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Enabling Floating Solar Photovoltaic (FPV) Deployment:
FPV Technical Potential Assessment for Southeast Asia

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June 2023

Image: iStock 12776646

Presentation Outline

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Full technical report: link

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Background

Motivation for Study

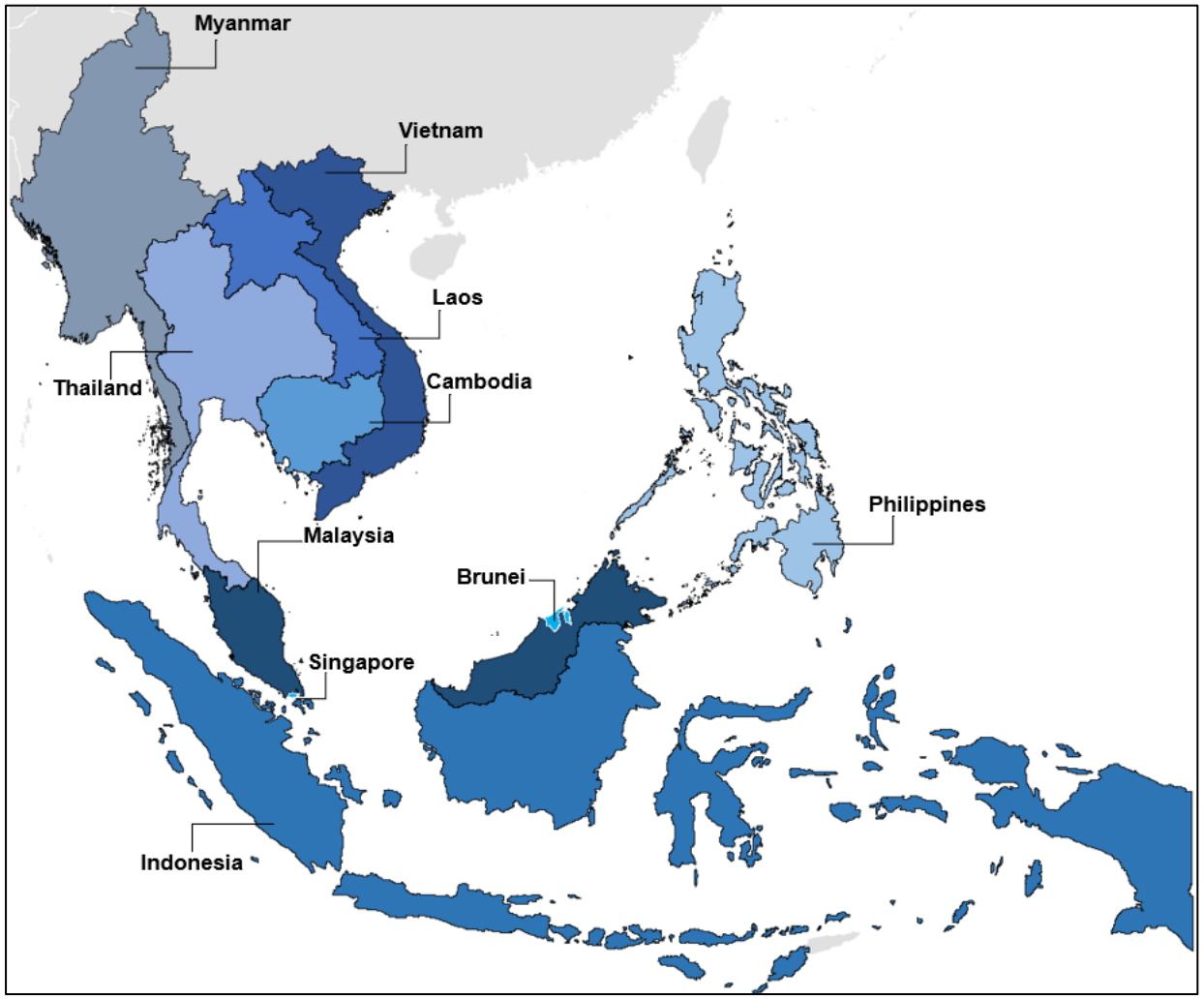

Figure. Countries included in the FPV technical potential assessment

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.

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What is Floating Solar PV (FPV)?

Solar PV sited on waterbodies such as lakes, reservoirs, and water treatment ponds.

Some Co-Benefits of FPV:

- Reduced land use
- Increased panel efficiency
- Water conservation
- Reduced solar PV curtailment (when hybridized with hydropower)

