Synergies of Hybridized Floating Photovoltaics

TECHNOLOGY INNOVATION

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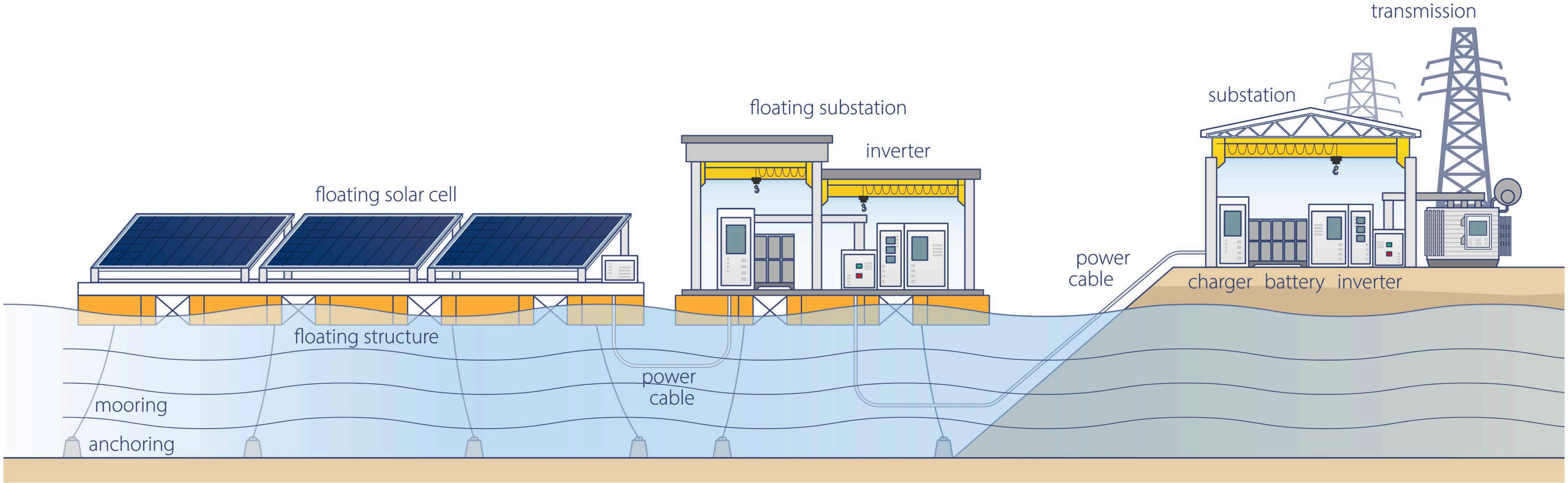
What is floating solar?

Floating photovoltaics (FPV) is a solar industry application where solar PV systems are attached to floats or pontoons placed on water bodies, whereas traditional solar PV systems are installed on rooftops or large tracts of land. The first commercial FPV system was commissioned in 2007. By 2022 global capacity expanded to over 3,800 MWdc.

What makes it hybridized?

Hybridized floating solar combines FPV with existing generation or storage. FPV is placed on inside-the-fence water bodies or hydropower reservoirs of a traditional electricity generating facility. This co-location results in additional benefits in hybridized FPV applications compared to stand-alone FPV.



Aspects of project delivery

Financial	Time	Production	BENEFITS	FLOATING SOLAR	HYBRIDIZED FLOATING SOLAR
	●		Land-use avoidance	●	●
		●	Temperature-related production enhancements	●	●
●	●	●	Modular expansion	●	●
●	●		Uses existing infrastructure		●
		●	Increased flexibility		●
		●	Increased capacity		●
		●	Increased stability		●
			CHALLENGES		
●	●		Complex, new construction	●	●
	●		Highly site-specific needs	●	●
●	●	●	Bird soiling	●	●
	●		Uncertainty	●	●

Benefits increase with hybridization

CO-LOCATING (HYBRID) OPTIONS

- Hydropower
- Pumped Storage Hydropower
- Thermal
- Offshore Wind

UNIQUE BENEFITS of co-locating floating solar with an existing generation source are discussed on the next pages.

