The third pillar: How floating PV can fulfil its potential

Credit: Lightsource BP

Floating solar | Despite its generation characteristics, floating solar has yet to truly fulfil its undoubted potential. Jules Scully explores why the technology continues to face hurdles, and what the industry is doing to surpass them.

Falling development costs combined with limited land availability in densely populated countries have seen floating PV (FPV) pitched as the third pillar of the solar sector alongside ground-mounted and rooftop installations.

Proponents of the technology point to its increased energy yield thanks to both the cooling effect of water on panels and the reduction in shading due to the surroundings. Colocation with hydropower plants – and taking advantage of existing transmission infrastructure – can bolster the generation of such assets and smoothen the generation curve, while also decreasing water evaporation and limiting algae growth.

However, as countries scramble to ramp up their renewable energy capacities to meet climate targets, floating solar remains underutilised, particularly in areas where space is not an issue, and tried and tested ground-mounted PV provides a less risky, cheaper proposition. Estimates suggest under 3GW of FPV was installed globally by the end of 2019 – less than 1% the world's total solar capacity.

Higher costs compared to ground-mounted PV, bankability hurdles and a lack of track record in terms of operations and maintenance (O&M) data are all reasons put forward by major solar developers, investors and financiers for having not entered the FPV market. According to Capital Dynamics, an asset management firm with a clean energy infrastructure portfolio of more than 7.3GW of power generation, FPV projects "are too unproven", while German developer Juwi says the technology is "relevant, but so far it is a niche application".

For CIT Group, the huge opportunity for land-based solar in the US means its client base has so far not approached the bank and renewable energy lender for FPV project funding. This is likely due to both economics and necessity, according to Mike Lorusso, managing director and group head for CIT's power and energy business.

Lightsource BP's only floating solar project to date, the 6.3MW install on the QEII Reservoir in the UK.

He says floating solar projects have more complexities and more risk factors to take into consideration: "It's going to drive up the cost of equity, it's going to drive up the cost of debt," he adds. Meanwhile, with high irradiation and large open space available for land-based PV in states such as California, Texas and Arizona, Lorusso says "there is no need" to develop floating solar in these areas, adding: "And it's going to be a lot more expensive."

Indeed, the cost of developing FPV systems is normally higher than ground-mounted projects of a similar size as a result of the requirement for floating structures, moorings and more resilient

electrical components. These costs are, however, expected to fall as the technology evolves and developers take advantage of economies of scale.

A landmark report published in 2018 by the World Bank and Solar Energy Research Institute of Singapore (SERIS) suggested that while floating solar systems are more expensive to install, their greater efficiency might partially offset the higher cost. The levelised cost of electricity (LCOE) for a generic 50MW FPV project "does not differ significantly from that of a ground-mounted system", the report said. Although floating solar projects are said to be 18% more expensive than a land-based equivalent, their performance ratio is 5-10% higher.

Though a considerable reduction in costs is difficult to predict, in part because floating structures remain dependent on crude oil prices, the World Bank and SERIS say FPV costs are approaching those of ground-mounted systems, and may eventually lead to an equal or lower LCOE.

The design of the floating structure and its anchoring system is based on each site, with costs depending on the engineering challenges involved. "Every water body is different and is exposed to varying climate conditions. These variables have a strong influence on the selection of the best floating structure and how the FPV system will perform over time," Thomas Reindl, deputy CEO at SERIS, says.

Noting that there are "different voices" in terms of O&M costs, Reindl is calling for industry players to share their experiences. SERIS is looking for launch partners to start the International Floating Solar Society, which would provide a common platform where information can be compiled and used by the industry.

Europe's FPV pioneers

One of the leaders in the European FPV market is German developer BayWa r.e., which completed the continent's largest floating solar facility – a 27.4MWp project built on a sandpit lake in the Netherlands – earlier this year.

After entering the FPV sector in 2018 with the acquisition of a 70% stake in Dutch firm GroenLeven and its project pipeline, BayWa r.e. went on to develop its own substructure suitable for large-scale installations, which is "much more easy to maintain over the lifetime of the system", according to Toni Weigl, BayWa r.e. product manager for floating PV. The GroenLeven deal combined with the creation of its own floating solution gave the company "the opportunity to really take off with floating PV", Weigl said.

