery manufacturing startup Northvolt.

Hydro and Northvolt have invested NOK120 million (US\$13.94 million) into the project, building a factory which will have high levels of automation and will crush and sort batteries.

AI energy storage pioneer Stem Inc to go publicly-listed

Stem Inc is set to be publicly-listed and expand its global reach, through a deal worth as much as US\$608 million agreed with special purpose acquisition company Star Peak Energy Transition Corp.

The US-headquartered provider of battery energy storage systems driven by artificial intelligence (AI) which optimises their ability to capture market opportunities said in early December that a definitive agreement for a business combination has been reached with Star Peak.

Star Peak is already publicly traded and the combined business will list on the New York Stock Exchange under the ticker 'STEM' once the transaction is closed. Stem Inc CEO John Carrington will lead it.

Fluence becomes 'unicorn' with Qatar investment

The sovereign wealth fund of Qatar has agreed to invest in energy storage solutions provider Fluence in a transaction that values the technology company at more than a billion dollars.

Qatar Investment Authority has committed to investing US\$125 million through a private placement transaction. Fluence's current joint owners, energy asset developer AES Corporation and engineering giant Siemens will maintain around 44% of the energy storage company's stock following the transaction.

The valuation of stock at US\$125 million for around 12% ownership of Fluence means that, as one source close to the company pointed out, the energy storage provider has become a 'unicorn' - aka a privately held startup worth a billion dollars or more, so-called because of the rarity of that phenomenon.

CATL partners with integrator FlexGen on 220MWh in Texas

Contemporary Amperex Technology Ltd (CATL) will supply lithium-ion batteries to energy storage system integrator FlexGen for two large-scale energy storage projects totalling 220MWh in Texas.

The two projects will be 110MW / 110MWh each, using 280Ah CATL lithium iron phosphate large format battery cells to form standalone battery systems for an unnamed independent power producer (IPP) customer.

FlexGen COO Alan Grosse said that CATL is among the suppliers able to provide the strongest performance warranties in the industry, which has been a crucial reason for its selection. The Texas ERCOT market is ripe for batteries to provide ancillary services such as frequency regulation, Grosse said, as well as arbitrage and energy trading.



3rd Annual Energy Storage USA 2021 VIRTUAL SUMMIT

Save 50% on
all tickets use code:
PVTP50

NEW FORMAT: 4 days of content
over the course of 2 weeks

23-24 Mar
30-31 Mar

ACCELERATING INVESTMENT & DEPLOYMENT OF ENERGY STORAGE ACROSS USA

23 March



**Keynotes and
Plenary Sessions**

24 March



**Safe Solutions,
Technology &
Innovation**

30 March



**Where Should You
Be Doing Business
in the US?**

31 March



**Driving
Development**

Top Speakers:



RANDOLPH MANN
President
ESOLTA



MARGARET O'RILEY
Business Recruitment -
Automotive, Batteries &
Electrification
DUKE ENERGY
CORPORATION



REID CAPALINO
Senior Vice President -
Business Development
LS POWER



PATRICK NORTON
Managing Director
JAVELIN CAPITAL



SARAH ORBAN SALATI
Chief Commercial Officer
NEW YORK POWER
AUTHORITY



DR. IMRE GYUK
Director, Energy Storage
Research
US DEPARTMENT OF
ENERGY

Register here: storageusa.solarenergyevents.com/tickets

2021 SPONSORS INCLUDE:

Gold Sponsor

Honeywell

Silver Sponsor



Bronze Sponsors



Exhibitor



Supporting Sponsors

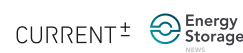
**JAVELIN
CAPITAL**



Partners



Editorial Partners



#StorageSummit

Enquire now for speaking opportunities: lucy@solarmedia.co.uk



'Longer-duration storage' and its role in the future of energy

Long duration | What are the best ways to match up long-duration energy storage technologies to applications and revenues? And what is 'longer-duration' storage and when will we need it? Florian Mayr and Dr Fabio Oldenburg at Apricum - The Cleantech Advisory offer some perspectives.

Between five and more than 1,000 hours of energy discharge – that's what the term "long-duration energy storage" encompasses in the industry today. It's a very broad definition that covers a wide array of storage technologies and use cases.

An increasing number of projects within this diverse space has been announced over the last few months. UK transmission system operator National Grid ordered a 50MW overground liquid air energy storage system with a five-hour discharge duration from Highview Power that will be connected to the grid in 2022. Lockheed Martin commissioned its first 500kW flow battery with a discharge duration of five hours and utility Dominion Energy just announced plans for an 800MW pumped hydro storage project in the USA with a 10-hour discharge time.

There seems to be one common attribute for most current long-duration projects: they focus on the lower end of the discharge duration range mentioned above, delivering energy at full power capacity for five to 10 hours.

The longer the desired discharge duration, the more challenging it is to apply storage. Why is that? Let's have a look at demand, cost and regulatory support of systems aiming for a discharge from multiple days up to months, at the mid- to upper end of the long-duration discharge range. To distinguish those from today's more common intraday applications (five to 10 hours discharge), they are referred to as "longer-duration" storage in the following.

Demand for longer-duration storage

The primary use case for a longer-duration storage system is always a form of "energy supply shift", shifting renewable energy from its time of generation to meet energy demand at a different time.

The motivation can be to sell more renewable energy by avoiding grid congestions



tion at times of abundant renewable resources and being able to also serve demand when the sun is not shining brightly or the wind is not blowing. Another common intention, also in combination with the previous, is to charge when energy is cheap and discharge when it's more costly, either to save money or to make profits.

Last but not least, security of supply can be a reason. For example, Californians are increasingly exposed to Public Safety Power Shutoffs (PSPS) when utilities stop transmitting power to areas at risk of wildfires, as faulty lines have caused major fire disasters. Shutoffs can last for days, weeks or even months.

Energy supply shift can be stacked with other services such as peak shaving or balancing services, but the primary use case always needs to be applicable. In other words, you always need longer periods of no wind or sun, high-power prices and/or supply disruptions to benefit from longer discharge durations.

Living in Germany, we can confirm that there are elevated periods of very limited sunshine in the winter. If at the same time there is low wind, variable renewable energy is not available to satisfy demand. There is even a term for this: "dunkelflaute" or "dark lull", which can last for days and usually results in higher wholesale power prices.

In other geographies, there are seasonal

Highview Power's liquid air energy storage (LAES) is being deployed at a 50MW / 250MWh site with a portion of the costs supported by the UK government.

power prices, such as Saudi Arabia where consumers often pay increased prices in summer when an even higher than usual need for air conditioning makes power demand surge. In theory, electricity generated in winter could be sold at a higher price in summer.

A certain revenue potential for longer-duration storage therefore exists, but the value today is often still limited. A recent study published by the US Electric Power Research Institute (EPRI) visualised this by comparing the time-shift value for different charge/discharge durations in California. Given the California ISO's day-ahead aggregated energy prices in 2019, a battery system with a four-hour discharge duration would have captured 76% of the value of a 20-hour battery.

Cost of longer-duration storage

This intrinsic challenge of longer-duration storage is often overlooked: the economics of an energy storage system in general depend a lot on the number of full charging/discharging cycles over the lifetime of that system — its utilisation. You usually get remunerated for each kWh of electricity stored and discharged. The higher the total number of full cycles at a given capacity, the higher the usable energy over the lifetime and the higher the return on investment.

Energy storage systems that target longer discharge durations such as weeks or months have limited annual cycles per definition. Take seasonal storage: if you transfer electricity generated by PV in winter to satisfy higher demand in the hot summer and only cycle once per year, the battery discharges during the summer months and will only recharge when it's winter again. The same logic applies to that "dark lull" in Germany. It typically occurs only twice a year at most.