Aspects of project delivery explained

Benefits

ALL APPLICATIONS

LAND-USE AVOIDANCE: Constructing arrays over water bodies avoids land-use conflicts, eliminates the need for soil grading, and shortens time required to prepare a site for solar deployment.

TEMPERATURE-RELATED PRODUCTION ENHANCEMENTS: Evaporative cooling from the water surface may lower module operating temperatures, which can boost PV production by up to 10% compared to ground-mounted systems. [3]

MODULAR EXPANSION: The option to start small and add modules incrementally allows for faster deployment and reduces upfront costs while retaining the option to increase capacity later.

+ HYBRIDIZED APPLICATIONS

USES EXISTING INFRASTRUCTURE: Installing a PV system where generation and inter-connection infrastructure already exists avoids the cost of constructing new systems and supporting infrastructure, like access roads and transmission lines.

INCREASED FLEXIBILITY: The option to meet demand using FPV provides generation managers a new tool to optimize and supplement existing power production.

INCREASED CAPACITY: Using FPV as a grid-tied supplement to existing generation, or as a net-metered source for plant parasitic load, allows for resources to be deployed optimally, leading to overall capacity gains.

INCREASED STABILITY: FPV provides additional power enhancing efficiency and reduces wear on the existing system, while also offering support for black-starts if the plant goes offline.

Challenges

COMPLEX, NEW CONSTRUCTION: Floating arrays need to withstand water movement, requiring new flotation devices, unique mooring and anchoring systems, and protection for electrical components from water.

HIGHLY SITE-SPECIFIC NEEDS: Mooring and anchoring systems, among the costliest components of floating solar, must be tailored to the bathymetry, water level variations and turbulence of each water body, necessitating highly site-specific installations.

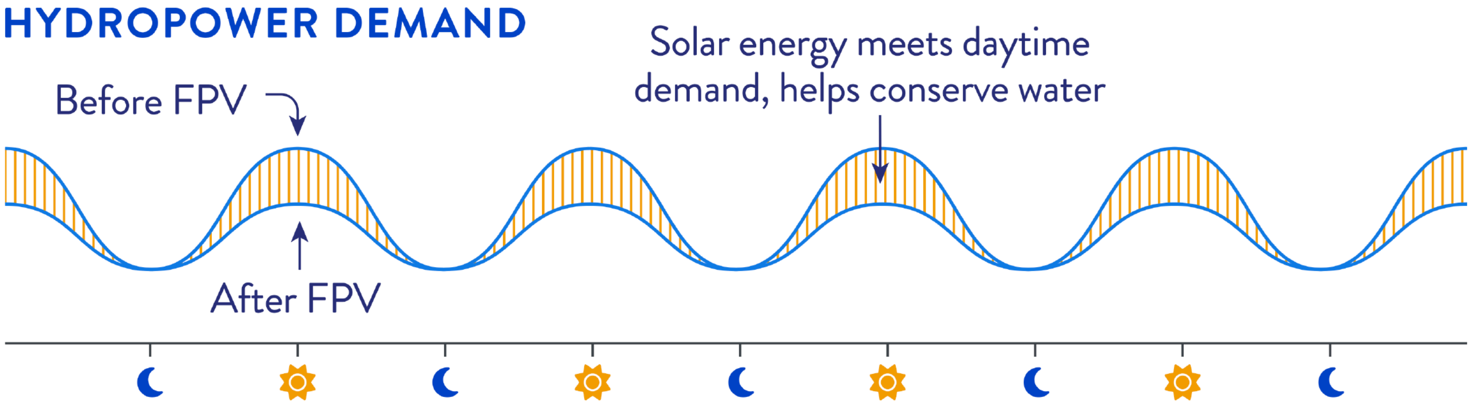
BIRD SOILING: Waterfowl waste covers PV modules resulting in limited energy production. Cleaning is eased by the availability of water on site but does require additional time and labor.

