Floating Solar: Overview of NREL Research and Initial Findings

ISES + GSC FPV Webinar

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Concept Note: International Applications for Floating Solar

- Floating solar photovoltaics (FPV) are becoming an increasingly competitive option; however, the technology is still nascent, and many potential adopters have questions about the underlying technology, its benefits, and how to analyze it appropriately.
- NREL is a leader in FPV research and is developing implementation, analysis, and research collaborations to further advance the technology and support global deployment.

Analysis

- How does FPV impact power system operations, and what benefits does it provide?
- What are the costs and benefits of co-locating FPV with hydropower?
- What tools can be developed for FPV analysis, or how can existing tools be used?

Implementation

- Identify FPV investment opportunities and technical potential in a given area.
- Conduct a techno-economic assessment of potential projects using NREL's established methodology.
- Identify unique regulatory and policy issues that need to be addressed for deployment.

Monitoring and Evaluation

- Monitor existing systems to document system output performance benefits.
- Validate and quantify the environmental benefits of FPV related to reduced water evaporation and reduced algal growth.

Technology Research

- Research and development of built-for-purpose PV and supporting systems for FPV
- Explore FPV system designs that reduce equipment weathering and erosion.

Figure. Potential FPV Research and Analysis Topics

Full text available here

NREL Point of Contact:
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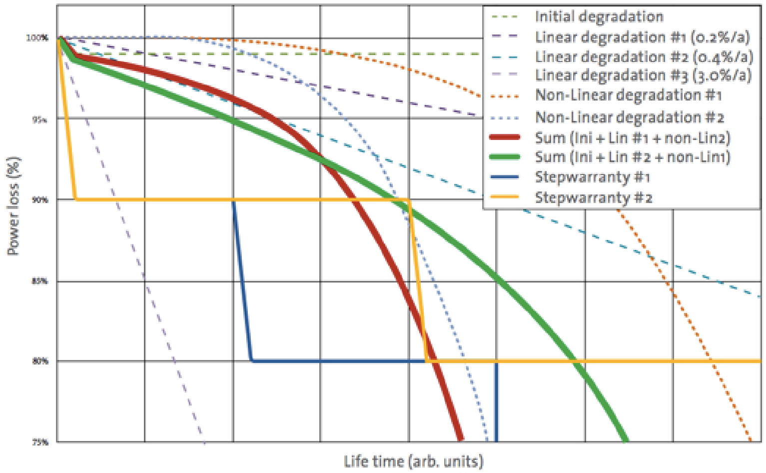
Contents

Floating Solar System Reliability and Degradation

National:
Reliability and Degradation Rates of Floating Solar

Research Objectives:

1. Examine the performance, durability, water quality impacts, and biodiversity interactions of FPV systems through monitoring and field surveys of four existing FPV sites in the U.S.
2. Compare FPV system performance with nearby land-based PV systems



Partners:

1. Florida Solar Energy Center
2. University of California-Davis

Status: Underway

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Floating Solar Co-Benefits

Float or Flop:

A Systematic Review of Purported Co-Benefits of Floating Photovoltaics

Research Objectives:

1. Review, verify, and consolidate data and information on reported floating solar co-benefits
2. Identify potential gaps in evidence for potential solar co-benefits

Key Findings:

1. Confirmed co-benefits include increased efficiency, reduced land use, and ease of installation
2. Some co-benefits are supported in theory
   - ➢ Such as reduced Evaporation, improved power quality, reduced curtailment (hybrid), among others
3. Others cannot be confirmed by available studies and data.
   - ➢ Such as reduced evaporation, improved water quality, among others
4. Draft. Do not cite; results will be published soon.