As well as a high module occupancy rate because of its east-west configuration, BayWa r.e's solution features inverter boats, maintenance walkways, cable ducts, wave barriers and a floating transformer station.

In terms of O&M costs, Weigl said developing solar projects on water means there is no need for video surveillance, theft protection and grass cutting that is required for land-based sites. "We have actually lower operational maintenance costs in our floating PV systems compared to ground-mounted PV," he says.

Having completed an initial 2.1MWp FPV project in 2018, BayWa r.e. has now constructed six facilities, all located in the Netherlands. "With every (floating) plant we are building, the costs are going down further," Weigl says.

Despite a reluctance among some lenders to bankroll floating projects, Weigl says BayWa r.e. works with banks that are "happy to invest in and finance these projects".

"And after, they realised it was also very easy to find a long-term investor to step into the project and take over that project… There was a huge appetite from investors to get our floating PV projects acquired."

With its 52,000 hectares of shallow inland water surfaces, the Netherlands is also of interest to another project developer, Lightsource BP, which is currently exploring opportunities for FPV in the country. To date, the company has commissioned 1.3GW of solar capacity globally and has a portfolio of 2GW under management. But its only outing so far in the floating solar sector came in 2016 when the firm completed a 6.3MW array – Europe's largest at the time – on London's Queen Elizabeth II reservoir on behalf of utility Thames Water.

"We went into that space mainly on the motivation of innovation," Chris Buckland, technical director at Lightsource BP, tells PV Tech Power. "The feed-in tariff at the time was enough to pay for us to spend a significant amount of time developing that technology together with [FPV structure provider] Ciel et Terre."

The facility, which took 15 months to complete, covers around a tenth of the reservoir, features just over 23,000 solar modules and will generate enough electricity to power Thames Water's local water treatment plants for decades. "The reason that was particularly useful for Thames Water is clearly around that site," said Buckland. "A lake in a built-up area is ideal for floating solar."

While the feed-in tariff combined with the power purchase agreement with the utility meant that the project "worked from a financial point of view", Lightsource BP has since steered clear of floating solar, opting instead to develop ground-mounted projects as it pursues a solar development pipeline in excess of 12GW.

Buckland says that while private financing "is not an issue" in terms of floating projects, Lightsource BP would need a market pull to fully embrace the technology. Without such an incentive, the company will continue to "put in the most cost-effective solution, which is dropping solar onto a piece of suitable land well away from urbanisation and connect to the transmission [grid]," he added.

A government's role

Land constraints combined with favourable policies and government support

BayWa r.e.'s Bomhofsplas project in the Netherlands.

Credit: BayWa r.e.

for the technology mean that Asia is the leader in the global floating solar market, with Wood Mackenzie suggesting the continent has 87% of total global capacity of the technology. Noting that Asia also "dominates the technology's project pipeline", a Fitch Solutions report published in October 2020 highlights China, South Korea, India, Thailand and Vietnam as "key outperformers" in the sector over the next decade.

According to the consultancy, China is the largest market for floating solar installations and is also home to the world's biggest project, the 320MW Cixi plant that was completed earlier this year. An additional 820MW of FPV capacity in the country will also be tendered by state-owned utility Datang Power by the end of 2021.

The crown of world's largest floating project will move to South Korea in 2022, when the first 1.2GW of a multi-billion-dollar facility being built inside the Saemangeum seawall goes online. Approved by the country's government last year, the facility will feature 5.25 million solar panels and a total capacity of 2.1GW when fully operational in 2025.

In Taiwan, the government has offered higher feed-in tariffs for floating solar projects than for ground-mounted farms, while Vietnam will hold FPV auctions for up to 400MW of FPV by the end of 2021.

Though feed-in tariffs can be used to encourage the large-scale adoption of floating solar, Thomas Reindl of SERIS calls for alternative policies. "When governmental support has been provided and eventually turned out to be too generous, tariffs have been renegotiated at a later stage afterwards, which is not helpful for the industry as a whole, and certainly not for [an] investor's/lender's confidence," he says.

"In most countries, PV and also floating PV have reached grid parity. The governments should therefore rather set the right legal frameworks and support floating solar projects on the administrative side, for example by facilitating permitting and coordinating the relevant government agencies involved."