UNCERTAINTY: While early adopter challenges may ease as more FPV is installed, unstandardized safety and O&M requirements contribute to uncertainty in project risk and cost.

Hybridized FPV Applications

Hydropower + FPV: Water conservation, continuous production

Hydropower acts as a stable backup when solar energy is intermittent, and FPV helps optimize the deployment of hydropower. This synergy increases overall energy capacity as solar energy can meet daytime demand. This allows hydropower resources to be conserved for nighttime use or agricultural purposes which is valuable during dry seasons. Together, FPV and hydropower can result in a more reliable and efficient energy system.

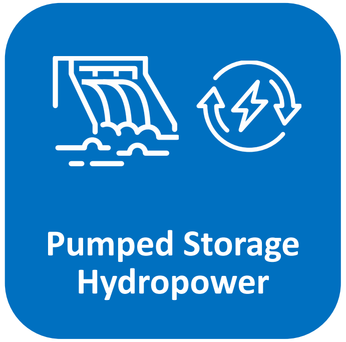


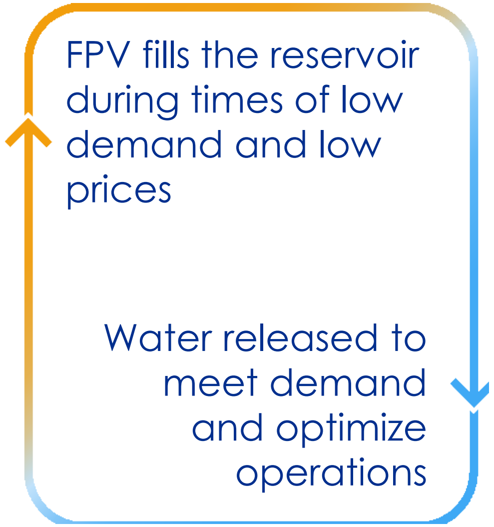
Specific Aspects of Project Delivery

Challenge: Water-level requirements

The reservoir must maintain a minimum water depth as to not strand the PV modules, constraining hydropower production during times of low water availability. Water bodies with highly-variable water levels add complexity to mooring and anchoring design, which may increase time to install and cost.

Hybridized FPV Applications





Pumped Storage Hydropower + FPV: Clean energy around the clock

FPV systems can generate electricity during peak sunlight hours, which can be sold directly or used to supplement grid power to pump water from the lower reservoir to the upper reservoir of a PSH system. The upper reservoir, filled during times of low demand, stores water until demand increases such that operations are optimized by generating hydropower with the stored water. This combination of FPV and PSH offers a flexible and reliable renewable energy solution.

Specific Aspects of Project Delivery

Benefit: Balanced Supply and Demand

Excess solar energy is used to pump water during peak sunlight hours when electricity costs are lower, which is released during times of low PV generation or high demand.

