Framework for Evaluation of Floating PV Project Proposals: A Guide for US Federal and State Agencies

Presented By

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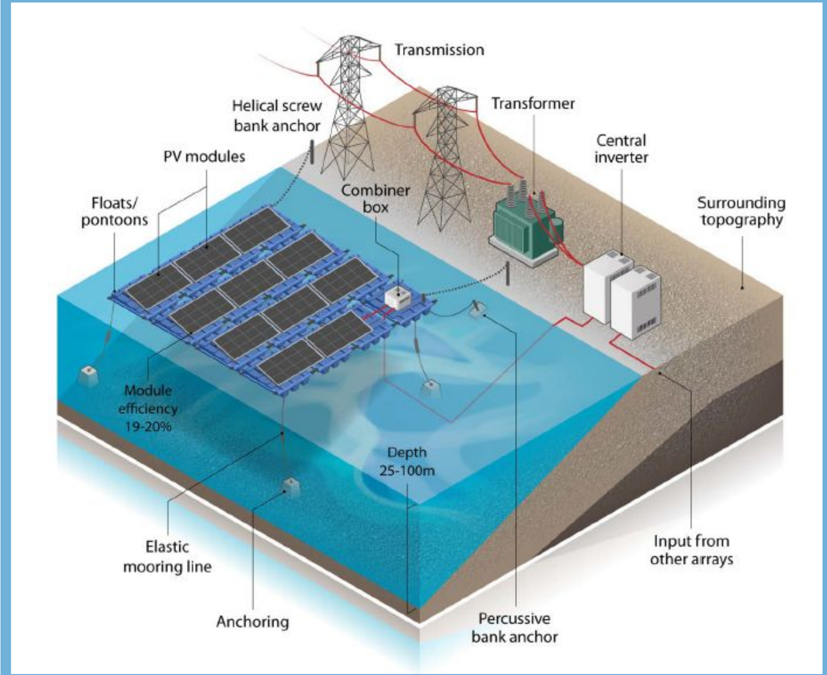


Schematic of an FPV system

Image Credit: Alfred Hicks, NREL

WHAT?

Generating power by strategically placing (floating) PV panels on still water bodies such as lakes, ponds, reservoirs, and oceans.

SIGNIFICANCE

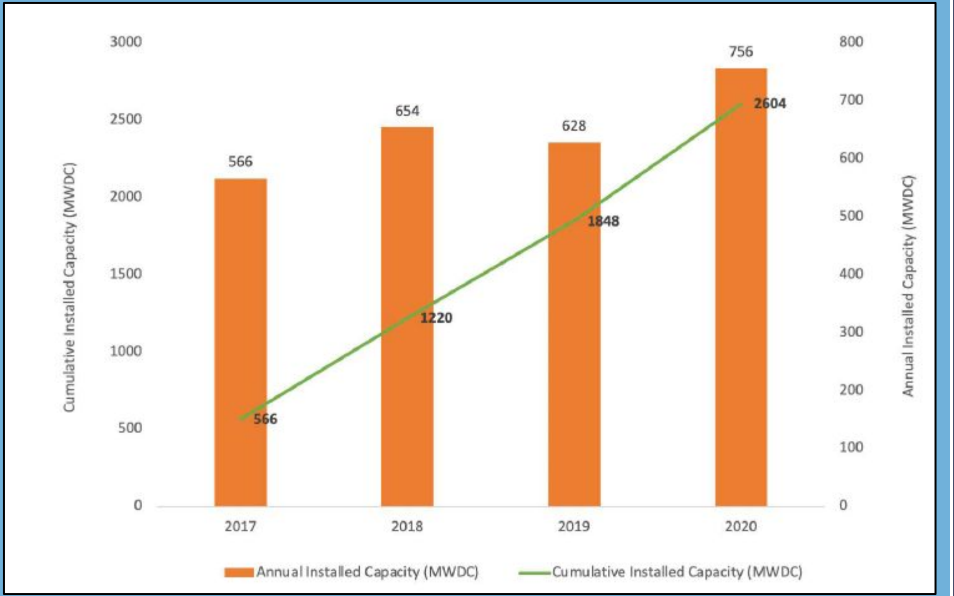
- 1.5 to 22% (Spencer et al) increased energy yield due to the cooling effect of water.
- Reduced land area usage.
- Lesser obstructions for incoming irradiation
- Faster completion time than their land-based PV - 30 MW has possible completion time of 8 weeks for completion (DOE, 2022).

