AquaPV: Regulatory and Environmental Considerations for Floating Photovoltaic Projects Located on Federally Controlled Reservoirs in the United States

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Photo by Dennis Schroeder, NREL 55200

Background

- The Department of Energy's Solar Futures Study forecasts that installed solar photovoltaic (PV) capacity must increase nearly 10x from 80 GW to 760 GW to meet the United States' 2035 electricity sector decarbonization goals.

- Ground-mounted solar alone would need 10s of millions of acres of land to meet this forecast.
  - Competing demands for land (e.g., agriculture, conservation, other development) and high land acquisition costs in certain regions of the country would make this very challenging without alternative siting approaches.

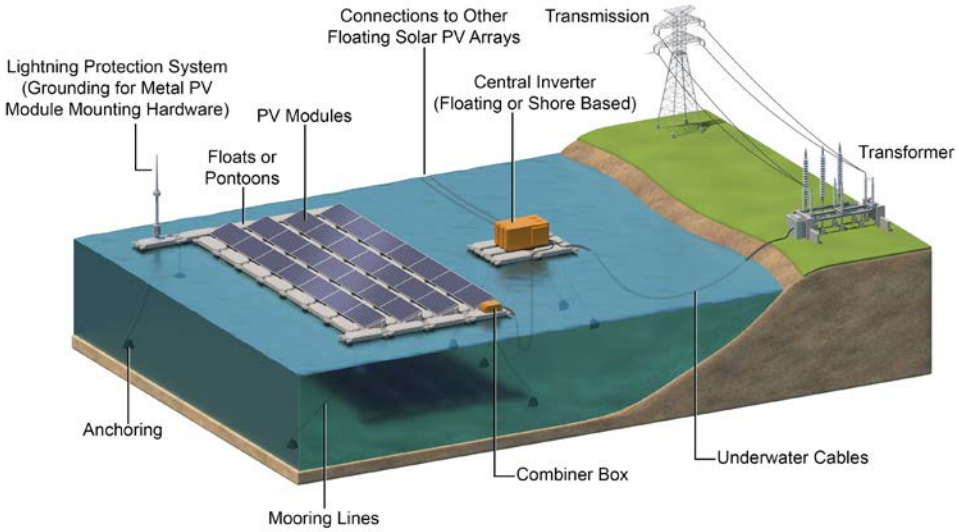
- Floating solar photovoltaic (FPV) may be one viable alternative to ground-mounted solar where it is not feasible.

Photo Credit: Josh Bauer, NREL

Floating Photovoltaic Technology

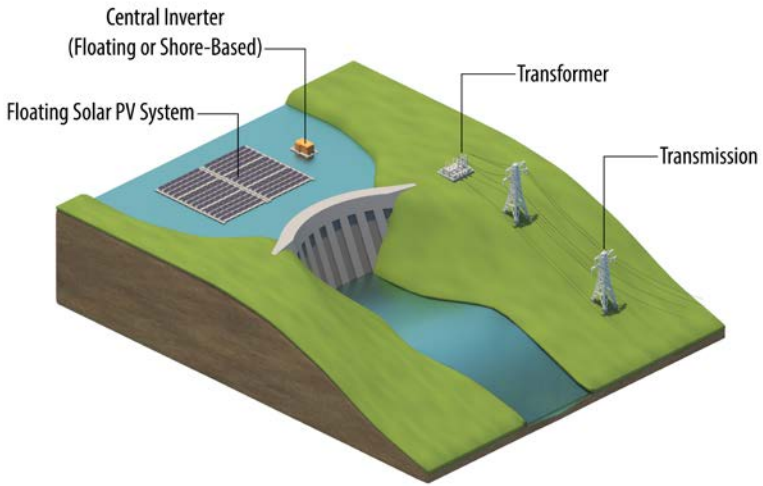
- Newer siting approach in which a solar PV array is affixed to a floating apparatus and sited on a water body (e.g., a reservoir) using anchoring and/or mooring.