Co-benefit	FPV	Hybrid	Values	References
Power				
Increased Panel Efficiency (lower operating temperature)	+	T	5% - 11%, >5°C	(H. Liu et al. 2018; R. Cazzaniga et al. 2012; Ferrer-Gisbert et al. 2013; Trapani and Millar 2013; Choi, Lee, and Kim 2013)
Pack PV panels more Densely	+	+	0° tilt for density	(Redón Santafé et al. 2014; Trapani and Millar 2013; Perez et al. 2018)
Reduced Shading	+	+	No cost to remove vegetation	(H. Liu et al. 2018; World Bank Group, ESMAP, and SERIS 2018; Smyth, Russell, and Milanowski 2011)
Water				
Reduced Evaporation	T	T	50%, 70%, >90%, 680-1850 mm/yr.	(SPG Solar 2011; Sahu, Yadav, and Sudhakar 2016; Perez et al. 2018; Hoffacker, Allen, and Hernandez 2017; H. Liu et al. 2018; World Bank Group, ESMAP, and SERIS 2018; World Bank Group, Energy Sector Management Assistance Program (ESMAP), and Solar Energy Research Institute of Singapore (SERIS) 2019; Spencer et al. 2019; Trapani and Millar 2013; Ferrer-Gisbert et al. 2013; Craig et al. 2005; Rosa-Clot, Tina, and Nizetic 2017; Ciel et Terre n.d.)
Reduced Algae Growth/Improved Water Quality	0	0		(Craig et al. 2005; Sahu, Yadav, and Sudhakar 2016; World Bank Group, ESMAP, and SERIS 2018; SPG Solar 2011; Ciel et Terre n.d.; Spencer et al. 2019; Z. B. Alam and Ohgaki 2001)
Lower Water Temperature	0	0		(SPG Solar 2011; Ciel et Terre n.d.)
Power During Drought	0	0		(Cox 2019; Silvério et al. 2018; SPG Solar 2011)
Reduced Wave Formation	0	0		(Ciel et Terre n.d.; Sahu, Yadav, and Sudhakar 2016; Perez et al. 2018)
Land				
Reduced Land Use/Repurpose Bad Land	+			(Hoffacker, Allen, and Hernandez 2017; Trapani and Millar 2013; Spencer et al. 2019; World Bank Group, ESMAP, and SERIS 2018; Ciel et Terre n.d.)
Location Near Demand/Population Centers	T	T		(World Bank Group, ESMAP, and SERIS 2018; Spencer et al. 2019; Trapani and Millar 2013; Hoffacker, Allen, and Hernandez 2017)
Cost & Other				
Ease of Installation	+	+	1.2 - 1.7 MWp installed < 1 year	(World Bank Group, ESMAP, and SERIS 2018; Peschel 2014; Manchevs 2015)
Reduced Site Preparation	+	+		(Cox 2019; World Bank Group, ESMAP, and SERIS 2018; Ciel et Terre n.d.)
Modular	+	+		(World Bank Group, ESMAP, and SERIS 2018; Sahu, Yadav, and Sudhakar 2016; Ciel et Terre n.d.)
Extends System Life	0	0		(SPG Solar 2011; Chandran 2019)
Hybrid with Hydroelectric Dam				
Use Existing Electrical Transmission Infrastructure		T		(H. Liu et al. 2018; World Bank Group, ESMAP, and SERIS 2018; Cox 2019; Raniers Cazzaniga et al. 2019; Farfan and Breyer 2018; Aghahosseini, Bogdanov, and Breyer 2017; An et al. 2015; Ming et al. 2018; Rogner 2015; L. Liu et al. 2019)
Reduced Curtailment		T		(H. Liu et al. 2018; World Bank Group, ESMAP, and SERIS 2018; Cox 2019; Raniers Cazzaniga et al. 2019; Farfan and Breyer 2018; Aghahosseini, Bogdanov, and Breyer 2017; An et al. 2015; Ming et al. 2018; Rogner 2015; L. Liu et al. 2019)
Improved Power Quality		T		(H. Liu et al. 2018; World Bank Group, ESMAP, and SERIS 2018; Cox 2019; Raniers Cazzaniga et al. 2019; Farfan and Breyer 2018; Aghahosseini, Bogdanov, and Breyer 2017; An et al. 2015; Ming et al. 2018; Rogner 2015; L. Liu et al. 2019)

+: Empirically Confirmed
T: Theoretical
0: Unconfirmed
Blank indicates not applicable