Source: Gadzanku et al. 2021

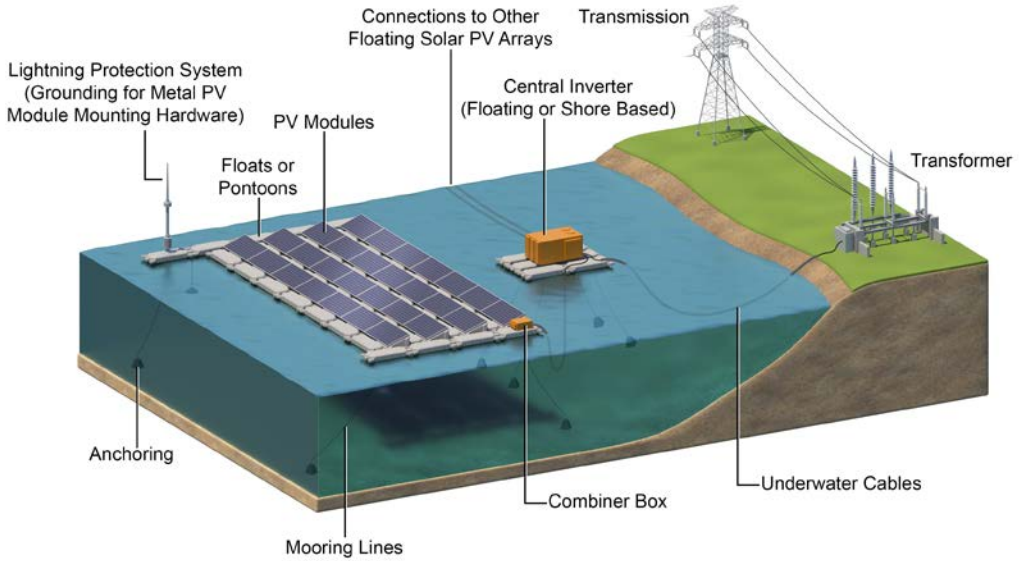

Figure. Schematic of stand-alone FPV system

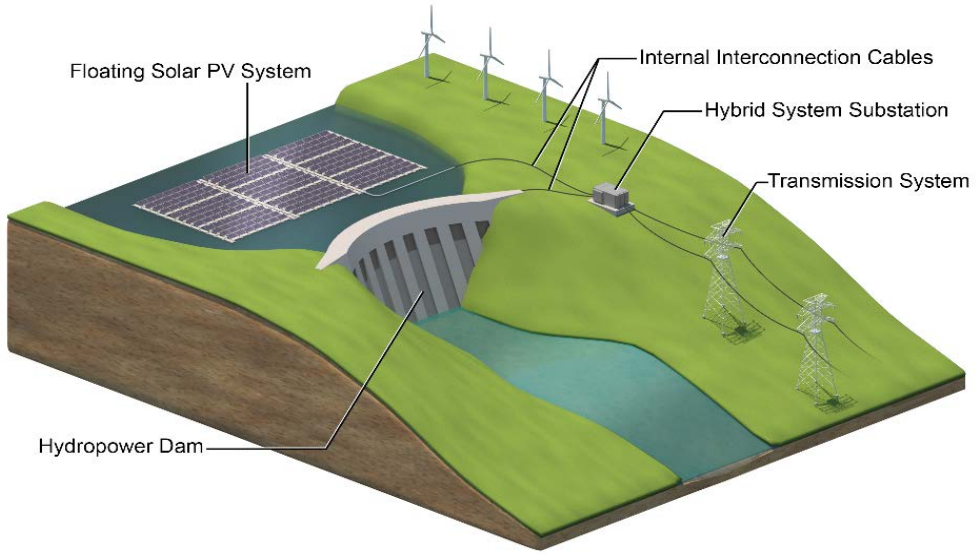

Figure. Schematic of hybrid FPV-hydropower system

Source: Lee et al. 2020

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Methods

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

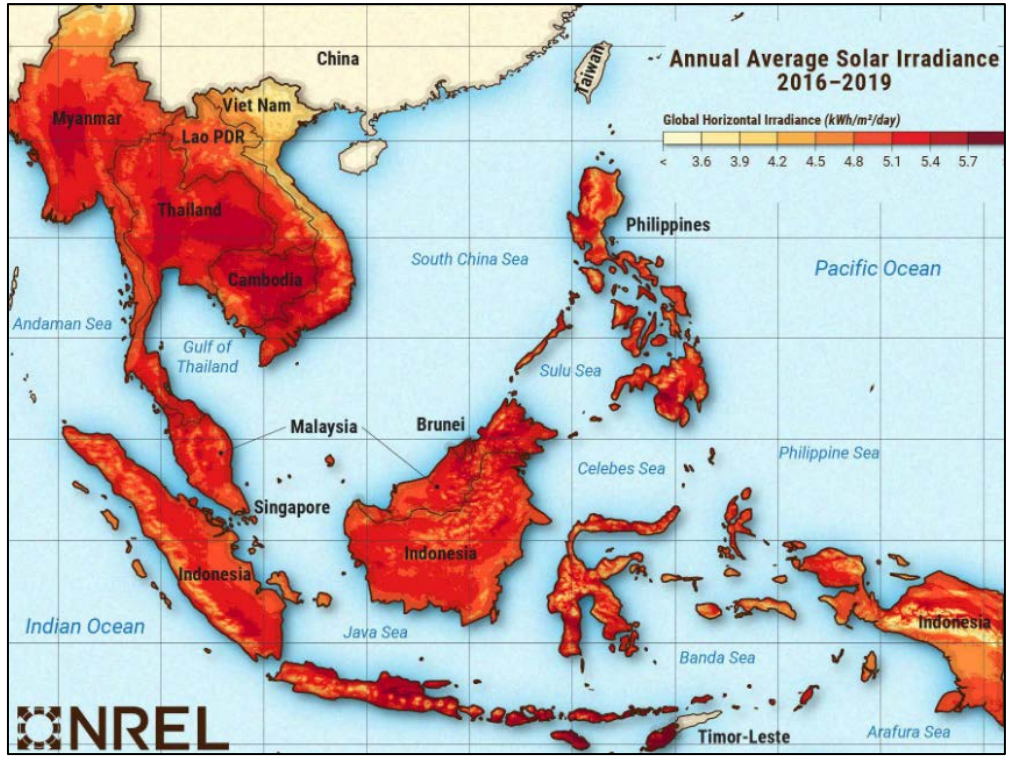

Figure. High-resolution solar resource data available for SE Asia

Source: Maclaurin et al. 2022

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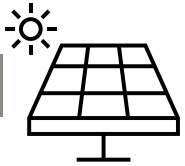
Analysis Scenarios

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

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).

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Findings

Technical Potential: Reservoirs

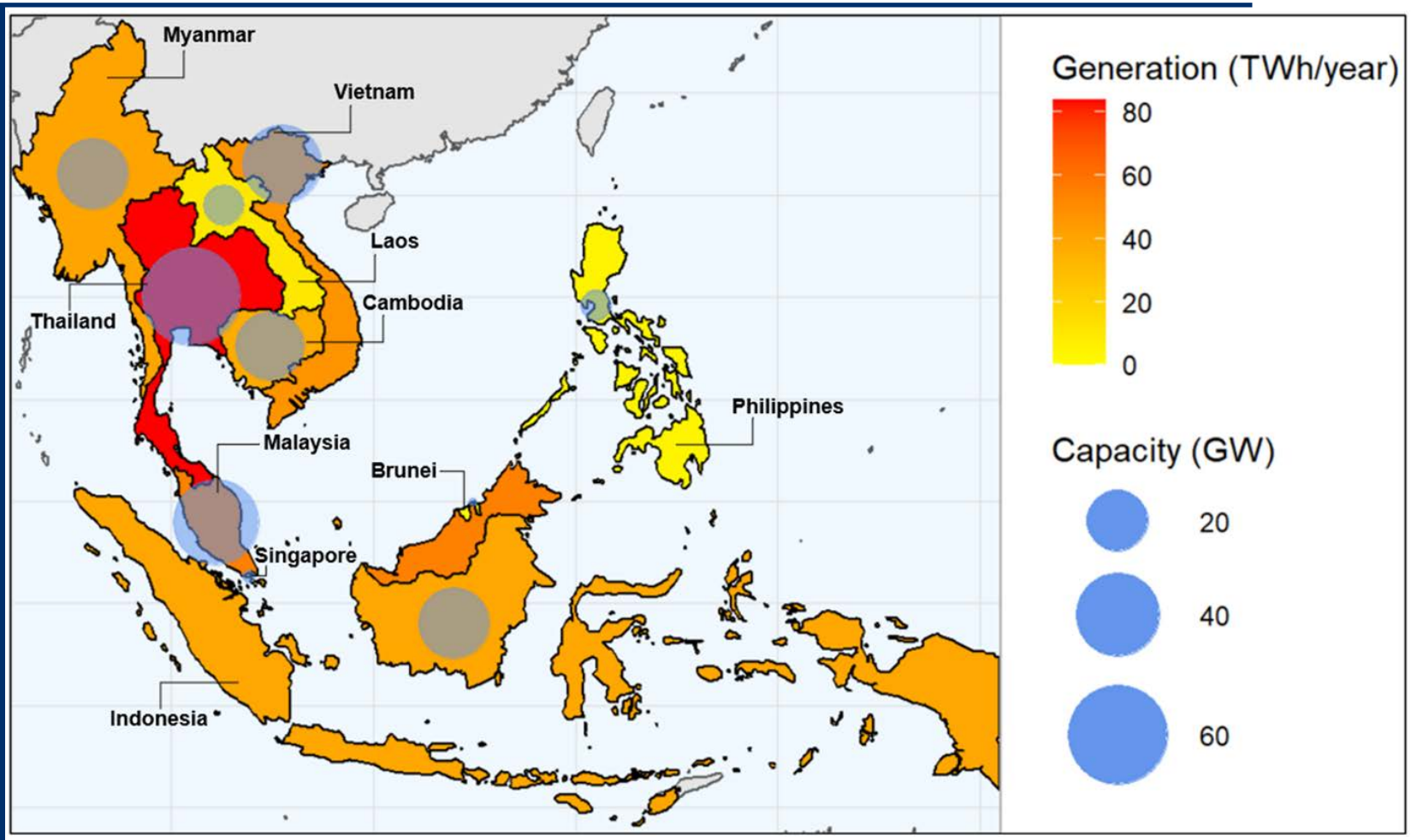

Figure. FPV generation and capacity technical potential for reservoirs in SE Asia

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.

