Advanced Energy Partnership for Asia

International Applications for Floating Solar PV (FPV)

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National Renewable Energy Laboratory (NREL)

United States Energy Association (USEA) Seminar Series
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Image: iStock 12776646

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Introduction

NREL is part of the U.S. Department of Energy's National Laboratory system.

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NREL at a Glance

3,675 workforce, including:

- 2,732 regular/limited term
- 490 contingent workers
- 211 postdoctoral researchers
- 152 graduate student interns
- 90 undergraduate student interns

—as of 9/30/2023

World-class research expertise in:

- Renewable Energy
- Sustainable Transportation & Fuels
- Buildings and Industry
- Energy Systems Integration

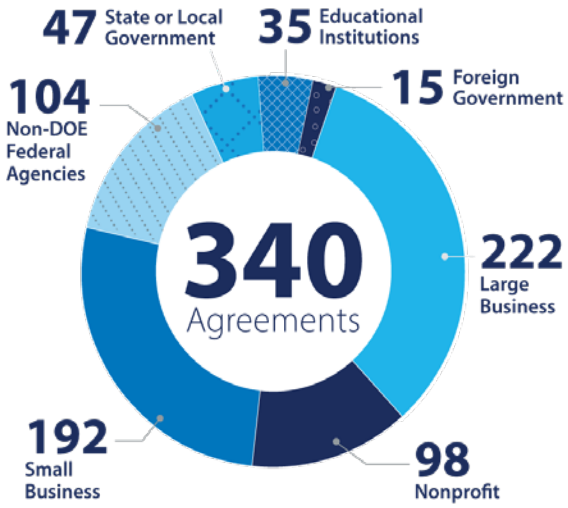
Partnerships with:

- Industry
- Academia
- Government

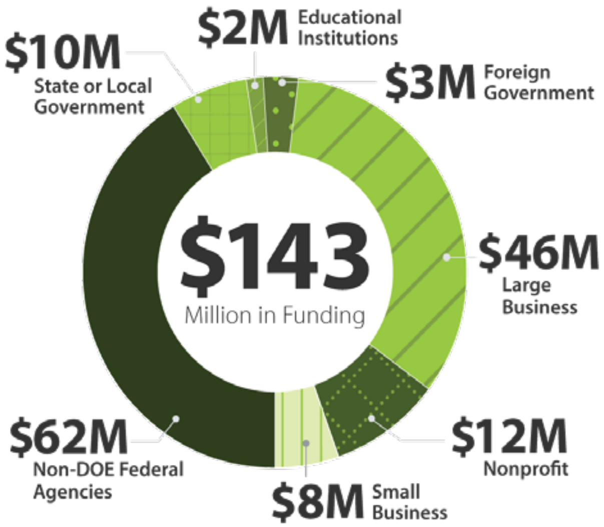
4 campuses operate as living laboratories

Image: Dennis Schroeder (NREL)

More Than 1,000 Active Partnerships in FY 2023



Agreements by Business Type



Funding by Business Type

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Global Technical Platforms

The USAID-NREL Partnership's global technical platforms provide free, state-of-the-art support on common and critical challenges to scaling up advanced energy systems.

REexplorer MAPPING OUR ENERGY FUTURE — www.re-explorer.org

Greening the Grid — www.greeningthegrid.org

I-JEDI — www.i-jedi.org

Resilient Energy Platform — www.resilient-energy.org

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NREL's FPV Research Activities

- FPV are becoming an increasingly competitive option;
- However, the technology is relatively nascent, and many potential adopters have questions about the underlying technology, its benefits, and how to analyze it appropriately.

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

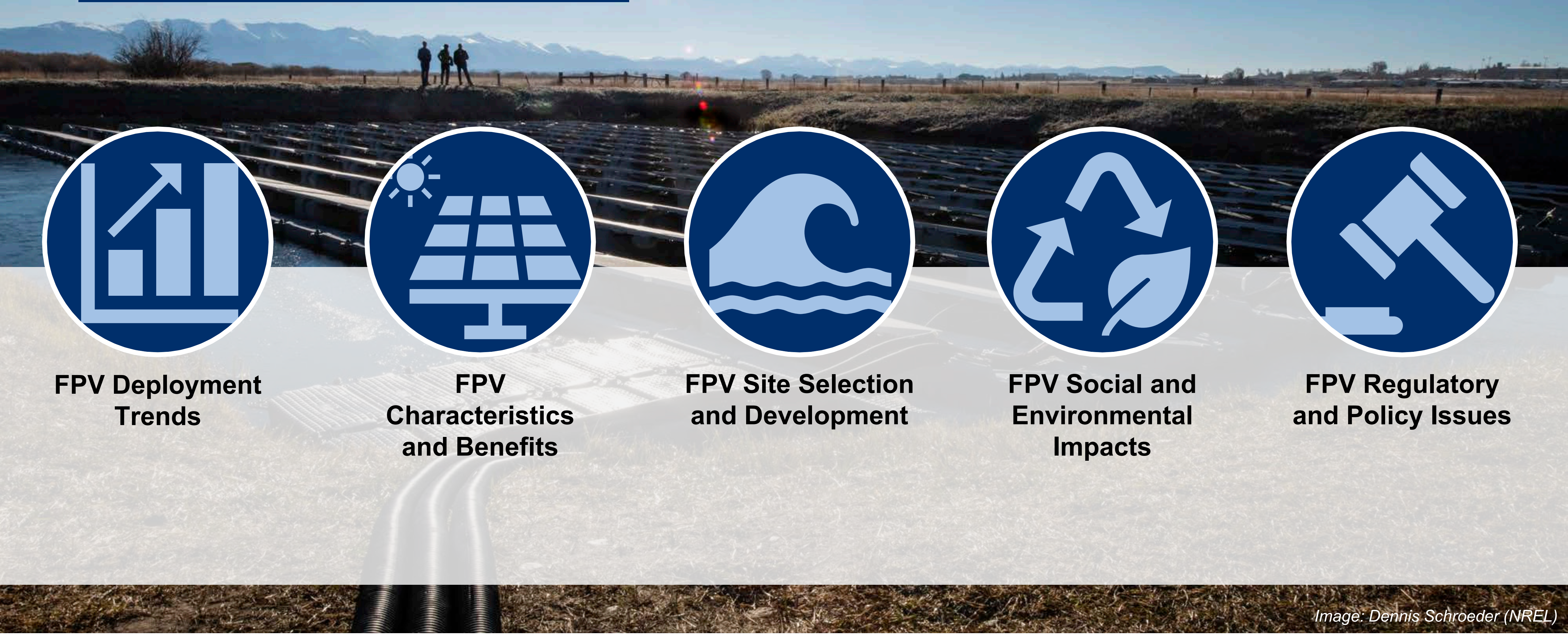
- Research and development of built-for-purpose PV and supporting systems for FPV
- Explore FPV system designs that reduce equipment weathering and erosion.

Activities completed or underway at NREL

Source: Joshi (2023b)

Figure. FPV Research and Analysis Topics

Agenda: Day 1



FPV Deployment Trends

FPV Characteristics and Benefits

FPV Site Selection and Development

FPV Social and Environmental Impacts

FPV Regulatory and Policy Issues

Image: Dennis Schroeder (NREL)

Agenda: Day 2

FPV Potential in Asia

FPV Financing and Costs

FPV Decision Support

Image: Dennis Schroeder (NREL)