Table. Review of purported benefits

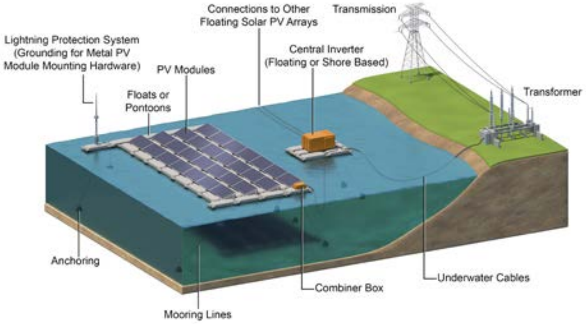

Figure. Adapted from Osborne (2017)

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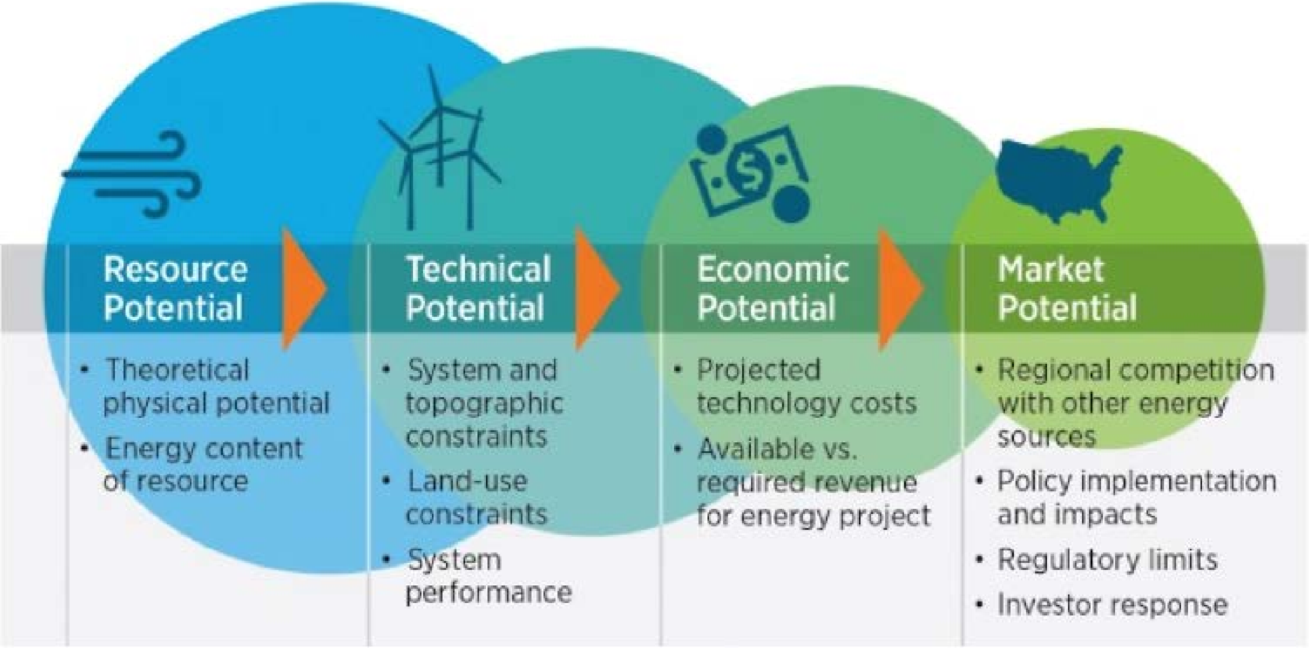
Floating Solar Technical Potential Assessments

What is "Technical Potential"



Global:
Technical Potential of Hybrid Floating Solar-Hydropower Systems

Research Objectives:
1. Review of potential hybrid system operational benefits
2. Conduct data-gap assessment of global, public datasets for hybrid technical potential assessment
3. Develop and deploy a methodology for assessing global, solar technical potential in hybrid systems

Key Findings:
1. Potential operational benefits of hybrid systems identified
2. Proposed spatial approach to assessing hybrid system technical potential
3. Identified approximately 5.3 TW of solar capacity, 7,470 TWh/year of generation potential for hybrid systems globally in a median constraints scenario.
4. Draft. Do not cite; results will be published soon.