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Technical Potential: Natural Waterbodies

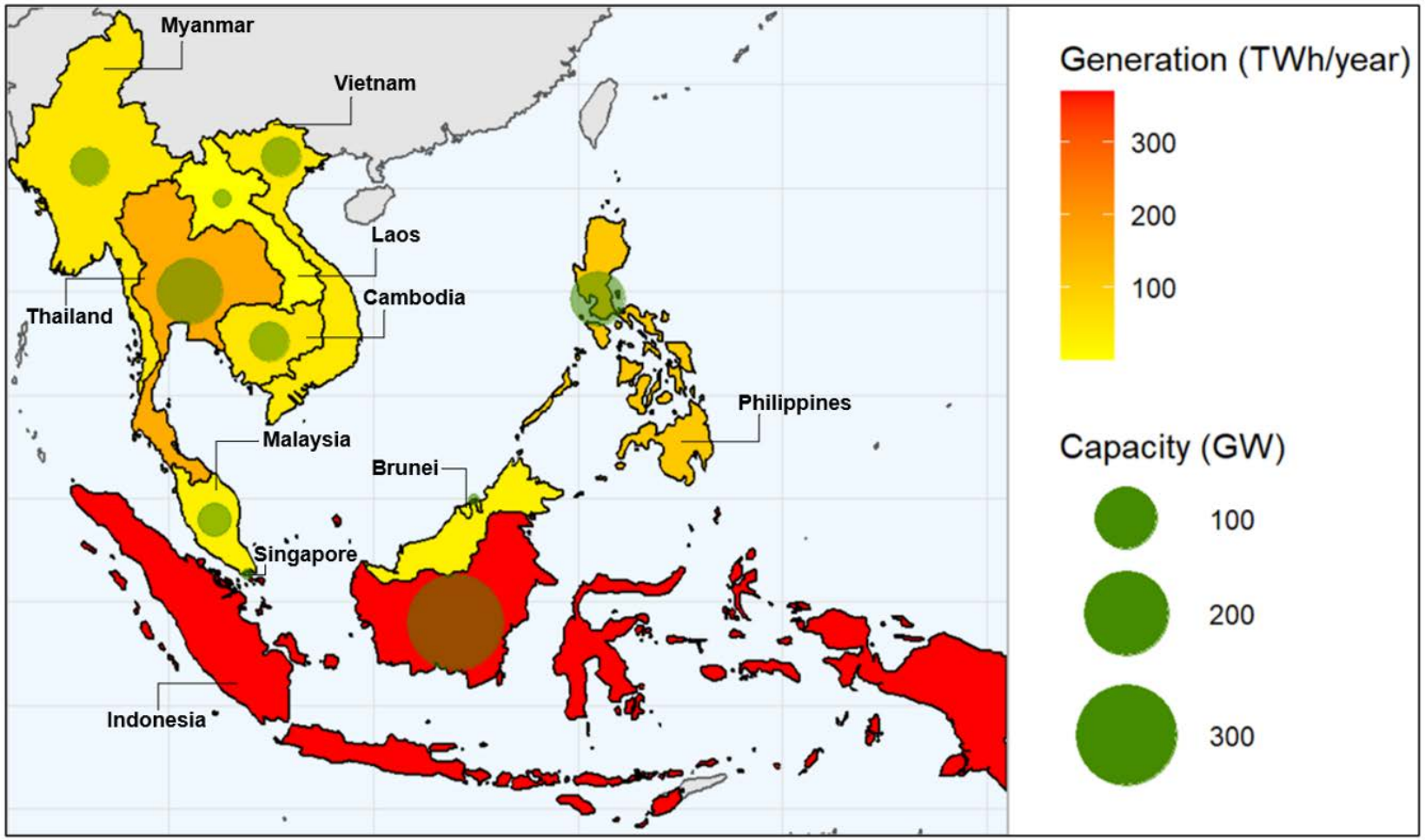

Figure. FPV generation and capacity technical potential for natural waterbodies in SE Asia

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.

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Discussion

Brunei

Total Installed Electricity Generation Capacity (2021):
2.1 GW

Renewable Energy Target:
30% generation by 2035

Transmission data not available for analysis

FPV Potential (Reservoirs):
N/A

FPV Potential (Natural Waterbodies):
137 – 669 MW

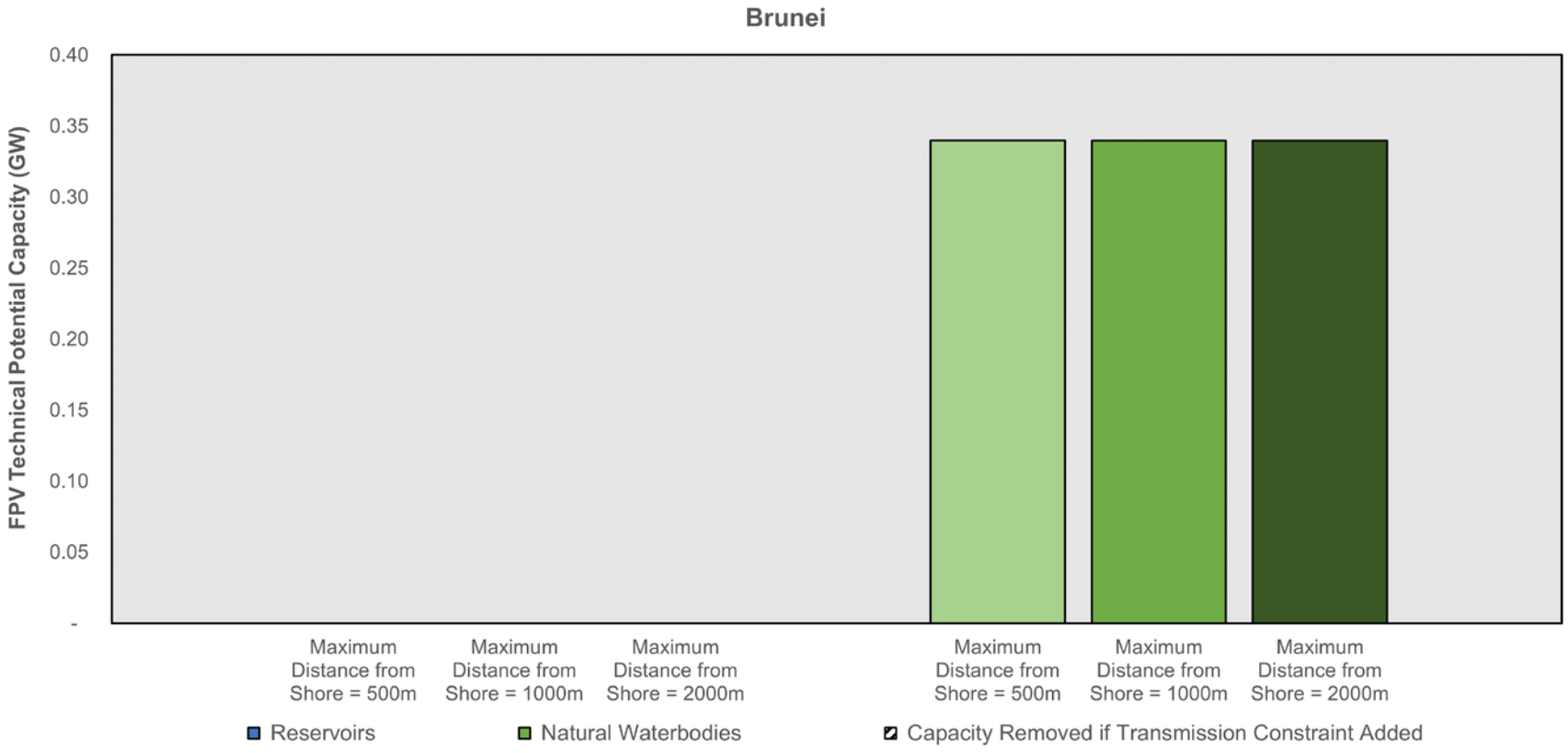

Figure. FPV technical potential capacity in Brunei

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Cambodia

Total Installed Electricity Generation Capacity (2021): 3.1 GW

Renewable Energy Target: 55% capacity hydro, 6.5% biomass, and 3.5% solar by 2030