- Can be a stand-alone system, co-located with hydropower, and co-located and operationally paired with hydropower and pumped storage hydropower.

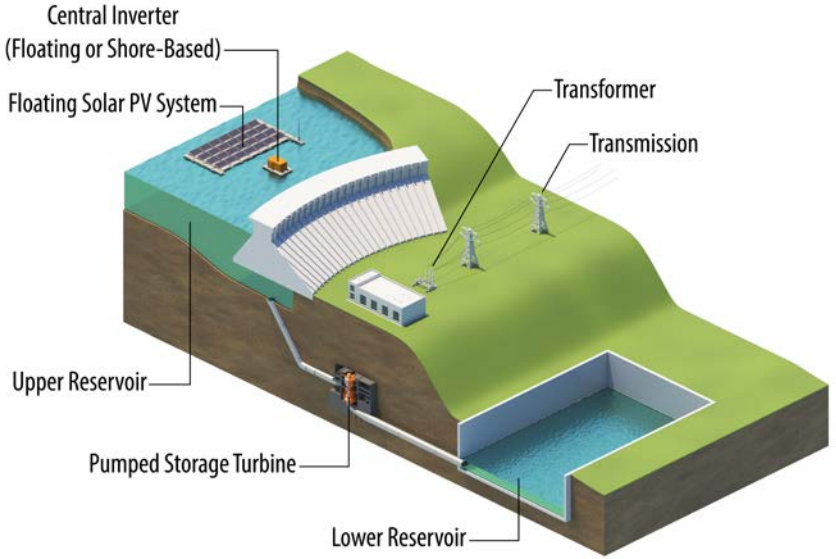


Stand-alone FPV system

Floating Photovoltaic Technology

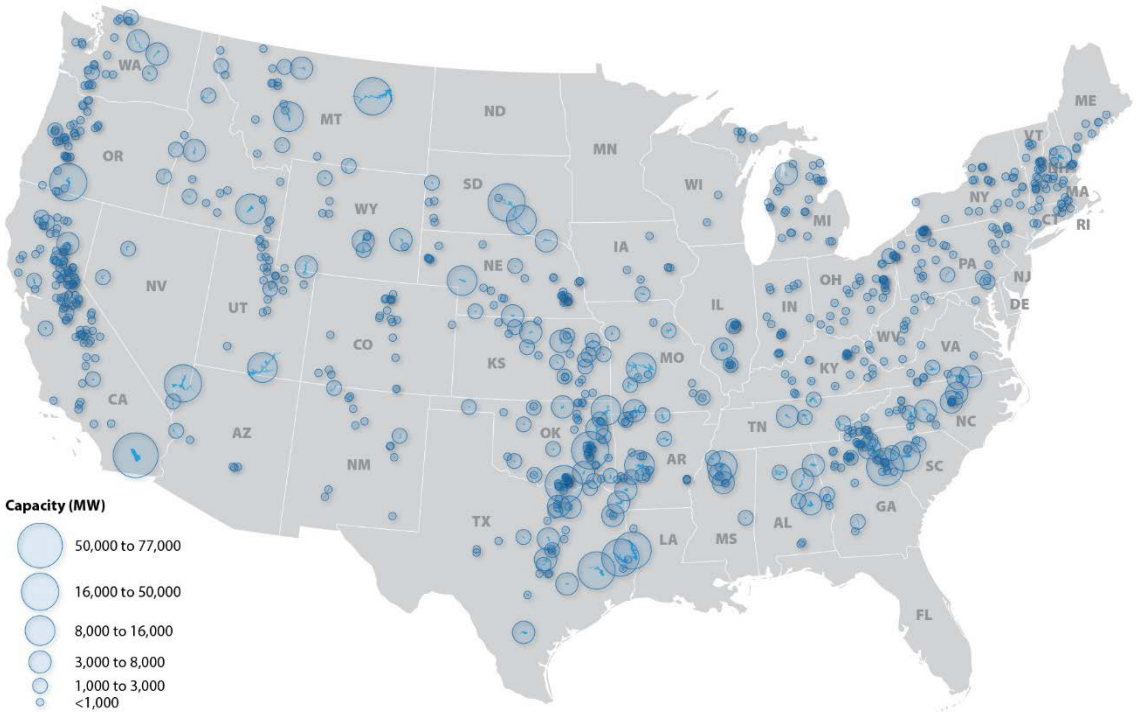


FPV at hydropower dam



FPV at PSH facility

Resource Potential at U.S. Federally Controlled Reservoirs



	25% Minimum Water Volume	35% Minimum Water Volume
2% Slope Cutoff	861 GW dc (1,221 TWhac)	961 GW dc (1,364 TWh ac)
3% Slope Cutoff	955 GW dc (1,347 TWhac)	1,042 GW dc (1,476 TWh ac)

Project Overview

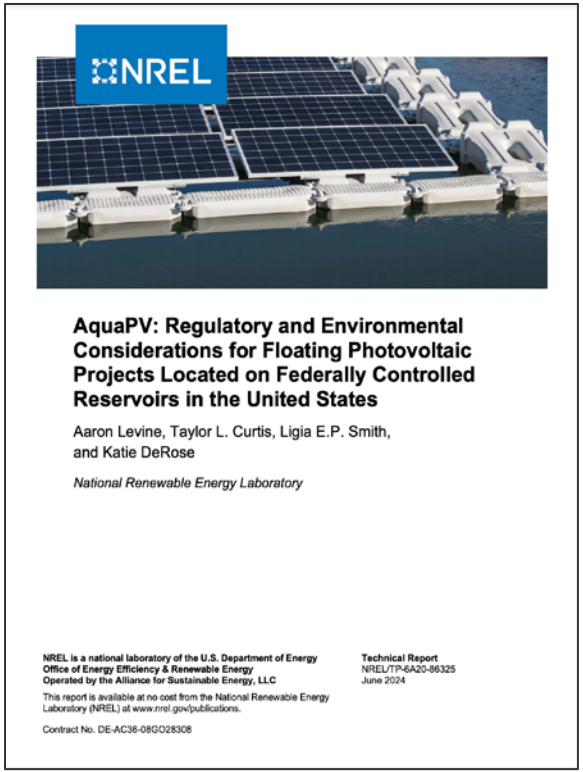
Scope of Research/Report:

- Focused on U.S. federally controlled reservoirs
  - Bureau of Reclamation (federal and nonfederal development)
  - U.S. Army Corps of Engineers (federal and nonfederal development)
  - Federal Energy Regulatory Commission (nonfederal licensed hydropower)

- Analyzed environmental and energy benefits

- Analyzed environmental and other project impacts

- Analyzed regulatory processes for approving floating photovoltaic (FPV) siting at U.S. federally controlled reservoirs.



Potential FPV Environmental and Energy Benefits/Environmental, Health, and Safety Impacts

Potential Environmental and Energy Benefits

- FPV systems require significantly less land than ground-mounted systems and reduce the need to clear, excavate, and grade land for site preparation.
- FPV systems can reduce evaporative water loss on water bodies by providing shade and acting as a windbreak across water surfaces, which may protect species habitat and provide recreational benefits for angling and boating activities. Reduced evaporative loss may also lead to improved water resource conservation, which may benefit areas experiencing drought, particularly in the western United States.
- FPV systems may Reduce environmental impacts and capital costs when paired with an existing hydroelectric or PSH facility by using existing infrastructure and grid connections.
- FPV-hydroelectric or FPV-PSH projcts may improve load planning and operational flexibility to optimize system- and facility-level load balance by using water resources during wetter daily and seasonal conditions and offsetting hydroelectric generation with PV during dryer conditions.