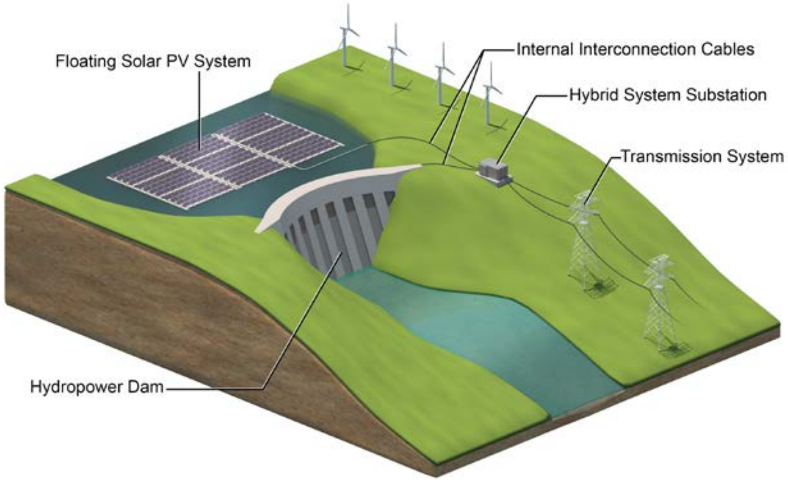


Figure. Adapted from Osborne (2017)

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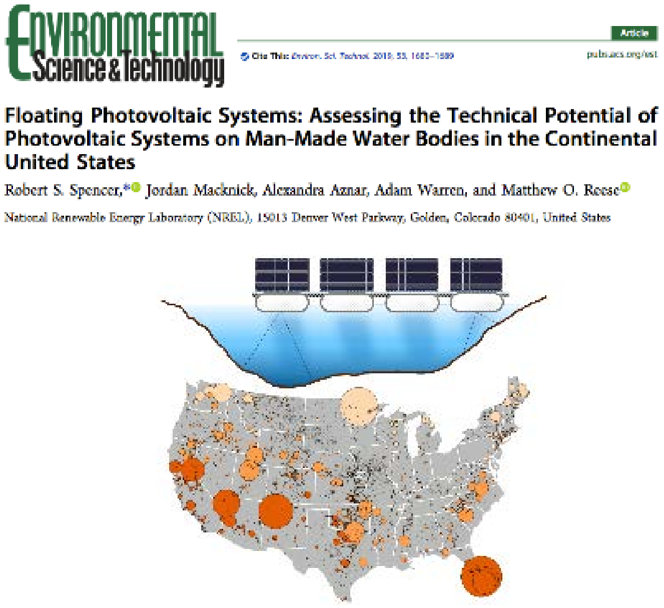
National:
Technical Potential of Floating Solar in the U.S.

Research Objectives:
1. Identify suitable water bodies in the U.S. that could support FPV using systematic process
2. Calculate potential capacity and generation from FPV in the U.S. under conservative assumptions
3. Define the key driving factors for FPV development in the U.S. to set stage for future research

Key Findings:
1. Developed systematic approach to identifying suitable water bodies for FPV
2. Identified 2.1 TW of capacity and 786 TWh/year generation potential across 24,419 suitable waterbodies in the U.S. *(~10% of U.S. annual generation possible*)
3. Published first national assessment



Floating Photovoltaic Systems: Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental United States

