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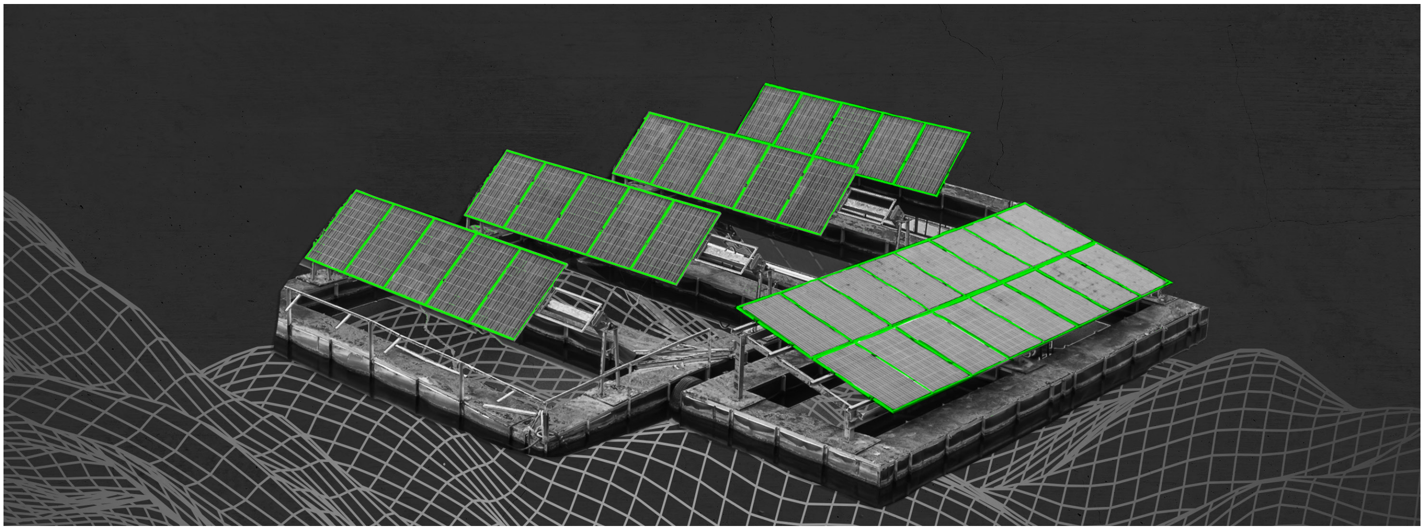


Floatovoltaics enters the renewable energy mix: Floating solar panels are now commercially viable

Asia/Pacific is taking the lead in deploying floating photovoltaic arrays as the technology advances and its economics improve

Karthik Ramachandran, Paul Lee, and Marlene Motyka

PLACES THAT DON'T have enough land to build large solar arrays will soon be able to build them on lakes and reservoirs instead. Deloitte Global predicts that the aggregate installed capacity of floating photovoltaics (FPVs)—solar panels floating on water rather than installed on land—will reach 5.2 gigawatts peak (GWp)[1] globally by the end of 2022, representing US$4–5 billion in spending.[2] Also known as "floatovoltaics," new FPV installations in 2021 and 2022 alone are anticipated to add a total capacity of 2.9 GWp, more than in the 13-year period from 2008 to 2020 combined.[3] Cumulative global FPV capacity could reach 13 GWp by 2025 (figure 1).

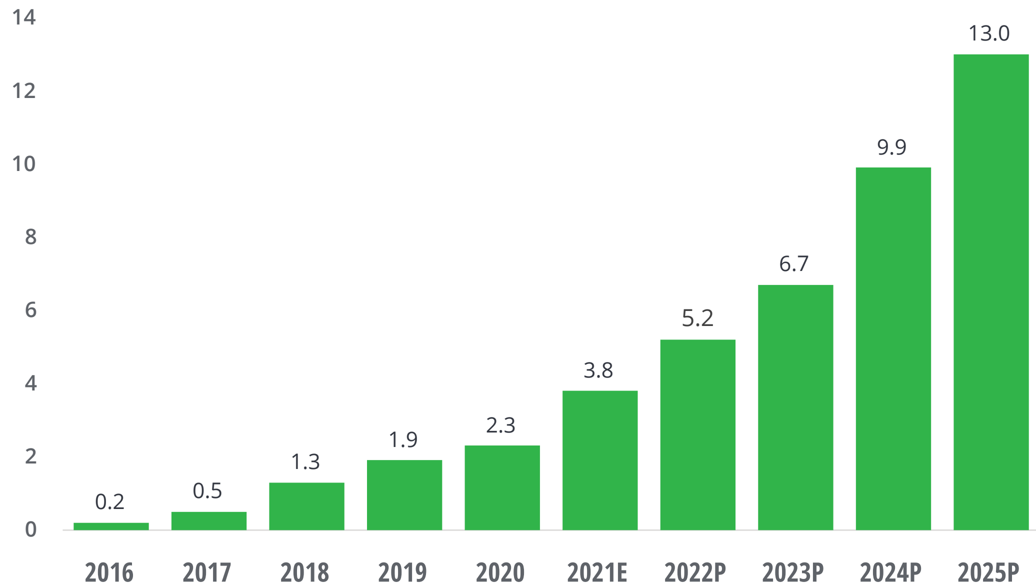
FPVs broaden the range of options for solar power generation