An energy storage system capable of serving longer-duration use cases could be used for long- or even short-duration appli-

cations as well. The number of full cycles could potentially increase, but you would need to compete with storage systems with a smaller energy capacity, which would require substantial cost advantages for each kWh of energy capacity added.

We can derive the following success factors for longer-duration storage: low marginal cost of capacity (entailing the use of a highly abundant and cheap energy storage medium), independent scaling of power and capacity to avoid extra cost for un-utilised power, low self-discharge rates and high flexibility to switch between different levels of utilisation.

Overcoming technical hurdles alone does not secure commercial viability. Innovative long-duration storage technologies may suffer punitive debt financing costs and structures. The challenge is to convince conservative creditors that an emerging technology's commercial and operating structures underpin bankable long-term revenues, and that its application is still robust across decades of potential operation - credit availability can depend on a 90% probability revenue scenario.

Comprehensive risk mitigation across all dimensions of construction and operation is required to achieve maximal project financing. Creditors seek reliable obligations and remedies for all counterparties to maintain stable operations. The performance and reliability of the energy storage asset must be proven, ideally by third-party audits, certificates, warranties and long-term demonstration in the megawatt scale. Such comprehensive assurances can be a stretch when applying innovative technologies in project development: underwriting from commercial sponsors eager to facilitate technological deployment can fill that breach.

Here we see the value of emerging technologies participating in government-backed demonstration projects, as with Highview Power's 50MW cryogenic battery in the UK, which has found both corporate and public sponsorship for the first commercial deployment.

The regulatory view

To achieve the CO₂-reduction targets that leading economies have committed to, policies and market regulations need to be adapted to further push the share of renewable energy sources. The proliferation of variable renewable energy automatically increases the value and demand for long- and longer-duration energy storage. At the same time, the attractive-



ness of their biggest competitor, the gas-fired power plant, would need to be reduced for maximum emission reductions. Strategic decisions that restrict the expansion of further gas-infrastructure in combination with an adequate taxation of CO₂-emissions can open doors for long-duration storage.

Recently, legislation has also started to directly ask for long-duration energy storage. Last year, policymakers in Australia's New South Wales debated a bill to strengthen the state's electricity infrastructure by investing in 2GW energy storage capacity that can be dispatched for at least eight hours.

In California, a group of 11 community choice aggregators (CCA) recently highlighted their need for 1GW long-duration storage by 2026 and launched the first tender for 500MW storage capacity with eight hours as a minimum discharge duration. Responses included Li-ion, flow batteries, CAES, pumped hydro, thermal and gravity storage.

When it comes to longer-duration storage, policies tend mostly to focus on promoting R&D and funding demonstration projects because of the current lack of demand for discharge durations over days, weeks or months as well as the commercial immaturity of suitable technologies. A prominent example is Minnesota electric utility Great River Energy's pilot for a 1MW/150MWh battery from startup Form Energy. Previously, the company received funding from the USA's Advanced Research Projects Agency-Energy (ARPA-E) as part of support for storage technologies with up to 100 hours of discharge duration.

Another example is the Advanced Clean Energy Storage Project in Delta, Utah (USA). Among other targets, by 2025 it aims to generate green hydrogen and store it in a salt cavern for later electricity generation – basically constituting longer-duration energy storage for 150,000MWh of renewable energy.

This wind farm in South Korea uses NGK sodium-sulfur batteries as a buffer to ensure stable hydrogen production is possible.

How long and when do you need it?

Is long- (or longer-) duration the "holy grail of energy storage" as is often claimed by the media? Well, that depends on your definition of "long". Are we speaking about hours, days, weeks or months of discharge duration? Are we looking at today's applications or use cases in five or 10 years from now?

In this upcoming "decade of energy storage", we see the biggest opportunity for long-duration storage that can shift PV and wind power within the course of a day to offer a dispatchable clean energy asset competitive to fossil fuel-based alternatives.

Increasing shares of renewables in the generation mix will create sufficient price spreads due to cannibalisation of prices at times of plentiful sun and wind. Depending on the demand profile when it's dark, five to 10 hours of discharge (at full power capacity) will usually do the trick. Liquid air energy storage, redox flow and sodium sulfur batteries all utilise a low-cost abundant storage medium where power and capacity can be scaled independently; this makes them promising candidates for long-duration storage that can be competitively applied in an increasing number of settings.

When all the lower hanging fruit for decarbonisation has been harvested, the urgency for longer discharge duration storage will increase. To approach a 100% renewable power system seasonal storage will be required.

Costs for suitable solutions that can easily scale up energy capacity to discharge for weeks and months, such as green hydrogen, will come down substantially due to technological advances and economies of scale. Until then, joint efforts across the entire value chain of energy storage and the strong support of policy-makers are needed to pave the way to a decarbonised economy.

Authors

Florian Mayr is a partner and founder of Apricum's energy storage practice. He supports clients to participate in the global clean energy transition through strategy and transaction advisory in the fields of energy storage, green mobility and renewable energies.



Dr. Fabio Oldenburg has significant expertise in the energy storage sector, particularly in materials. At Apricum he supports clients in a range of strategy consulting mandates with developing differentiated products, market-entry strategies and competitive business plans.



Vanadium flow batteries for a zero-emissions energy system

Long duration | Growth in renewables and corresponding market pricing is the key driver for the commercialisation and global adoption for vanadium flow batteries (VFBs) and an important reason why we will see further growth for this technology over the years to come, says Ed Porter of Invinity Energy Systems.

In addition to the predictable seasonal and daily variation in demand, renewables are increasingly adding their characteristic “rhythm” or “shape” to the supply side. This causes both over- and under-supply events to be greater in size, frequency and duration, prompting the market to increasingly value flexibility.

VFBs’ primary advantage lies in the ability to deliver vast amounts of energy at low cost over a working life measured in decades, not years. As a form of non-degrading energy storage, it has an extremely low marginal cost of use and is well suited to doing the sort of cycle intensive, deep-discharge flexibility that future energy systems will need.

The past 10 years have shown that initial system-wide carbon reductions are both possible and affordable and have been well supported by short duration storage to date. The challenge now is towards a zero-carbon system, which represents a huge opportunity for VFBs.

Consider solar PV, which has a low levelised cost of energy (LCOE) and is easy to develop at a range of scales. As the proportion of on-site demand or grid connection met by PV increases, it reaches an economic level of curtailment where deploying one more panel does not bring the revenues required to pay for itself. This supports on-site decarbonisation of around 40-50% for behind-the-meter solar.

Beyond that level, local curtailment issues mean that solar PV deployment is beginning to get stuck. For solar to provide more dispatchable low carbon generation, energy storage must be deployed. Storage becomes constrained not by the duration required for discharge, but by the duration of the charging opportunity. With the first and final hours of the day’s solar PV generation taken up by demand, this leaves 4-6 hours to charge during the midday generation peak (with seasonal and geographic variation). This would be considered

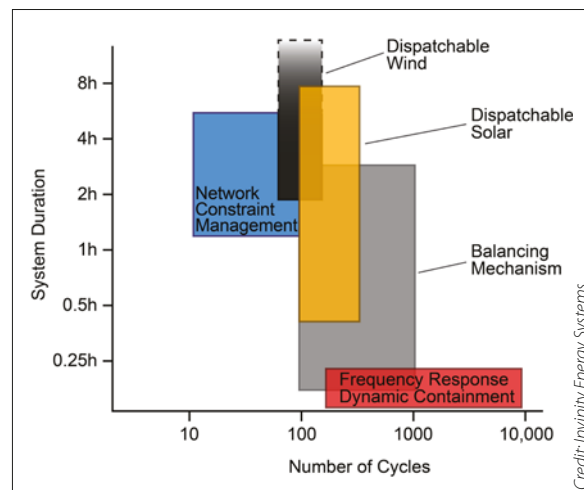


Figure 2: Energy storage services in the UK market

long-duration storage in today’s market and, given solar PV’s reliance on the diurnal cycle, would require near-constant cycling of any energy storage asset.

