Exploring the Technical Potential of Solar PV and Wind Energy System in ASEAN

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Background

Renewable energy is essential for ASEAN's carbon neutrality, but without proper zoning, development may cause environmental degradation or encroach on residential areas.

PV system on forested slopes (Japan)

Reference:Google map

PV system near residential areas (Japan)

Reference:Google map

ASEAN must identify priority zones for deployment and set realistic targets to scale up renewable energy adoption.

Observed Siting of PV system in ASEAN

Government-related projects in ASEAN tend to focus on rooftops and underutilized land with low environmental and social impact.

Abandoned mine planned for PV installation by Indonesian state-owned enterprise

Reference: Google map

Promotion of deployment on underutilized land [1]
(also in Malaysia [2])

PV system deployed under Singapore's SolarNova program

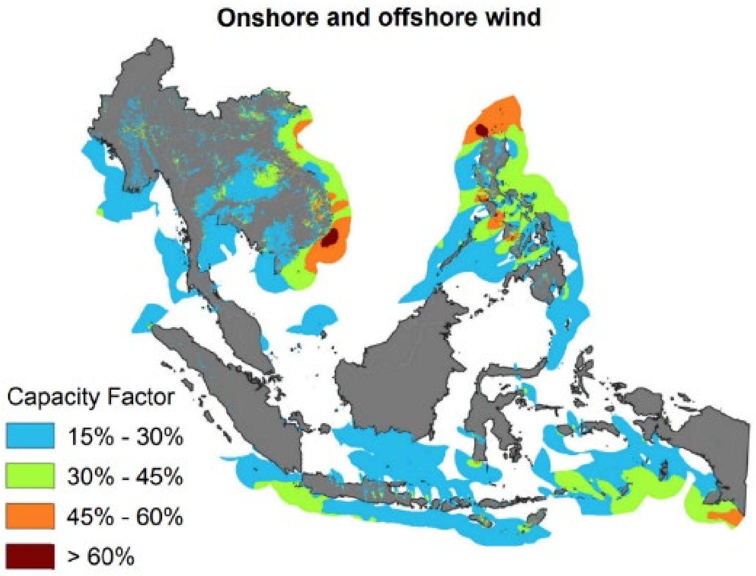
Reference:Housing development board [3]

Promotion of rooftop solar deployment [3]
(also in Brunei [4])

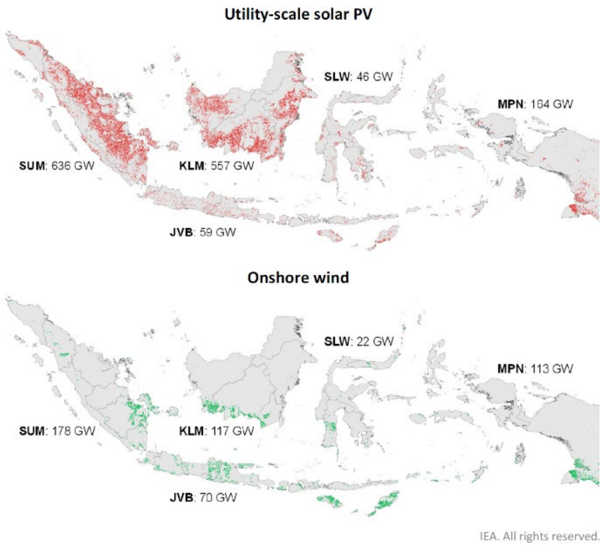
Previous Studies on Technical Potential in ASEAN (1)

- IEA [5] identified technically suitable areas in ASEAN and estimated the total solar and wind capacity there at 20 TW.
- Separately, IEA [6] estimated Indonesia's potential at 1,500 GW for utility-scale solar and 500 GW for onshore wind.

Wind energy resource map by IEA[5]



Technical potential for utility-scale solar PV and onshore wind in Indonesia by IEA[6]



Indonesia's solar PV and wind technical potential is concentrated on Sumatra and Kalimantan, far from the load centres on the island of Java

Previous Studies on Technical Potential in ASEAN (2)

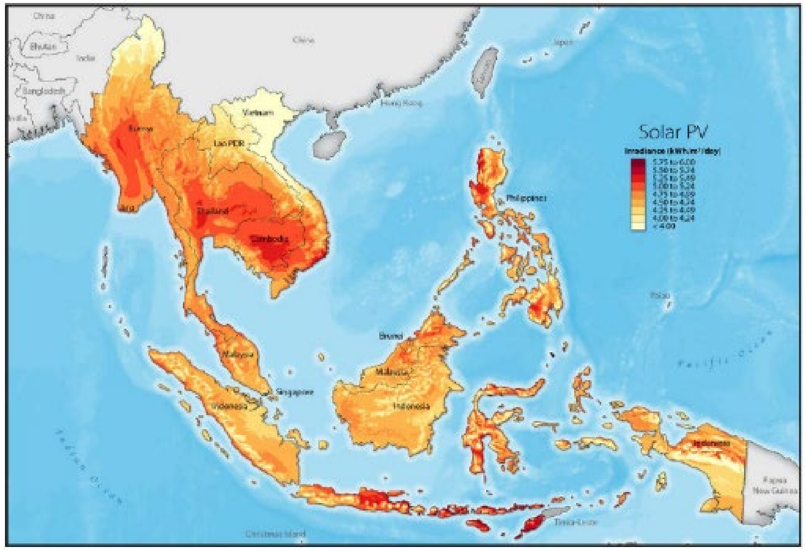
- IRENA [7] used 1 km grid–cell geospatial data, excluding protected areas, forests, urban areas, wetlands, farmland, and steep slopes when estimating technical potential—15.6 TW for solar, 0.1 TW for onshore wind, and 1.1 TW for offshore wind.
- Lee et al. [8] also used 1 km grid cell data to assess technical potential under different land-use scenarios.

ASEAN's renewable energy potential by IRENA[7]

Table 11 ASEAN's renewable energy potential for power generation

	RENEWABLE ENERGY RESOURCES (GW)					
	PV	ONSHORE WIND	OFFSHORE WIND	BIOMASS	HYDRO	GEOTHERMAL
Brunei Darussalam	1.9	-	-	-	0.1	-
Indonesia	2 898	19.6	589	43.3	94.6	29.5
Cambodia	1 597	2.5	88.8	-	10	-
Lao PDR	983	11.9	-	1.2	26	0.1
Myanmar	5 310	2.4	-	1	40.4	-
Malaysia	337	-	53.3	4.2	29	-
Philippines	122.5	3.5	69.4	0.2	10.5	4
Singapore	0.3	0.1	-	-	-	-
Thailand	3 509	32.4	29.6	18	15	-
Viet Nam	844	31.1	322.1	8.6	35	0.3

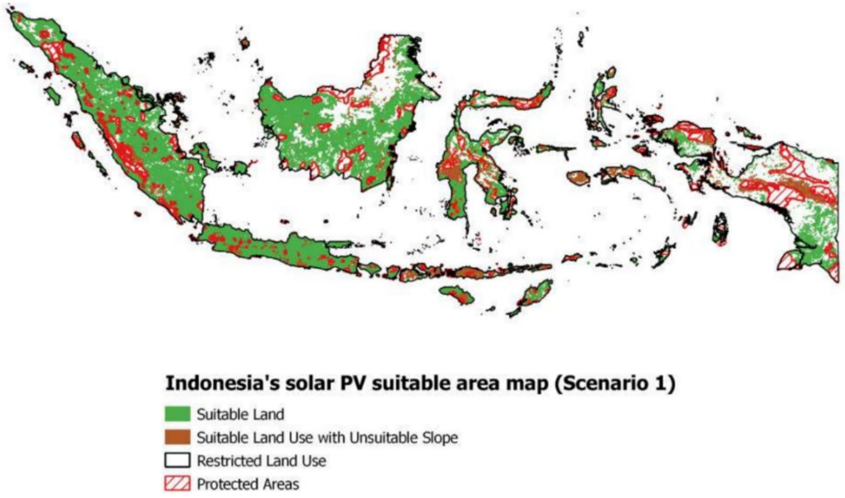
Solar resource potentials across ASEAN member states by Lee et al.[8]



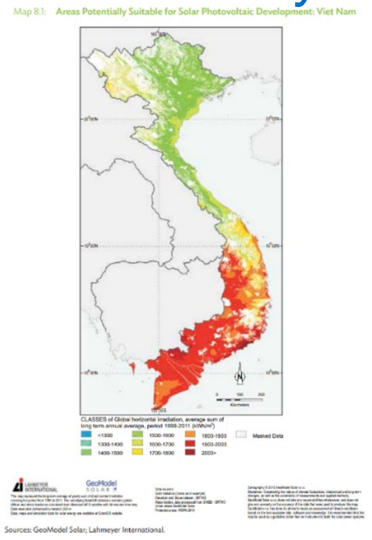
Previous Studies on Technical Potential in ASEAN (3)

- Siala et al. [9] evaluated solar power generation in ASEAN using high-resolution solar irradiance data.
- Vidinopoulos et al. [10] estimated technical potential based on statistical land area data, assuming installation outside forests, farmland, and urban zones.
- Several studies [11]–[16] have focused on ASEAN subregions.

Indonesia's solar PV suitable area map by ISER[14]



Areas Potentially Suitable for Solar Photovoltaic Development in Vietnam by World bank[15]



Limitations of Previous Studies

While previous studies suggest substantial technical potential relative to electricity demand, several key limitations remain:

(1) Lack of consideration for deployment barriers

Grid connection challenges, political instability, rooftop structural limits, household income, and competition between solar and wind are often overlooked.

(2) Insufficient spatial resolution of rooftop data

Although some local studies have used statistics or DSM*s to estimate rooftop areas in detail [14][16], large-scale evaluations are lacking.

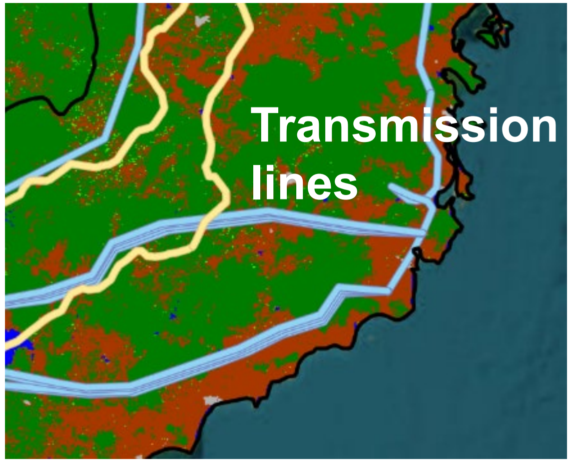
Studies covering all of ASEAN rely mostly on 1 km land-use grids, with limited understanding of rooftop areas at the building level.