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FPV Deployment Trends

FPV Market Growth

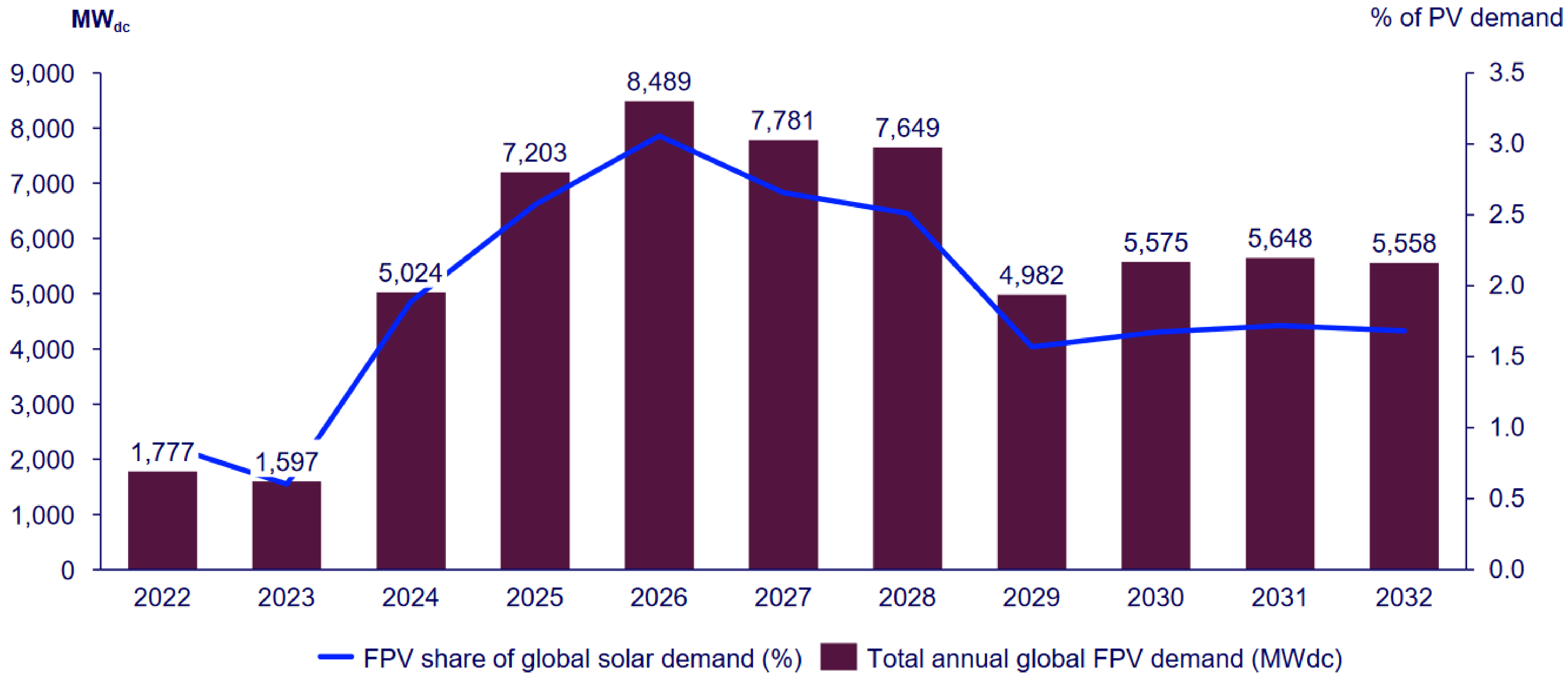

Figure. Projection of Annual FPV Installations

Source: Sagardoy (2023) – Wood Mackenzie

FPV Market Growth by Region

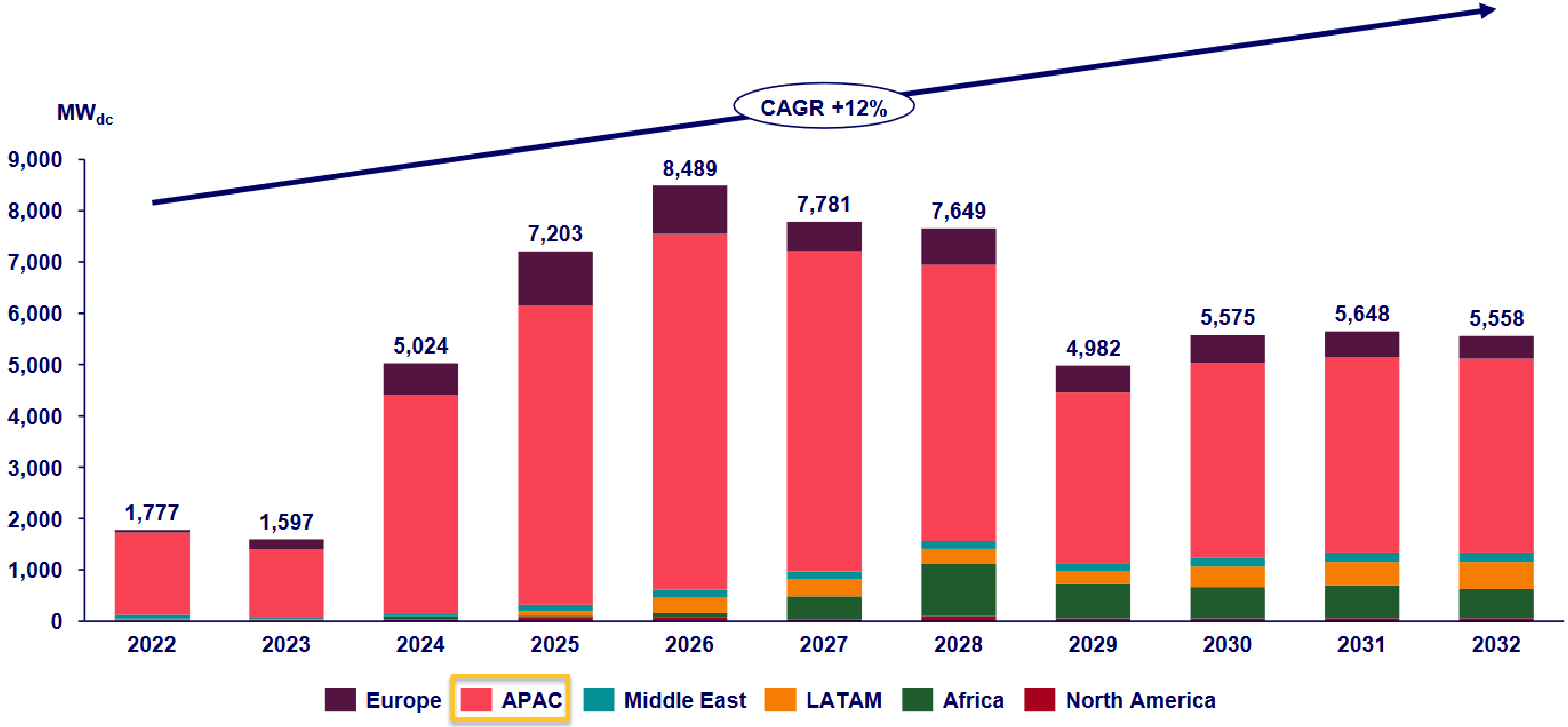

Figure. Projection of Annual FPV Installations by Region

Source: Sagardoy (2023) – Wood Mackenzie

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FPV Market Growth in Asia

Top FPV markets globally are in Asia, primarily:

India

China

Thailand

Indonesia

South Korea

Malaysia

Philippines

Taiwan

Laos

Vietnam

Figure. Top FPV Markets in Asia

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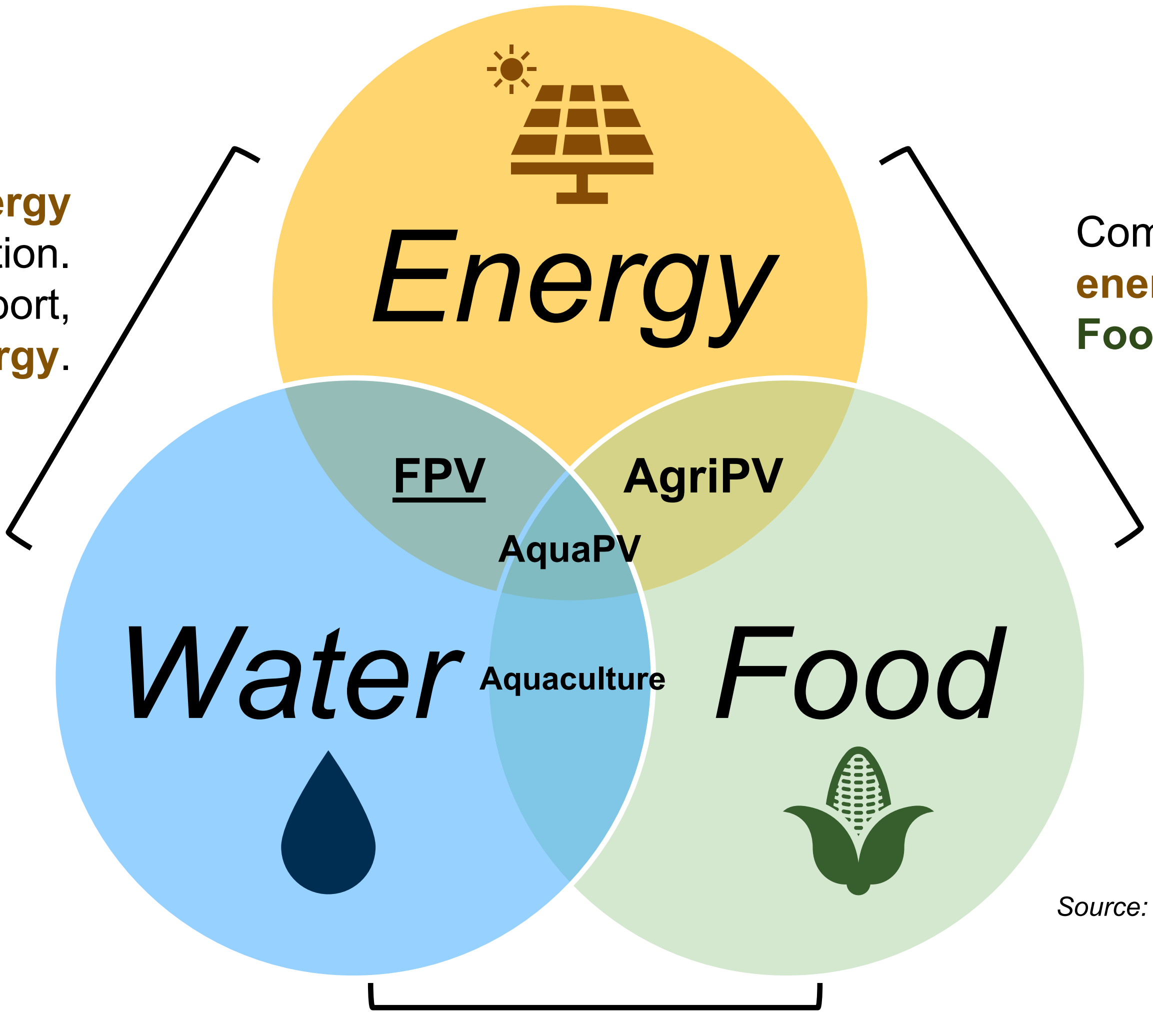
FPV Characteristics and Benefits

Food-Energy-Water Nexus for Solar PV

Water shortages could limit **energy** production.
Water infrastructure (transport, treatment, etc.) requires **energy**.



Competing land use for **food** and **energy** production.
Food production requires **energy**.

Source: Joshi (2023a)

Food production could impact **water** quality and availability.
Water shortages and contamination could limit **food** production.

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FPV Technology Overview

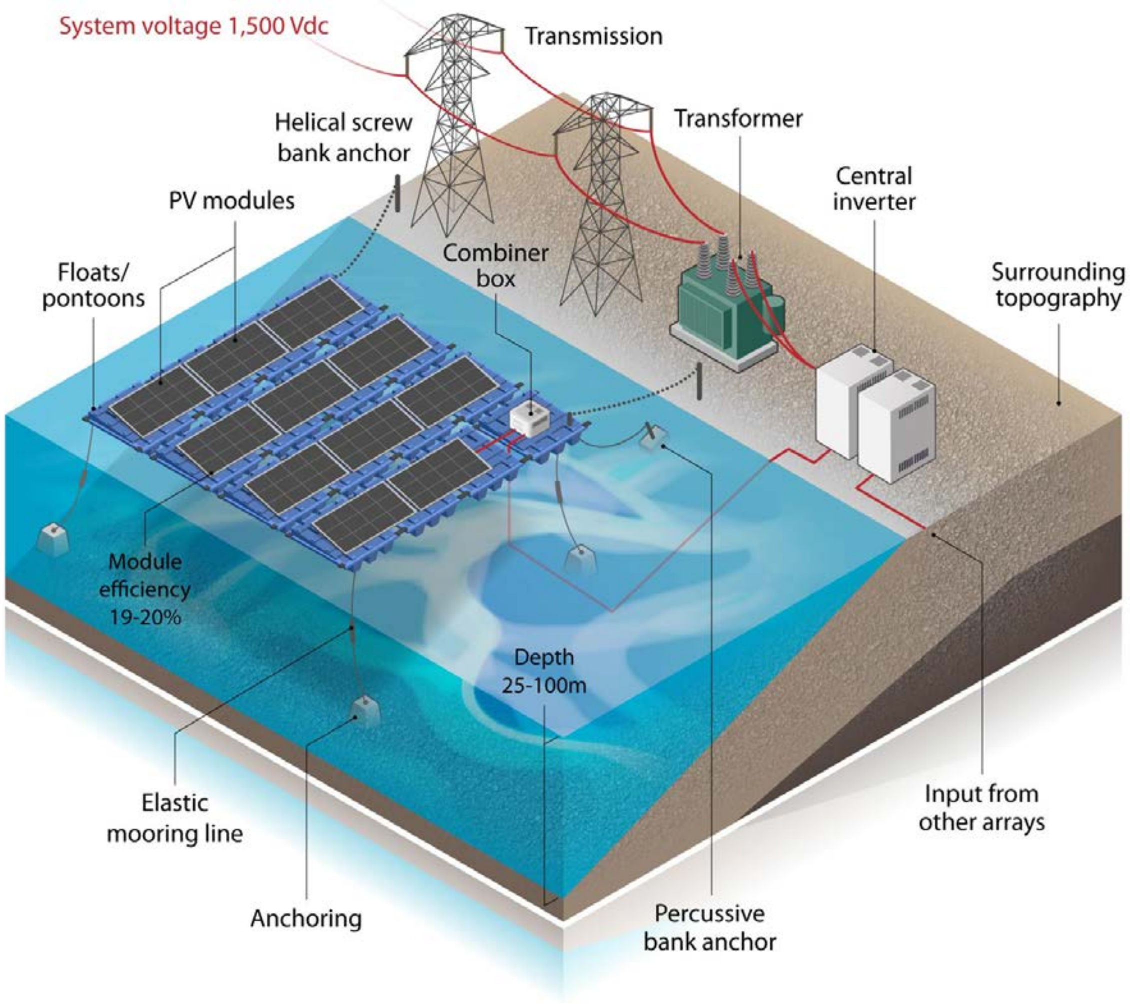


Figure. Schematic of Typical FPV System

- **Modules:** Same PV technology as ground-mount or rooftop PV, with the emerging potential for tracking and/or bifacial panels.
- **Site:** Typically sited on artificial waterbodies (e.g., reservoirs, retention ponds, etc.), with emerging applications on natural waterbodies, both inland and offshore.
- **Structure:** Platforms consist primarily of high-density polyethylene (HDPE) floats, with potentially different considerations for offshore sites. Anchors and mooring lines minimize lateral movement of the system. Racking material is similar to land-based PV (e.g., stainless steel).
- **Electrical Components:** Similar equipment as a land-based PV installation, with some different considerations for freshwater or marine environments (e.g., electrical cables connecting the modules to each other, and connecting the modules to the central inverter).