WHERE?

- Regions with high population densities, limited availability of land, and abundant water resources.
- Sectors such as Municipal wastewater, Agriculture, Aquaculture (Aquavoltaics), and Coastal resources.

GLOBAL OUTLOOK

- The total installed capacity for FPV globally has risen from 6 megawatts (MW) to 2,579 MW from 2013 to 2021, respectively (Reindl and Paton 2020).
- The global FPV market predicted to grow at a CAGR of 16.89% and reach an estimated $775.85 million by 2024 (Infiniti Research, 2022).



Annual global FPV capacity, 2017–2020 (Cox 2021)

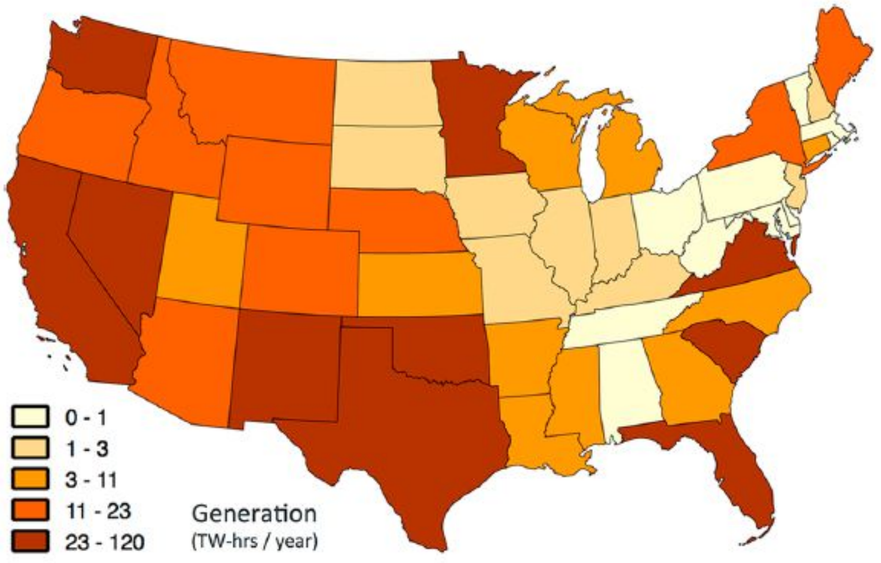
UNITED STATES OUTLOOK

- From 2 in 2016 to 20 in 2020, the number of FPV projects in the US increased to a total capacity of 12 MW (V. Ramasamy, 2021 - NREL).
- 24,419 man-made water bodies in the contiguous US are suitable for FPVs and covering only 27% of the area can produce equivalent to 10% of 2018 national generation statistics (418 TWh) (Spencer 2018 - NREL) .