Enter vanadium flow batteries. Energy shifting over a 4-6 hour period is the business case for long-duration, heavy cycling storage technologies like VFBs. Electric system operator requirements are also expanding from shorter duration, power-focussed services, such as frequency response, to longer duration, heavy cycling, energy-focussed services, driven by the need to effectively dispatch renewables at a network level. You can see this demonstrated in the graphic below which uses the UK market as an example, but can be conceptually applied to US, Australian and European markets too.

This deepening of the “energy” (as opposed to power) flexibility market has been a key driver in the rapid commercialisation of long duration energy storage technologies in the last 12 months. As volatility in wholesale markets increases, utilisation (energy storage capacity factor) and consequently, marginal cost per cycle has become more critical in determining activation prices for energy storage assets.

We see a flexibility ‘merit order’ developing where lithium-ion batteries continue

to address high-frequency stability and fast reserve response services (rewarding ‘power’) with rapid adoption of VFBs to capture growing revenue opportunities for years to come. Fundamentally, VFBs and other longer duration technologies bridge the gap between shorter duration applications, which are suitable for lithium-ion and the ultra-long duration (e.g. 24+ hour) applications where we are likely to see hydrogen and other “power-to-x” technologies make headway.

In front of the meter, VFBs are an excellent fit for large-scale solar projects and network balancing. We will deliver an 8MWh flow battery system to a 6MWp solar array in South Australia. Performing multiple, long duration charge/discharge cycles each day, otherwise curtailed solar output can be made ‘dispatchable’, allowing it to be deployed to the local grid at the most economically optimal time.

Behind the meter, flow batteries are also being used at a smaller scale, peak shaving and enabling a greater proportion of onsite renewable generation to be consumed, reducing site energy costs.

VFBs are uniquely capable of unlocking further penetration of renewables and capturing the opportunity in the ever-deepening market for energy-based flexibility. Their value lies in their proven ability to de-risk expansive renewable generation projects, effectively matching the changing shape of renewable generation to the changing shape of demand.

Author

Ed Porter is the Business Development Director at Invinity Energy Systems, a provider of vanadium flow battery energy storage systems for commercial & industrial sites, grid network infrastructure projects and off-grid applications, either standalone or alongside renewable energy such as solar PV.



Why Zinc should be a star player in long-duration energy storage

Long duration | Using abundant resources for components and as 'fuel', zinc batteries can be a cost-effective, flexible and scalable technology to deliver many of the needs of a resilient, low-carbon energy system, says Ron MacDonald at Zinc8.

Amongst the many chemistries utilised for the construction of high-capacity batteries, the zinc-air combination has long been recognised as highly advantageous due to its inherent safety, high energy density and the abundance of its raw material fuel (zinc and air).

Zinc8's patented energy storage technology decouples the link between energy and power, providing long-duration energy storage (8+ hours) with the lowest cost per kWh installed. The battery chemistry is safe, non-toxic and has no thermal runaway.

Something that we see with many new technologies is that installation can be geographically dependent or need to be installed on a massive scale to become economic. What we are bringing to market can serve a wide range of storage durations on a flexible scale, from kilowatts to the order of megawatts.

The key attributes of the system are:

- The closed-loop system continues to generate electricity for as long as fuel (zinc and air) is available.
- The power (kW) and energy (kWh) supplied by the system can be scaled independently: the decoupling of energy and power
- The system does not use or produce any toxic metals, liquids or gases. It is based upon a very safe chemistry foundation.
- The fuel (zinc and air) is abundant, easily accessible and inexpensive.
- Low self-discharge rate
- No complicated charging or cell balancing requirements, offering complete operational flexibility
- Simultaneous charge and discharge
- Secured supply chain – all components can be sourced locally in each respective market.

The principle of operation of the system is illustrated in Figure 1.

The three major components of the

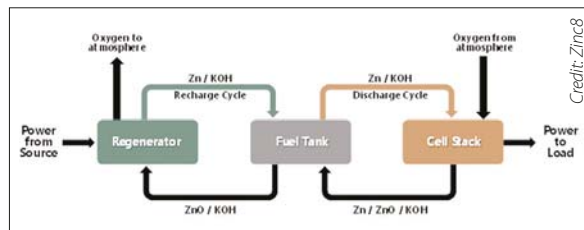


Figure 1: Principle of operation of Zinc-air Fuel Cell.

system are: the fuel tank where the zinc particles and a potassium hydroxide (KOH) electrolyte are stored, the cell stack where the fuel is converted to electrical power and the regenerator unit where electrical power is converted back to fuel. The fuel consists of zinc particles suspended in a KOH electrolyte. In operation, electrical energy from a source is used to convert zinc oxide to zinc metal particles in the regenerator unit.

The zinc "fuel" thus created is stored in the tank until required. When stored energy is to be released, the zinc fuel is pumped into the cell stack where it reacts with atmospheric oxygen to produce electricity.

Zinc as a fuel has an advantage over other metals due to its abundance, low cost, environmental compatibility and ease of storage and handling. In a zinc-air fuel cell, the oxygen reagent that reacts with the zinc fuel is drawn from the atmosphere. The reagent has no material cost, does not need to be stored and does not add any volume or mass to the system. Thus, the zinc-air fuel cell has about twice the specific energy and energy density of a comparable zinc-bromine/chlorine fuel cell.

Energy capacity (in kilowatt-hours) can be varied by altering the size of the fuel tank. A system with multiple times of energy but identical power can be created simply by quadrupling the size of the fuel tank. Since the tank is a passive element constructed of plastic, this is a relatively simple and inexpensive alteration to make.

The rate at which fuel can be regenerated (or system recharge time) can be reduced by increasing the quantity of regeneration stacks.

There are several key technologies that contribute to the unique properties of the system. These technologies include the design of the regenerator stack, the fuel cell stack, the cathode membranes that separate the zinc and air flows in the fuel cell, and the fluidiser that creates the zinc/KOH mixture. The architecture of the distributed system enables the flexibility of the core technology to be realised in a variety of configurations.

After many iterations to our technology, we have developed a battery that uses abundant and affordable materials, which translates into a best in its class economics and scalability without volatile or controversial supply chains. Our battery's architecture provides the same performance of redox flow batteries, but without the high electrolyte costs.

Long-duration storage provides multiple values at all levels of the electric grid, whether behind or in front of the meter, or on islanded microgrids. However, we believe behind-the-meter energy storage systems will be the first to adopt our technology because it can provide the largest number of services to the customer and the electricity grid at large. Our vision is to serve every level of the electricity grid and allow islanded operations to become independent from fossil fuels. ■

Author

Ron MacDonald is President and CEO of Zinc8 Energy Solutions, the leader in Zinc-Air battery technology. MacDonald has over 35 years of both public and private sector experience, ranging from international roles within the Parliament of Canada to serving on the boards of numerous publicly listed resource companies.





Energy Storage

NEWS

www.energy-storage.news

EMISSIONS-FREE TECHNOLOGY

Towards a renewable energy future



Energy storage is a key component of any serious attempt to integrate large shares of renewable energy and a key flexibility tool for modern energy networks all over the world, both on and off-grid.



Our insights into industry developments and notable projects provide key intelligence for the global market.



News, views and interviews, analysis and opinion from across the energy storage value chain for a business audience.