Abhishek Kumar, head of solar system technology group at SERIS, says that in terms of technical development, governments can support industry by providing incentives to innovate new technology, products and floating PV field demonstrations. "Such innovation and thorough testing would reduce the risk of large-scale deployment and improve the techno-commercial feasibility of FPV projects as a reliable and bankable source of energy," he adds.

Singapore, the Netherlands and India are among the countries that have supported pilot floating solar projects. The first of its kind in India was founded by the Ministry of New and Renewable Energy and became operational in 2014. Since then, other test projects have been developed, including one in the southwestern state of Kerala that has a water level variation of 21 metres between summer and monsoon seasons.

The massive potential for floating solar in India was revealed in a recent report from the Energy and Resources Institute (TERI), which found the country's reservoirs could be used to generate 280GW of solar power. The think tank estimates that figure would be achieved if 30% of the water surface area of the country's medium and large reservoirs were fitted with FPV.

With India aiming to reach 100GW of installed solar by 2022, TERI said alternatives such as such as floating PV "need to be explored and established". It is time to bring "a conducive policy framework to encourage tapping this potential", says Ajay Mathur, director general at TERI.

State-owned Solar Energy Corporation of India, which last year issued a tender involving 20MWac of floating solar projects coupled with 60MWh of battery energy storage systems, previously revealed plans to use the large availability of water of major reservoirs in the country to develop floating PV and bypass physical and legal hurdles regarding land acquisition when setting up ground-mounted solar projects.

However FPV could find its future prospects emboldened not by policy or tender initiatives, but by combining with another generation technology.

The ideal situation of FPV-plus-hydro

According to the Institute for Energy Economics and Financial Analysis (IEEFA), India is a country to watch among Southeast Asian states as it continues to remove roadblocks and ensure policy stability to accelerate renewable energy.

A recent report from the think tank says Southeast Asia's land scarcity, and the lack of primary energy resources and associated infrastructure, have created a high barrier for some land-intensive renewable energy options. The geography and demographics of the region present a "distinctive opportunity" for floating solar, IEEFA says. It is estimated that at least 24GW of the technology could be installed there by co-locating with existing hydropower facilities.

"Our research shows more and more ASEAN countries are building solar farms that float on rivers, dams, lakes and reservoirs – even the sea – to produce clean electricity at prices that can compete with power from polluting coal-fired plants," says Sara Jane Ahmed, energy finance analyst for IEEFA.

The report says much of the cost advantage of hybridising FPV with hydropower comes from having minimal site costs and the opportunity to connect to existing grid, substation and transmission infrastructure. "Focusing on the economics of generation assets in isolation does not make sense because of the need to invest in transmission lines. A grid-level solution, considering the cost of generation plus transmission requirements, is key," Ahmed adds.

The research highlights the potential for FPV-plus-hydro projects in Southeast Asia to increase power output while reducing variability, providing renewable energy

The 100MW FPV project along the Hunan River in China.

Credit: Sungrow.

that can be dispatched as needed by grid operators.

These grid benefits were also noted in a recent study from a team of Michigan State University scientists who explored the potential of offsetting the underproduction of Brazilian hydropower dams with floating solar. While 68% of Brazil's electrical energy comes from large dams, the researchers say there is around 12GW of underproduction of rated capacity at these facilities.

The research, titled 'Floating PV system as an alternative pathway to the Amazon dam underproduction', indicates that FPV could increase hydroelectric plant production flexibility by 76% and the capacity factor by 17.3% on average. Although the Brazilian government is planning to build more dams to meet future power demand, the study says mixed generation resources could provide an alternative approach to avoid the environmental and social impacts of these developments. The research says floating solar on dams' reservoirs leads to a "significant improvement" in the overall system reliability, minimises load curtailment and could potentially add more flexibility to the operator to dispatch power generated by hydropower plants during peak demands.

Despite the advantages of collocating solar with hydropower, developers who take on such projects are confronted with a host of challenges that are not seen at ground-mounted sites. For example, problems may arise when designing insurance policies that include liabilities for potential damage of a hydropower plant, while there may be issues surrounding permitting and environmental impacts.

Chris Buckland of Lightsource BP describes PV-plus-hydro as an "ideal situation, in that solar itself, all of a sudden has a huge battery associated with it". However, he warns that transmission connections can often be quite a long way from dams.