* Digital Surface Model

Study Objective

This study assesses the technical potential of solar and wind using geospatial data on underutilized land, rooftops, and offshore areas, considering deployment barriers.

(1) Land use data

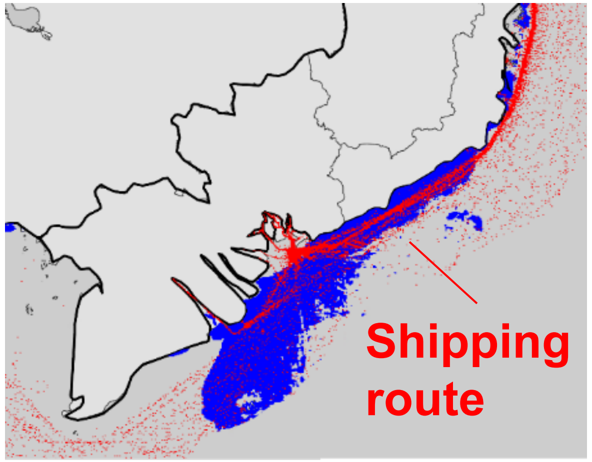


Grid connection feasibility on underutilized land

(2) Building data

Detailed building data based on satellite imagery

(3) Marine use data



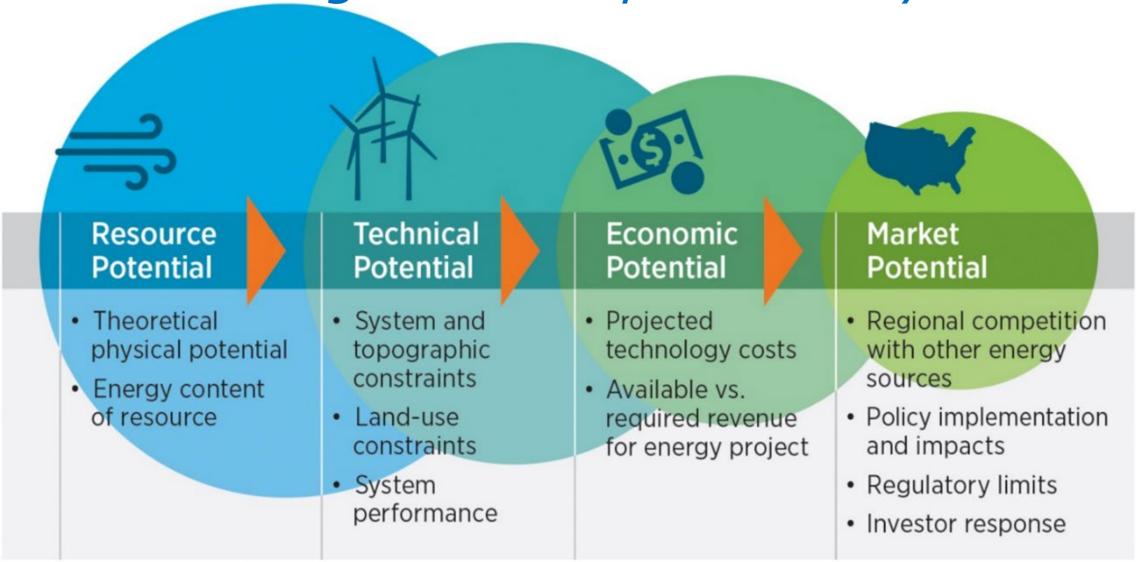
Consideration of competition with maritime use

This study identifies priority areas for solar and wind deployment and clarifies policy challenges through analysis of deployment barriers.

Definition of Technical Potential in This Study

- This study defines "technical potential" with reference to the framework of Lopez et al. [17], incorporating system and topographic constraints, land use, and system performance.
- Economic and social constraints, as well as ecological impacts, are excluded from the assessment, and temporal changes such as future land use transitions are not considered.

Types of renewable generation potential by Brown et al.[18]



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Approach to Defining Suitable Areas in This Study

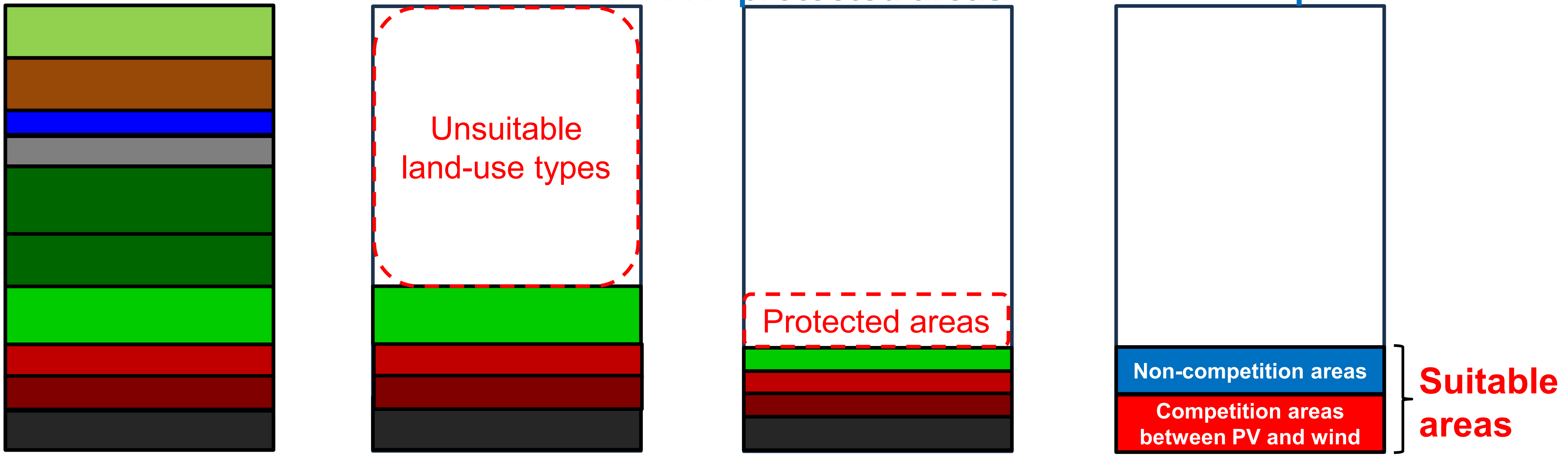
- This study follows Obane et al. [19] to assess suitable areas for ground-mounted PV and onshore wind power.
- Unlike prior studies, this study incorporates competition between PV and wind power.

(1) Land use classification

(2) Exclusion of unsuitable land uses

(3) Exclusion of protected areas

(4) Identification of PV/wind competition areas



Classification of Land Use Categories

Land-use categories were classified based on legal frameworks in each country.

Classification of Land Use Categories

	Land use	Note
Unsuitable	Forest	Not recommended for power installation due to environmental protection.
	Tree open	Lower tree density than forest. Treated as unsuitable for power installation, like forests.
	Farm land	Requires coexistence with farming; excluded from this study.
	Water bodies	Ground-mounted PV is physically difficult to install.
	Wetland	Not recommended due to environmental concerns.
	Urban	Non-building land like roads; physically unsuitable.
	Snow/Ice	Physically unsuitable for power installation.
Suitable	Gravel	No relevant land-use regulations. Likely to have minimal environmental impact.
	Herbaceous	
	Sand	
	Shrub	
	Buildings	Target for rooftop PV installation

Selected Land Use Types for Installation

With reference to Milbrandt et al. [20], land-use categories for each generation type were defined as "land with inherent disadvantages or land marginalized by natural and/or artificial forces" and corresponding categories were selected for development.

Gravel

Sand

Shrub

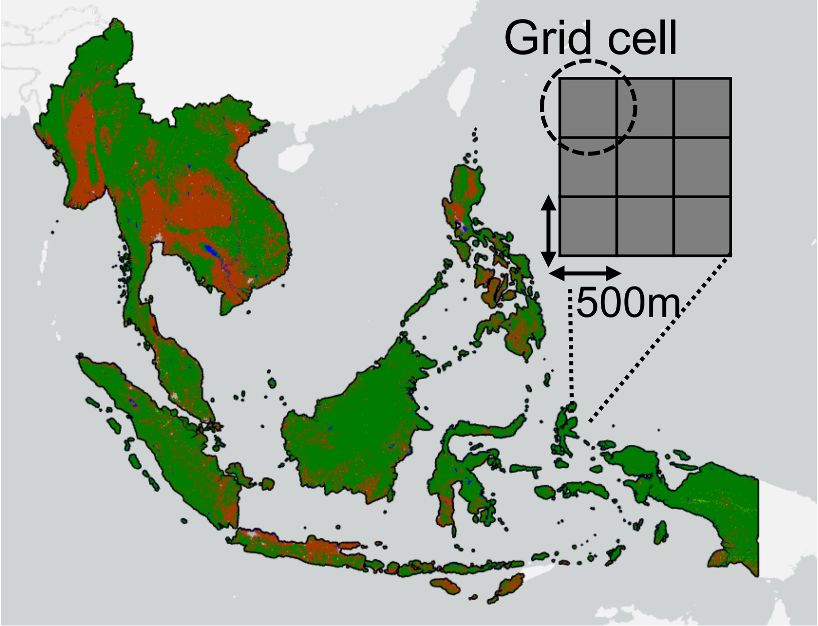
Herbaceous

* All figures generated by ChatGPT-4o.

Method

- Land use was divided into 500 m grid cells, with each cell assigned attributes such as land-use type, protected zones, and distance from transmission lines.
- Among available datasets, GLCNMO ver.3 was adopted due to its higher classification accuracy for identifying suitable land-use types (Appendix III).