Source: Ramasamy and Margolis (2021)

Image: Alfred Hicks (NREL)

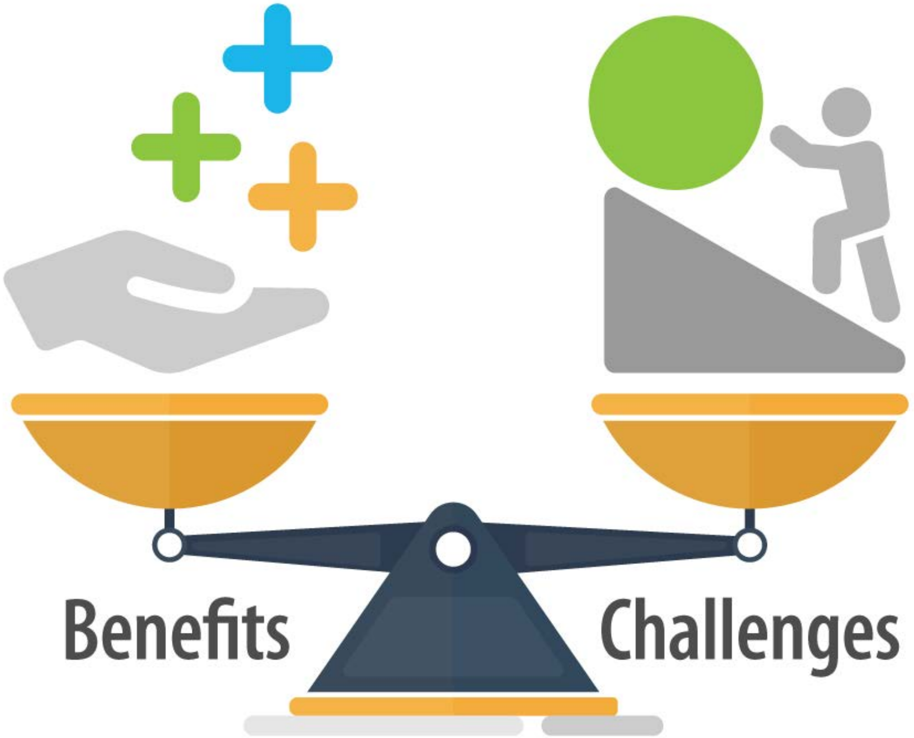
FPV Benefits and Challenges

Benefits

- Avoided land-energy conflicts
- Reduced land acquisition costs and site preparation costs
- Potentially an increased PV energy gain (3%-5%) due to cooling effect of water
- Operational benefits when paired with hydropower

Challenges

- Relatively immature technology & economies of scale remain constrained by relatively smaller installation capacity
- Expensive O&M as the durability of floating structure is yet to be tested & adapted
- Lack of standards & procedures
- Potential impact of plastic floats on the water ecosystem
- Higher (5-25%) system capital cost



Potential Co-Benefits of FPV Systems

	Social	Economic	Energy	Water	Food/Land
Empirically Confirmed	• Reduces land use (S) • Repurposes otherwise unusable land (S)	• Increases ease of installation (S,H) • Reduces site preparation (S,H) • Modular (S,H)	• Increases panel efficiency (S) • Increases panel packing density (S,H) • Reduces shading (S,H)		• Reduces land use (S) • Repurposes otherwise unusable land (S)
Theoretically Confirmed	• Preserves valuable land and water for other uses (S,H)	• Uses existing electrical transmission infrastructure • Reduces curtailment • Improves power quality	• Increases panel efficiency (H) • Improves power quality (H)	• Reduces evaporation (S,H) • Reduces algae growth/ Improves water quality (S)	• Increases energy sources near demand/ population centers (S,H)
Unclear, Unconfirmed, or Understudied	•Avoids or reduces conflicts over land and water use (S,H) • Reduces or avoids power-generation related air pollution (S,H) • Reduces displacement of local communities for energy development (S,H) • Improves power sector resilience (S,H)	• Extends system life (S,H)		• Reduces algae growth/ Improves water quality (H) • Reduces water temperature (S,H) • Provides power during drought • Reduces wave formation (S,H)	

Social and water-related co-benefits remain understudied.

Figure. Summary of FPV Co-Benefits (S = stand-alone, H = hybridized)

Source: Gadzanku et al. (2021a)

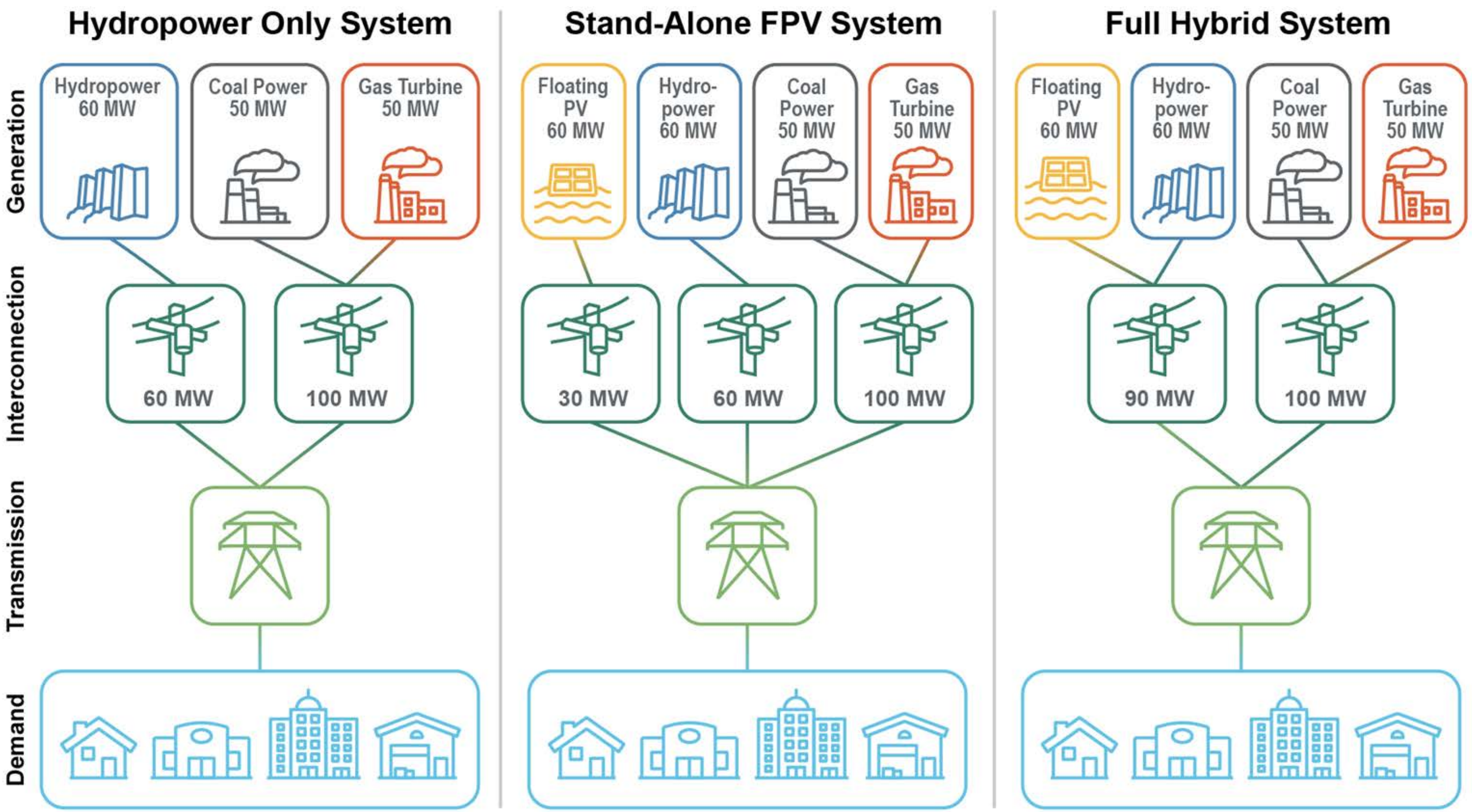
Ground Mount PV & FPV System Components

	Site staging	Site preparation	Structural BOS	Electrical BOS	Inverter	O&M
Ground mount PV 	Building Access Roads, Security Fencing etc.,	Geotechnical Investigation, Soil Stripping, Grading, Compaction etc.,	Torque Tube, Vertical Support, Foundation & Trenches etc.,	Wiring & Cables, Combiner boxes, Onsite Switch-gear, transformer etc.,	On site inverter with housing	Regular Inspec-tion
Floating PV 	Building Water Walkway, Specialized workforce etc.,	Extensive Hydrogeological investigation	Floats/Pontoons, Lightning Protection System, Anchoring (bottom vs bank), Mooring lines (30 lines/MW) etc.,	Buoy supported cabling or cabling with water-proof conduits, Onsite Switchgear, transformer etc.,	Inverter onshore or on a floating device	Inspection carried out with water boats and divers

Image: Alfred Hicks (NREL)

FPV-Hydropower Hybrid Modeling (1/2)

Research Question: What are the operational benefits of hybridizing FPV with hydropower?



Source: Gadzanku et al. (2022)

Figure. Example System Configurations for the Hydro-Only (left), FPV Stand-Alone (middle), and Hybrid FPV-Hydropower (right) Systems

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FPV-Hydropower Hybrid Modeling (2/2)

Key Findings:

Compared to a Stand-Alone FPV system, hybridizing FPV with hydropower helps:

- Conserve water by shifting hydropower generation to other periods of the year (top graph).
- Lower PV curtailment when transmission constraints cause curtailment (bottom graph).
- Reduce dependence on other types of generation, such as gas-fired generation, by reducing PV curtailment.

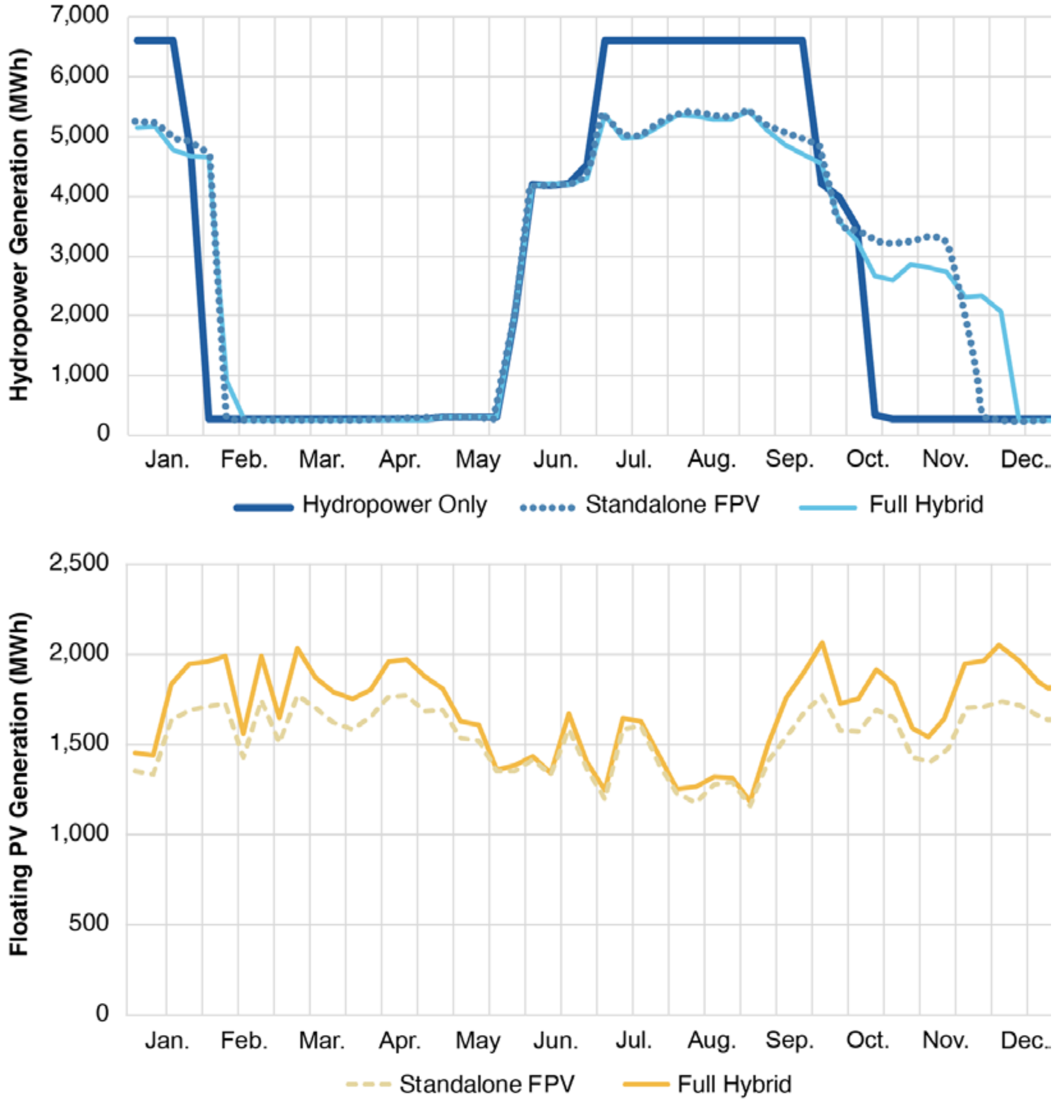

Figure. Annual Hydropower (Top) and FPV Generation (Bottom) in Different Scenarios

Source: Gadzanku et al. (2022)

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FPV Site Selection and Development

Technical Potential Assessment

- Resource assessment or technical potential assessment quantifies the amount of FPV that can be built when considering the technical limitations of the technology.