Scan QR Code to sign up to the twice-weekly newsletter



Or visit www.energy-storage.news/subscribe

Part of the Solar Media Ltd group, which includes  **PVTECH**, the world's number 1 solar PV technology website

160
countries

Over
1 MILLION
Annual page views

Piecing together the 'jigsaw of value' in UK energy storage

The UK | With a project pipeline in excess of 14GW, a developing regulatory envelope and maturing revenue streams, the UK's energy storage sector continues to be at the forefront globally. Molly Lempriere charts the market's development to date and uncovers how it has responded to deployment barriers.

The UK's utility-scale battery energy storage sector is widely considered to be amongst the world's leaders, with a quickly expanding pipeline of assets along with a growing number of potential revenue streams. With renewables producing a record 41% of Britain's energy mix in 2020, the challenge of balancing the grid has become ever more present, and batteries are stepping up to the plate.

A number of significant changes in revenue streams and planning legislation has further spurred on the market, with changes to legislation allowing projects over 50MW in England without the need for Nationally Significant Infrastructure Project (NSIP) status, as well as the hugely attractive Dynamic Containment (DC) frequency regulation service launched by system operator National Grid ESO attracting attention for its high rewards.

Growth so far has matched demand, with increased renewables demanding increased flexibility from the grid, a service batteries are exceptionally well placed to meet. But how much more storage will be needed, and could we see the market become oversaturated?

Growing pipeline and expanding assets

In the UK, there is currently a pipeline of just over 14GW of storage projects, and around 1.2GW of operational projects, according to research from Solar Media Market Research. Of this, around 7.5GW already has planning permission. This has grown dramatically in recent years, with the pipeline jumping from just 2.3GW in 2017.

The number of projects has grown, but so has the size of the assets, with 2020 seeing a raft of 50MW storage projects energised. This included Gresham House Energy Storage Fund (GRID) acquiring a number of assets, such as the 50MW Wickham Market site in November, while

Northern Ireland's largest battery storage project, 50MW site in Drumkeel, Co. Tyrone was energised in the same month by developers Low Carbon and Gore Street Energy Storage Fund.

According to Gore Street, this growth in size has been driven by both demand and economies of scale, something it has seen in its portfolio of around 100MW of operational energy storage since it acquired its first battery site – the 6MW Boulby battery in North Yorkshire – in 2015.

"It's funny that 6MW site – which was our first asset and we still own it – at the time that was commissioned was the largest privately owned lithium-ion facility in Britain and the largest in the world, providing frequency services," explains Gore Street Capital CEO Alex O'Connell. "Our average deal size now is 50MW, because there is this huge maturity of the sector, the assets are getting bigger and bigger, which is what the grid operators want, and we want them to be bigger because we've got economies of scale with the manufacturers."

Whilst there are currently no projects larger than 50MW in operation, there are a number of co-located projects that have a total capacity greater than 50MW. This includes the Minety battery storage scheme in Wiltshire, which secured land rights, planning permission and a grid connection offer back in March 2020 to extend its current 100MW project by a further 50MW. The initial 100MW is made up of two 50MW ternary lithium batteries provided by Penso Power and, at the time the extension was announced, was the biggest battery storage project in Europe.

A key change to planning legislation in July 2020 opened up the possibility of



Credit: GRID.

Gresham House Energy Storage Fund acquired the 40MW facility in Glassenbury battery site in Kent, England, in 2019. It forms part of the company's nearly 400MW strong portfolio.

large-scale battery storage sites. Ministers passed secondary legislation to allow battery storage to bypass the NSIP process in Britain, meaning storage projects above 50MW in England and 350MW in Wales can proceed without approval through the national planning regime.

Unlike projects like Minety – which are made up of multiple co-located batteries, with multiple grid connections – single-site large-scale battery storage is now possible in the UK, and companies were quick to set their sights on it.

The largest in this pipeline is InterGen's 320MW London Gateway Project, announced in November and quickly hailed as a significant moment for the UK's storage sector. The London Gateway Project will be InterGen's first – and rather dramatic – step into the storage sector, having focused on flexible assets in the form of Combined Cycle Gas Turbines (CCGTs) previously. By dint of how large the project is, however, it will propel it to being one of the major players in the sector.

Currently, GRID has the largest portfolio of operating battery storage sites in the UK, with 395MW of operational storage at the time of publication and a number of other

14GW
The UK's current
energy storage
pipeline

InterGen's London Gateway: The first of the giants?

InterGen's London Gateway project is set to be the biggest battery facility in the UK by a significant measure, utilising energy storage technology from the company's partner Fluence. The project is expected to use the company's sixth-generation Gridstack system design.

It will be a merchant risk project, but speaking to PV Tech Power, InterGen's Jim Lightfoot says he isn't concerned about attracting investment given the strong appetite for carbon free flexibility projects in the UK.

Lightfoot is more conservative in his predictions for large-scale battery storage projects in the UK following in InterGen's footsteps however.

"I think there will be larger scale batteries, but I think there's a limit to the amount that can be put on the system... Ones of this scale are very, very big and the costs associated with them aren't insignificant. So I think you'll see less of them."

projects in the pipeline. It has grown this substantially over the past year, and has expanded its portfolio by 80MW in 2021 already through the acquisition of a 25MW battery-only Tynemouth site, the 35MW Port of Tyne site, the 10MW Nevendon site, and the completion of its Glassenbury B extension.

The 'hot new investment class'

With a growing market has come new revenue opportunities for battery storage, featuring increased demand leading for a growing number of services playing into the UK's ancillary market in particular.

"The fundamental... relatively islanded nature of the UK is a big driver," explains Marek Kubik, managing director for UK, Ireland and Israel at Fluence. "Limited interconnection, aging thermal generation, the variable and distributed nature of renewables... all trend towards an increased need for locational and temporal flexibility – batteries can solve both, easing congestion by offering virtual transmission line solutions, and by shifting wind and solar from when it is available to when supply is tightest."

The need for further flexibility services was identified almost a decade ago, with both the UK Government and the country's energy market regulator Ofgem embarking on work to address the "missing money" problem, says Alastair Martin, founder and COO of aggregator Flexitricity. This effectively sought to tackle the challenge of power stations being underfunded for the security role they provided, and saw the government launch the Capacity Market (CM) and Ofgem sharpen imbalance prices, although "no-one was quite sure why we needed both," adds Martin.

"It looks like Ofgem's measures have

finally stolen the lead from the CM. Batteries, which the CM largely spurns, are the hot new investment class. The volatility seen in day-ahead auctions – by far the most accessible of the short-term market opportunities – is driven directly by cash-out risk. As real time approaches, intraday churn opportunities arise as uncertainty gradually diminishes and system stress either becomes real or melts away," Martin says.

"Most importantly, National Grid ESO's ability to make use of batteries in the Balancing Mechanism (BM), has leapt ahead, despite the burden of legacy IT. The BM contributes one extra feature of great importance to battery investment: a directly attributable track record of revenue performance."

The need for these flexibility services has led to new pathways opening up, with battery storage playing into services such as the BM, Fast Frequency Response

There are three general stages of market development, the first of which sees the first assets entering the market, with companies still focused on managing construction and operation risks, and requiring subsidies of some kind, he says. Then you move onto the fierce competition stage, where falling prices of the technology and in the Capacity Market have helped drive a swift development of assets.

"And then you move into what I think we're into now, which is the integration stage," Murphy says. "These assets now become fully integrated into the wholesale market, and that's when they find their value, they find it in the wholesale market, they find it in ancillary services, they find it in stacking multiple revenue streams, and getting comfortable with managing merchant risk. And I think that's the long-term future for the sector, getting comfortable with how you manage merchant risk."