Developed land use data

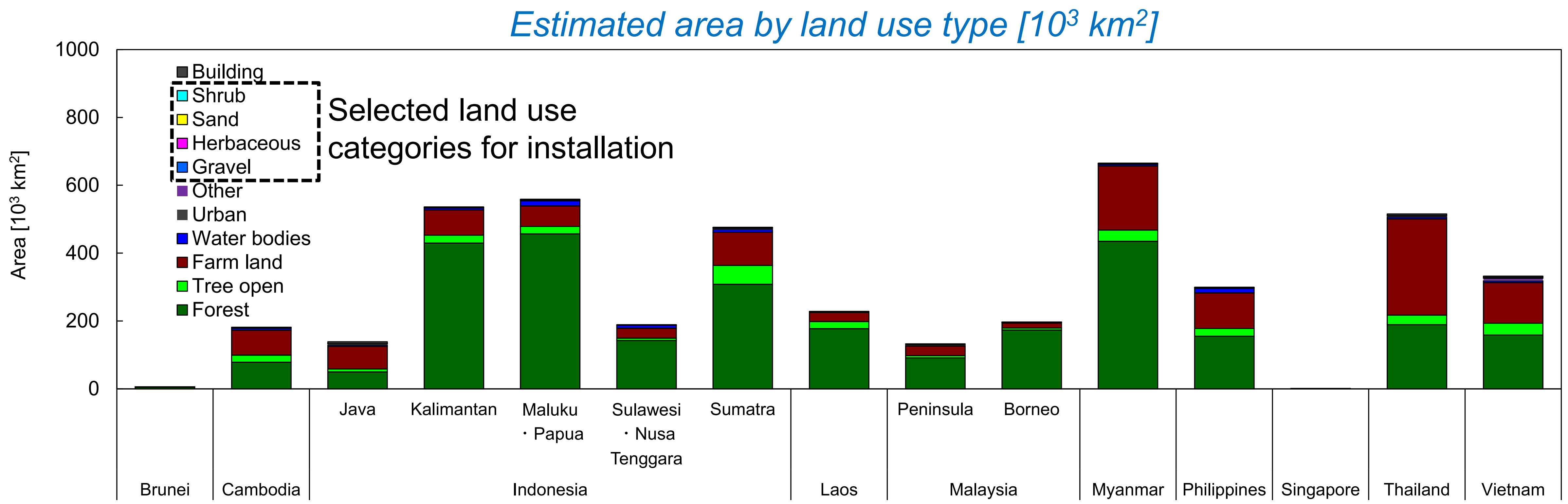


	Data
Land use classification	GLCNMO ver3 [21]
Protected areas	WDPA*1[22], KBA*2[23]
Annual average irradiance	Global Solar Atlas [24]
Annual average wind speed	Global Wind Atlas [25]
Topography	Average slope in 1km grid cell[26]
Distance from Transmission lines	Distance from transmission lines calculated using OSM [27] API
Administrative boundaries	Administrative subdivisions (levels 1 & 2) based on HDX [28]
Grid cell area	Estimated using geodesic measurement in ArcGIS; building areas subtracted

*1 The World Database on Protected Areas
*2 Key Biodiversity Areas

Estimated Area by Land Use Type

This figure shows the estimated land area by category based on GIS* data.



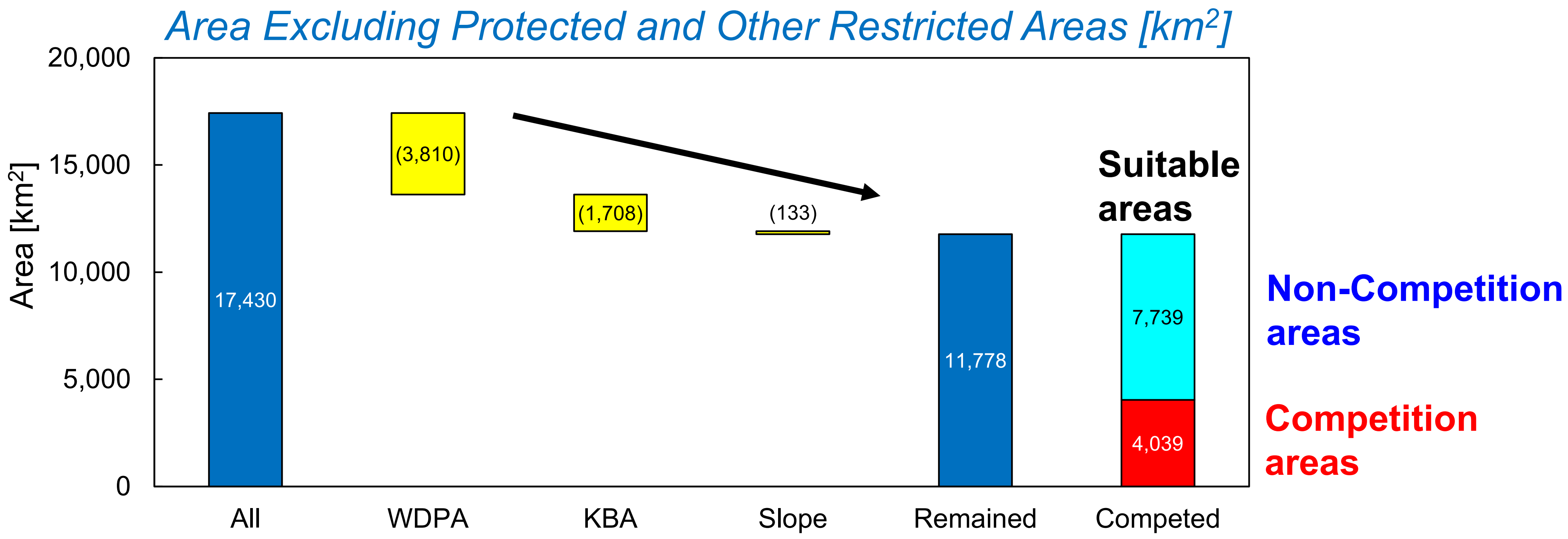
Forests cover 70% and farmland 26% of ASEAN's area (4,455,782 km²), while just 0.4% (17,430 km²) is suitable for solar and wind power, such as graval.

* Geographic information system

Area Excluding Protected and Other Restricted Areas

Suitable areas for installation were refined by excluding protected areas (WDPA), key biodiversity areas (KBA), and land with slopes over 30°.

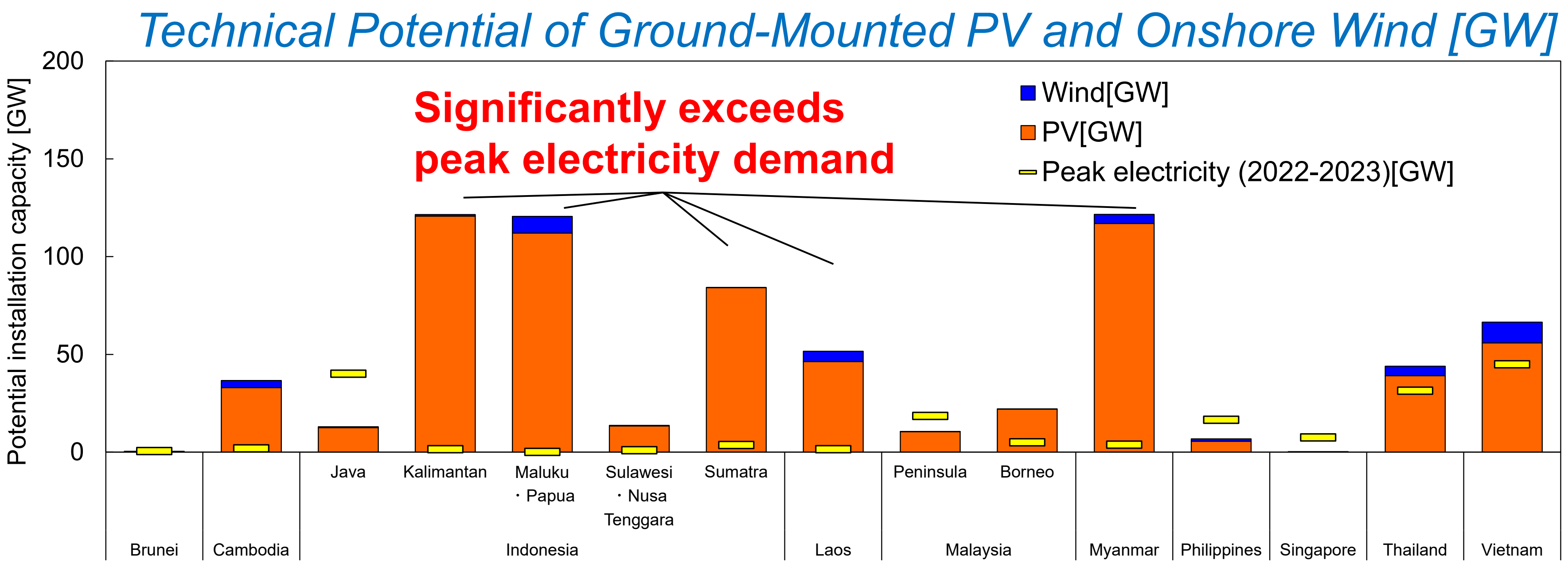
Areas with mean wind ≥5.0 m/s were treated as solar-wind competition areas.



After exclusions, 11,778 km² remains, with ~30% facing solar-wind competition.

Technical Potential of Ground-Mounted PV and Onshore Wind

Technical potential was estimated by assigning solar PV to areas with mean wind speeds < 5.0 m/s, and onshore wind to areas ≥ 5.0 m/s, assuming mutual exclusivity.



* Technical potential of PV was converted using a benchmark capacity density of 0.087 GW/km², based on Bolinger and G. Bolinger [29].
* Technical potential of onshore wind was converted using a theoretical capacity density of 0.010 GW/km², consistent with Obane et al. [19].
* Peak electricity demand was estimated based on reports from electricity companies and related sources [30]–[39].

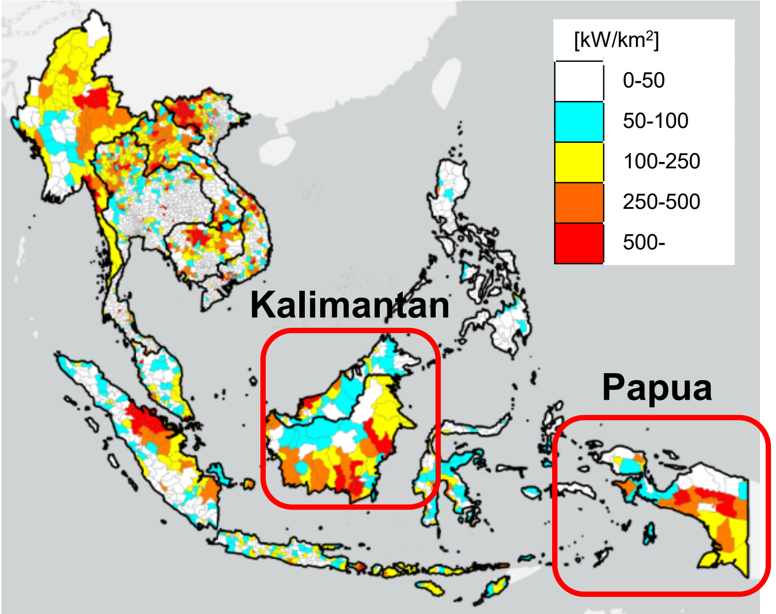
ASEAN's technical potential on underutilized land is estimated at 673 GW for solar PV and 40 GW for onshore wind. However, suitable areas are concentrated in low-demand regions like Maluku, Papua and politically complex regions such as Myanmar.