Table 1. U.S. FPV Projects as of March 2021

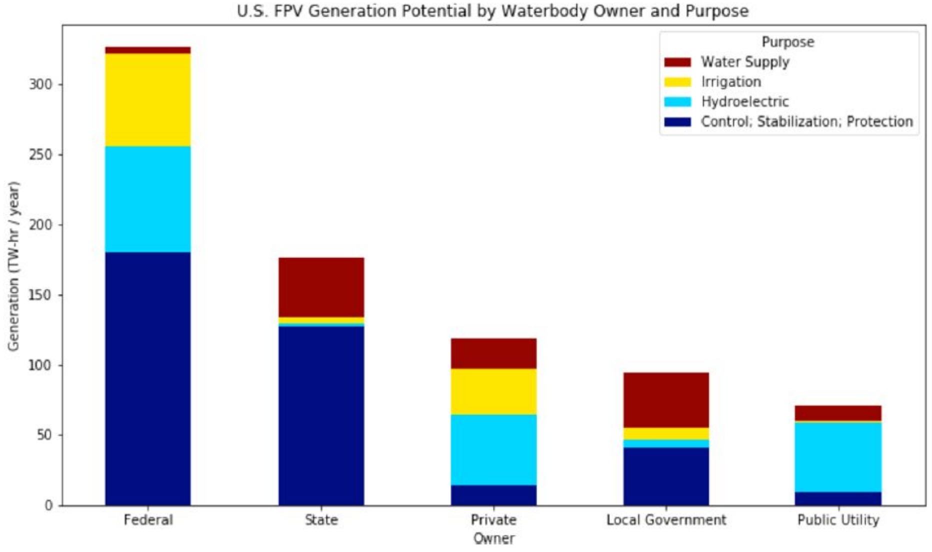
Location	MW_{DC}
Healdsburg, California	4.78
Sayreville, New Jersey	4.40
Windsor, California	1.78
Gidding, Texas	0.99
Altamonte Springs, Florida	0.96
Dixon, California	0.61
Kelseyville, California	0.25
Orlando, Florida	0.25
Miami Airport, Florida	0.15
Orlando Airport, Florida	0.13

U.S. FPV Projects as of March 2021 (<100 kW)
(V. Ramasamy, 2021 - NREL)



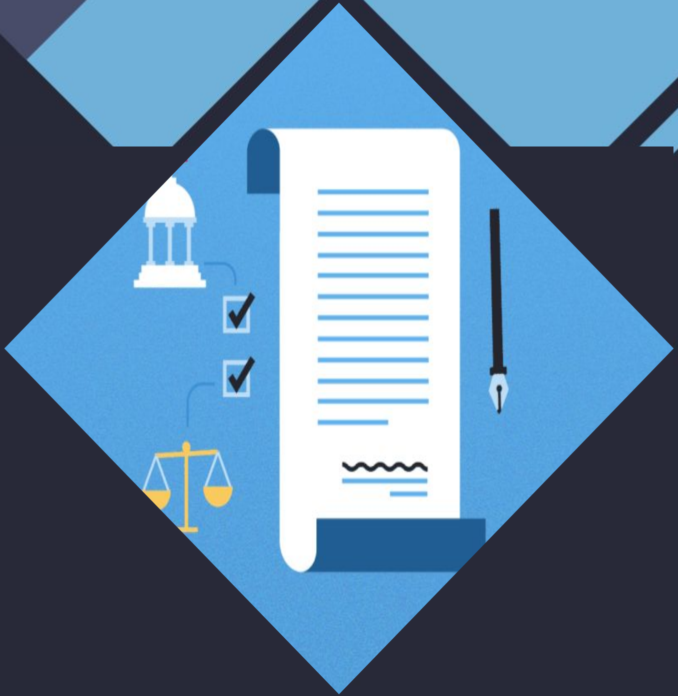
Potential annual generation of FPV systems covering 27% of feasible U.S. water bodies (Spencer 2018 - NREL) .

Potential annual generation of FPV systems covering 27% of feasible U.S. water bodies, categorized by the primary purpose and primary owner of the water bodies (Spencer 2018 - NREL).



Need for a Framework

- FPVs have higher upfront costs than land-based PV and hence adequate allocation of funds becomes imperative.
- There is an abundance of climate funds and subsidies or grants offered by state and federal agencies for solar development.
- Land-based PV has been explored and developed over the years, however, a holistic framework to evaluate such proposals for FPV does not exist.



OBJECTIVE STATEMENT

"This paper aims to present a viable framework to evaluate the deployment of FPV solutions in a certain geographical area and assess its potential, reducing the overall complexities associated with evaluating projects in different areas with varying climate factors and economic scales and providing a consistent framework to benchmark projects."

Methodology

Questionnaire

The framework is complemented with a supporting questionnaire. It collects the basic information of the region representative and the geographic, demographic, technical and financial inputs required for a fair evaluation. It is limited to collecting the data available to the citizens through government offices or open source platforms.