Transmission data available for analysis

FPV Potential (Reservoirs): 15 – 29 GW

FPV Potential (Natural Waterbodies): 22 – 46 GW

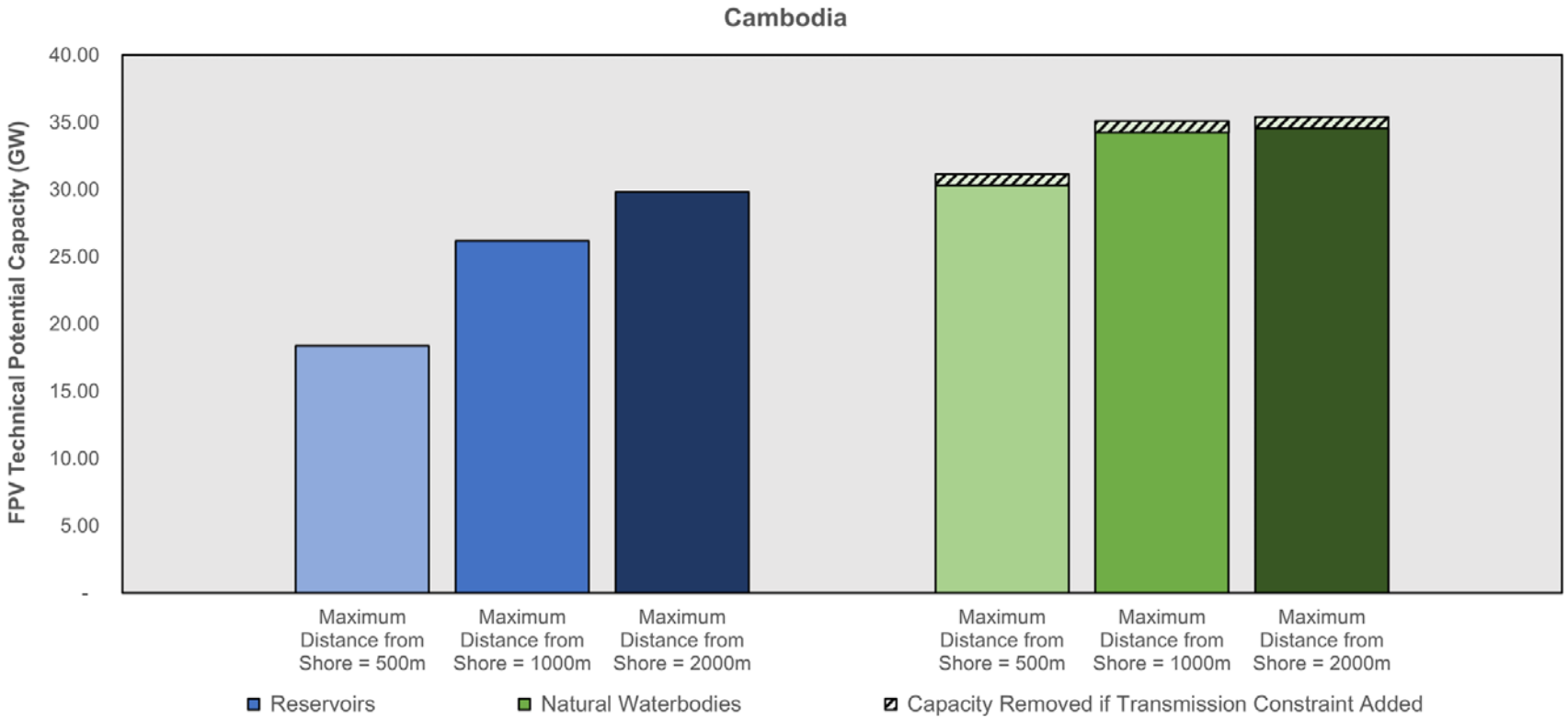

Figure. FPV technical potential capacity in Cambodia

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

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Indonesia

Total Installed Electricity Generation Capacity (2021): 74 GW

Renewable Energy Target: Add 21 GW by 2030, including 4.9 GW hydro and 2.5 GW solar