"The other aspect is, particularly in mid-size hydros, what you're looking at is a flooded valley, and by definition they have relatively steep sides. It's impossible to anchor floating solar, in distances of let's say 30 metres or 40 metres," he says. "Dropping anchors down vertically is not a solution that is appropriate for solar, because you really don't want it floating around like a boat, it needs to be tethered and anchored in a shape or form."

Anchoring that has to withstand waves as well as large fluctuations in water levels may also require more complete solutions, further driving up the cost of floating solar projects. One company set to tackle some of these issues is Norwegian independent power producer Scatec Solar, which struck a US$1.1 billion deal in October to acquire hydropower developer SN Power, touting the potential for floating solar on reservoirs.

"SN Power will give Scatec Solar immediate access to existing reservoirs and grid infrastructure on which to build floating PV," says Terje Pilskog, EVP project development at Scatec. "SN Power has done extensive feasibility studies on floating pilot plants in the Philippines which will give Scatec immediate practical experience to leverage."

In addition to SN Power's portfolio of hydropower assets in the Philippines, Laos and Uganda that have a total capacity of 1.4GW, the transaction includes the firm's 2.5GW project pipeline, mainly across Asia and Sub-Saharan Africa.

As well as the Philippines, Pilskog forecasts "strong growth" in the FPV sector of countries such as Bangladesh, Malaysia, Indonesia. "We see great potential in countries that experience significant power demand growth, but at the same time have limited access to large-scale land areas for traditional ground-mounted PV," he says.

According to Pilskog, two factors are driving the potential of FPV globally: solar increasingly becoming the lowest cost form of new energy; and the rapidly maturing floating PV supply chain, with installations "increasingly both sufficiently reliable and cost competitive to compete head-on with thermal generation".

Pilskog now calls for government action to help unleash the potential of floating solar. "Currently, the cost development for FPV is still lagging traditional ground-mount PV. This creates a bit of a chicken-and-egg situation, where slow adoption. Due to, for example, FPV having to compete with ground-mount PV in tenders, limits the ability to build the large-scale supply chain that can bring down costs in the mid-term. The industry and authorities should therefore seek to establish framework that enable larger-scale adoption of FPV specifically," he says.

While new policies and regulations could help industry players expand their presence in the FPV market, a lack of standards to ensure quality as well as harmonised approaches when developing projects mean investors may shy away from backing planned developments. This is one of the issues that a collaborative joint industry project (JIP) launched by DNV GL looks to address. The risk management firm has brought together 14 industry participants – including BayWa r.e., Scatec and Norwegian hydropower company Statkraft – to develop a recommended practice for FPV facilities. It will focus on five topics: site conditions assessment, energy yield forecast, mooring and anchoring systems, floating structures, and permitting and environmental impact.

"Until now, the growth of FPV has been quite impressive, especially in Asia, and has taken place without standards and guidelines," said Michele Tagliapietra, project manager of the JIP consortium. "In other markets, such as Europe, the situation is slightly different and the FPV industry has faced some obstacles particularly in permitting processes because of lack of clarity and guidelines."

The recommended practice will therefore contain requirements on what needs to be taken into account to ensure that floating projects are safe and reliable throughout their lifetime. Tagliapietra says it is "imperative" to share lessons learnt and standardise procedures to increase quality in installations and prevent an impact on trust in the FPV sector. Publication of the recommended practice, which will be freely available to download and consult, is scheduled for the first quarter of 2021.

According to Tagliapietra, the main obstacles for harnessing the full potential of FPV relate to quality and procedures. "There is still a lot to be learnt and understood, especially on aspects such as environmental impact, O&M procedures, testing, safety and durability of floating structures under environmental loads and stresses."

Thanks to the falling cost of developing projects and an increased understanding of the benefits of floating solar, Fitch Solutions expects utility-scale floating PV "to take off globally over the next few years", forecasting nearly 10GW of new additional installations by the end of 2025.

As projects mature and collaborative standards develop, governments and investors should gain more confidence to back floating PV. Reindl of SERIS believes it is necessary for the sector to "learn by doing" and by sharing the experiences. "In any case, there are lots of developments ongoing, and like in other industries, those who take early-stage risks have the chance to gain a first-mover advantage." ■