O'Conneide says that when Gore Street entered the market in 2015, there were only about three revenue streams for batteries; frequency regulation, the Capacity Market and potentially agreements with industrial partners.

"You still have those three revenue streams, but now you have DC, you have localised revenues, things like reactive power, that are location dependent, and you also have trading, and there's actually more and more opportunities around trading. Trading, not so much in selling and buying electricity, but in the second-to-second work, keeping the grid in balance."

Localised flexibility tenders have grown substantially over the last year, with distribution network operators such as Western Power Distribution tendering for hundreds of megawatts of reactive power capacity.

"Limited interconnection, aging thermal generation, the variable and distributed nature of renewables etc all trend towards an increased need for locational and temporal flexibility – batteries can solve both."

(FFR) and Enhanced Frequency Response (EFR). As Colm Murphy, head of Electricity Market Change Delivery at National Grid ESO explains, some of this is driven by the maturity of the market.

InterGen's London Gateway site is set to be the largest in the UK, with Fluence's sixth-generation Gridstack system design (seen in this render) to be used for the 320MW site.



Credit: InterGen.

6th Edition



Energy Storage

SUMMIT 2021

Save 50% on
all tickets use code:
PVTP50

NEW FORMAT:
4 days of content over
the course of 2 weeks

23-24 Feb
02-03 Mar

storagesummit.solarenergyevents.com

ACCELERATING INVESTMENT & DEPLOYMENT OF ENERGY STORAGE GLOBALLY



250+

› Registered
Delegates



75

› Industry
Speakers



200+

› Participating
Companies



33

› Countries
Represented



25

› Interactive
Presentations
& Panels

Top Speakers:



AARON LALLY
Managing Partner
VEST ENERGY



**ALICJA
KOWALEWSKA-
MONTFORT**
Commercial Manager,
Energy Storage
GORE STREET CAPITAL



BEN GUEST
Managing Director,
British Strategic
Investment Fund
GRESHAM HOUSE



CATHERINE NEWMAN
CEO
LIMEJUMP



CHLOE LIANOS
Energy Storage
Innovation Lead
DEPARTMENT FOR
BUSINESS, ENERGY
AND INDUSTRIAL
STRATEGY (BEIS)



GERARD REID
Co-Founder & Partner
ALEXA CAPITAL

Register here: storagesummit.solarenergyevents.com/tickets

2021 SPONSORS INCLUDE:

Technology & Industry Diamond Partner



Platinum Sponsors



Gold Sponsor



Silver Sponsors



Supporting Sponsor



Bronze Sponsors



Exhibitors



Partners



Editorial Partners



#StorageSummit

Enquire now for speaking opportunities: lucy@solarmedia.co.uk



SOLAR MEDIA
Energy & Industrial Research

This is a sector that is expected to grow even further over the next few years, with more than 1.3GW of flexibility required across the UK's electricity grid in 2021 as the country accelerates the transition to renewable energy, according to research from Cornwall Insight.

While the electricity trading market has always been large, says Aaron Lally of 'cleantech trading house' VEST, it has previously been focused on the futures market and aimed specifically at centralised assets like nuclear, gas and coal. But over the past few years with the move to decentralised assets such as battery storage, things are changing. Traders have shifted to focus more on intraday and BM markets, as well as shifting away from utilities and traditional generators to the more flexible and reactive decentralised assets that have come into play.

"Utilities have shown they cannot integrate technology into their existing businesses and I think this is exactly what is starting to happen on the generation side now," Lally says. But in order for this to participation to grow further, he adds, changes to market frameworks are necessary.

"We need to develop more long-term trading products for flexible assets to allow them to hedge their activities ahead of the day ahead auction and give investors certainty in longer term revenues. We also need exchanges for futures to look at reducing capital requirements for trading as these are a large barrier to entry to a lot of new companies entering the space as it means tying up hundreds of thousands or millions of pounds as collateral to trade."

Whilst more could be done, the market expansion over the past decade means that for asset operators there are probably seven or eight different types of contracts available for each storage asset now. While this adds a level of complexity, it can provide multiple routes that asset managers can utilise to maximise their revenue streams.

"We are actively managing those assets and making decisions about which contracts our assets should go for this week, next month, six months, two years' time, and moving around to get best value," Gore Street's O'Connell says.

The value available in the asset optimisation area has grown to the point where some companies are moving away from asset ownership, most notably Arenko, which sold its Bloxwich battery to GRID to become a pure play software company last

summer. Since then, it has focused in on optimising the battery in markets like the BM and DC.

There has been significant activity in this space over the past year in particular, with the volatility of the supply profile in the UK allowing assets to cash in during particularly tumultuous periods. For example, the imbalance price skyrocketed to £4,000/MWh (US\$5,400) in January due to low winds and low temperatures driving up demands. Providing such balancing and stability services, while less predictable as a revenue stream, offers substantial benefits and there is a growing interest in these more high risk, high reward areas.

"Before I think maybe investors were looking for stable returns," explains

"The fundamental requirements of operating a secure electricity system transitioning to net zero are driving opportunities across the different revenue categories. The investment case for batteries has never been stronger."

Murphy. "So they probably wanted a guaranteed contract that's going to pay them out for 15 years. That's not in the interest of the consumer because the cost of technology comes down, you get more competitions, the cost of commodities come down. Whereas now what we're doing is offering deep, liquid, competitive regular markets every day sending out a really stable price signal. And so now what we're seeing is hopefully more investment and more batteries coming online."

The 'brutal' nature of Dynamic Containment

One of the most significant changes to battery revenue recently has been the introduction of DC by National Grid ESO. Introduced in October 2020, the day-ahead ancillary service is the first of three new frequency services designed to meet trips and outages incredibly fast.

It has been particularly significant in the industry as it offers the highest price for frequency, with a cap of £17/MW/h, equivalent to almost three times what is offered by other services. Given the challenges of operating in the market, it has remained

undersubscribed and therefore prices have remained high.

There are a number of challenges assets face when participating in Dynamic Containment, in particular the technical demands of the control system capability. Arenko's chief technology officer Roger Hollies describes these technical requirements as "pretty brutal" and says they have proven difficult for a number of system operators.

The speed of the required response falls somewhere between being very fast and not fast enough so as to require tunable onsite control, a spanner in the works for some operators. "The data reporting requirements require two separate data management dances working on two timelines: Second by second operational reporting and hourly upload of high-resolution performance data. These both require rich data collection and flexible communication interfaces at the same time. Many assets have been built with controllers that serve the current market at the time of the business case: That was firm frequency response (FFR). DC is out of their reach for the moment," Hollies says.

Only two companies were successful in their tenders when DC was first launched, Arenko and Flexitricity. While more companies are now participating in the market, it is still falling below its target, with an average daily volume of 333MW in National Grid ESO's newest ancillary service in January 2021, less than half the 600-800MW target set for the month according to consultancy EnAppSys.

Hollies says it is worth highlighting that this is not due to technological challenges with batteries, which are very fast, but the control systems that dispatch them. Currently, although National Grid ESO is technology neutral and the service is open to a wider range of assets, batteries are the only technology playing into DC due to their speed.

As the service has matured, National Grid ESO has opened up DC to allow operators to stack revenues alongside those from the BM. "That means if I'm providing DC with my battery and providing the low frequency service with the BM, when frequency drops, I can discharge my battery. And then I'm able to issue a bid that basically says 'I need to recharge the battery', I will do that at a really competitive price for you. And so they're able then to earn money that they wouldn't have otherwise earned by charging and we were able to take an action that's much cheaper," Murphy says.