Parameter Selection

Recent studies - only technical parameters under consideration. No existing frameworks take demographic and social impact parameters into account. When considered, these parameters outweigh the financial costs for the project since **the impact created by the FPV on the community can be far greater than what it costs to build the project.**

Assignment of Weights

The core of the model provides weights to each parameter (taken as input from the applicant or calculated) by suitable prioritization.

Questionnaire

Geographic and Demographic

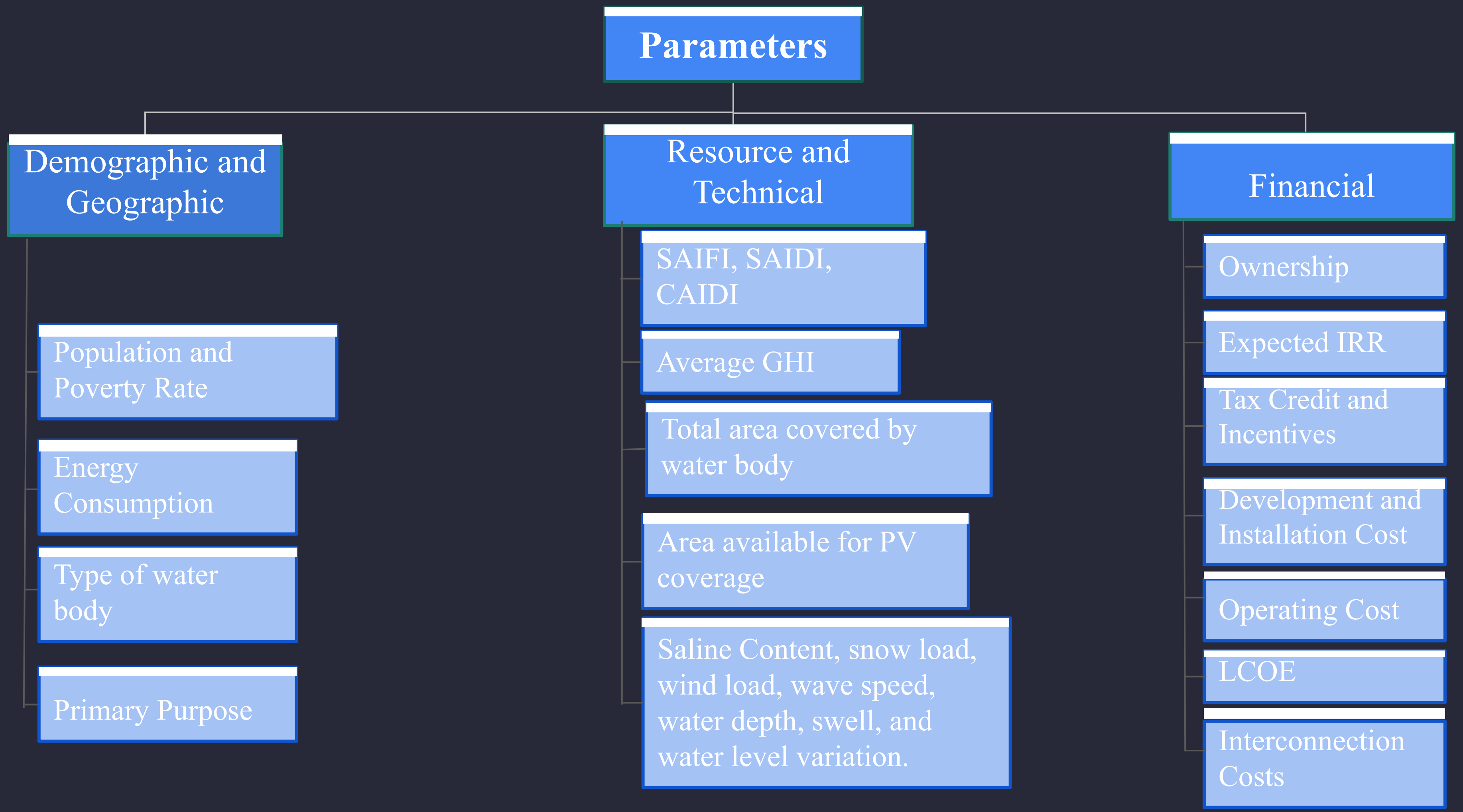
S. No.	Parameter	Cross-check reference
1.	*Population*	https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html
2.	*Poverty Rate*	https://data.ers.usda.gov/reports.aspx?ID=17826
3.	*Latitude and Longitude*	https://www.google.com/maps/
4.	*Elevation*	https://www.freemaptools.com/elevation-finder.htm
5.	*Snow Load*	https://hazards.atcouncil.org/#/
6.	*Wind Load*	https://hazards.atcouncil.org/#/
7.	*Wave Speed*	https://waterdata.usgs.gov/nwis
8.	*Water Depth*	https://waterdata.usgs.gov/nwis
9.	*Swell*	https://waterdata.usgs.gov/nwis
10.	*Water level variation*	https://waterdata.usgs.gov/nwis
11.	*Environmental considerations*	https://www.epa.gov/national-aquatic-resource-surveys/nla