We predict that several factors will drive continued FPV growth across regions after an extended period

FIGURE 1

Global FPV capacity could reach 13 GWp by 2025

Global cumulative installed FPV capacity, 2016–2025 (GWp)



Note: 2021E and 2022–2025P values are based on Deloitte's estimate based on partial data for 2021, and our prediction for 2022–25.

Source: Deloitte analysis based on data from publicly available sources.

of sluggish progress.[4] In Asia/Pacific, several governments have set aggressive renewable energy (RE) targets, and solar power typically plays into these countries' plans to meet those targets. However, competing needs for scarce land from sectors such as agriculture and real estate are pushing up land acquisition costs.[5] High population density also limits land availability, making land-based PV commercially challenging. Under these circumstances, FPV will likely emerge as a feasible alternative for Asia/Pacific countries with suitable bodies of water. In addition, electricity shortages in a number of the region's developing countries, coupled with their anticipated strong economic growth, will likely escalate energy demand.[6] In fact, Asia/Pacific accounted for more than 90% of global installed FPV capacity in 2020, and it is currently leading the charge in FPV adoption, with the majority of new FPV capacity additions in the next 3–5 years expected to be in that region (figure 2).

New floating panel installations in 2021 and 2022 alone are anticipated to add a total capacity of 2.9 GWp, more than in the 13-year period from 2008 to 2020 combined.

Africa may be another market ripe for FPV. The continent struggles with unreliable electricity supplies and drought in several countries. Moreover, reservoirs face issues with evaporation due to high sunlight exposure, which floating solar panels would combat. One scientific study found that covering

FIGURE 2

Asia/Pacific is home to many of the world's largest FPV projects

Select major FPV projects with a capacity of at least 300 MWp, 2020–2025

Country	Type of water body	Capacity (MWp)	Status
China	Reservoir	320	Completed in 2020
South Korea	Estuarine tidal flat (Yellow Sea coast)	1,200	Phase 1 expected to be completed in late 2022/early 2023
Vietnam	Freshwater pond/lake	500	Expected to be completed in 2023
India	Hydropower reservoir	600	Expected to be completed in 2023
India	Hydropower reservoir	300	To be completed in 2023 (feasibility studies done)
Indonesia	Reservoir	2,200	Work to start in 2022, and to be completed during 2024–2025
South Korea	Estuarine tidal flat (Yellow Sea coast)	900	Phase 2 to be completed by 2025
Vietnam	Hydropower reservoir facilities	400	Auction to be conducted
Portugal	Reservoirs near to various hydropower plants	500	Auction to be conducted

Source: Compiled using data from publicly available sources.

even 1% of Africa's hydropower dam reservoirs with FPVs could double the continent's hydropower generating capacity to 58 GWp.[7]

FPV could also gain ground in Europe, where favorable policies toward RE, such as Fit for 55[8]—the EU's commitment to cutting emissions by 55% by 2030—could accelerate the adoption of new RE technologies such as FPV. Potential decarbonization agreements arising from the November 2021 COP26 climate change conference could also prompt greater interest. Western European countries, with high penetration of RE deployments, currently view FPV largely as a complement to existing RE installations, but some early European pilots point to growing interest. For instance, Portugal, Netherlands, France, and Norway are looking at deploying FPVs on hydropower dam reservoirs and along shorelines on the open sea. There are also ongoing pilots in the North Sea and the Adriatic Sea to assess the feasibility of using FPV to complement offshore wind farms.[9]