- From previous FPV technical potential assessments, NREL has identified the following criteria as being the most important for determining whether an area is feasible for FPV development:
  - The area must be free of swift currents.
  - The area must be free of ice flows and heavy snow loads.
  - The area must be free from freight shipping due to excessive wakes.
  - The area must either be continuously covered by water, or if it is sometimes dry it must be flat enough to support the grounding of the FPV float.

- Data on bathymetry (water depth) is helpful when evaluating the potential for FPV development

- Other helpful data: protected areas, ports, wave heights, transmission lines, major roads, water resource availability, solar resource, etc.

- Assess the use of the waterbody: recreation, water storage, flood control, irrigation, power generation, navigation, fishing, etc.

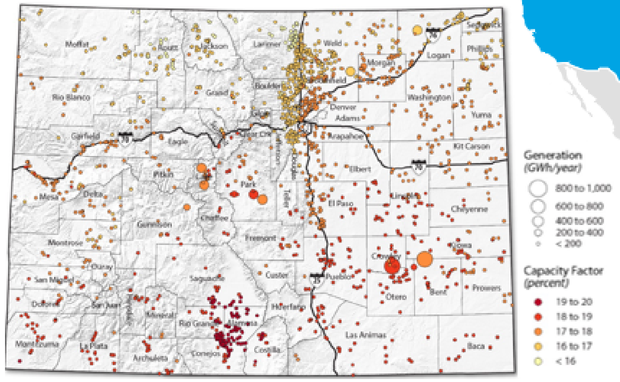
Select Technical Potential Assessments

Differences in: Waterbodies assessed, scenarios, assumptions, data sources etc.

Global Assessments:
- Lee et al. 2020
- Jin et al. 2023

Subnational Assessment

Colorado (Liber et al. 2020)



Site specific assessment also conducted considering evaporation, algae, wildlife, water quality, and land-use trade-offs.

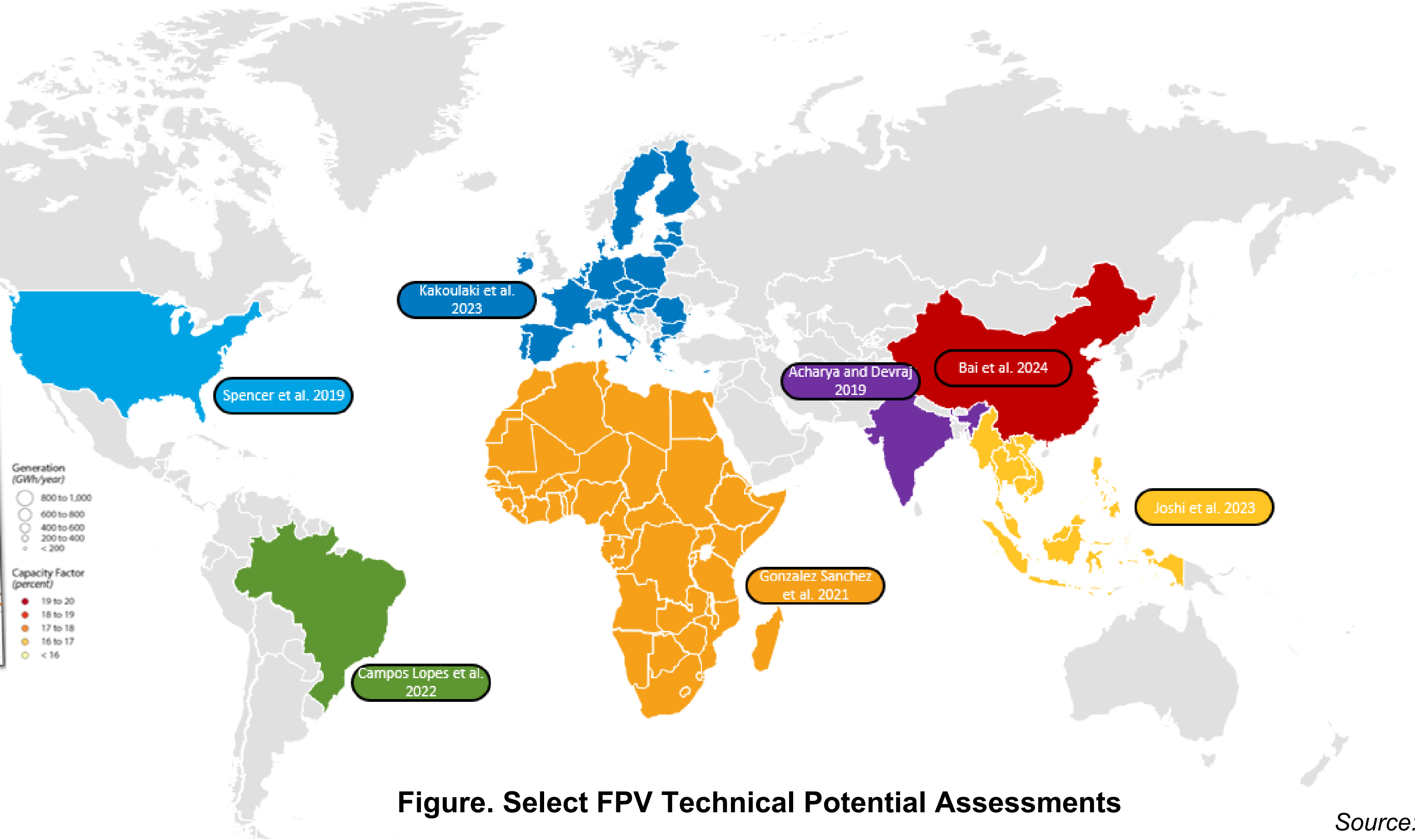


Figure. Select FPV Technical Potential Assessments

Source: Joshi (2023b)

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Site Assessment

Water Depth, Stability and Slope of Bottom
Ideally, water bodies should have consistent and moderate depths, neither too shallow nor too deep, to ensure the stability and safety of the floating structures.

Water Fluctuations
Sites with minimal seasonal water level fluctuations are more suitable as large variations might affect the system's anchoring and electrical connections.

Solar Resource
The site should have optimal solar insolation with minimal shading from nearby structures or trees.

Wave and wind conditions, presence of currents, and anchoring and mooring
Protected or calm areas are preferred as strong waves or winds might affect the stability of floating structures. Suitable conditions for securely anchoring or mooring the floating solar panels without causing damage to the waterbody floor.

Water Quality
Sites with lesser organic material can reduce potential degradation or damage to the FPV structures.

Environmental Impact
The site should pose minimal environmental risks when transformed into an FPV site. Minimal disruption to local ecosystems, aquatic life, and water quality. Monitoring potential temperature changes in the water underneath is also crucial.

Site Accessibility and Proximity to Infrastructure
Assess accessibility for construction and maintenance; ensure connectivity to transmission lines and substations for easier and cost-effective grid connection.

Regulatory Compliance and Water Use Compatibility
Sites where the necessary permits for FPV installation can be easily obtained, and where there are no major regulatory hurdles. Compatibility with other uses of the waterbody, like recreation, fishing, or reservoir functions.

Source: Pastor et al. (forthcoming)

Sub-National: Technical Potential Assessment and Analyses on select U.S. Bureau of Reclamation sites

Research Objectives:

Extract and expand NREL's prior FPV national technical potential analysis for federal reservoirs.

Summarize the current state of known information for 5 categories of obstacles (Economic, Technology, Evaporation, Policy, and Environmental/Recreational) for all Reclamation reservoirs.

Perform case studies examining same categories of obstacles and overall site feasibility of FPV deployment for four reservoirs.

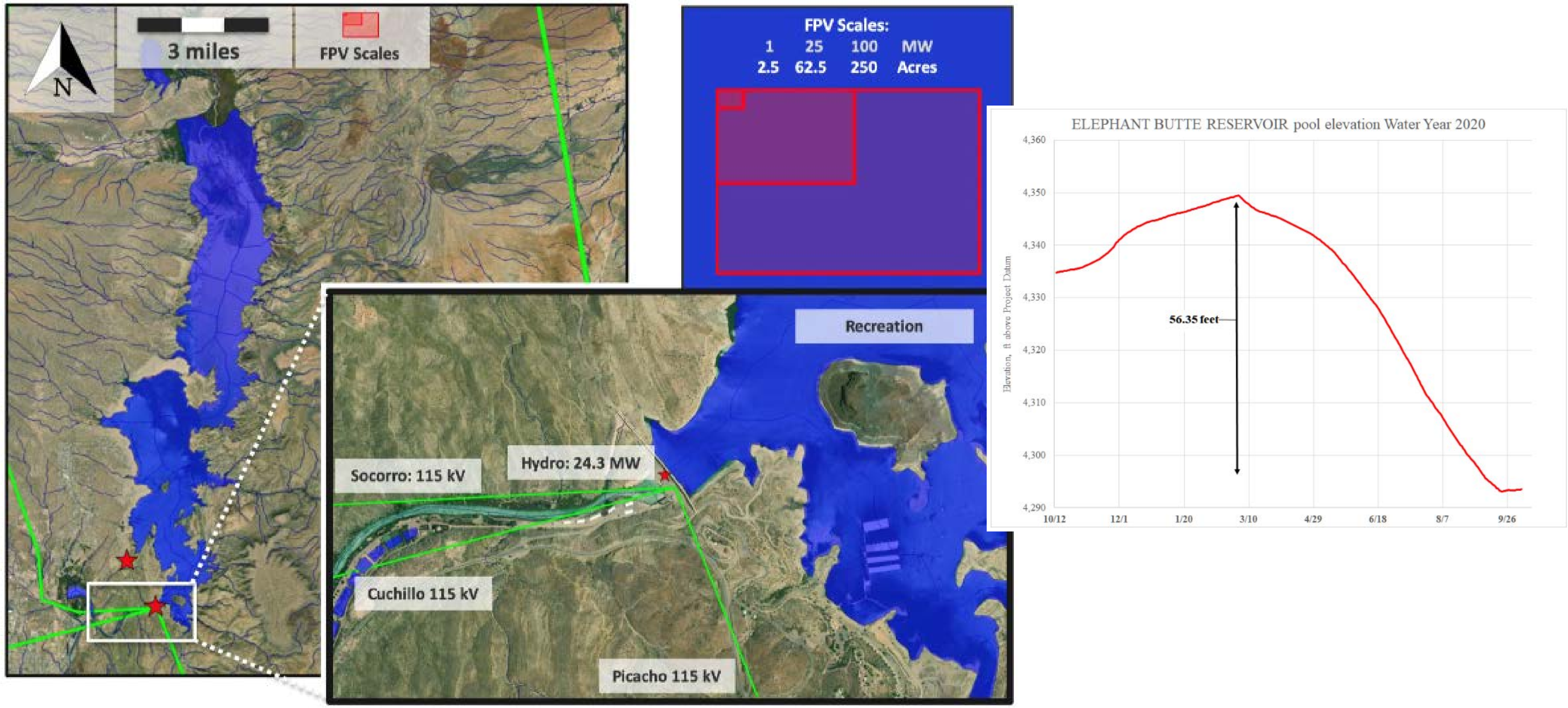

Figure. Site Diagram and Water Level Variation for Elephant Butte Reservoir

Source: Park et al. (2021)