Technical

S. No.	Parameter	Cross-check reference
1.	*Energy Consumption*	https://data.openei.org/submissions/149
2.	*Utility*	https://www.eei.org/-/media/Project/EEI/Documents/About/EEI-Member-Map.pdf ;
3.	*SAIFI*	Reported by utility
4.	*SAIDI*	Reported by utility
5.	*CAIDI*	Reported by utility
6.	*Grid coverage*	https://www.epa.gov/sites/default/files/2019-10/documents/interconnection_plugging_re_powering_sites_into_the_electric_grid_oct2019_508.pdf ;

Financial

S. No.	Parameter	Cross-check reference
1.	*Expected IRR*	Decided by owners
2.	*Interconnection cost*	Reported by utility
3.	*ITC Rate*	30% or 2.75c/kWh https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses
4.	*RECs ($/kWh)*	$0.0066 - https://www.nrel.gov/docs/fy22osti/81141.pdf
5.	*Interest rate of term debt*	5% - https://www.nrel.gov/docs/fy22osti/80695.pdf
6.	*Inflation Rate*	2.5% - https://atb.nrel.gov/electricity/2022/definitions
7.	*PPA Escalator*	Decided by owners
8.	*Capacity Factor*	https://www.eia.gov/todayinenergy/detail.php?id=39832
9.	*O&M Costs*	https://www.nrel.gov/docs/fy22osti/80695.pdf
10.	*Corporate Tax Rate*	25.74% - https://www.nrel.gov/docs/fy22osti/80695.pdf

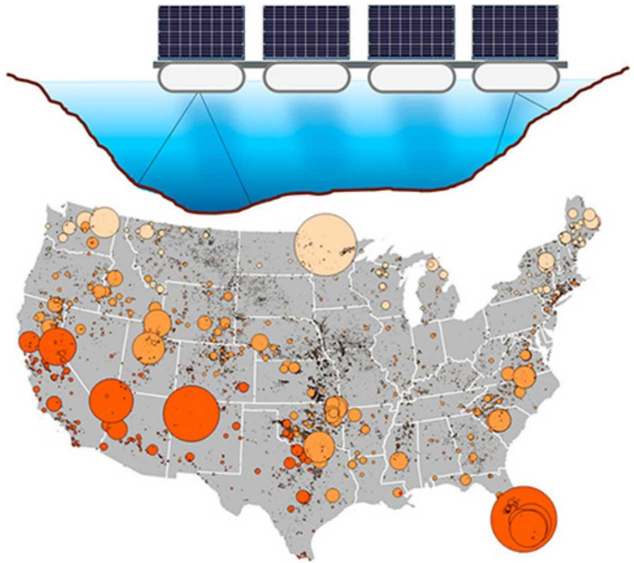

Parameters
Demographic and Geographic
Population and Poverty Rate
Energy Consumption
Type of water body
Primary Purpose
Resource and Technical
SAIFI, SAIDI, CAIDI
Average GHI
Total area covered by water body
Area available for PV coverage
Saline Content, snow load, wind load, wave speed, water depth, swell, and water level variation.
Financial
Ownership
Expected IRR
Tax Credit and Incentives
Development and Installation Cost
Operating Cost
LCOE
Interconnection Costs

Assignment of Weights

Table 1. Assigned weightage and percentage contribution for considered KPIs.