Regional Technical Potential of ground-mounted PV and onshore wind

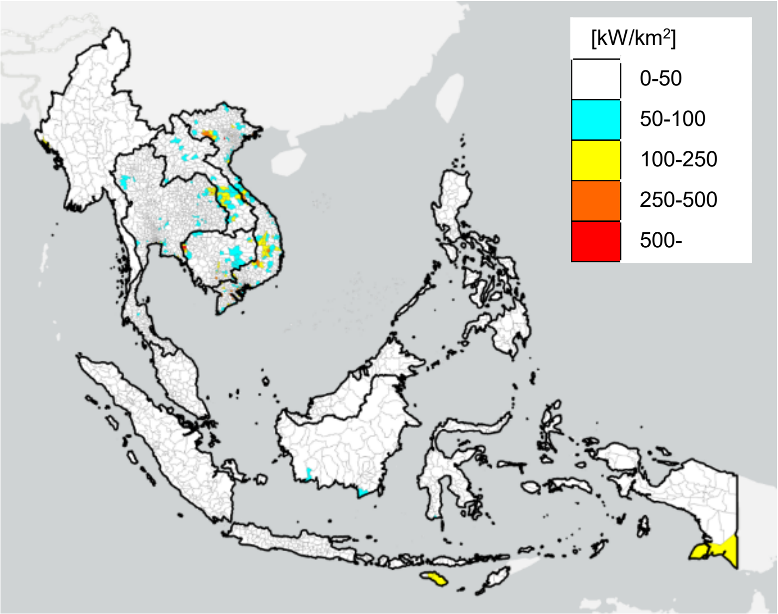
The figure shows regional densities of technical potential [kW/km²].

Regional densities of technical potential [kW/km^2]

(A) Ground-mounted PV



(B) Onshore wind

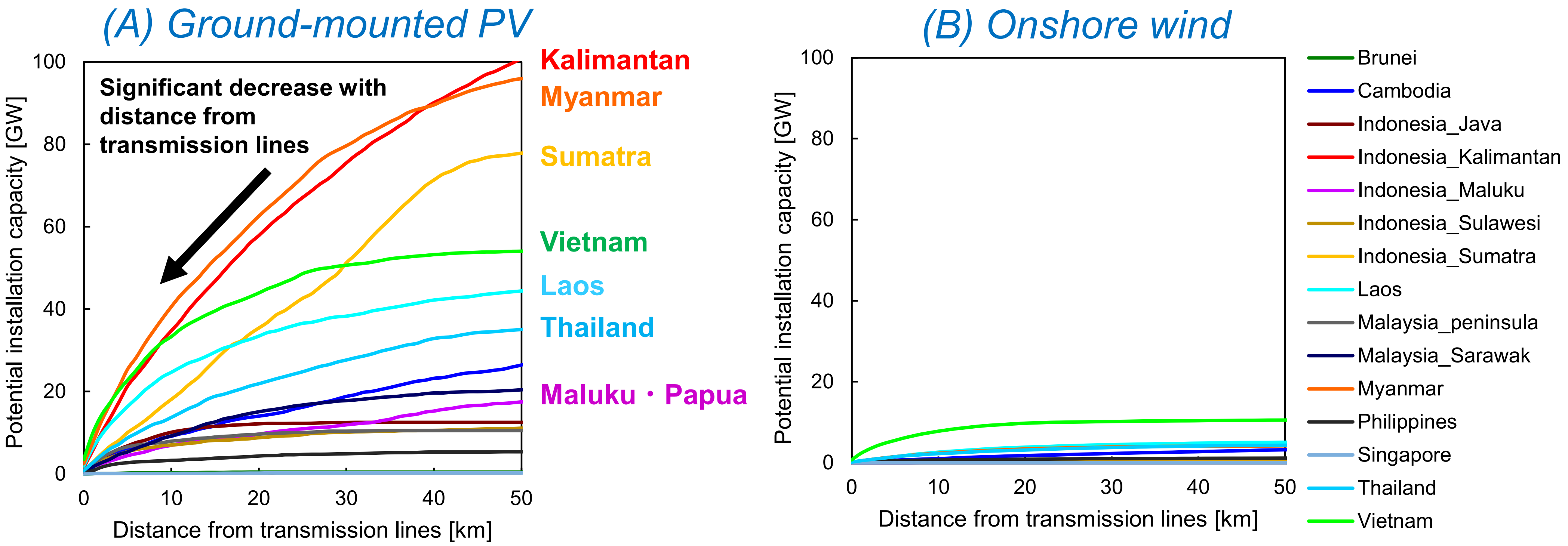


Many suitable areas for ground-mounted solar PV are found in inland Kalimantan and Papua, surrounded by forests. Consideration is needed not only for grid connection costs but also for environmental impacts of expanding grids into forests.

Technical Potential by Distance from Transmission Lines

The technical potential is shown by distance from the nearest transmission lines.

Technical Potential by Distance from Transmission Lines [GW]



* Each x-axis shows the upper threshold of distance from transmission lines. Lines represent technical potential assuming installations are limited to areas within x km.

If solar PV or wind is installed close to transmission lines, technical potential significantly decreases as distance thresholds tighten.
This highlights the need to align grid planning with deployment of both technologies.

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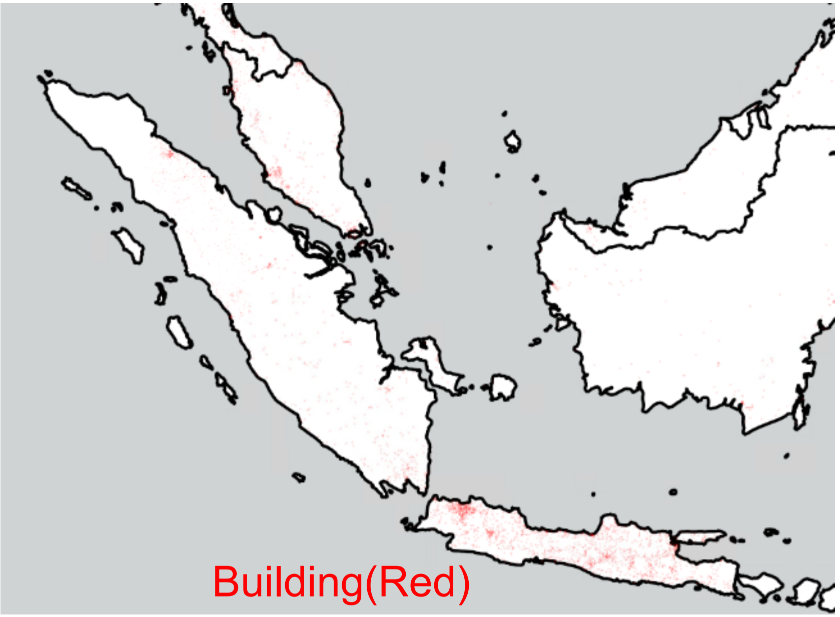
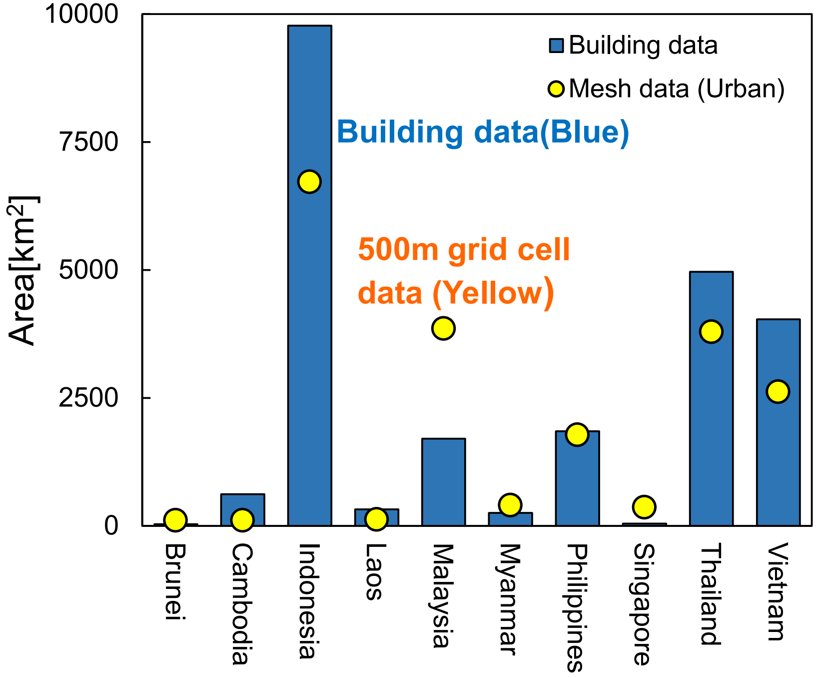
Method for Rooftop PV Analysis Using Building Data

GIS data were developed based on shape information of approx. 290 million buildings from Google Open Buildings [40], and the rooftop area of each building was estimated.

Building footprint (near Java)



Comparison of estimated rooftop areas: building data (bars) vs. grid cell data (dots)



Compared with conventional approaches, the area estimated using building data differed significantly, indicating that the suggested approach can better reflect reality.

Assumptions for PV Installation Ratio on Rooftops

Since GIS-estimated area represents the total rooftop surface, an installation ratio (the proportion of rooftop area suitable for PV installation) was applied based on literature.