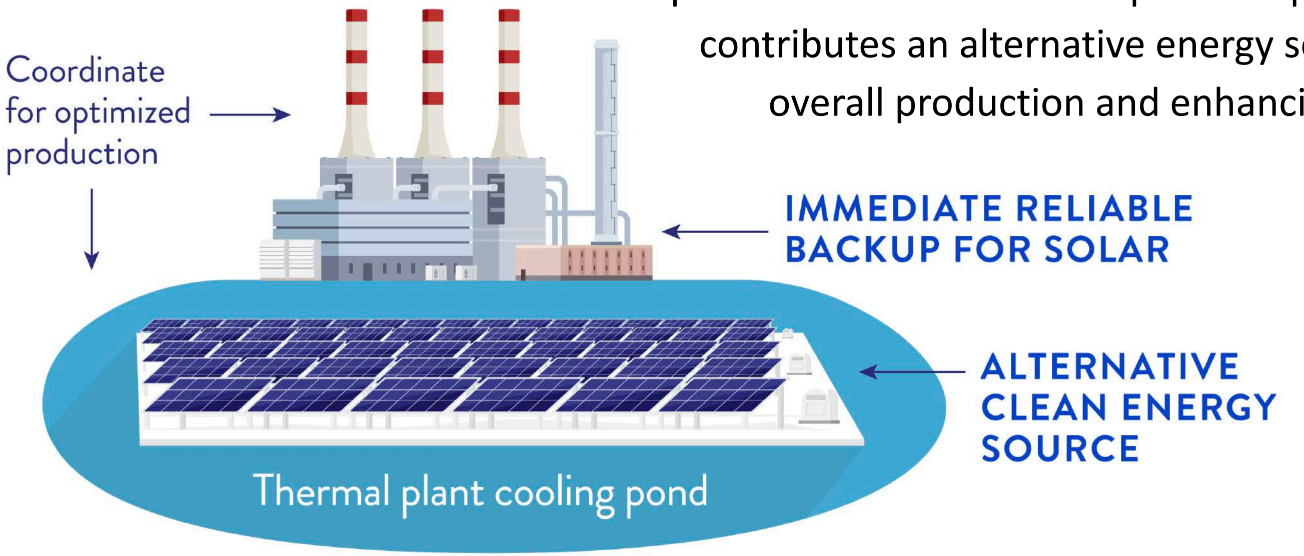
Benefit: Best Use of Interconnection Resources

Implementing FPV into hydro project sites could provide increased utilization of the rated values from the switchyard, which makes more effective use of additional capacity that may be available.

Hybridized FPV Applications

Thermal Plant + FPV: Reliability and Flexibility Enhancement

The thermal plant, which generates electricity using heat energy from fossil fuels or nuclear reactions, generally has multiple in-the-fence water bodies such as cooling towers and water storage reservoirs where FPV may be installed. This setup allows FPV to supplement the plant's power output, providing additional capacity and flexibility. During periods of solar intermittency, the thermal plant ensures a consistent power supply, while FPV contributes an alternative energy source, optimizing overall production and enhancing system reliability.



Specific Aspects of Project Delivery

Benefit: Onsite Capacity Supplement, Replacement

Carbon-free generation alternative at same site as fossil generating thermal source allows for local capacity replacement if fossil fuel source is retired and offsetting of parasitic load for plant operation, thus increasing exports to grid.

Hybridized FPV Applications

Offshore Wind

Offshore Wind + FPV: Potential for Growth

Early projects that combine offshore wind with FPV aim to leverage the consistent, strong winds at sea to balance the intermittent nature of solar energy. The key advantage of this hybrid approach is the use of existing electrical infrastructure in vast offshore areas without competing for land. However, more research is necessary to fully understand the benefits that could offset the challenges faced by developers, such as the long distances, harsh marine conditions, and the complexities of being early adopters of this technology.

Specific Aspects of Project Delivery

Challenge: Harsh Conditions

Turbulent waters and storms increase risk of damage to floating solar systems, thus requiring increased investment in design and construction to ensure stability.

Challenge: Nascent Tech

This application is less mature than others, so uncertainty about capital costs, operational costs, durability and longevity increase project risk.

Environmental impacts of FPV lack consensus

Environment

Environmental impacts of FPV lack consensus and have not been shown to differ between stand-alone and hybridized applications. Impacts depend on site- and array-specific characteristics. Percent surface area of array compared to water body is likely a determining factor in ultimate environmental impact.

Early research points to potential environmental benefits and challenges and has produced questions for further research.

Potential Impacts

Benefits

IMPROVED WATER QUALITY: Reduction of light to water may limit algae growth.

REDUCED EVAPORATION: Shading from the FPV modules may mitigate evaporation losses.

Challenges

ECOSYSTEM DISTURBANCE: Anchoring systems may lead to soil erosion, compaction, and increased turbidity.

POLLUTION: There is risk of material leaching or other pollution to the water body from arrays or pontoons.