Transmission data not available for analysis

FPV Potential (Reservoirs): 16 – 34 GW

FPV Potential (Natural Waterbodies): 154 – 330 GW

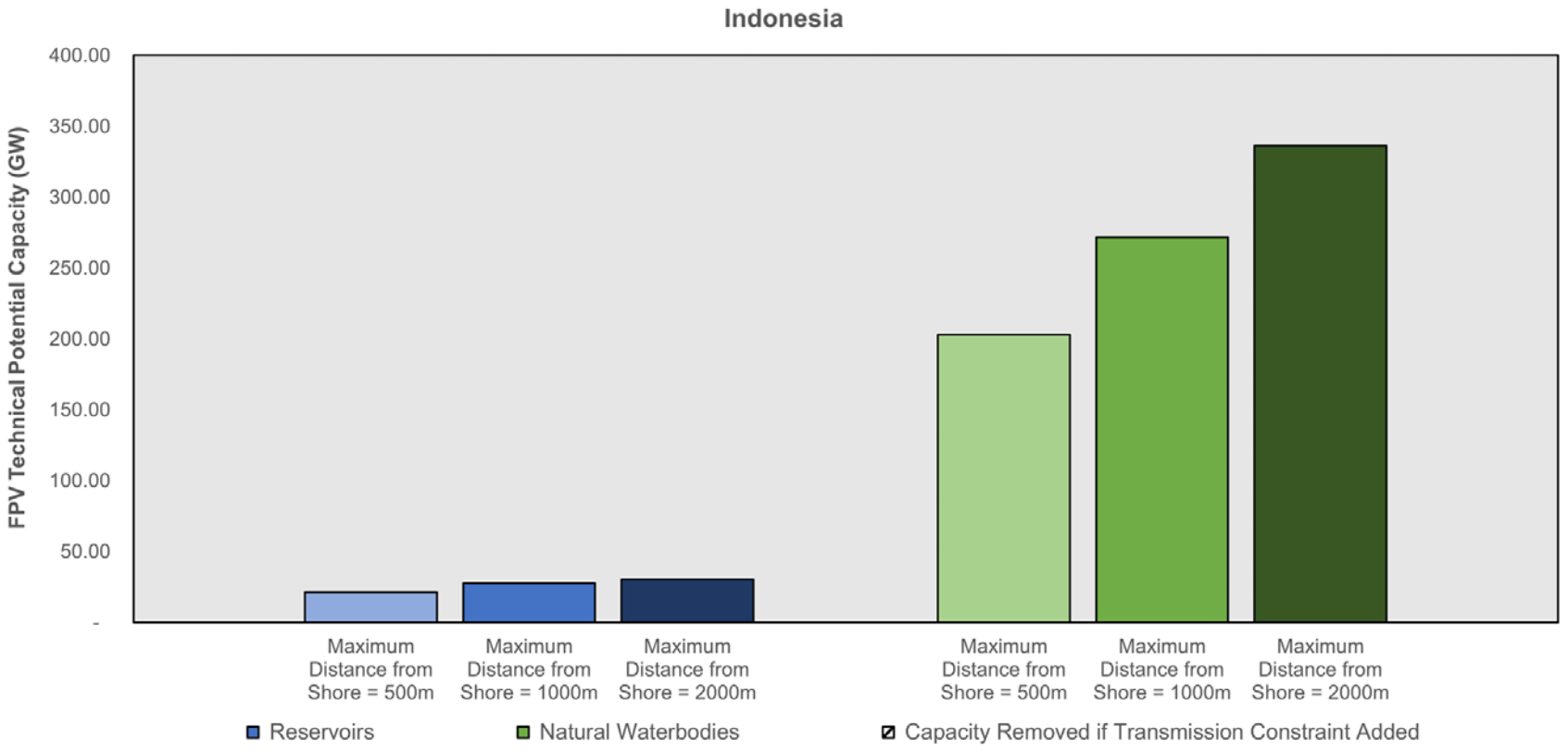

Figure. FPV technical potential capacity in Indonesia

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

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Laos

Total Installed Electricity Generation Capacity (2021):
10 GW

Renewable Energy Target:
30% of consumption by 2025

Transmission data available for analysis

FPV Potential (Reservoirs):
5 – 10 GW

FPV Potential (Natural Waterbodies):
2 – 5 GW

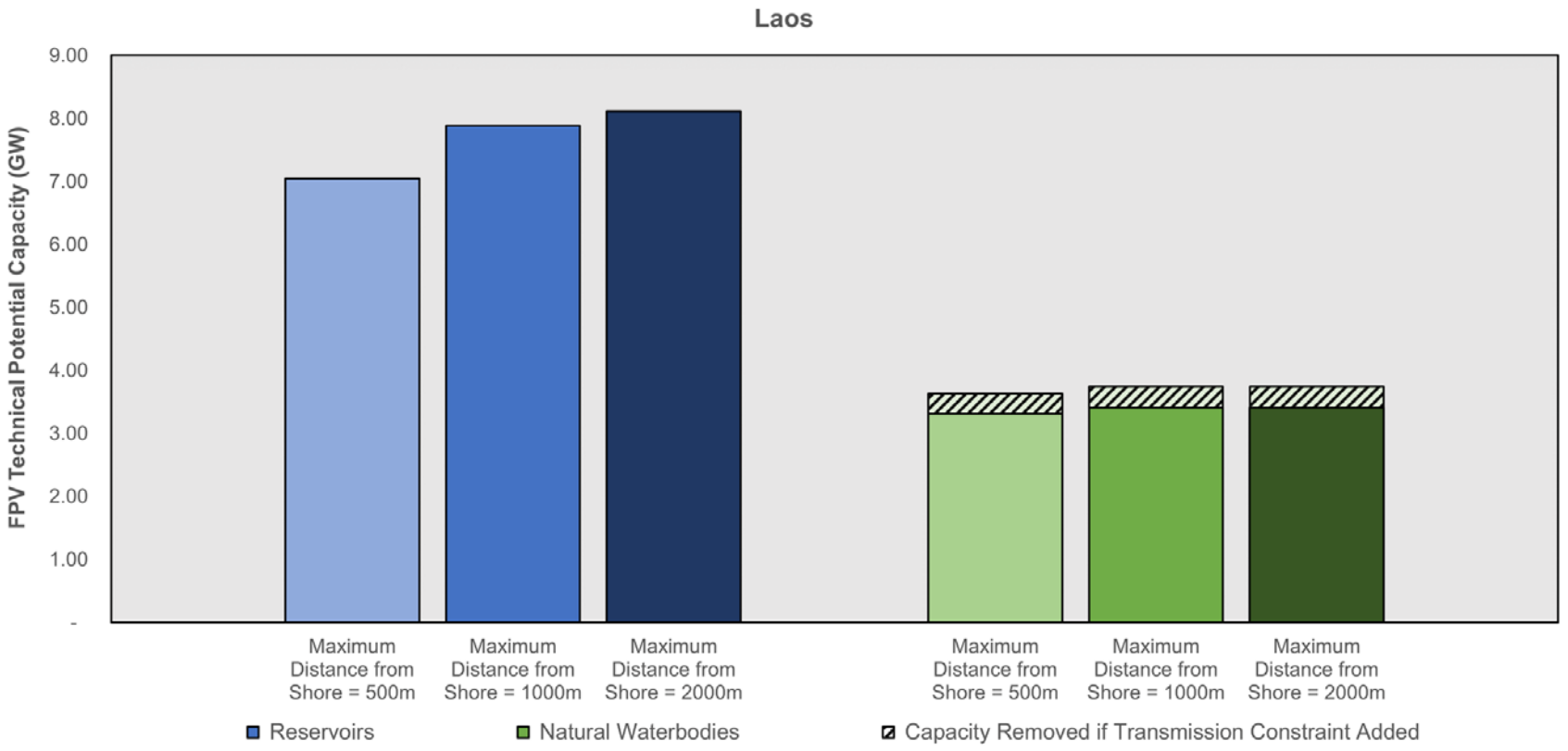

Figure. FPV technical potential capacity in Laos

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Malaysia

Total Installed Electricity Generation Capacity (2021):
39 GW

Renewable Energy Target:
31% of installed capacity by 2025

Transmission data not available for analysis

FPV Potential (Reservoirs):
23 – 54 GW

FPV Potential (Natural Waterbodies):
13 – 30 GW

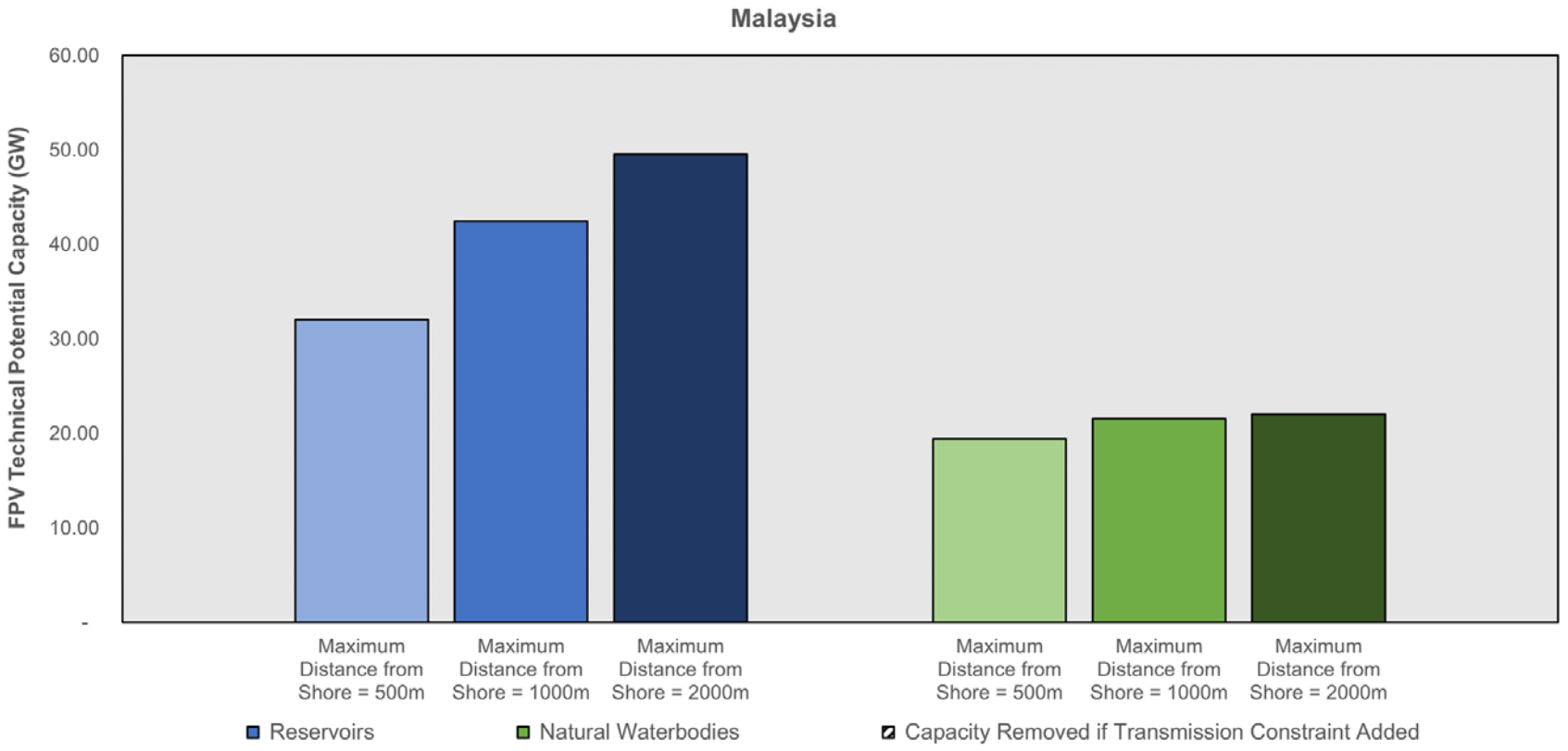

Figure. FPV technical potential capacity in Malaysia