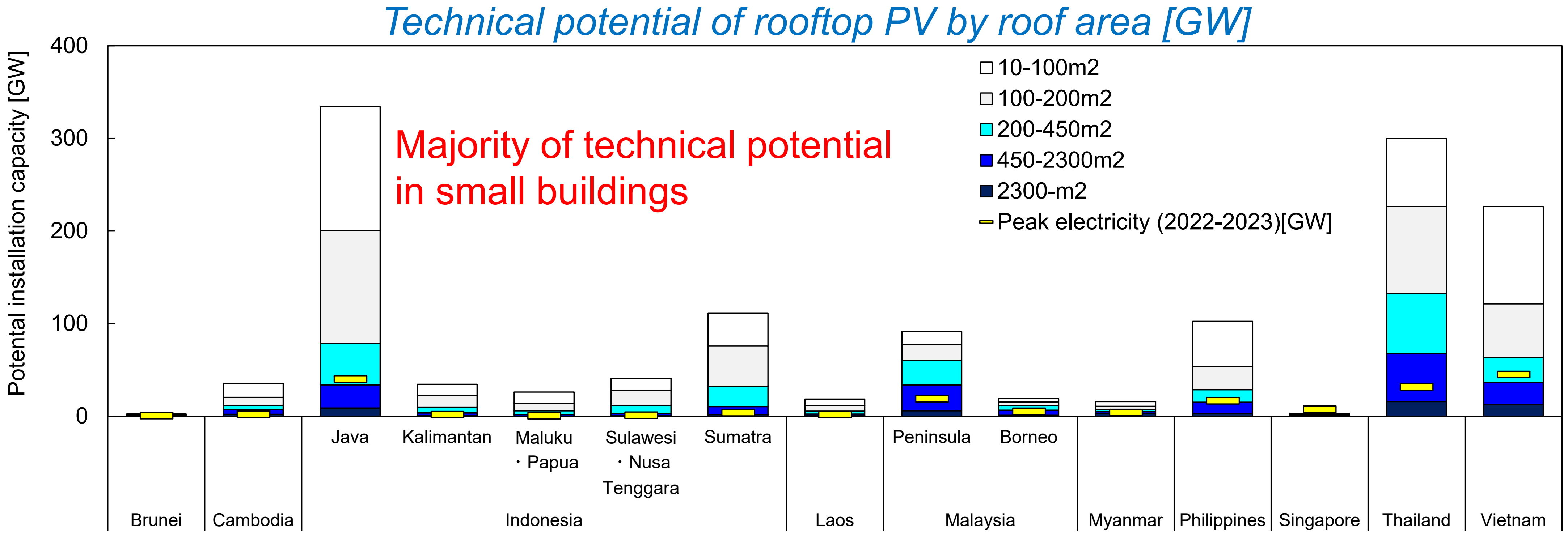
Assumptions for PV installation ratio on rooftops

Roof area [m^2]	Installation ratio	Note
0 – 10	0	Even if PV can be installed, very small rooftops (e.g., <10 m^2) are assumed not suitable due to space for only a few panels.
10 – 100	0.30	Based on a sample survey in Indonesia (Damayanti et al. [41]); typical size for detached houses in ASEAN.
100 – 200	0.36	Based on a sample survey in Indonesia (Damayanti et al. [41])
200 – 450	0.41	Midpoint between installation ratios for roofs of 100–200 m^2 and 450–2,300 m^2.
450 – 2,300	0.49	Based on a U.S. sample survey of medium buildings (5,000–25,000 ft^2) (Gagnon et al. [42]).
2,300 –	0.66	Based on a U.S. sample survey of large buildings (over 25,000 ft^2) (Gagnon et al. [42]).

- A study of 148,882 buildings in Da Nang, Vietnam [16] reported an average installation ratio of 0.32 (no breakdown by roof size).Small residential rooftops are generally assumed to fall within 0.30–0.40.

Technical Potential of Rooftop PV by Roof Area

Using the defined installation ratios, technical potential was estimated by roof size.



* Installed capacity was converted from area using a capacity density of 0.167 W/m², based on the specifications of major residential solar PV system manufacturers [43].

Total potential across ASEAN is 1,361 GW, of which ~70% (898 GW) is concentrated in small buildings with <200 m² of roof area.

-> Despite the large potential, structural limitations may pose challenges.

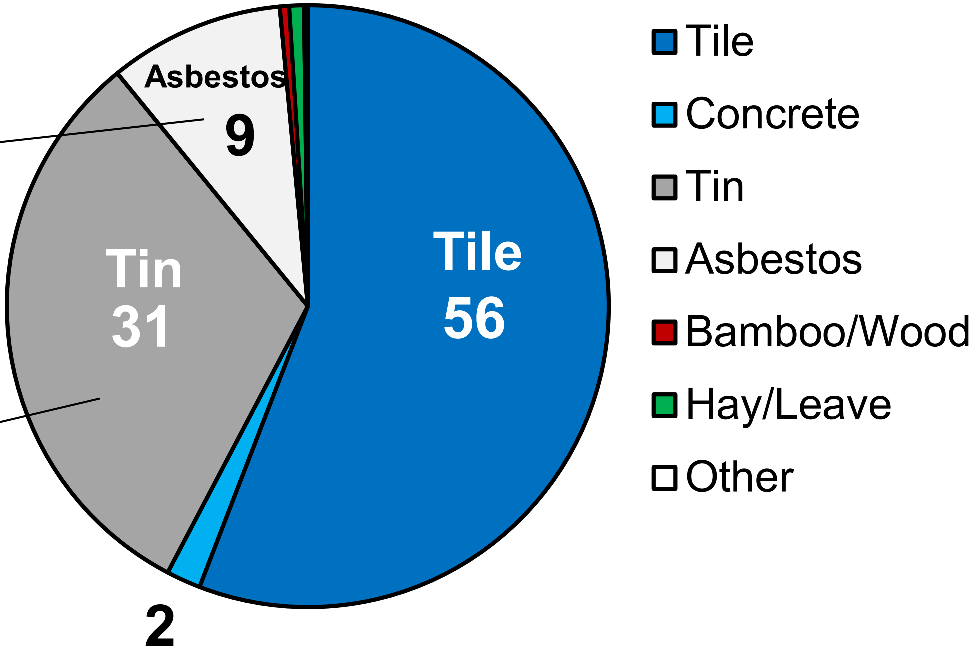
Consideration on roof strength

Roof statistics are unavailable for all ASEAN countries, but in Indonesia—where the potential is highest—around 30% of residential buildings have tin roofs and 10% asbestos. These may lack sufficient structural strength for PV installation.

Roof Types in Indonesian residential buildings [44]

Asbestos

Tin

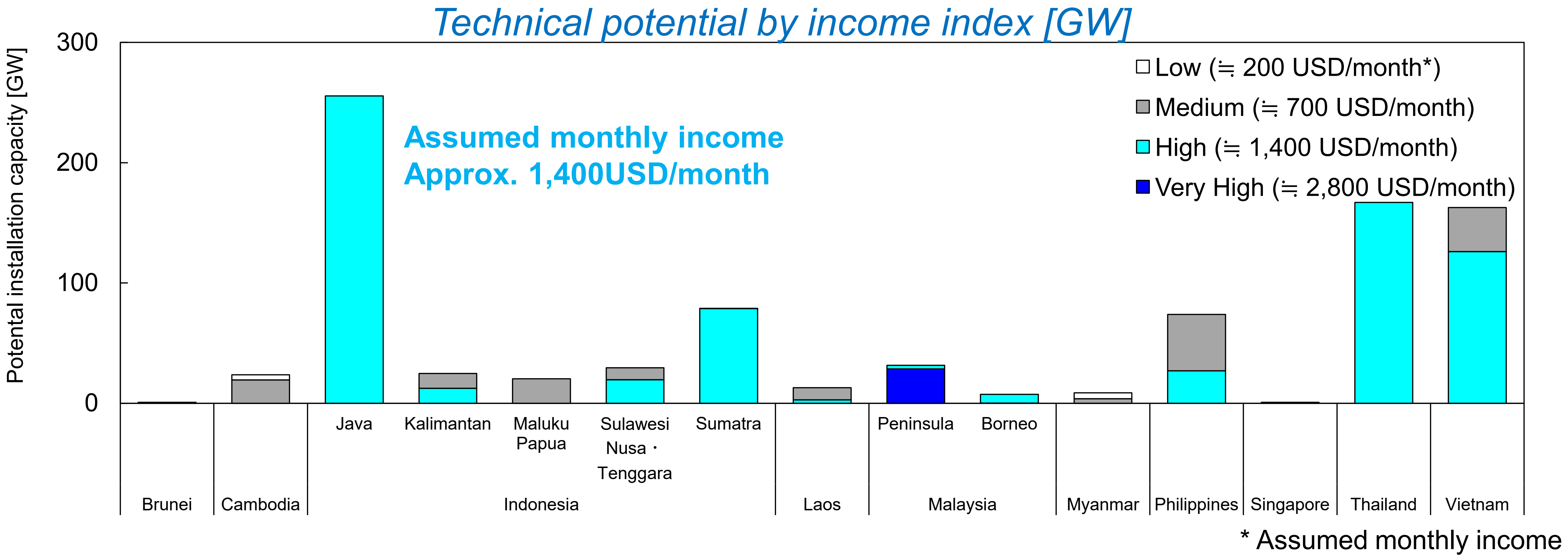


* Figures of roof type generated by ChatGPT-4o.

Policies supporting PV deployment should include roof strength standards.

Technical Potential by Income Index

Technical potential was estimated for buildings under 200 m²—assumed primarily residential—based on regional Income Index values used by UNDP [45].



Regions with high technical potential may not have sufficient income levels to support initial investments, potentially limiting deployment.

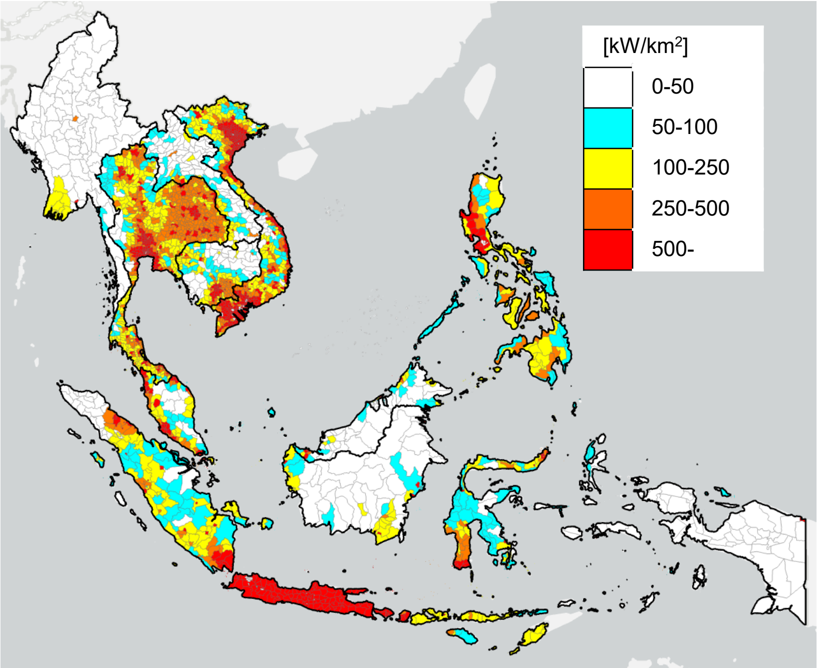
* The Income Index is provided by region.