Category	KPI	Unit	Weightage	Contribution %
Demographic/Geographic	Population Size	Million	5	2.86
	Poverty Rate	%	7	4.00
	Energy Consumption	kWh	7	4.00
	Type of water body		9	5.14
	Proximity between the neighborhood center and the system	Miles	5	2.86
	Primary purpose		10	5.71
Resource/Technical	Annual average GHI	W/(m^2)	9	5.14
	Presence of aquatic life	Yes/No	7	4.00
	Protected area	Yes/No	10	5.71
	Energy Yield	kWh/kWp	8	4.57
	Area available for PV coverage	sq. meter	9	5.14
	SAIDI, SAIFI, CAIDI		6	3.43
	Grid Coverage	% of houses with access to electricity	7	4.00
	Interconnection facility	Yes/No	8	4.57
	Natural disaster prone		10	5.71
Financial	Ownership type	Public/Private/Joint	6	3.43
	Expected IRR	%	7	4.00
	Development and Installation Costs	$	8	4.57
	Operating Cost	$	9	5.14
	Interconnection Cost	$	7	4.00
	LCOE	$	9	5.14
	Total		175	100

Policy Suggestions



NREL has identified almost 25,000 human-made bodies of water that would be suitable for floating PV, yet there are currently less than 10 installments across the country. *Image by NREL*

- Specific Regulatory Framework
  - Streamlined permitting process
  - Establish environmental and safety standards
- Financial Support
  - Incentives, grants, and innovative financing mechanisms for R&D
- Infrastructure and Grid Integration
- Collaborative partnerships to drive community development and clean energy generation

Limitations

- Locked data and paywalls restrict framework and market analysis.
- Weight assignment based on existing literature, requires tailoring for projects.
- Limited availability of technical parameters in the public domain.
- Project-specific characteristics may change, requiring adaptable framework.
- Challenges in accessing and updating data, evolving technical requirements.

Further Work

- Examination of existing FPV projects and their community impact.
- Extension of metrics and new weights for parameter validation.
- Comparative analysis between two potential locations.
- Elaboration of policy framework based on existing solar legislation.
- Consideration of granular financial parameters during project development phase.

References

Cox, Molly. 2021. Floating Solar Landscape 2021. United States: Wood Mackenzie. https://www.woodmac.com/reports/power-markets-floating-solar-landscape-2021-476537.