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FPV Social and Environmental Impacts

FPV Environmental Impacts

Potential for:

- Lower greenhouse gas emissions
- Reduced water evaporation
- Lower algae growth and improved water quality
- Lower sunlight and dissolved oxygen levels

Consider:

- Impact on aquatic life and nearby wildlife
- Potential degradation of floating structures

FPV Social Impacts

Potential for:

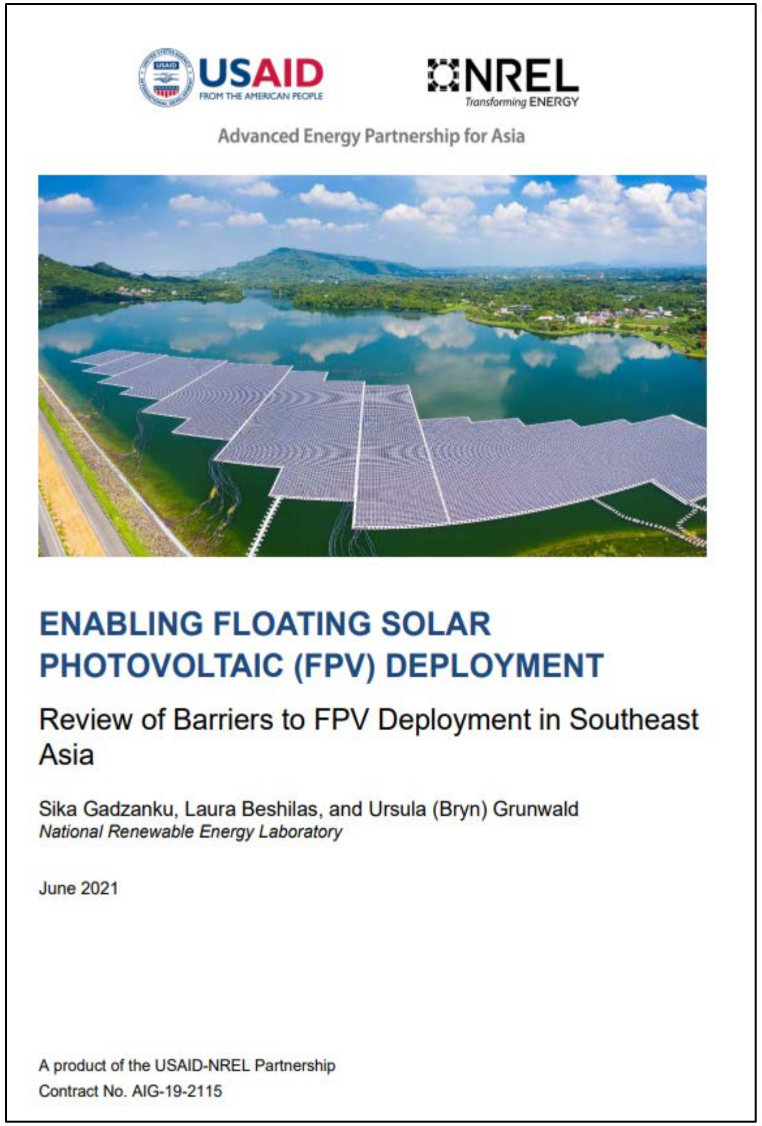
- Applications with aquaculture
- Reduced conflicts over land-use (for housing, agriculture, infrastructure, conservation, etc.)
- Increased conflicts over water use (for power generation, recreation, fishing, navigation, etc.)
- Economic development and jobs

Consider:

- Impact on different community groups
- Distribution of the benefits and burdens of the project

FPV Regulatory and Policy Issues

FPV Policy Barriers and Best Practices (1/2)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ENABLING FLOATING SOLAR PHOTOVOLTAIC (FPV) DEPLOYMENT

Review of Barriers to FPV Deployment in Southeast Asia

Sika Gadzanku, Laura Beshilas, and Ursula (Bryn) Grunwald
National Renewable Energy Laboratory

June 2021

A product of the USAID-NREL Partnership
Contract No. AIG-19-2115

Considerations Covered

- Cultural
- Environmental
- Economic
- Regulatory
- Technical
- Hybrid Systems

Environmental and Cultural Considerations

Barriers

Uncertainty about FPV ecological impacts may increase public opposition to projects and lengthen the environmental review process.

Lack of public buy-in of FPV technology due to visual impacts and competing uses of water bodies could stall project development.

Previous negative experiences with RE projects may lead to an unfavorable public opinion of FPV systems.

Best Practices to Consider

Government support for additional research and development (R&D) and analysis on the environmental impacts of FPV systems could shorten the environmental review process.

Prioritizing obtaining public buy-in and support through outreach and engagement can avoid delays during the FPV project development process.

Developing educational programs to inform the public about the benefits of FPV systems.

Source: Gadzanku et al. (2021)

Economic Considerations

Barriers

Subsidizing fossil fuels can create an uneven playing field, making it difficult for FPV systems to compete in the market.

Economic policy uncertainty may stall private sector interest in FPV systems.

Trained workforce shortages raise FPV deployment costs.

Best Practices to Consider

Creating clear, complementary, transparent, and consistent incentives for energy development can reduce uncertainty for FPV projects and reduce project development cost.

Consistent and targeted government support to FPV systems in the form of rebates, tax incentives, and competitive RE auctions could help de-risk FPV systems and attract private sector financing.

Source: Gadzanku et al. (2021)

Regulatory Considerations

Barriers

Uncertainty about water rights may delay FPV project development and increase costs.

Lack of interagency cooperation and coordination may stall FPV deployment.

Lengthy, expensive, and unclear environmental approval processes for FPV systems can make projects less financially appealing.

Best Practices to Consider

Clear policies around water rights for FPV projects could reduce uncertainty during the project development process.

Engaging with policymakers and financial institutions to increase awareness of FPV systems can lead to increased support for investing in R&D and deployment projects.

Source: Gadzanku et al. (2021)

Technical Considerations

Barriers

Unclear or nonexistent FPV installation, operation, and maintenance (O&M) and equipment standards.

Uncertainty about climate change impacts on extreme weather events leading to uncertainty about resilience of FPV.

Poor transmission planning may stall grid integration of utility-scale FPV.

Difficulty quantifying FPV system performance.

Best Practices to Consider

Develop appropriate and consistent standards and certifications to ensure installation of high-quality FPV systems.

Supporting R&D on the resilience of FPV installations to natural disasters.

Proactive transmission planning through renewable energy zones or other methods can reduce uncertainty about siting of transmission.

Enhanced interconnection procedures and grid integration planning approaches.

Source: Gadzanku et al. (2021)

Hybrid System Considerations

Barriers

Nonexistent or unclear rules on the ownership, market participation, and operation of hybrid hydropower-FPV plants may complicate and stall project development.

Best Practices to Consider

Clear regulatory processes on the ownership and market participation models and valuation methods for hybrid hydropower-FPV systems could provide useful clarity to all stakeholders and support and informed decision-making process.

Development of operational and engineering best practices and training of hydropower plant operations could ensure smooth operation of these hybrid systems.

Source: Gadzanku et al. (2021)

Case Study: Taiwan AquaPV Policy

What are the challenges and opportunities in implementing Taiwan's aquavoltaics policy? A roadmap for achieving symbiosis between small-scale aquaculture and photovoltaics

Yao-Jen Hsiao [a], Jyun-Long Chen [b,*], Cheng-Ting Huang [c]

[a] Institute of Applied Economics, National Taiwan Ocean University, Taiwan
[b] Marine Fisheries Division, Fisheries Research Institute, Council of Agriculture, Taiwan
[c] Department of Aquaculture, National Taiwan Ocean University, Taiwan

- Transforming small scale aquaculture into cooperative aquaculture can increase the feasibility of implementing the AquaPV policy by decreasing the risk and uncertainty to individual farmers
- Increasing efficiency of aquaculture practices through management techniques and smart technologies reduces the risk after PV installation
- AquaPV demonstration areas can provide complete information about environmental impacts and make the technology more appealing to both farmers and environmentalists
- Catering to the energy needs of local communities and aquaculture farmers increases the effectiveness of AquaPV policies

Source: Hsaio et al. (2021)

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FPV Potential in Asia

FPV Assessments in Asia

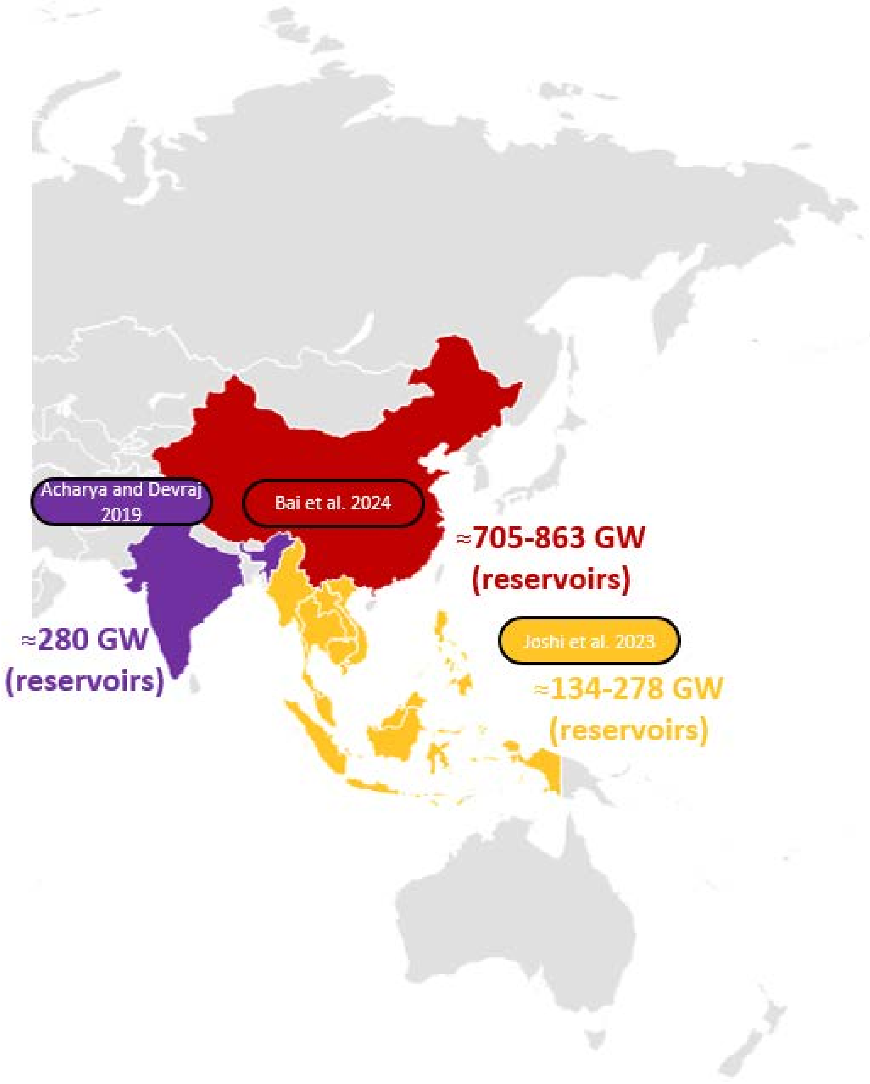

Figure. FPV Assessments in Asia

Regional Trends in Asia

- India will surpass China as the leading market by 2025 (hybridization with hydropower drives its FPV market)
- New environmental regulations (banning FPV deployment on natural waterbodies) will significantly slow FPV development in China
- FPV prospects in Thailand, which is the third largest market, are enhanced due to lack of transmission capacity
- Large projects will boost capacity in Indonesia in the short-term, while there are opportunities for electricity exports in the long-term
- South Korea, Japan, and the Philippines are also important floating solar markets

Source: Sagardoy (2023)