Regional Technical Potential of Rooftop PV

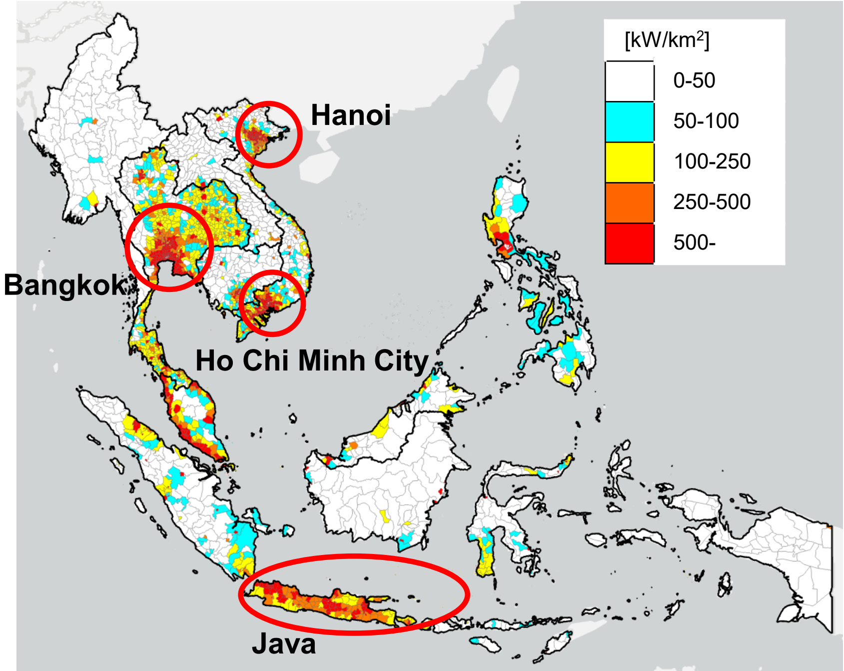
The density of technical potential by region is shown below.

The density of deployment potential by region [kW/km²]

(A) Small buildings (10 – 200m²)



(B) Large buildings (200m² –)



Large buildings with fewer installation constraints are concentrated in urban areas, requiring measures to manage output fluctuations from sudden downpours.

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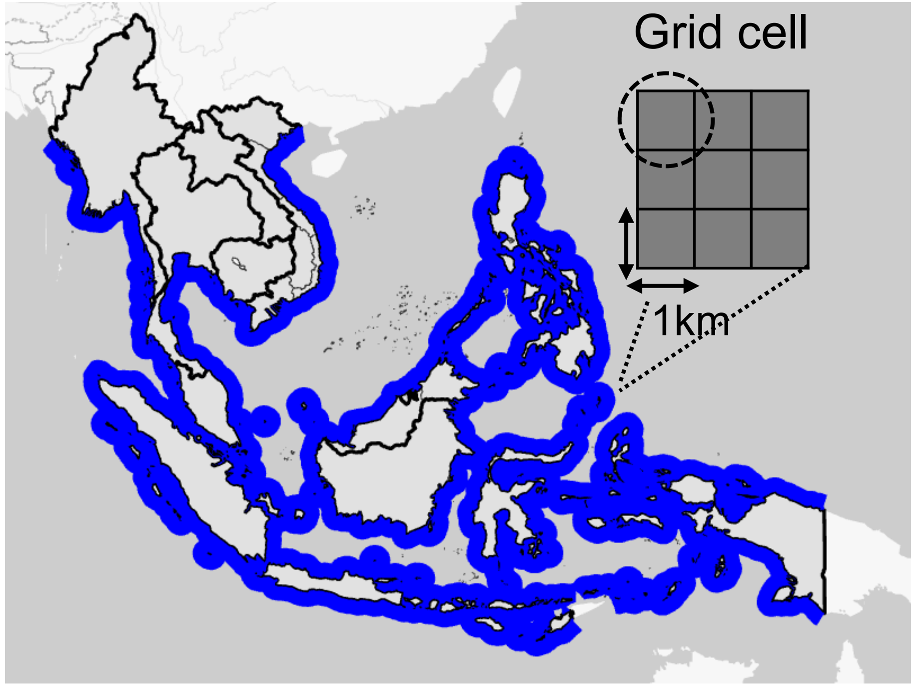
Method for Offshore Wind

Offshore areas (<100 km from shore) around ASEAN (excluding remote islands) were divided into 1 km grid cells with data on wind speed, water depth, and shipping density.

Grid cells around ASEAN



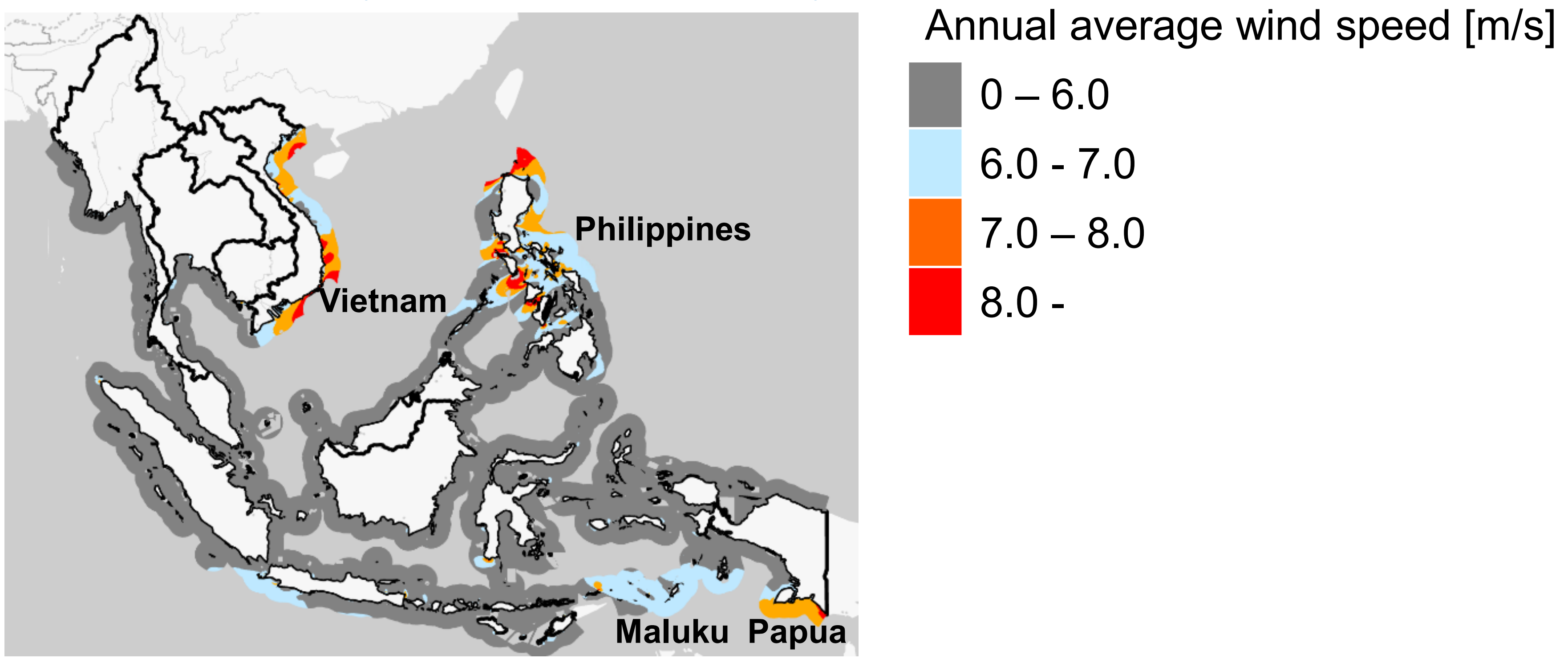
	Data
Annual average wind speed	Global Wind Atlas [25]
Depth	GEBCO[46]
Shipping Density	Based on AIS* data (2015 Jan–2021 Feb, World Bank [47])
Protected areas	WDPA[22]
Grid cell area	Estimated using geodesic measurement in ArcGIS

* AIS: Automatic Identification System

Available Areas by Wind Speed Category

Available areas classified by annual average wind speed, excluding protected zones.

Available areas by wind speed category

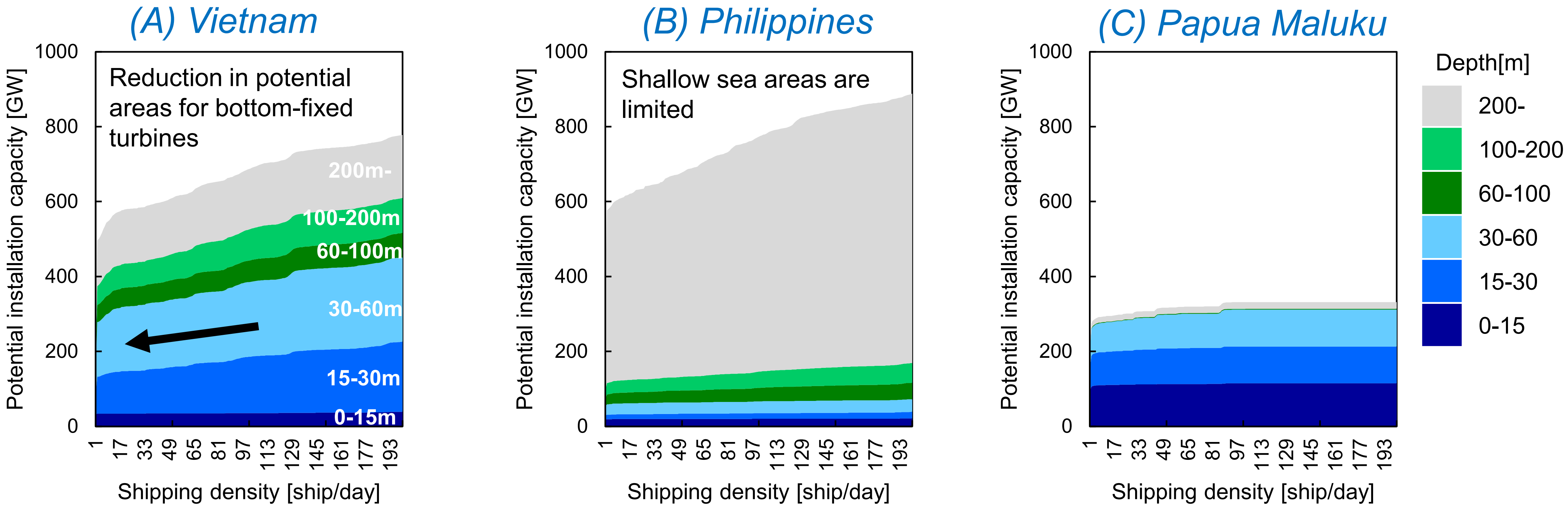


Key offshore areas with favorable wind (≥7.0 m/s) lie near Vietnam, the Philippines, and Maluku/Papua. For Maluku/Papua, long-distance transmission is a challenge due to its remoteness from high-demand areas.