In several parts of the world, government support for FPVs include exclusive tenders/auctions and feed-in-tariffs to encourage new capacity buildouts. However, even with these incentives, FPV adoption will likely be slower in some regions. In the United States, for instance, a relative abundance of land continues to favor ground-mounted solar PV projects—although FPVs have started to attract some initial attention (for example, Fort Bragg announced a 1.1 MWp FPV project in late 2020).[10]

FPVs offer RE project developers distinct operational and environmental benefits that, in combination, make them commercially viable. For one thing, FPVs present a range of deployment options compared with traditional land-based solar systems. Floating panels can be set up on lakes, basins, water treatment plants, drinking water reservoirs, dam reservoirs, estuarine tidal flats, or even nearshore along a coast.[11] Pilot projects have shown that they can be deployed on fish farms as well, with no impact on the welfare of the fish.[12]

Hydropower developers and operators could also stand to gain much from FPVs. Several countries in Asia/Pacific and Europe are planning to install 100 MWp+ FPVs systems on hydropower dams to enhance hydro energy generation by reducing water loss due to evaporation.[13] Installing FPVs on a dam's reservoir requires less effort than implementing land-based solar PV, as the hydropower plant is already connected to the grid and the substation and infrastructure are also available. A hybrid hydro and solar power system can also enable overall energy output to be managed better across seasons.[14] And some hydropower plants are looking at tapping into FPV to address peak demand—by, for example, using pumped storage hydropower to store excess solar output.[15]

FPVs could also be an option for residential and small-scale users with energy requirements in the range of 5–20 kilowatts peak, as long as they are located near a water body. Even though rooftop solar panels are far easier to install, as it only involves putting a panel on top of the roof, floating panels overcome the limitations dictated by a roof's angle, which can affect energy capture and yield.[16] Moreover, FPVs on a nearby lake or reservoir could generate enough energy to power nearby residential and small-scale commercial units on a broader scale, and with greater ease than putting panels on every single building.

Of course, FPV also poses risks and uncertainties. Few technicians would likely be familiar with FPVs' operations and maintenance procedures, making their upkeep challenging; the long-term environmental impact is unknown; weather-related challenges to floating panels are of concern (e.g., strong winds in Northern Europe); and regulations and permitting for FPV projects are often complex to navigate.

Floating panels can be set up on lakes, basins, water treatment plants, drinking water reservoirs, dam reservoirs, estuarine tidal flats, or even nearshore along a coast.

For the FPV market to become self-sustaining in the longer term, FPV producers and operators likely need to experience an overall increase in demand. RE power purchase agreements (PPAs), which lock in capacity through multiyear agreements, continue to be critical in securing financing and generating revenue streams. As is the case with land-based solar PV, buyers of FPV projects will also likely be exposed to risks such as weather fluctuations and the financial and cost implications of multiyear PPAs.

Due to these factors, coupled with the fact that FPV technology is still nascent, energy producers might view FPV projects as riskier than implementing more-established, conventional RE technologies. Nonetheless, a particular FPV project's operational, environmental, and technological benefits could still outweigh the risks enough to make the project attractive to the financiers and banks that would fund it.

THE BOTTOM LINE

Energy ecosystem players—solar and hydropower producers and operators, photovoltaic system developers, enterprises, residential consumers, clean energy companies, and technology solution providers—all have an opportunity to tap into FPVs' emerging value based on each player's role in the value chain.

Technology companies could help organizations plan, develop, and deploy the foundational infrastructure for FPVs, maintaining the infrastructure once it is deployed, and measuring and monitoring its performance. Semiconductor companies could design and develop core manufacturing equipment and chipsets for solar panels. Software providers might help businesses and governments use AI-based dashboards that allow them to design, plan, review, and dynamically change their energy efficiency targets and goals for RE sources, including FPVs; they could also develop products that monitor weather and provide situational awareness when managing FPV panels. Analytics providers could partner with RE end users to offer them insights on where and how panels can be deployed, and they could help FPV operators assess grid operations and discover system issues early on.

Apart from these potential revenue opportunities, FPVs could be a part of the overall mix of clean energy investments that companies can contract for in the form of PPAs. One emerging use case is for data center and cloud service providers to tap into FPVs to supply energy for their operations. Some countries in southeast Asia are already experimenting with submersible data centers that use the surrounding water as a cooling agent. FPVs could be installed on top of or adjacent to these data centers as a backup or primary source of power.[17]

With the technology advancing and commercial interest and adoption increasing, FPV is poised to gain a firm foothold in the RE space. The day may fast be approaching when floating solar panels will play a prominent role alongside other RE sources in powering a cleaner world.