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

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Myanmar

Total Installed Electricity Generation Capacity (2021):
7.6 GW

Renewable Energy Target:
20% of installed capacity by 2025

Transmission data available for analysis

FPV Potential (Reservoirs):
18 – 35 GW

FPV Potential (Natural Waterbodies):
21 – 47 GW

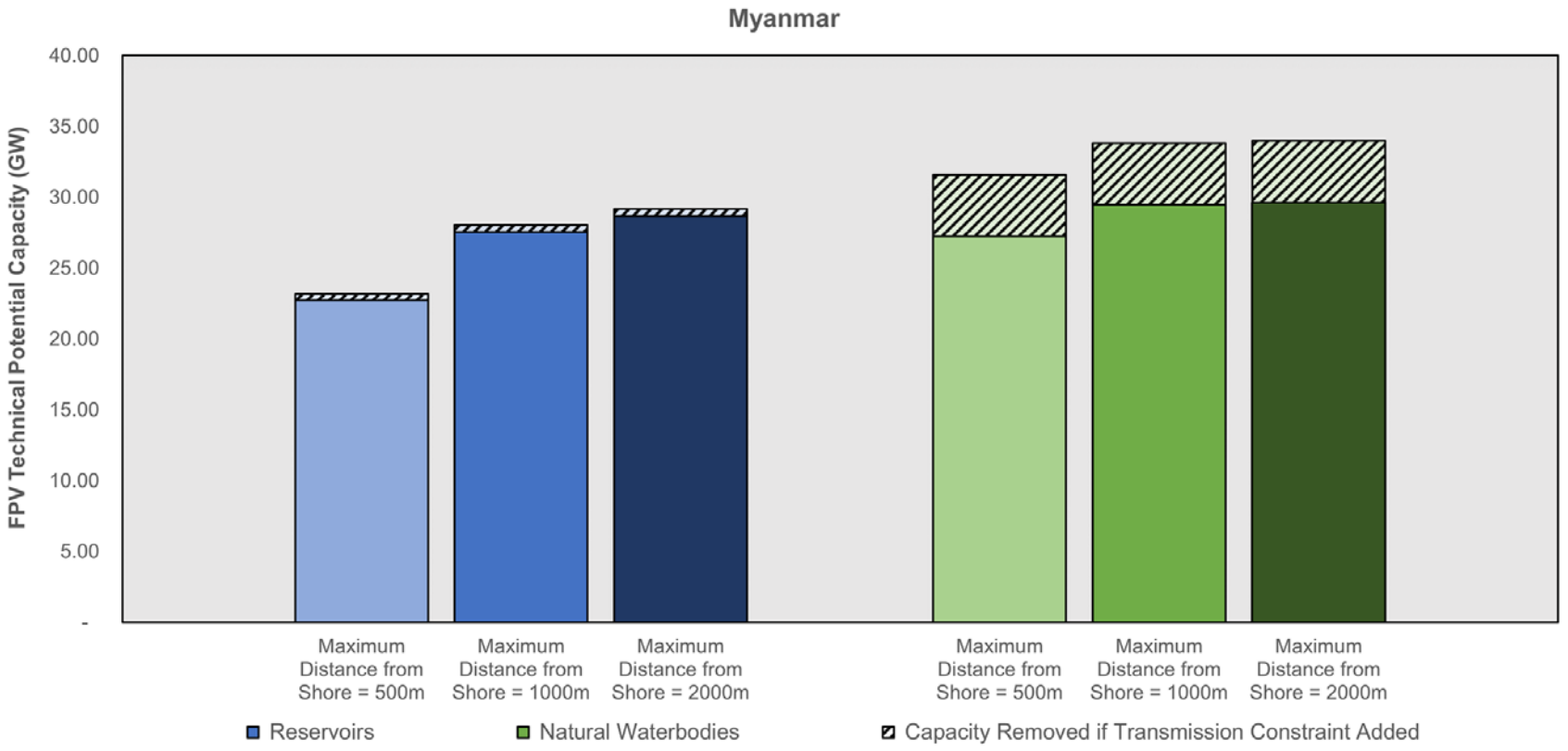

Figure. FPV technical potential capacity in Myanmar

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Philippines

Total Installed Electricity Generation Capacity (2021):
28 GW

Renewable Energy Target:
Add 15 GW by 2030

Transmission data available for analysis

FPV Potential (Reservoirs):
2 – 5 GW

FPV Potential (Natural Waterbodies):
42 – 103 GW

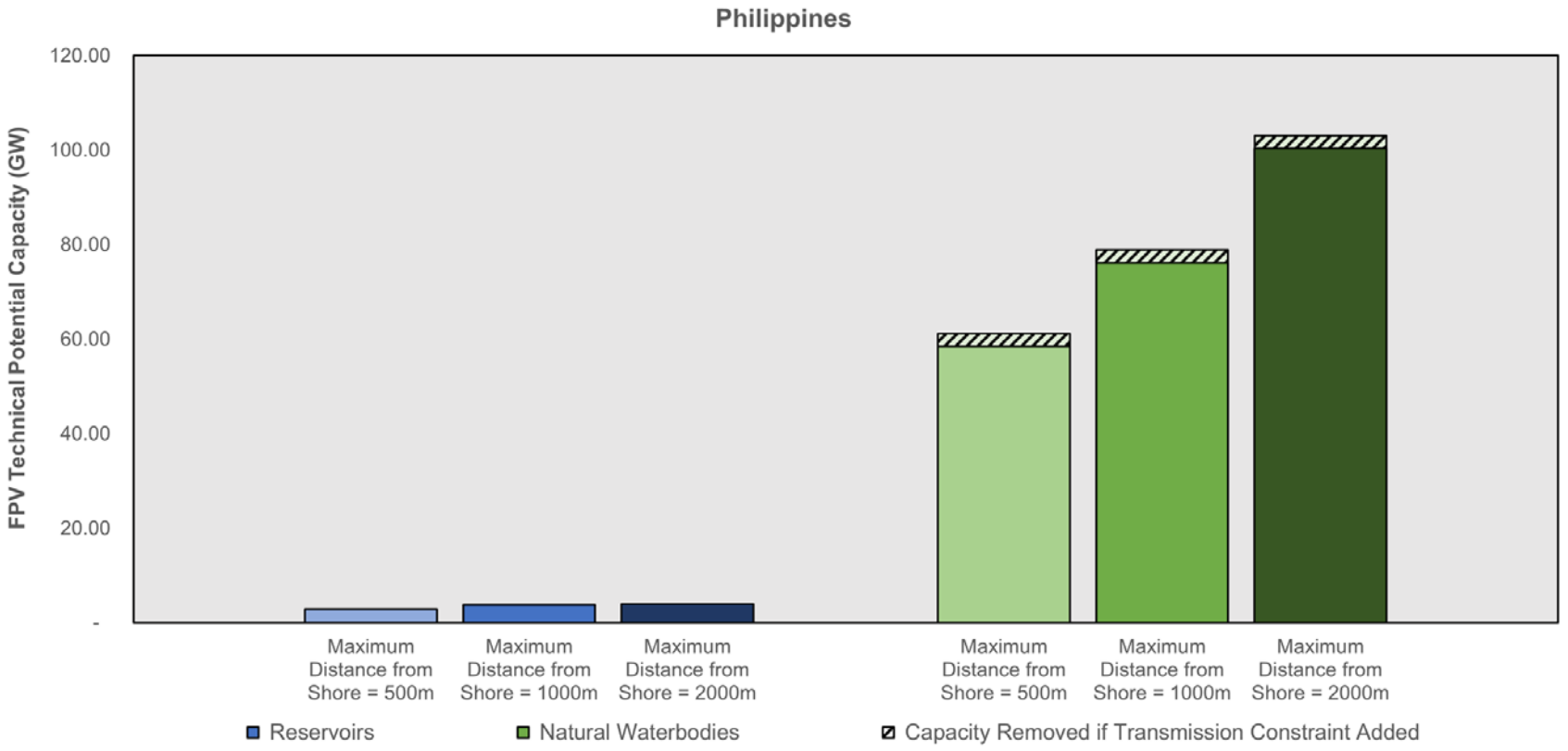

Figure. FPV technical potential capacity in the Philippines

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

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Singapore

Total Installed Electricity Generation Capacity (2021): 12 GW

Renewable Energy Target: 2 GW solar by 2030 and 30% of energy from low carbon imports by 2035