Gore Street's 10MW Lower Road storage site forms part of the company's 110MW operational portfolio, which the company utilises in a number of different markets such as the Balancing Mechanism.

Credit: Gore Street.

This is a key area where National Grid ESO has been able to play a role in the development of the battery sector in the UK. The operator has worked to remove barriers for the technology along with other flexibility assets by standardising, simplifying and rationalising necessary processes. It allows for National Grid ESO to ensure that “the jigsaw of value fits together”, as Murphy describes it, allowing batteries to maximise their potential.

The move to allow assets to stack DC and BM revenues was welcomed by the storage sector, including Arenko, who began stacking from the first day. As such, when the French interconnector IFA2 tripped just two days after on 29 January 2021, Arenko's assets were able to jump into action in DC and then benefit from charging to aid the BM.

Enabling revenue stacking has increased revenue agility without increasing risk, Flexitricity's Martin adds. The strict requirements of both DC and the BM have not been relaxed, with the onus still on providers to ensure they can meet all the obligations they've committed to. “It's something of a step into the unknown for National Grid ESO, who would previously prefer to have assets ‘sterilised’ for particular ancillary services which they might provide,” Martin says.

“It remains to be seen whether market volatility will continue to deliver the scarcity rents seen in early January. This is, ultimately, the reason that government and Ofgem took different tracks. Paradoxically, volatility has most value when it is consistent. However, the fundamental requirements of operating a secure electricity system transitioning to net zero are driving opportunities across the different revenue categories. The investment case for batteries has never been stronger.”

How much is too much?

With the utility-scale battery storage sector going from strength to strength in the UK, there seems a wealth of opportunity still waiting to be tapped into. Despite its exceptional growth, the sector is a long way from being saturated, in particular as the nation's decarbonisation targets loom large on the horizon. In particular, Prime Minister Boris Johnson's 40GW of offshore wind by 2030 target will push the nation's grid dramatically, with increases in flexibility essential to keep it balanced as renewable generation increases.

In National Grid ESO's most recent Future Energy Scenarios publication, a projection for the UK's power system which is published and updated each year, the demand for energy storage in the run up

to net zero by 2050 is clear, with a spike in electricity storage capacity within the most ambitious scenario calling for 40GW by 2050, while even the lowest scenario - which would see the UK fail to meet net zero - still calls for just over 20GW.

This could be needed soon, according to Murphy. “Depending on which scenario you're looking at that could be as quickly as by 2035, so I think there's a huge opportunity there.” Furthermore, Murphy highlights the opportunities beyond lithium-ion batteries, highlighting the need for seasonal storage solutions, an area that is much less developed in the UK.

With services like DC still undersubscribed, there remains space in the current frameworks that provide strong financial incentives for those keen to enter the market. These operate on the basis of variable energy prices offering an opportunity, but with a strong increase in storage deployment the endpoint could be a system so balanced there's no spread in electricity prices, suggests O'Connell.

“We're very focused on the services side, and that will need to continue in basically reverse correlation with the decommissioning of baseload power. And that's huge, we still have an enormous way to go on that. So there are gigawatts that need to be built over time,” he says.

Software: The driving force putting batteries at the heart of the energy transition



Software | Software is rapidly becoming recognised as key to the value proposition and bankability of energy storage, which in turn lies at the heart of the low carbon energy transition. Andy Colthorpe speaks to three providers of software aimed at the energy storage industry.

Credit: Contour Global Bonaire

If energy storage is the great enabler of the clean energy transition, then software is the great enabler of energy storage. A lot of discussion rightly focuses on hardware: the types, sizes and quality of batteries, the right configurations of power conversion equipment and so on. Yet it is software that drives the systems to deliver their optimal value and allows both the machines themselves and the humans operating them to make the right decisions.

Energy storage is perhaps the most versatile asset available today to modernise and decarbonise the electricity grid, allowing for the integration of renewable energy, enhancing the resilience and quality of electricity supply and lowering the cost of operating the network.

Batteries can be charged from the grid at off-peak times when power is cheap or

from renewable energy at zero marginal cost of fuel. They can discharge rapidly to balance out supply and demand or maintain the operating frequency of the grid. They can reduce the use of fossil fuels to meet the peak demand periods which prove so expensive and polluting for everybody and they can reduce the need for the build-out of transmission and distribution infrastructure. They can even be used to bring offline thermal generators back to life much more efficiently than diesel generators, which could be a valuable use case in those areas where the transition to renewable energy will be more gradual one.

Energy storage can do all of these things, and much more. Often at the same time, or at the very least, from the same asset, at different times. In many cases, being able to do more than one of these

Wärtsilä's project on the Caribbean island of Bonaire integrates local renewable energy with a 6MW / 6MWh battery storage system.

things will be central to the value proposition that makes a battery project stack up economically. But in order to be able to serve these applications smartly and in a way that doesn't lead to excessive wear and tear and degradation of the asset, smart software is as important as choosing the right battery cells and other hardware.

In this article, we speak to providers of diverse software and software-as-a-service solutions to the battery energy storage industry. We look briefly - and in simplified form - at:

Modo Energy, which offers data intelligence on the UK energy storage industry via a cloud-based platform.

ION Energy, using machine learning to provide services including measuring and predicting degradation in battery storage at the cell level.

Wartsila Corporation's Intellibidder

Credit: Modo Energy



software, which matches energy and resource availability with the right market-based opportunities.

Informational liquidity

"The world's got a challenge that we need to build more renewables and storage, everybody knows that. And the energy storage industry has got a challenge that it's a maturing market, with immature technologies that are constantly changing," Modo Energy CEO Quentin Scrimshire says.

From technology risks to finance risks and various regulatory risks, the sector remained the preserve of early adopters and investors for a while. That profile is now changing, Scrimshire says, and software-driven data companies can help people become better informed of the risks and how to make the right decisions.

"What we do in our analysis, and what our software is capable of doing, we call it 'informational liquidity'. We provide informational liquidity to the market through data, which helps everybody make better informed decisions, which essentially greases the wheels of getting money into the sector and getting more energy storage built. If we weren't providing this kind of service, there'd be a lot of gaps and black holes in people's knowledge. And that will stop investment happening."

Like many good stories in the tech world, Modo Energy's tale really begins with a huge pivot, co-founder and CEO Quentin Scrimshire says. After leaving UK market-leading aggregator Kiwi Power to start up Modo, the plan had been to create software that could automate participation in market opportunities for grid and energy services.

"The idea was, if you've got an asset that'll be spending a lot of the time in the Balancing Mechanism, participation in that market should be automated. We could sell that directly to asset owners, and they could get into the market and register with National Grid. And they could save themselves some money and hopefully improve performance. Win-win," Scrimshire says.

The company raised capital and spent six months building the software to do that during 2019. Then came the realisation that competition for that type of service in Britain's energy storage market was growing fierce, with big players like utilities Centrica and EDF able to offer floor prices to customers and "impressive new players" like Habitat Energy and Arenko offering state-of-the-art optimisation and trading.

"We also realised that the market wasn't growing quite as big as we expected, so batteries weren't at that time being delivered or built as fast as we expected. We had a conundrum. We were burning cash and we said, 'What else should we do with all of this data and software that we've built?' By that time, we had built essentially a model of the whole UK asset portfolio, the whole energy storage market, and how those assets were behaving," the Modo CEO says.

The team at Modo Energy decided that instead, the company would become "an independent and impartial provider of data intelligence" on the country's energy storage market. This increased its addressable market from battery asset owners to all interested stakeholders and helped Modo to find its own, less competitive, niche. The 'secret sauce' that makes the

Modo Energy built a model of the UK energy storage asset base and uses it to provide data-driven intelligence on the rapidly-changing market.

offering standout, Scrimshire says, is the data science that enables Modo to offer what that "informational liquidity" to the market.