Southeast Asia Study: FPV Potential

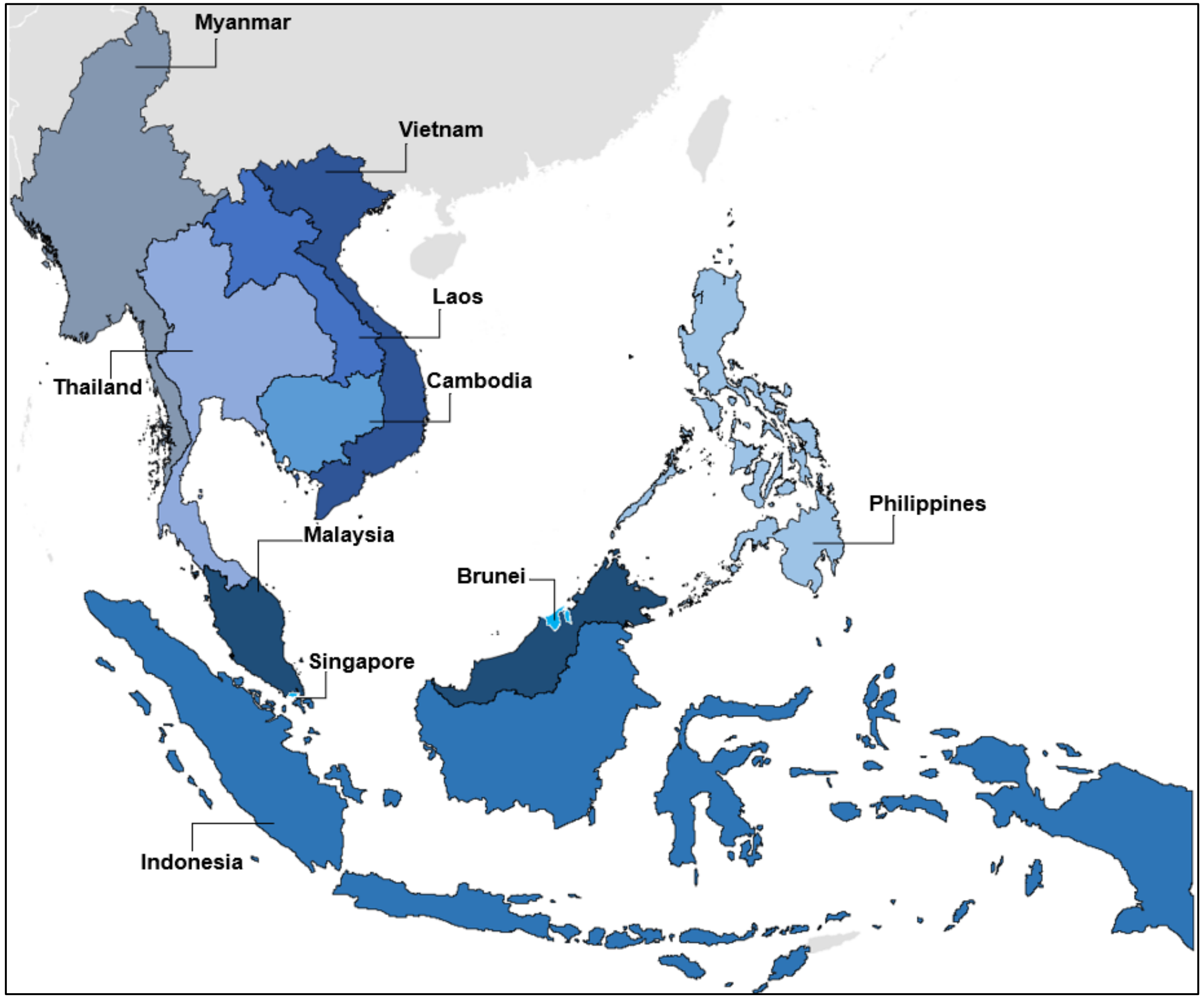

Figure. Countries included in the FPV technical potential assessment

Association of Southeast Asian Nations (ASEAN)

2025 target: achieve a 35% share of renewable energy (RE) in installed power capacity

Source: ASEAN 2022

FPV is an option that can help countries leverage existing hydropower resources to meet:

- ✓ growing electricity demand
- ✓ energy security objectives
- ✓ renewable energy targets

This first-of-its-kind upper-bound estimate of FPV technical potential for SE Asia can help policymakers, planners, and decision makers better understand the role that FPV could play in meeting regional energy demand.

Source: Joshi et al. (2023b)

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Data Collection

Waterbodies

Reservoirs (hydropower and non-hydropower)

[Global Reservoir and Dam Database (GRanD)]

Natural Waterbodies (e.g., inland lakes, ponds, etc.)

[HydroLAKES Database]

Infrastructure

Transmission lines, major roads, and protected areas

[RE Data Explorer]

[Stimson Mekong Infrastructure Tracker]

Solar Energy Resource

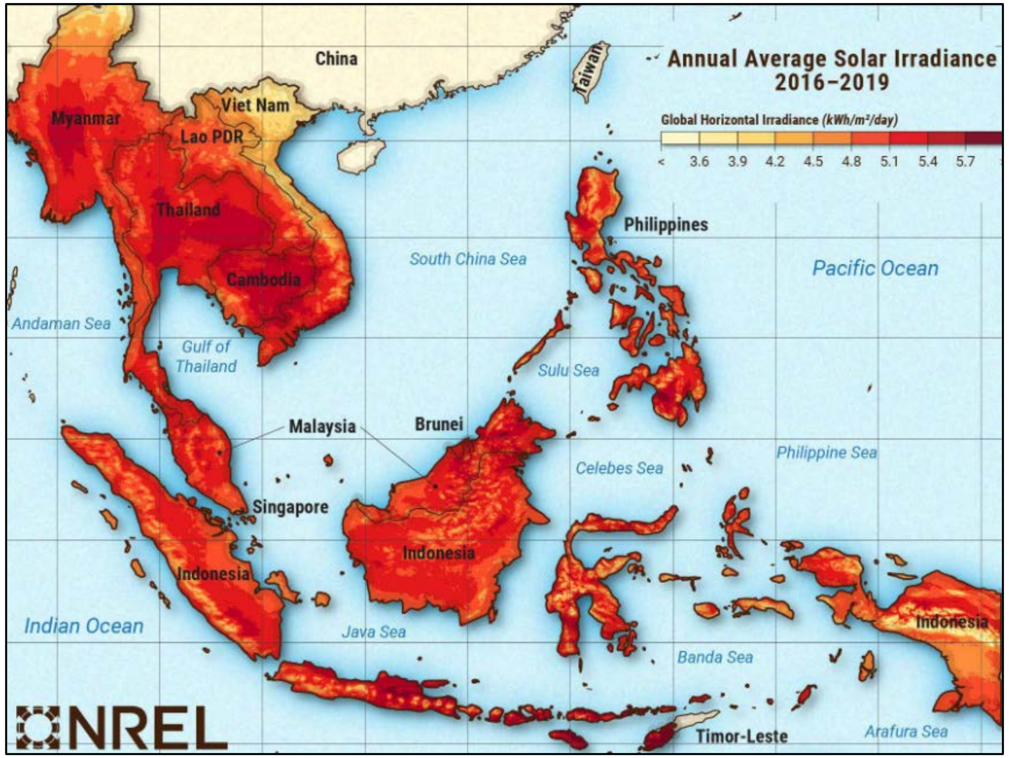

Figure. High-resolution solar resource data available for SE Asia

Source: Maclaurin et al. 2022

Analysis Scenarios

Waterbody Type

- Reservoir: hydropower and non-hydropower
- Natural: inland
- Natural: offshore

\+

FPV Technology

- Fixed Tilt: monofacial
- Fixed Tilt: bifacial
- 1-axis Tracking: monofacial
- 1-axis Tracking: bifacial

Included	Excluded

Source: Joshi et al. (2023b)

Technical Potential Calculation

Exclusions*

Waterbodies in protected areas are excluded.

Waterbodies further than 50km from the nearest major road are excluded.

+

Sensitivities

Minimum distances from shore:
0 m, 50 m, and 100 m

Maximum distances from shore:
500 m, 1000 m, and 2000 m

FPV Technical Potential:
Suitable Area (km^2)

+ Technology Assumptions

FPV Technical Potential:
Capacity (GW)

+ Solar Resource Data

PVWatts

System Advisor Model

FPV Technical Potential:
Generation (TWh/yr)

*A distance-from-transmission exclusion was included for certain results, but not the default results, because this data was only available for certain countries (Cambodia, Laos, Myanmar, the Philippines, Thailand, and Vietnam).

Source: Joshi et al. (2023b)

Technical Potential: Reservoirs

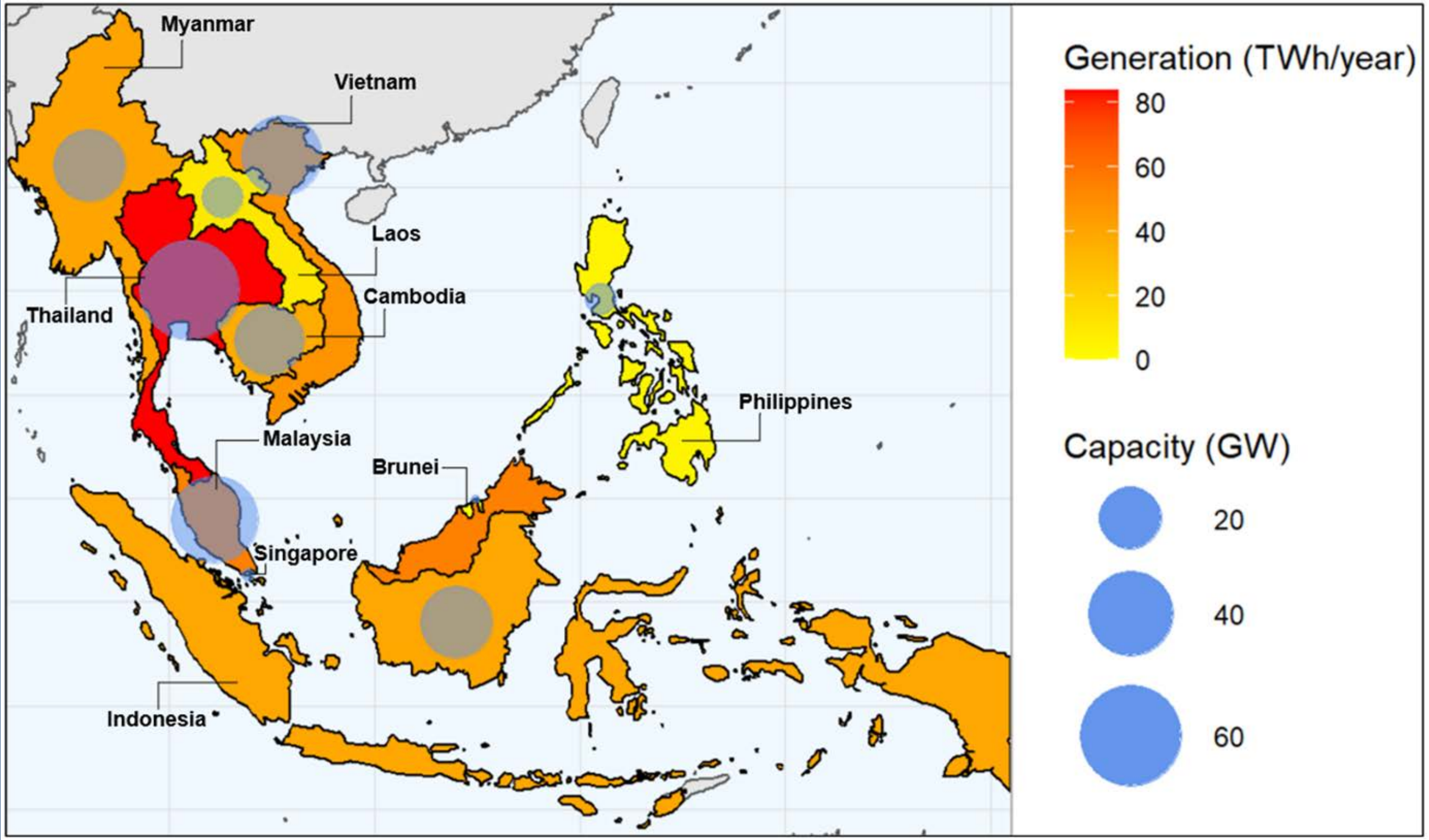

Figure. FPV generation and capacity technical potential for reservoirs in SE Asia

Note: These results assume fixed-tilt monofacial FPV panels, with a 50 m minimum distance-from-shore and 1000 m maximum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. These results do not reflect a filter for distance-from-transmission.