Transmission data not available for analysis

FPV Potential (Reservoirs): 67 – 153 MW

FPV Potential (Natural Waterbodies): 206 – 381 MW

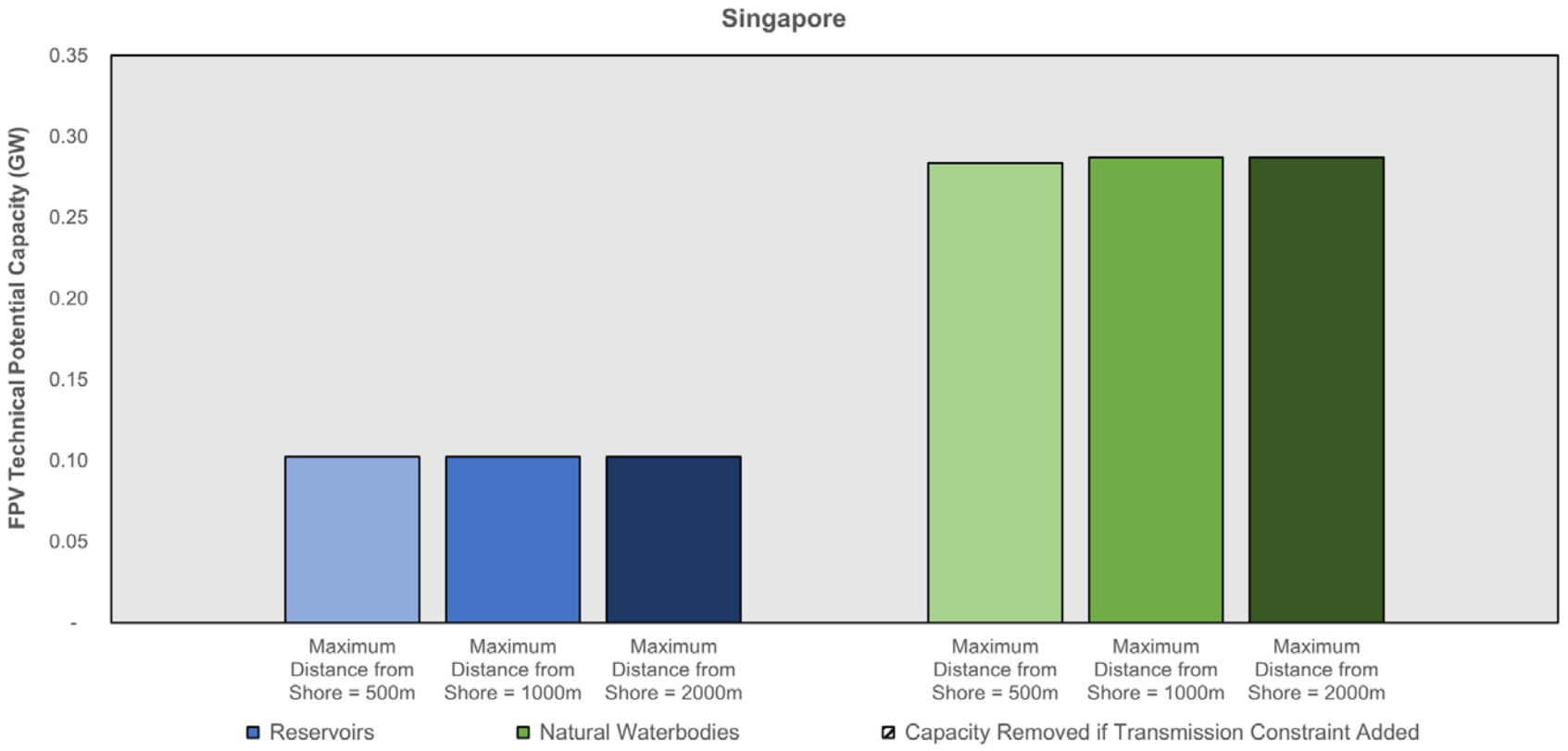

Figure. FPV technical potential capacity in Singapore

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Thailand

Total Installed Electricity Generation Capacity (2021):
55 GW

Renewable Energy Target:
36% of installed capacity by 2037

Transmission data available for analysis

FPV Potential (Reservoirs):
33 – 65 GW

FPV Potential (Natural Waterbodies):
68 – 152 GW

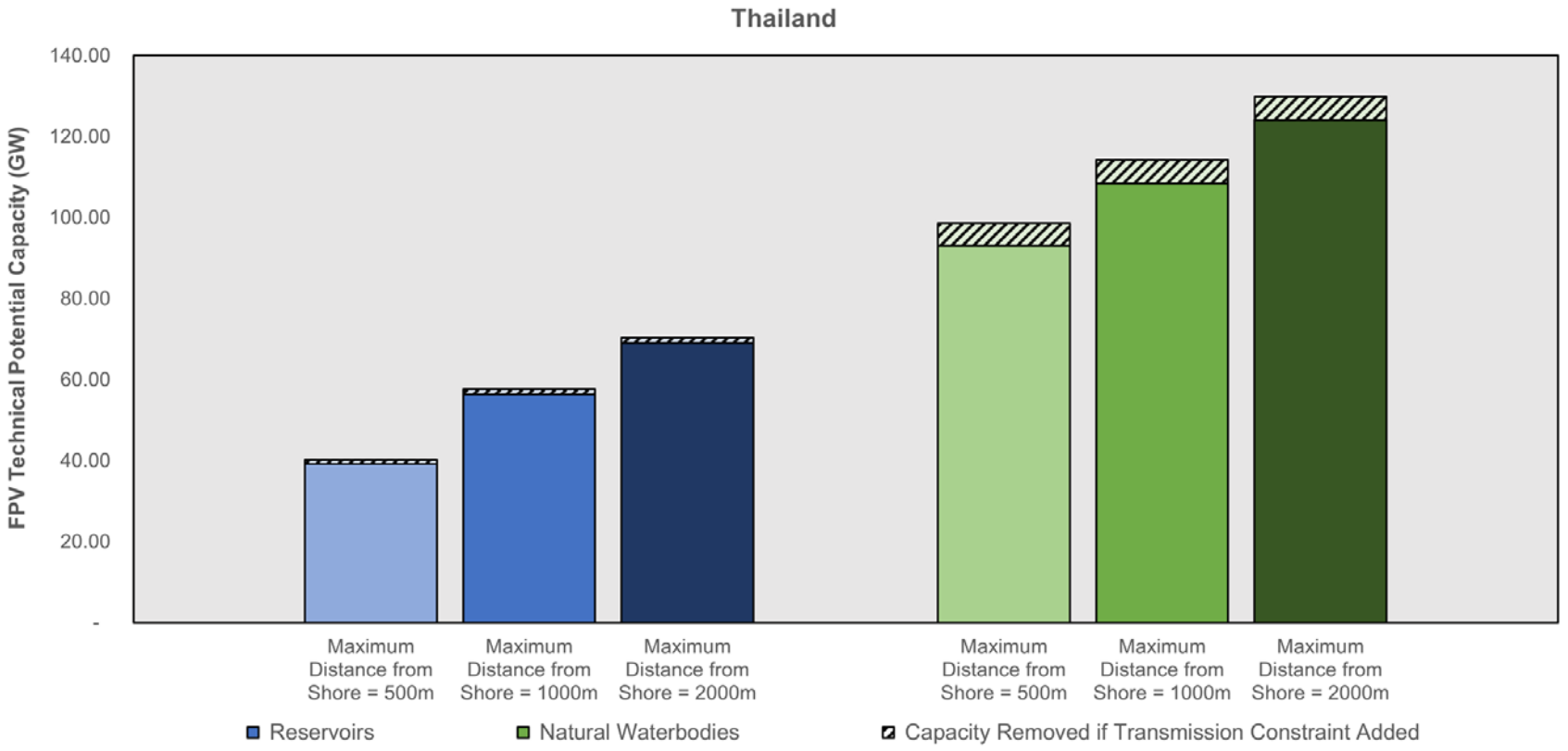

Figure. FPV technical potential capacity in Thailand

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Vietnam

Total Installed Electricity Generation Capacity (2021): 76 GW

Renewable Energy Target: Add 31-38 GW of solar and wind capacity by 2030

Transmission data available for analysis

FPV Potential (Reservoirs): 21 – 46 GW

FPV Potential (Natural Waterbodies): 21 – 54 GW

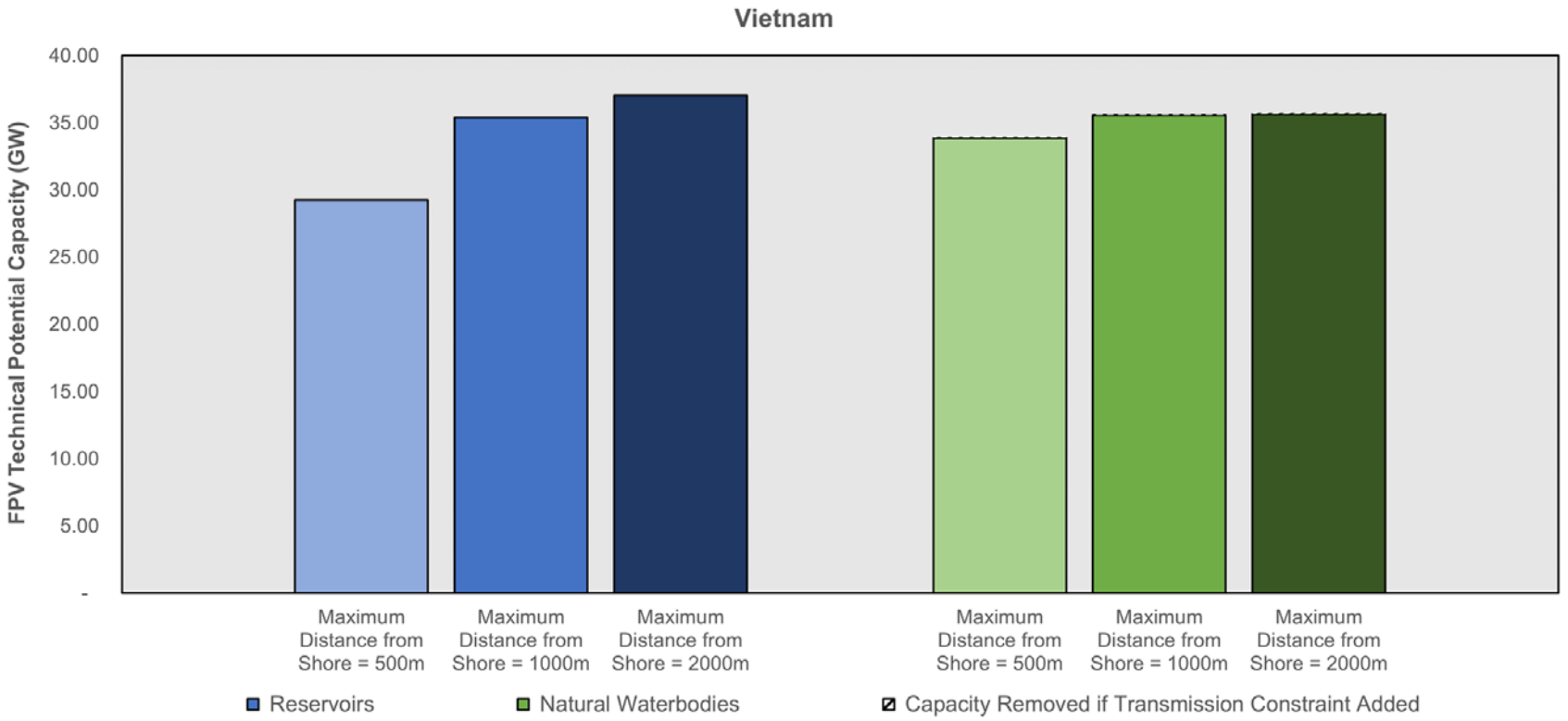

Figure. FPV technical potential capacity in Vietnam