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Full text available here

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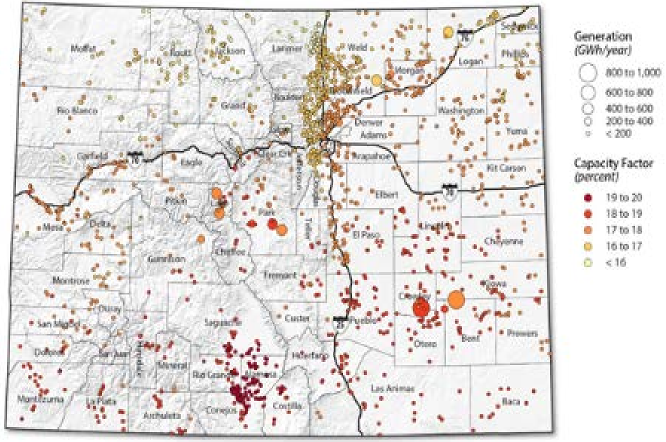
State:
Technical Potential of Floating Solar in Colorado

Research Objectives:

1. Identify suitable water bodies in Colorado that could support floating solar
2. Calculate potential capacity and generation from floating solar in Colorado
3. Provide insights on environmental impacts of floating solar
4. Perform case studies on select sites in the state



Key Findings:

1. Applied systematic approach to identify 1,900 suitable, state waterbodies
2. Identified 11 GW of potential capacity and 16.9 TWh/year of generation potential (*32% of total state generation possible)*
3. Top 10 largest sites provide ~25% of state potential
4. Published with Colorado Energy Office and Ciel et Terre

Full text available here

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U.S. Bureau of Reclamation:
Technical Potential Assessment and Analyses

Research Objectives:

1. Extract and expand NREL's prior FPV national technical potential analysis for federal reservoirs
2. Summarize the current state of known information for 5 categories of obstacles (Economic, Technology, Evaporation, Policy, and Environmental/Recreational) for all Reclamation reservoirs
3. Perform case studies examining same categories of obstacles and overall site feasibility of FPV deployment for four Reclamation/USACE reservoirs

Status: Underway

Figure. Roosevelt Dam. Bureau of Reclamation. www.usbr.gov

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Floating Solar Hybrid System Modeling

International:
Creating an Enabling Policy and Regulatory Environment for Floating Solar in Southeast Asia

Research Objectives:

1. Identify potential regulatory and policy gaps for floating solar deployment in the region
2. Model hybrid FPV-hydro plant to quantify potential short-term and long-term operational benefits

Status: Underway

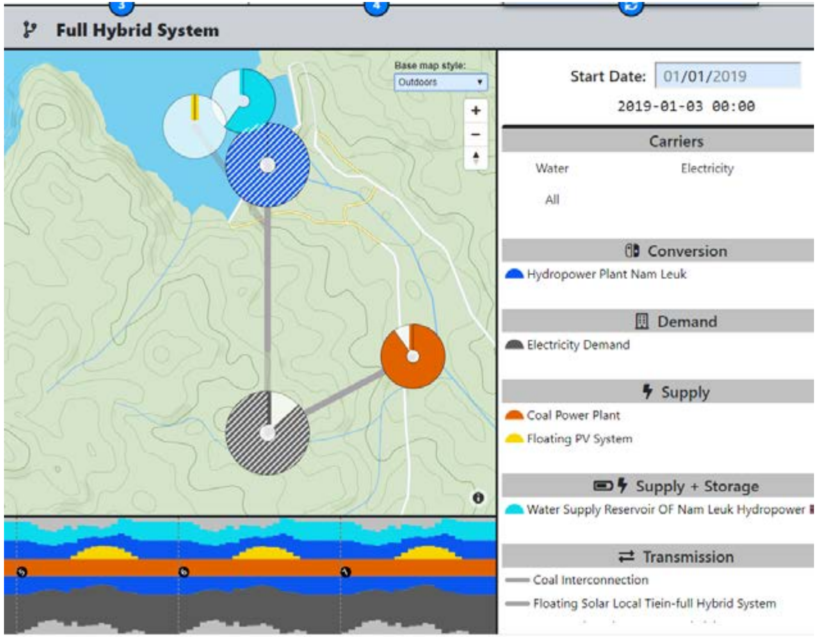

Figure. Hybrid modeling in Engage

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Disclaimer

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The data, results, conclusions and interpretations presented in this document should not be disseminated, quoted, or cited.

Thank you!

We are interested in exploring partnerships to expand this work. Please reach out if you would like to discuss.

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