Technical Potential Based on Shipping Density Threshold

Technical potential is shown based on shipping density thresholds in the potential areas.

Technical potential based on shipping density thresholds



Coordination with maritime users is essential

Reducing capital costs in deep-sea areas is critical

Grid connection to demand areas remains a challenge (previous slide)

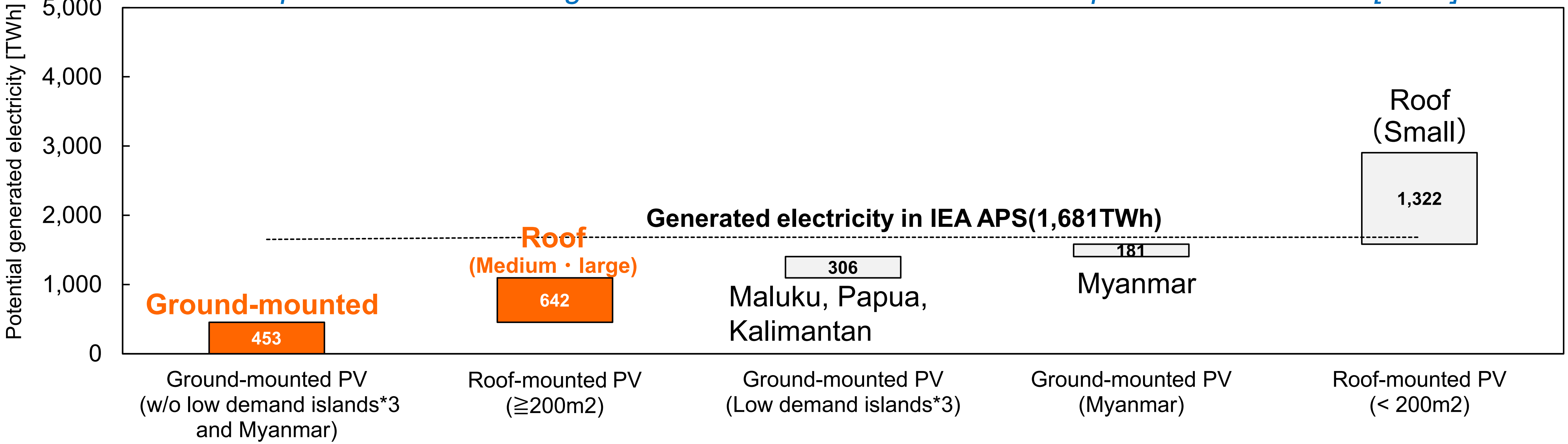
* The x-axis in each figure indicates the upper threshold of ship traffic density, showing the technical potential assuming installations only in areas below x ships/day.

Contents

Comparison with IEA APS (Solar)

- As one roadmap close to ASEAN's carbon neutrality, the IEA APS*1 scenario [5]—which reflects each country's NDCs*2 and net-zero pledges— estimates PV generation of 1,681 TWh in 2050.
- Achieving this scale requires deployment in challenging areas, including remote islands (e.g., Maluku/Papua), politically complex regions , rooftops with structural or income limits, and excluded land types such as farmlands, which were excluded from this study.

Comparison of 2050 PV generation in IEA APS and technical potential in ASEAN [TWh]

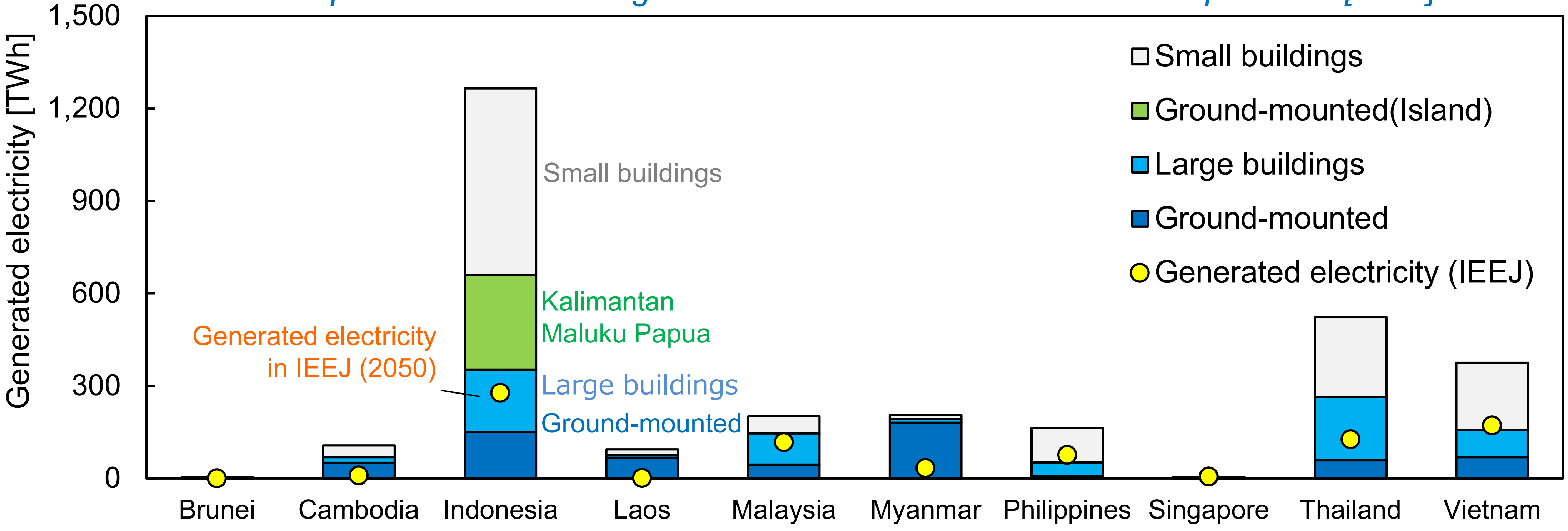


*1 Announced Pledges Scenario, *2 Nationally Determined Contribution, *3 Maluku, Papua, Kalimantan

Comparison with IEEJ ATS (Solar)

Even under the IEEJ Outlook 2025 ATS* scenario [48], which does not fully assume carbon neutrality, achieving projected generation levels would still require extensive use of underutilized land and large rooftops.

Comparison of 2050 PV generation in IEEJ ATS and technical potential [TWh]

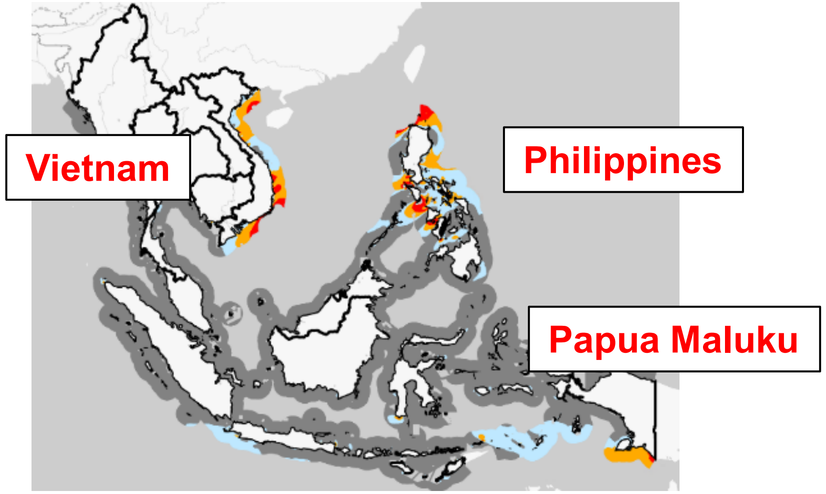


* Advanced Technologies Scenario

Comparison with IEA APS (Wind)

- The IEA's APS scenario projects 1,549 TWh of wind power generation by 2050 [6].
- Even if all available land is used for onshore wind, only 95 TWh can be generated. Meeting the gap requires offshore wind or installation on farmland.
- Offshore wind would require large-scale development of ~400 GW (~50,000 km²) —about one-third of Java. Such expansion raises various challenges and potential ecological and fishery impacts that remain to be assessed in detail.

Potential installation areas by IEEJ



The coral triangle by WWF [49]

* Assuming an optimistic capacity factor of 40%.

Need for Energy System Analysis Considering Integration Costs

- Although the levelized cost of electricity (LCOE) for solar and wind is currently lower than that of thermal power, this study indicates that large-scale deployment involves substantial costs for grid connection—especially in remote areas—and for mitigating rapid output fluctuations caused by local weather events such as squalls.

- Planning to rapid increase in the share of solar and wind based solely on their low LCOE* may not be optimal from the perspective of overall power system cost efficiency.

- To support carbon neutrality, energy system analyses must incorporate regional deployment potential, grid integration costs, and variability mitigation measures.

* Levelized Cost Of Electricity

Limitations and Challenges

Comparison and Verification of Land Use Classification Data

The estimated technical potential of ground-mounted PV in this study is significantly lower than previous studies. This is likely due to two factors: consideration of land-use competition between technologies and the improved accuracy of the land use classification data (see Appendix III).

While this study uses high-accuracy land use data for suitable areas, further comparison using multiple land use datasets is needed for a more robust assessment.

Need for Dynamic Assessment

While this study assesses current technical potential, future changes in land use, building stock, or shipping traffic are expected.

Therefore, dynamic assessment incorporating these potential changes is essential.

Conclusion

Refinement of Underutilized Land Data

Detailed GIS data revealed spatial unevenness in technical potential.
Supports planning to mitigate grid access and regional constraints.