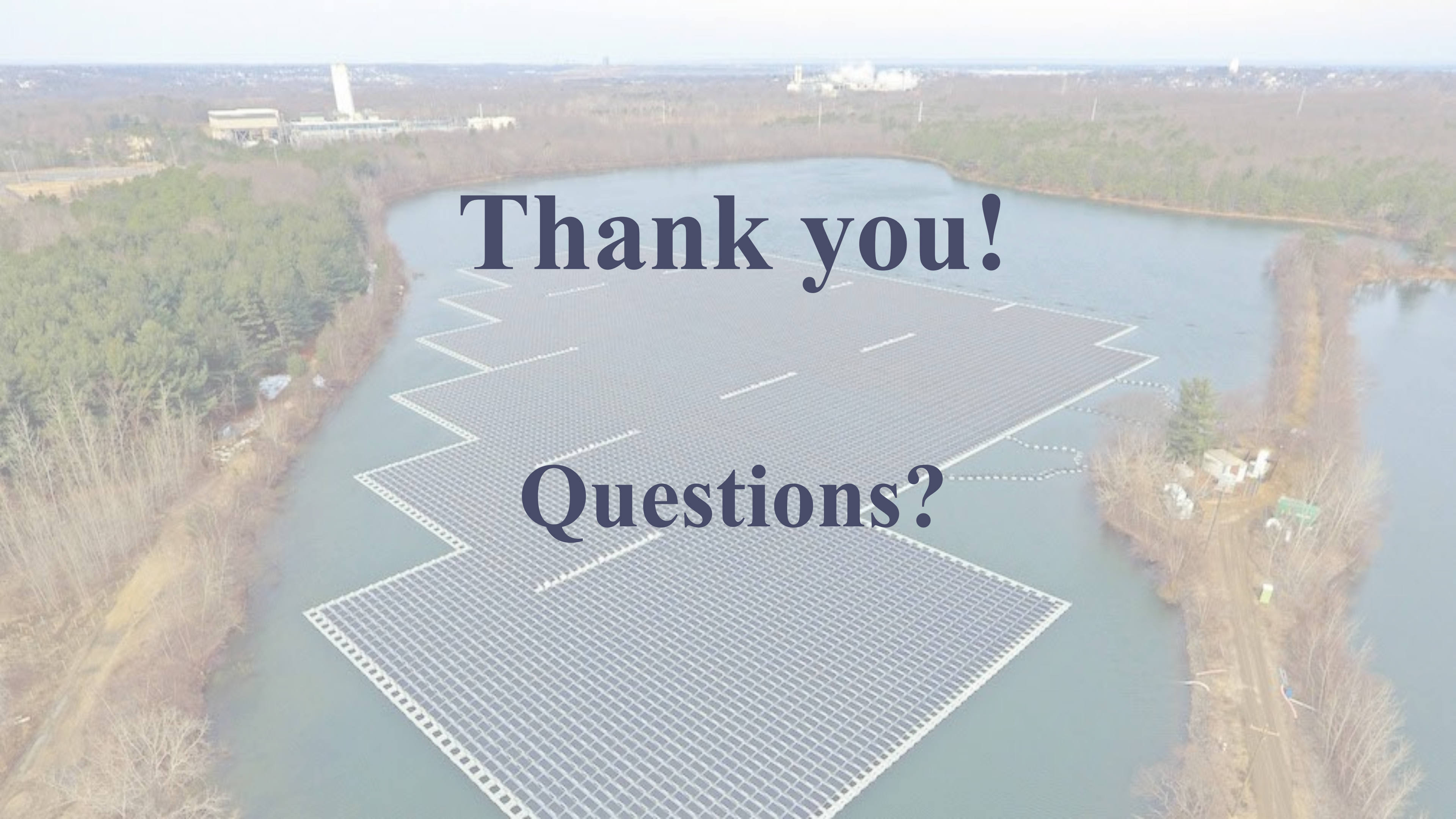
Department of Energy (USA) and Dawnbreaker. Market Research Study: Floating Solar Photovoltaics (2022). https://science.osti.gov/-/media/sbir/pdf/Market-Research/SETO---Floating-Solar-Photovoltaics-August-2022-Public.pdf

Infiniti Research, Global Floating Solar Panels Market 2022-2026, Technavio (2022). https://www.marketresearch.com/Infiniti-Research-Limited-v2680/Global-Floating-Solar-Panels-31324059/

Reindl, Dr Thomas, and Celine Paton. 2020. “Where Sun Meet Water: Global Market Status, Project Database and Economics.” Keynote presented at the Solarplaza 2020 Floating Solar Conference, Online, November 3.

Ramasamy, V., & Margolis, R. (2021). Floating Photovoltaic System Cost Benchmark: Q1 2021 Installations on Artificial Water Bodies (NREL/TP-7A40-80695, 1828287, MainId:77479; p. NREL/TP-7A40-80695, 1828287, MainId:77479). https://doi.org/10.2172/1828287

Spencer, R. S., Macknick, J., Aznar, A., Warren, A., & Reese, M. O. (2018). Floating Photovoltaic Systems: Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental United States. Environmental Science & Technology. https://doi.org/10.1021/acs.est.8b04735


Thank you!
Questions?