SE Asia Regional Results:

Waterbodies: 88

Area: ~1,343 – 2,784 km^2

Capacity: ~134 – 278 GW

Generation: ~187 – 389 TWh/yr

Ranges in results are due to different distance-from-shore assumptions.

Source: Joshi et al. (2023b)

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Technical Potential: Natural Waterbodies

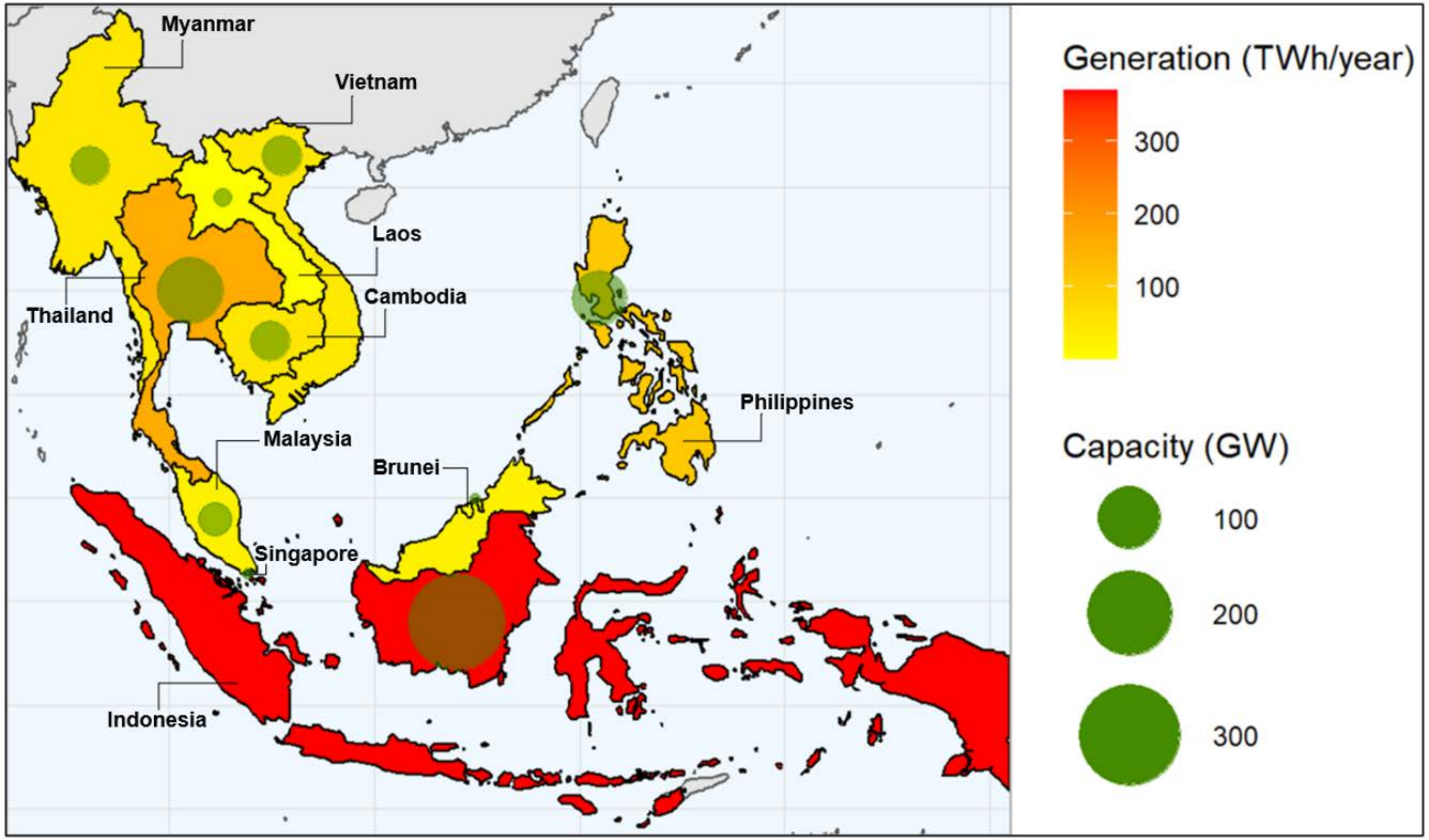

Figure. FPV generation and capacity technical potential for natural waterbodies in SE Asia

Note: These results assume fixed-tilt monofacial FPV panels, with a 50 m minimum distance-from-shore and 1000 m maximum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. These results do not reflect a filter for distance-from-transmission.

SE Asia Regional Results:

Waterbodies: 7,213

Area: ~3,427 – 7,676 km^2

Capacity: ~343 – 768 GW

Generation: ~476 – 1,062 TWh/yr

Ranges in results are due to different distance-from-shore assumptions.

Source: Joshi et al. (2023b)

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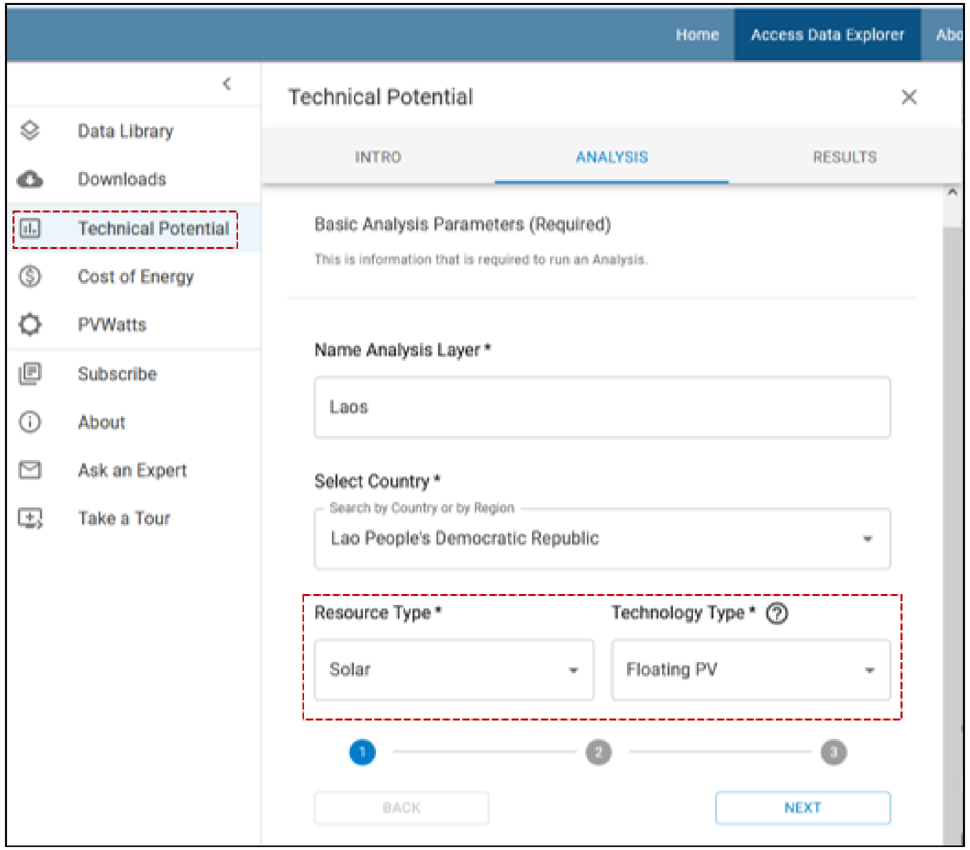
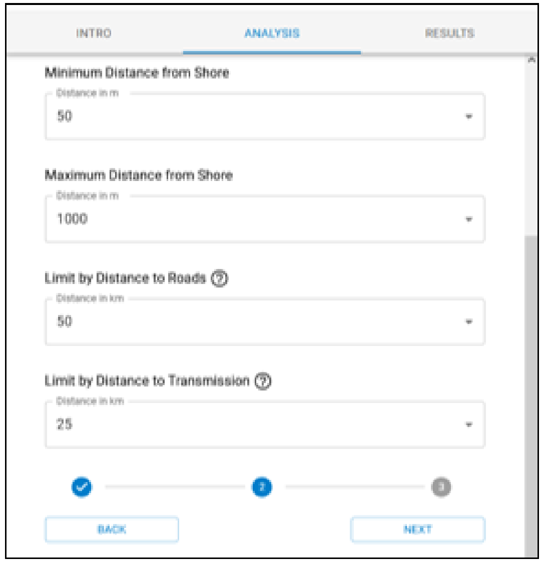
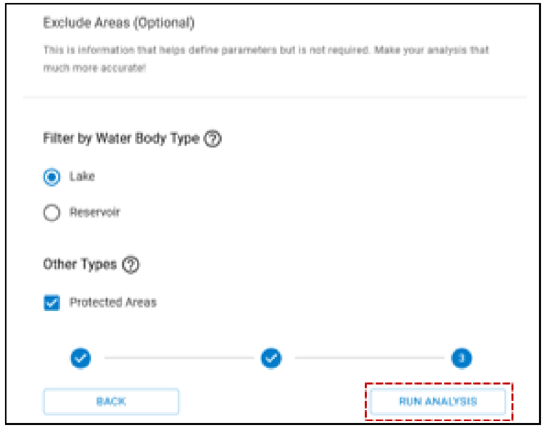
Open Access Data

Technical Potential Tool

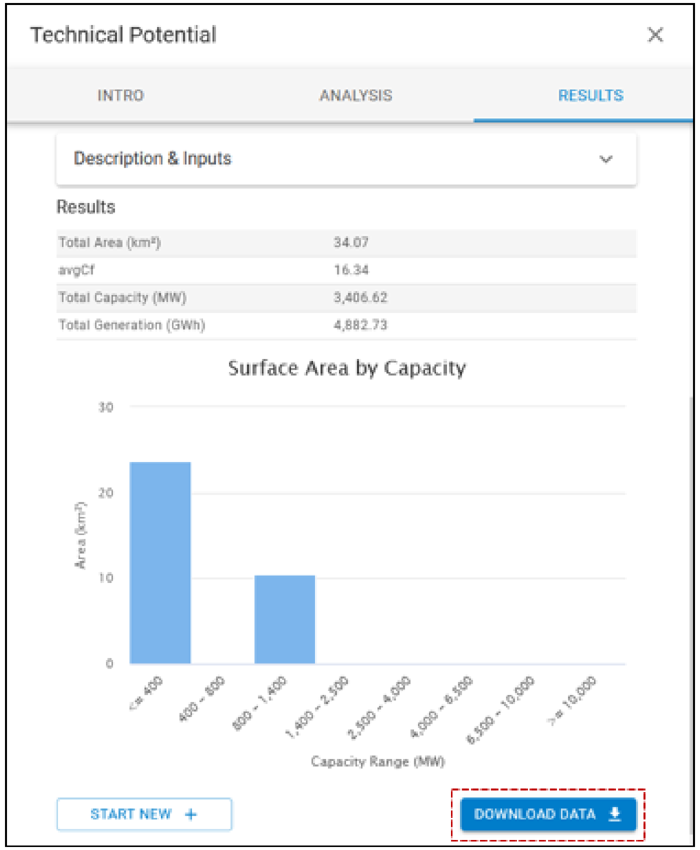


Inputs





Results



RE data explorer

https://www.re-explorer.org/home

Source: Joshi 2023b

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Key Takeaways

Role of FPV

Reservoirs (hydropower and non-hydropower)

~134 – 278 GW

Natural Waterbodies (e.g., inland lakes, ponds, etc.)

~343 – 768 GW

The installed capacity of renewables in ASEAN countries is expected to reach 235 GW by 2030 (81 GW of utility-scale solar) and 1,311 GW by 2050 (841 GW of utility-scale solar).