Potential Environmental, Health, and Safety Impacts

- Heat from PV modules may be transferred to the water body, which could impact fish, aquatic species, habitat, and water quality.
- Reflective PV modules may cause avian species to mistake FPV modules for bodies of water and attempt to land on them, which may result in strandings, injuries, or mortality.
- Coverage of the reservoir by PV modules may cause potential impacts to aquatic species, water quality, and birds due to changes in nutrient level concentrations, dissolved oxygen levels, and/or dissolved carbon levels.
- Ultraviolet degradation of high-density polyethylene floats may impact water quality.
- The addition of FPV system infrastructure may create perching habitat for predatory bird species (e.g., raptors, cormorants), which can impact the mortality rate of other avian species as well as aquatic species

Potential Environmental, Health, and Safety Impacts

- Introduction of overwater structures may potentially result in the damage or removal of riparian habitat and disrupt migration routes for terrestrial and aquatic species.
- Depending on project location, siting, and percentage of reservoir coverage, the addition of FPV could affect reservoir aesthetics and recreation (e.g., boating, fishing) opportunities and/or create a potential hazard for recreational users (e.g., boating collisions).
- Intemperate weather (e.g., flash flooding and storms) could cause FPV structures to become unmoored, causing damage that inhibits the use of existing dam infrastructure and creating human safety concerns.
- FPV could be incompatible with existing reservoir operations, including irrigation, hydropower generation, flood control, and navigation.

Other Considerations

- Some types of reservoirs may be unsuitable for FPV development due to their location or site-specific attributes, particularly reservoirs subject to large fluctuations in fill level.
  - E.g., some Bureau of Reclamation reservoirs see operational fluctuations in surface water elevation of 50-200 feet or more.

- Interviews with NGO staff focused on river restoration and removal of non-beneficial dams expressed concern that the addition of FPV to an existing hydroelectric dam could provide an economic incentive to extend the lifespan of older and/or arguably environmentally unsound hydroelectric dams that might otherwise be considered for dam removal.

Regulatory Authorizations for FPV Development at U.S. Federally Controlled Reservoirs

General Framework

- **FERC Regulatory Considerations:** FERC has authority over the construction, operation, and maintenance of FPV developed at a FERC-licensed hydroelectric or PSH project that is determined to be "a miscellaneous structure used and useful" in connection with the hydroelectric project or that is within the jurisdictional boundary (i.e., FERC license boundary) utilizing project lands and waters.

- **Reclamation Regulatory Considerations:** Reclamation has authority over the construction, operation, and maintenance of stand-alone FPV, co-located FPV-hydroelectric, or co-located FPV-PSH projects sited at Reclamation reservoirs subject to Reclamation jurisdiction (i.e., Reclamation reservoirs where FERC licensing jurisdiction has been withdrawn).

- **USACE Regulatory Considerations:** USACE has authority over the construction, operation, and maintenance of stand-alone or co-located federal FPV-hydroelectric sited at USACE reservoirs. In addition, for nonfederal hydropower, a co-located FPV-hydroelectric or FPV-PSH facility sited at a USACE reservoir with a proposed or existing FERC-licensed hydroelectric or PSH facility will require both a USACE authorization and a FERC authorization.

Authorizations to Develop Floating Photovoltaic

Summary of federal agency, state agency, and Indian Tribe roles under federal statutory authorizations for FPV project development