"We build a picture of all the assets in the UK, which is quite simple. Then determine which ones are attributed to which markets and which optimisers, or owned by who or which transactions. Then we have software that builds a picture of what operationally each asset has done on every settlement period of every day of every month. From that, we can match all of those assets to trades and participation in frequency response markets, or the Balancing Mechanism or the wholesale market."

The last two steps in that process in particular, are "incredibly computationally complex," he says. But being able to do them are what sets Modo apart as an end-to-end data science company. Once you've done that, he says: "You can find out some really interesting stuff".

"You can look at the whole market on aggregate; all 55 assets that we track in the UK, and you can say, for every day, or every week or every month, 'where are people making money, where's the value? How many cycles do you need to do to access that value? What is the estimated megawatt-hour throughput of each battery?'

"You can look on a specific asset level, you can rank on assets, you can rank on optimisers, you can rank on any market participant once you've got this data set. We build a complete data set for the energy storage industry in Great Britain. And then we provide analytics on top of it," Scrimshire says.

"So what we're trying to do is on a macro level, get more assets built because that helps the world. But on a day-to-day basis, what does that really mean? It's informational liquidity."

'Slicing and dicing from the same data set'

ION Energy on the other hand more explicitly joins the dots between hardware and software. The Mumbai, India-headquartered company was contracted last year to use its platform, Edison Analytics, to manage battery cell degradation across a portfolio of around 600MWh of assets for US energy storage developer esVolta.

Machine learning technology and algorithms can be applied to vital services like predictive maintenance — tracking data from the many thousands of sensors at esVolta's sites to identify the health



**20% OFF conference
registration or FREE
expo hall access**

STRONGER TOGETHER

JULY 14-16, 2021

Long Beach Convention Center / Long Beach, CA USA

**Intersolar North America and
Energy Storage North America come
together for the first time this year
to advance the clean energy future.**

Connect with installers, developers,
utilities, technology providers, policy makers,
and key stakeholders from around the world for
innovative programs, networking events, and
exhibits that maximize learning and deal-making.

**Help shape the next phase of our
clean energy transformation.**



of the systems at every single point and figuring out how the batteries can best be used to maximise revenues while minimising degradation — ION Energy CEO Akhil Aryan says.

Someone that uses an energy storage asset to buy and sell energy off the grid and make money from arbitrage, for example, would typically make decisions based on the price of buying and selling that energy. When that means charging and discharging a battery pack, however, the “hidden cost of degradation” has to be factored in.

“When you charge it and every time you discharge it, you’re actually causing the battery to degrade. If you want to get a sense of your net profitability per transaction, you would have to convert that degradation into a dollar value and take that as an input into your trading strategy,” Aryan says.

“That’s one of the things that we do with our feature called dispatch optimisation, meaning that it takes in the forecasted prices for the next seven days on a 24 hour window, and helps identify the best opportunities to dispatch the power, but scheduling that dispatch, by co-optimisation with the degradation of the battery pack. So that you’re making sure the battery never witnesses temperatures above 60 degrees, it’s being discharged at less than 1C discharge rate.”

The CEO had his own pivot moment when it came to co-founding ION Energy: after finding success in developing and selling various IT and artificial intelligence (AI) ventures, he decided in 2015 it was time to leave a role in the advertising technology space and focus on solving

“problems that really matter”.

“I decided to think about places where I can leverage my experience, but have an impact on some of the real problems that face humanity,” he says.

Like many in the tech world, Aryan was following Tesla “quite closely” around that time when he realised that Tesla is “an energy storage company that also sells cars”. This got him interested in batteries and another realisation that while batteries were both complex and expensive assets, there could be a “tremendous value in leveraging data from how energy is being consumed from batteries to help extend the life and performance of those assets”.

In other words, applying his experience from “pure software machine learning” to the context of energy storage: “Because that has a direct impact on the adoption of new energy assets, both in mobility and stationary”.

ION Energy has worked — and continues to work — in a number of areas including developing its own battery management system (BMS) and providing support to the growing e-mobility industry. Aryan says that over the years, “general data literacy has really gone up significantly,” meaning that nearly all companies believe in and understand the value of data.

Using that data smartly and generating insights however, is another question and then becomes more of a “creative problem” than a computational one, the CEO says. Amassing terabytes of sensor data in a server inherently has no value, which is where data science comes in to extract or create value.

“Edison, which is our analytics product, is an endpoint for data streams that are

being generated from any sensor in any asset. In the start, we’re limiting that to new energies, meaning that you have battery management systems, you have inverters, you have even independent sort of sensors, inside of any system that are now capable of logging data, and

“You can build more trust and transparency with your investors by showcasing the factual data of the unit economics of your sites”

collecting that data in one sort of central database.”

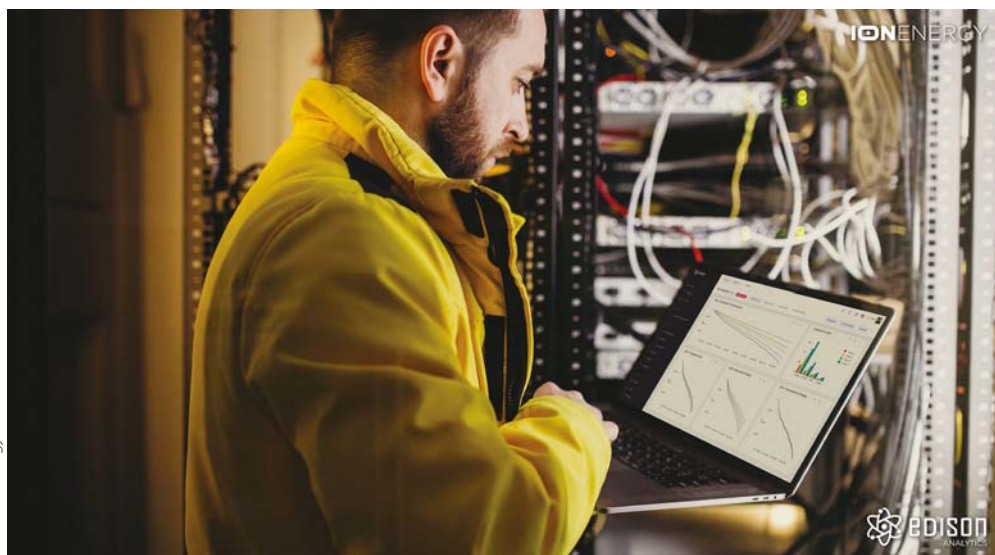
That data can then be used in any number of ways, including or besides predictive maintenance. Different departments managing the same portfolio can benefit from essentially “slicing and dicing the same data set”, Aryan says. The work ION Energy is doing for esVolta, which has large-scale battery storage sites in California performing a multitude of applications, spans different areas where this ‘creative’ application of machine learning and analytics can be likewise be applied.

From doing a pilot run-through of analytics service on one or two of esVolta’s sites, many of which are already operational, ION Energy won the multi-year deal to work across the whole portfolio after “showcasing the value” and “material impact on the ROI” that the platform could deliver.

“For different departments inside of esVolta, we’re doing different things. We might be doing one thing for helping them improve their uptime, while helping them ensure that they’re using these batteries within the boundary conditions of their warranties, which allows them to build trust and transparency with their investors and raise more money which they did — eventually they raised US\$140 million [investment].”

“You can build more trust and transparency with your investors by showcasing the factual data of the unit economics of your sites,” Aryan says.

“There is an operations and maintenance angle, there is a financing insurance warranty angle, there is a degradation and smarter trading strategies and also there are different types of things that we’re doing for them. They really appreciate how sophisticated batteries can become if you leverage software.”