Note: These results assume fixed-tilt monofacial FPV panels, with a 50-m minimum distance-from-shore buffer. The dataset excludes waterbodies that are more than 50 km from major roads and waterbodies that are within protected areas. Optional transmission constraint removes waterbodies that are further than 25 km from the nearest transmission line.

Conclusion

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

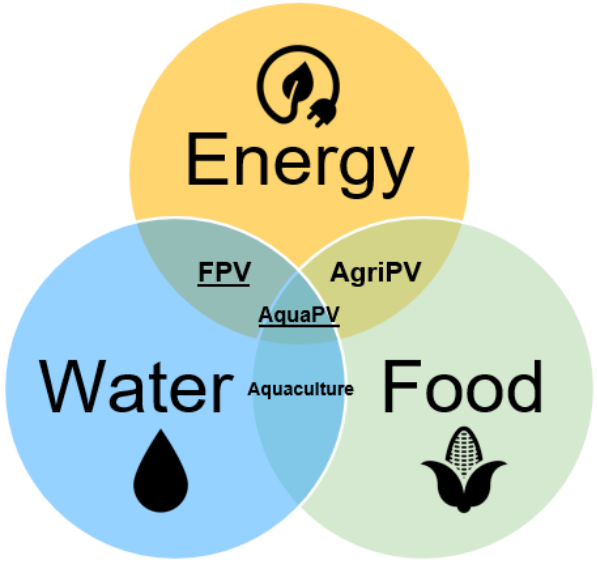

Figure. Food-Energy-Water nexus with role of FPV and AquaPV

Source: Joshi 2023

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Thank you!

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This work was authored, in part, by the National Renewable Energy Laboratory (NREL), operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the United States Agency for International Development (USAID) under Contract No. IAG-19-2115. The views expressed in this report do not necessarily represent the views of the DOE or the U.S. Government, or any agency thereof, including USAID. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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