FPV can thus play a significant role in meeting SE Asia's energy needs.

Source: IRENA and ASEAN Centre for Energy 2022

Data Limitations

For specific sites, detailed site-specific analysis will need to be conducted given the lack of bathymetry, wind, wave, and sediment data at a regional level.

Potential Future Research

- ❑ More detailed representation of bifacial FPV
- ❑ Offshore FPV technical potential
- ❑ Aquaculture + PV ("AquaPV") technical potential

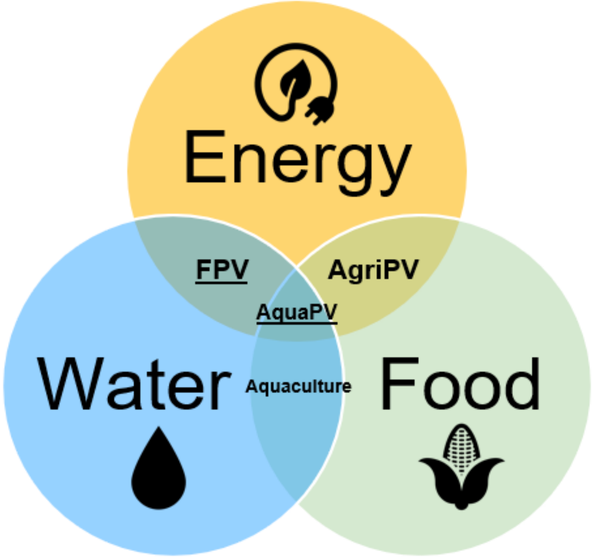

Figure. Food-Energy-Water nexus with role of FPV and AquaPV

Source: Joshi et al. 2023b

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FPV Financing and Costs

FPV Cost Comparison

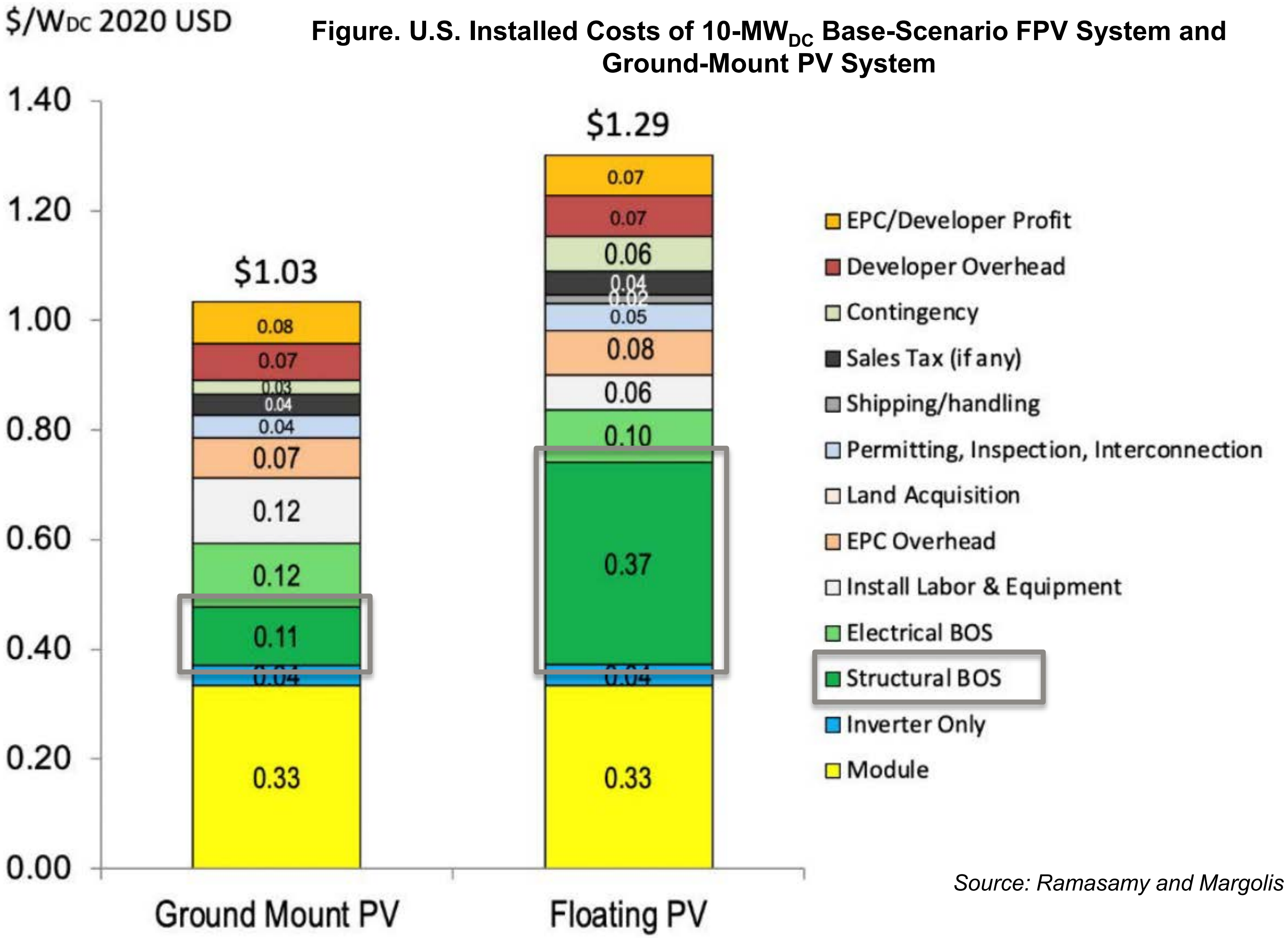
Modeled FPV system has a higher installed cost, $0.26/W_{DC}$ (25%) greater than the cost per W_{DC} of ground-mounted PV.

- *Higher cost is largely due to higher structural costs related to the floats and anchoring/mooring system.*

Levelized cost of electricity (LCOE) estimated to be 20% higher for FPV system compared to ground-mount PV.

- *Accounts for higher installed cost, higher energy production, and lower operating and maintenance costs for FPV (but does not account for other FPV co-benefits).*

Figure. U.S. Installed Costs of 10-MW$_{DC}$ Base-Scenario FPV System and Ground-Mount PV System



Source: Ramasamy and Margolis (2021)

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FPV Decision Support

Geospatial Resource Assessment

- Developed FPV technical potential methodology, determining scenarios of interest, and collecting input data.
- Conducted initial FPV technical potential assessment.
- Finalized FPV technical potential assessment based on stakeholder feedback.

Figure. Existing FPV system in Orlando, FL
(Source: www.orlando.gov)

Data Collection

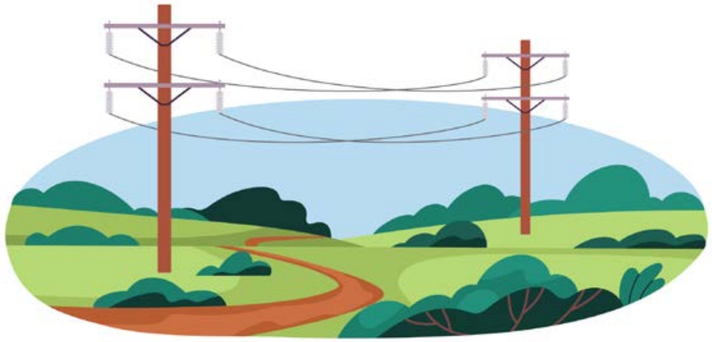
Waterbodies

Hydrography Datasets

Other location specific datasets

Others

Infrastructure



Distribution network, major roads, and protected areas.

Solar Energy Resource

Solar resource data. Typically use hourly long-term average of resource data from 1998 – 2021.

Analysis Scenarios

Waterbody Type

- Reservoirs
- Natural: lakes/ponds
- Natural: offshore

\+

FPV Technology

- Fixed Tilt: monofacial
- 1-axis Tracking: monofacial
- Fixed Tilt: bifacial
- 1-axis Tracking: bifacial

Included | Excluded

Technical Potential Calculation

Waterbodies outside of OUC territory are excluded. →

FPV Technical Potential: *Suitable Area (km^2)* + Technology Assumptions

FPV Technical Potential: *Capacity (GW)* + Solar Resource Data

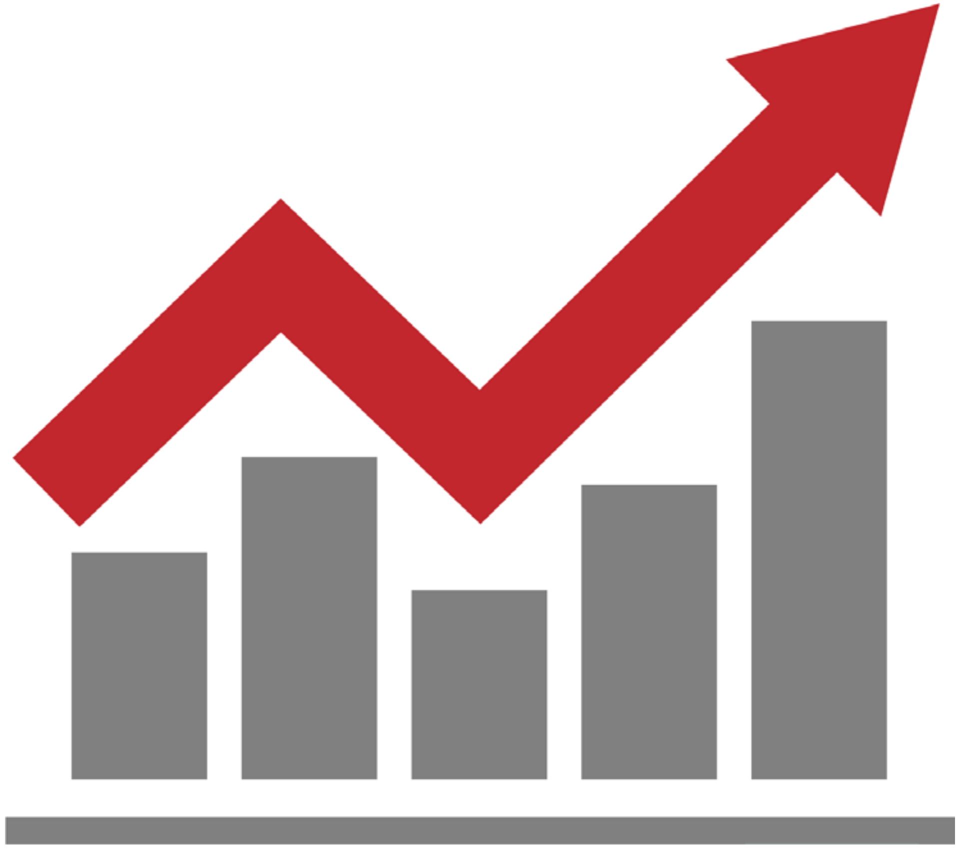
PVWatts

System Advisor Model

FPV Technical Potential: *Generation (TWh/yr)*

Cost Analysis

- Economic valuation and cost analysis, determine scenarios of interest and collect input data.
- Leverage existing cost model and data to get a detailed cost breakdown for major FPV system costs.
- Conduct initial economic valuation using existing cost data.
- Update analysis using cost-benchmarking data obtained through interviews with FPV developers.
- Develop site-specific capital cost estimates using location specific financial assumptions and geospatial technical potential assessment findings.
- Results provided in terms of system cost and LCOE estimates for a range of system sizes.



Factors Affecting Floating PV BOS

Loading Factor

- Wind, snow and waves/current determines the type of floating structure.
- Mooring lines with anchoring need to provide sufficient resistance to external forces such as wind, snow and waves/current.
- Soil condition affects the anchoring methodology.
- Finite Element Analysis helps design optimal float structures given these location factors.

Water Depth

- Depth of water & islanding requirements impact the anchoring length and number of mooring lines.
- Project size could affect the anchor type, number of anchors, and its weight.
- Anchor scope varies between 3:1 to 10:1 depending on water depth and weather conditions.

Source: Kim et al. (2020)

Thank you!

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