ION Energy won a deal to work across esVolta’s portfolio after “showcasing the value” and “material impact on the ROI” that its Edison Analytics platform could have.

Making the revenues stack up

Unlike Modo Energy or ION Energy, Wärtsilä Corporation is not purely a software and data analytics company, it's a multi-billion Euro power equipment company that has a software and data analytics team in-house within its energy division.

It did however enter the energy storage industry when it acquired an energy storage company with a deep background in software, taking over Greensmith Energy in 2017. Greensmith's founders were "really heavily into cloud computing" and more than 10 years ago realised that batteries would play a "very central" role in the clean energy transition that was starting to take shape, Luke Wittmer, a data science and optimisation manager at Wärtsilä, says. The founders also recognised, Wittmer adds, that the best use of batteries was not a hardware question, but a computing one.

A battery is still "arguably an expensive asset, but it can serve critical functions simultaneously. It can do so many things at once, in both directions, charging and discharging, it's a really handy balancing tool for any grid," Wittmer says. But without software such as GEMS, the software platform Greensmith developed to act as a "central computing hub for any power generation asset," not just for batteries, many of the fundamental problems of renewable energy would remain unsolved.

More recently, Wärtsilä launched Intelbidder, an application layer that adds automated market bidding capabilities for energy asset operators. For battery storage plants, that increasingly means enabling the stacking of multiple applications and therefore multiple revenues.

"Whether it's the UK or Australia or some of the US markets where we're active, the value of what we're doing with Intelbidder comes from that revenue stack. It's very common for us to participate in ancillary services, so in the UK, that's the Balancing Mechanism, or frequency response. Whatever the ancillary service markets are in your area, Intelbidder is going to look at the prices of each of these markets, look at your contractual position."

The software then determines to ensure that contract is met, but could then decide that, for example, based on prices in other markets, different fractions of the remaining power stored in the battery could be played into different markets.

"So if there's a price spike in the energy price, and you're discharging for 15 minutes or something, at some power

Access to different grid services and energy markets is part of what makes the business case for a low-carbon future work.



Credit: Modo Energy.

level, if I have a 100MW site, and I bid 25MW to do that, then I'll be discharging 25MW, but I still have this other 75MW, that if suddenly the Balancing Mechanism needs me to discharge, you can do that on top of it. You'll be doing these things literally stacked on top of each other, until all of your power is allocated somewhere."

As is pretty much always the case, technology moves faster than policies and market rules account for. This means that platforms like Intelbidder and the teams behind them need to be modelling "different dynamic changes in the markets all the time," Wittmer says. It also means designing both the bidding software and the GEMS control platform it sits on top of to give asset operators and optimisers control and visibility to track the right key performance indicators (KPIs) against both real-time, historical and simulated market conditions.

Empower the customer, empower consumers

One really interesting point is that unlike battery manufacturing, software doesn't need gigafactories to scale — valuable services can come from startups just as easily as they can from established market players.

So why buy or subscribe to data analytics or other software services rather than develop it in-house? ION Energy's Akhil Aryan points out that his customers are in the energy business, not in the data analytics platform business. Putting that side of things into the hands of a specialist software-as-a-service provider can empower those customers to drive up their ROI, he says.

"What we're trying to do is really give them the tools that allow their analysts and their data scientists to spin up applications

that have an ROI impact without having to build everything ground up. So we're basically accelerating their journey in leveraging data to make smarter business decisions."

And for all that software technology matters, having a motivated team with the right skillsets behind it is just as, if not more, important. Quentin Scrimshire says that "everybody at Modo is an engineer, or data scientist or software engineer of some sort," able to meet the challenges of combining an understanding of the very complex, highly regulated energy market with tracking the emergence of opportunities that energy storage presents. In time, Modo's platform could be as important for energy as a Bloomberg Terminal is for other kinds of trading.

Luke Wittmer would argue too that although now part of a much bigger entity, the cloud computing evangelist ethos of Greensmith Energy lives on as part of Wärtsilä. The corporation has kept much of the Greensmith core intact as a "very autonomous software group within Wärtsilä," or "a pure software shop" — albeit one dedicated to solving some of the biggest questions facing the energy transition.

"This software is not just maximising revenue for an asset owner, it's minimising electricity prices for consumers. That's the passion that everybody on the team has. That's why we do what we do. These are the cheapest technologies that compete directly with fossil fuels. People are choosing them because they are the best option for making cheaper energy.

"If you can make cheaper energy and sell it successfully in these open markets you are undercutting the fossil fuel plants. That's what we do here!" ■

advertisers & web index

Advertiser	Web address	PAGE No.
Energy Next	www.energynext.com.au	63
Energy Storage News	www.energy-storage.news	79
Energy Storage Summit 2021	storagesummit.solarenergyevents.com	82
Energy Storage Summit USA	storageusa.solarenergyevents.com	74
Energy Taiwan	www.energytaiwan.com.tw	70
EUPVSEC	www.photovoltaic-conference.com	57
Expo Solar Korea	www.exposolar.org	67
FIMER	www.fimer.com	16, 17
Green Energy Expo	www.energyexpo.co.kr	54
Huawei	solar.huawei.com	5
Intersolar Global	www.intersolar-events.com	29, 37
Intersolar North America	intersolar.us/pv-tech	87
Large Scale Solar Europe	lss.solarenergyevents.com	49
LONGi Solar	en.longi-solar.com	Inside Front Cover
PV CellTech	celltech.solarenergyevents.com	61
PV Expo	www.pvexpo.jp	24
PV ModuleTech 2021	moduletech.solarenergyevents.com	33
PV Tech	pv-tech.org/newsletter	65
PV Tech Power	pv-tech.org/pv-tech-power	Inside Back Cover
PV Tech TechTalk	marketing@solarmedia.com	47
Risen Energy	www.risenenergy.com	11
Seraphim	www.seraphim-energy.com	7
SNEC 2021	www.snec.org.cn	20
Solar Media Market Research	marketresearch.solarmedia.co.uk	44
Solar Solutions International	en.solarsolutions.nl	40
Trina Solar	www.trinasolar.com	Outside Back Cover

next issue

European solar under the microscope
The end of Performance Ratios as a metric?
Extreme weather proofing your project



SUBSCRIBE TODAY! www.pv-tech.org/power



The PV Tech Power journal is focused on the challenges and solutions concerned with designing, building and operating commercial & utility scale PV power plants.

- Quarterly edition
- Print and online subscription packages available

DIGITAL ONLY

US\$ **58**
per year

- Includes digital access to the current edition AND 4 upcoming issues in the next 12 months
- 5 issues in total!

PRINT & DIGITAL

US\$ **149**
per year

- Includes digital access to the current edition AND 4 upcoming issues in the next 12 months
- 5 issues in total! (Digital copy)
- 4 upcoming issues in print
 - Free worldwide delivery

PRINT, DIGITAL & ARCHIVE

US\$ **180**
per year

- Includes 12 months of unlimited digital access to the PV Tech Power content:
 - o Full online archive
 - o Full technical paper collection (over 400)
 - o 4 upcoming issues digital access
 - o 4 upcoming issues in print
- Free worldwide delivery

SAVE US\$ 180

BEST VALUE



Subscribe at: ➔ store.pv-tech.org/pv-tech-power



Embarking on the Future

The Ultra High Performance Module Series for All Rooftops



- ✓ Module power increase up to 410W
- ✓ Power generation increase 10~23%
- ✓ Better performance against wind, excellent system adaption
- ✓ Lower attenuation, longer warranty, and higher revenue from power generation
- ✓ Full black aesthetics with ultimate appearance