Endnotes

1. Watt-peak (Wp) indicates the maximum electrical power that one PV panel can supply—under standard temperature and sunlight conditions. Standard conditions imply a solar radiation of 1,000 watts/square meter, a temperature of 25°C or 77°F, a clear sky, and around midday/noon—for example.
2. Based on data and information from secondary research, average project cost ranges from US$80 to US$120 million for a 100 MW floatovoltaics plant. Therefore, aggregate investments could reach US$4–US$5 billion, worldwide, in 2022.
3. World Bank, *Where sun meets water: Floating solar market report*, October 30, 2018.
4. Though the first FPV installations were completed in 2007, only a little over 1 GWp of capacity had been installed worldwide through 2018.
5. For example, South Korea faced land-related issues due to its aggressive land-based solar deployment efforts. To read further: Emiliano Bellini, "Korea's South Jeolla province is becoming a solar hub," *pv magazine*, September 18, 2019.
6. As a case in point, between 2021–2025, South Korea, India, Vietnam, Thailand, and China are cumulatively planning to add more than 5 GWp of FPV capacity. South Korea alone is planning to install an additional 2.1 GWp capacity by 2030. Greater interest in FPV over offshore wind can be attributed to the relatively lower wind velocity in Asia/Pacific countries compared with what is typically seen in the wind-rich areas of Northern Europe.
7. Fred Pearce, "Floating solar ready for take-off," *Eco-Business*, May 21, 2021.
8. As part of EU's Green Deal, the EU has set a target of achieving climate neutrality by 2050. This requires current greenhouse gas emission levels to drop considerably going forward. As an intermediate step to help achieve climate neutrality, the EU has raised its 2030 climate goal, committing to cutting emissions by at least 55% by 2030. To read further: Council of the European Union, "Fit for 55," accessed October 6, 2021.
9. Deloitte analysis based on information gathered from publicly available sources.
10. Jean Haggerty, "Floating solar nearing price parity with land-based US solar," *pv magazine*, October 7, 2020.
11. EnergySage, "Floating solar: What you need to know," accessed October 6, 2021.
12. Timothy McDonald, "Could fish farms inspire the next wave of solar energy?," Tech For Impact, August 18, 2020.
13. Emanuele Quaranta, "Floating solar+hydropower hybrid projects can benefit both technologies," *Solar Power World*, May 28, 2020.
14. A World Bank study notes how hydropower and solar can complement each other. Reservoirs would retain water in summers when solar PV output is maximum. During monsoons and winters, when PV output is low and/or whenever electricity demand increases, water can be released to help increase hydropower generation. To read further: World Bank, *Where sun meets water*; Guido Agostinelli, *Floating solar photovoltaic on the rise*, International Finance Corporation, May 2020. The report by International Finance Corporation notes that a floating panel deployment in one of Portugal's hydropower facility reservoirs has found that the additional power output from solar PV arrays helps regulate the hydroelectric plant's overall output.
15. National Renewable Energy Laboratory, "News release: Untapped potential exists for blending hydropower, floating PV," press release, September 29, 2020.
16. Bruno Paixão Martins, *Techno-economic evaluation of a floating PV system for a wastewater treatment facility*, KTH Industrial Engineering and Management, 2019.
17. Deloitte analysis based on information gathered from publicly available sources.

About the authors

Karthik Ramachandran | India | karramachandran@deloitte.com

Karthik Ramachandran is a senior research manager with Deloitte's Center for Technology, Media & Telecommunications. He has more than 14 years of experience in performing industry deep-dive analyses, strategic business research, and financial benchmarking.

Paul Lee | United Kingdom | paullee@deloitte.co.uk

Paul Lee is a UK partner and the global head of research for the Technology, Media & Telecommunications (TMT) Industry at Deloitte. In addition to running the TMT research team globally, Lee manages the industry research team for Deloitte UK.

Marlene Motyka | United States | mmotyka@deloitte.com

Marlene is Deloitte's US Renewable Energy leader and a principal in Deloitte Transactions and Business Analytics LLP. She consults on matters related to valuation, tax, M&A, financing, business strategy, and financial modeling for the power, utilities and renewable energy sectors. Marlene has been at Deloitte for more than 22 years and holds a Master of Business Administration in finance from Rutgers University and a Bachelor of Science in mechanical engineering from Lehigh University.

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