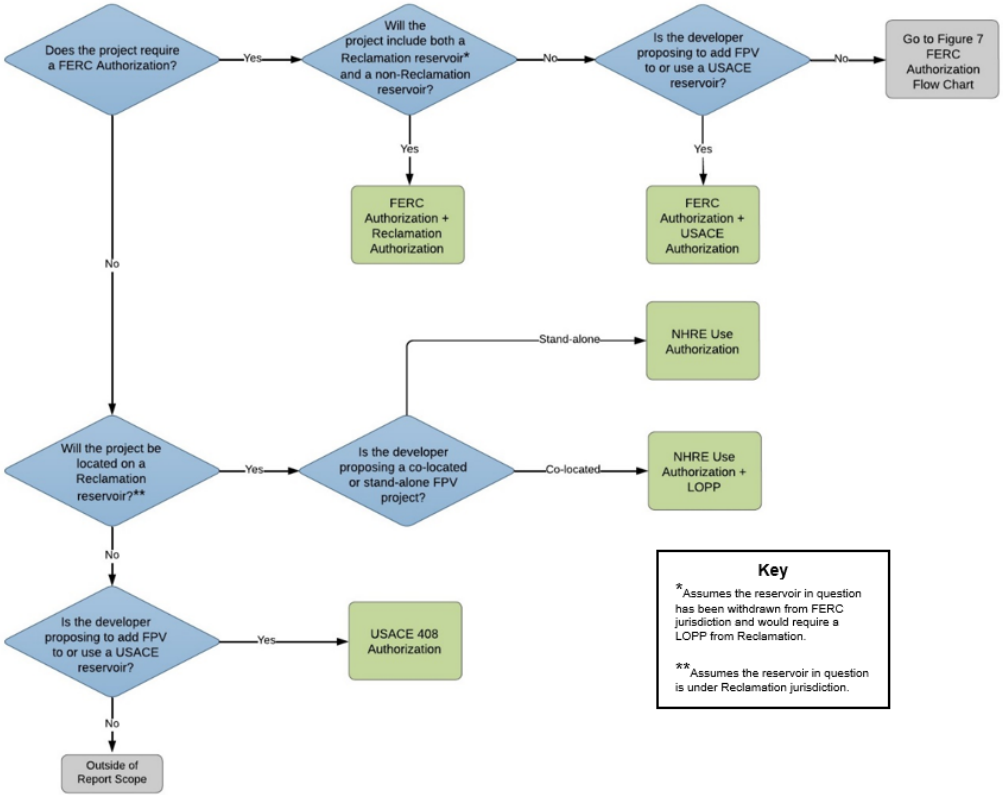
	FERC	Reclamation	USACE	BIA	BLM	EPA	NOAA Fisheries	NPS	USFS	USFWS	Indian Tribe	State Agency
Infrastructure Authorizations and Licenses												
FPA Original or New License	●											
FPA Non-Capacity Amendment	●											
NHRE Use Authorization		●										
Lease of Power Privilege		●										
RHA Section 14 "Section 408" Authorization			●									
Land Access												
Rights of Way				● [c]	●						● [c]	
Special Use Authorization									●			
Biological Resources Protection												
Endangered Species Act Section 7							● [c]			● [c]		
Other Biological Species Acts (BGEPA, EFH)							● [c]			● [c]		
Pre-Existing Land Use and Natural Resource Protection												
CZMA												●
WSRA Section 7					● [c]			● [c]	● [c]	● [c]		
Water Quality												
CWA Section 401						● [a]					●	●
CWA Section 404			●									● [d]
Cultural Resources												
NHPA Section 106	●	●	●								○	○
Environmental Review												
NEPA	● [b]	● [b]	● [b]		○	○	○	○	○	○	○	○

● = Primary Permitting Role
○ = Cooperating Permitting Role

a Authorized states and Indian Tribes are generally responsible for issuing Clean Water Act Section 401 water quality certifications or waivers; however, in cases where a state or Indian Tribe does not have authority, EPA is responsible for issuing a certification or waiver (33 U.S.C. § 1341).
b A lead agency or agencies takes primary responsibility for preparing a NEPA document. Federal, state, or Tribal authorities may act as cooperating agencies if involved in the same action.
c Primary responsibility is dependent on the type and/or location of the resource and who manages it.
d The states of Florida, Michigan, and New Jersey have assumed the CWA 404 program from USACE.

Authorizations to Develop Floating Photovoltaic

Army Corps of Engineers, Bureau of Reclamation, and FERC Authorizations



Concluding Thoughts

Three Big Takeaways:

1. Technical potential for FPV is promising, but environmental, health, and safety impacts as well as regulatory processes and timelines may limit real world deployment.

2. More research into both environmental benefits and environmental, health, safety impacts are necessary.

3. Despite these uncertainties, FPV appears to be a viable alternative to ground-mounted PV under certain conditions where ground-mounted solar is not feasible due to land availability or acquisition costs and its future in the United States could be bright.

Download the Report!

Thank You!

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