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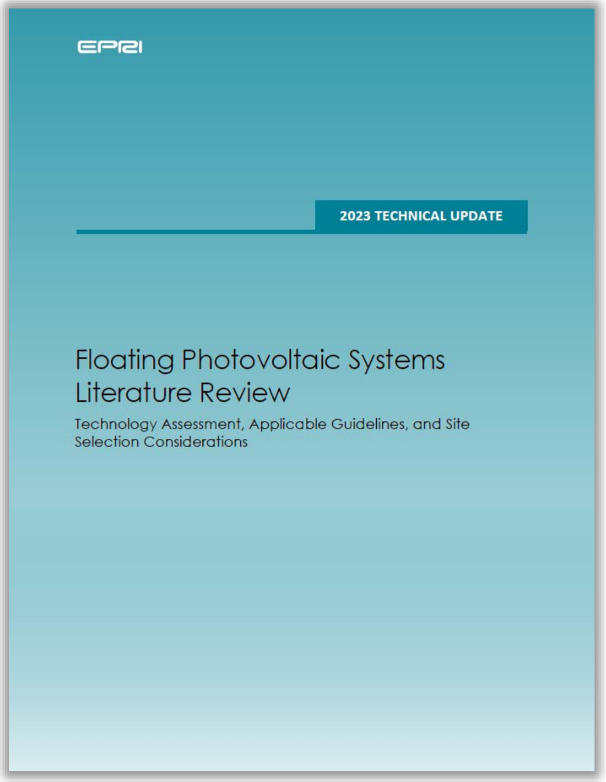
THERMAL STRUCTURE: FPV modules shield the water surface from cooling winds while simultaneously blocking warming sunlight. The direction of impact to surface temperature, vertical mixing, and therefore water body thermal structure, is site-dependent.

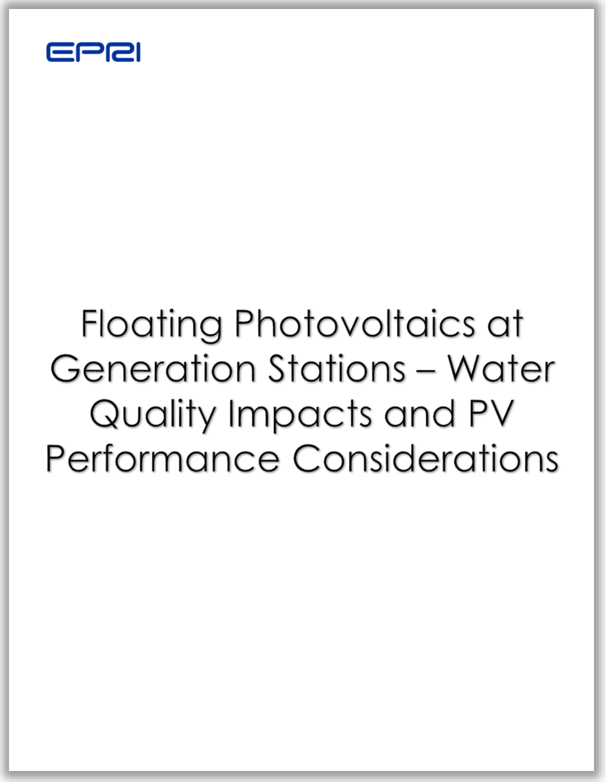
Learn More

EPRI continues to conduct research on FPV

[Program on Technology Innovation: Floating Photovoltaic Systems](). 2020. EPRI, Palo Alto, CA. 3002017712



[Floating Photovoltaic Systems Literature Review: Technology Assessment, Applicable Guidelines, and Site Selection Considerations](). 2023. EPRI, Palo Alto, CA. 3002027684.



available by end of 2024

[Program on Technology Innovation: Floating Photovoltaics at Generation Stations –Water Quality Impacts and PV Performance Considerations](). 2024. EPRI, Palo Alto, CA. 3002028898

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Acknowledgments

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