ASEAN-Wide Rooftop Analysis

Assessed roof size and income-based potential across ASEAN.
Highlights priority areas with large roofs or higher incomes.

Barriers Toward Achieving Carbon neutrality

Visualized barriers to meeting carbon neutrality-level electricity needs.
Clarified physical challenges and suggested strategic actions.

Reference (1)

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Appendix I
Details of land use classification data

Comparison of land use classifications: this study vs. GLCNMO ver.3

	This study	GLCNMO ver3
Unsuitable	Forest	Broadleaf Evergreen Forest
		Broadleaf Deciduous Forest
		Needleleaf Evergreen Forest
		Needleleaf Deciduous Forest
		Mixed Forest
		Mangrove
	Tree Open	Tree Open
	Farmland	Sparse vegetation
		Cropland
		Paddy field
		Cropland / Other Vegetation Mosaic
	Wetland	Wetland
	Water bodies	Water bodies
	Urban	Urban
	Snow/Ice	Snow/Ice
Suitable	Gravel	Bare area, consolidated(gravel, rock)
	Herbaceous	Herbaceous
		Herbaceous with Sparse Tree/Shrub
	Sand	Bare area, consolidated(gravel, sand)
	Shrub	Shrub
	Buildings	(Estimated by Google Open Buildings)

Areas by Land Use Classification in GIS [km^2]

Unit:km^2

Country		Forest	Tree open	Farm land	Water bodies	Urban	Snow/Ice	Gravel	Herbaceous	Sand	Shrub	Building	Total
Brunei		4,912	113	364	102	98	0	1	6	0	0	35	**5,632**
Cambodia		78,252	21,045	73,600	6,184	74	2	7	1,271	8	325	618	**181,385**
Indonesia	Java	49,639	8,876	67,005	3,596	3,400	0	14	167	1	57	6,001	**138,756**
	Kalimantan	429,867	23,360	74,153	5,327	288	679	36	1,483	0	268	612	**536,072**
	Maluku・Papua	456,503	22,394	60,081	15,123	59	2	33	3,140	1	934	480	**558,749**
	Sulawesi・Nusa Tenggara	142,750	6,522	29,426	8,574	171	346	3	252	0	31	728	**188,804**
	Sumatra	308,222	55,832	97,396	8,415	1,003	2,209	23	952	0	149	1,955	**476,156**
Laos		177,685	20,517	27,210	944	101	0	2	1,130	0	190	325	**228,104**
Malaysia	Peninsula	91,287	6,706	28,034	1,920	2,866	0	13	109	0	24	1,409	**132,368**
	Borneo	173,444	6,186	14,341	2,001	348	0	2	275	0	25	297	**196,920**
Myanmar		434,893	32,856	188,971	4,510	374	211	98	1,881	1	894	256	**664,946**
Philippines		155,218	22,823	104,757	13,281	1,406	0	5	208	1	65	1,849	**299,613**
Singapore		68	18	72	16	320	0	1	2	0	1	44	**544**
Thailand		188,982	28,339	283,981	4,757	3,022	60	9	950	0	386	4,967	**515,451**
Vietnam		158,507	34,923	119,825	5,008	2,060	5,923	43	1,339	2	616	4,037	**332,282**
Total		**2,850,230**	**290,509**	**1,169,216**	**79,761**	**15,591**	**9,430**	**289**	**13,164**	**12**	**3,964**	**23,614**	**4,455,782**

* The area values in the table are based on 500-meter grid cells and may differ from actual areas near national borders or coastlines.
Therefore, they do not necessarily match official statistical figures.

Appendix II
Breakdown of assessed technical potential

Technical Potential of Rooftop PV

Unit:GW

		Area of roof [m^2]						
		0-10	10-100	100-200	200-450	450-2300	2300	Total
Brunei		0.0	0.3	0.4	0.9	0.7	0.1	**2.3**
Cambodia		0.0	14.9	8.8	4.8	4.8	2.1	**35.3**
Indonesia	Java	0.0	133.8	121.7	45.0	24.9	8.8	**334.3**
	Kalimantan	0.0	12.2	12.5	6.2	3.1	0.4	**34.5**
	Maluku ･Papua	0.0	12.1	8.2	4.0	1.7	0.1	**26.1**
	Sulawesi ･Nusa Tenggara	0.0	13.7	15.8	8.5	2.7	0.4	**41.1**
	Sumatra	0.0	35.3	43.4	22.2	8.6	1.6	**111.1**
Laos		0.0	6.8	6.1	3.2	1.9	0.4	**18.4**
Malaysia	Peninsula	0.0	14.0	17.5	26.4	27.7	5.9	**91.6**
	Borneo	0.0	3.5	3.8	5.1	5.5	0.9	**18.9**
Myanmar		0.0	5.1	3.6	2.2	2.2	2.6	**15.7**
Philippines		0.0	48.8	25.0	13.4	12.0	3.1	**102.4**
Singapore		0.0	0.3	0.4	0.7	1.3	0.5	**3.1**
Thailand		0.0	73.3	93.7	65.3	51.9	15.6	**299.8**
Vietnam		0.0	104.8	57.8	27.3	23.8	12.5	**226.3**
Total		**0.0**	**478.9**	**418.8**	**235.1**	**172.8**	**55.2**	**1,360.8**

Technical Potential of Ground-mounted PV

Unit:GW

		Distance from the nearest transmission lines[km]						
		0-10	10-20	20-30	30-40	40-50	50-	Total
Brunei		0.2	0.2	0.0	0.0	0.0	0.0	**0.4**
Cambodia		9.2	4.9	4.8	4.4	3.2	6.6	**33.1**
Indonesia	Java	10.1	2.1	0.3	0.0	0.0	0.0	**12.5**
	Kalimantan	34.7	23.1	17.6	14.6	10.7	20.0	**120.8**
	Maluku ･Papua	6.9	2.8	2.2	3.3	2.2	94.6	**112.1**
	Sulawesi ･Nusa Tenggara	7.1	1.8	1.3	0.5	0.5	2.3	**13.4**
	Sumatra	18.1	17.3	15.8	20.1	6.5	6.3	**84.1**
Laos		24.7	8.8	4.9	3.9	2.2	2.0	**46.4**
Malaysia	Peninsula	7.9	1.7	0.7	0.1	0.0	0.0	**10.5**
	Borneo	9.2	5.8	2.7	1.8	0.8	1.7	**22.1**
Myanmar		40.6	22.0	17.1	9.9	6.4	21.0	**116.9**
Philippines		3.3	1.1	0.5	0.4	0.1	0.2	**5.6**
Singapore		0.1	0.1	0.0	0.0	0.0	0.0	**0.3**
Thailand		13.7	8.2	5.8	5.2	2.2	4.0	**39.1**
Vietnam		33.3	10.6	6.7	2.6	0.8	1.9	**56.0**
Total		**219.1**	**110.3**	**80.6**	**67.0**	**35.6**	**160.7**	**673.3**

Technical Potential of Onshore Wind

Unit:GW

		Distance from the nearest transmission lines[km]						
		0-10	10-20	20-30	30-40	40-50	50-	Total
Brunei		0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Cambodia		1.0	0.8	0.5	0.4	0.5	0.5	**3.6**
Indonesia	Java	0.3	0.1	0.0	0.0	0.0	0.0	**0.5**
	Kalimantan	0.2	0.3	0.1	0.1	0.0	0.0	**0.8**
	Maluku・Papua	0.1	0.1	0.1	0.1	0.0	8.2	**8.5**
	Sulawesi・Nusa Tenggara	0.2	0.1	0.0	0.0	0.0	0.0	**0.3**
	Sumatra	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**
Laos		2.6	1.2	0.6	0.3	0.2	0.2	**5.3**
Malaysia	Peninsula	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
	Borneo	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Myanmar		2.4	1.1	0.5	0.2	0.1	0.5	**4.7**
Philippines		0.7	0.2	0.1	0.1	0.0	0.1	**1.2**
Singapore		0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Thailand		2.2	0.9	0.6	0.4	0.2	0.5	**4.8**
Vietnam		7.7	2.0	0.4	0.2	0.2	0.2	**10.5**
Total		**17.4**	**6.6**	**3.1**	**1.8**	**1.2**	**10.2**	**40.4**

Technical Potential of Offshore Wind

Unit:GW

		Depth [m]					
		0-15	15-30	30-60	60-100	100-200	200-
Brunei		0	0	0	0	0	0
Cambodia		1	0	0	0	0	0
Indonesia	Java	0	0	0	0	1	3
	Kalimantan	0	0	0	0	0	0
	Maluku ･Papua	115	99	98	2	0	18
	Sulawesi ･Nusa Tenggara	2	1	2	1	1	1
	Sumatra	0	1	0	0	0	0
Laos		0	0	0	0	0	0
Malaysia	Peninsula	0	0	0	0	0	0
	Borneo	0	0	0	0	0	0
Myanmar		0	0	0	0	0	0
Philippines		21	19	36	48	58	759
Singapore		0	0	0	0	0	0
Thailand		0	0	0	0	0	0
Vietnam		40	201	247	72	97	172
Total		**179**	**321**	**384**	**123**	**157**	**953**

Annual average wind speed ≥ 7.0 m/s
No shipping density constraints

Appendix III
Comparison of Assumptions with Previous Studies

Comparison of Technical Potential with Previous Studies (PV)

- Compared to previous studies, this study assesses significantly lower technical potential of ground-mounted solar PV.
- While some assumptions in previous studies are unclear, the differences likely stem from this study's consideration of land use competition between technologies and the use of different land use classification data. Further verification is needed (see next slide for details).

Comparison of technical potential with previous studies [GW]

	This study	IEA[5][6]	IRENA[7]	Lee et al. (Relaxed)[8]	Lee et al. (Moderate)[8]	Lee et al. (Restricted)[8]
Brunei	0.4	Unknown	2	104	16	2
Cambodia	33		1,597	4,826	3,198	966
Indonesia	343	1,500	2,898	55,079	12,389	654
Laos	46	Unknown	983	7,961	1,278	547
Malaysia	33		337	9,557	1,965	199
Myanmar	117		5,310	26,312	7,717	1,642
Philippines	6		123	8,001	1,910	342
Singapore	0.3		0.3	4	2	0
Thailand	39		3,509	15,277	10,538	585
Vietnam	56		844	10,315	2,847	729
Total	**673**	**20,000***	**15,603**	**137,436**	**41,858**	**5,666**

* Including onshore wind

Comparison of Assumptions with Previous Studies

	This study	IEA [5][6]	IRENA[7]	Lee et al. (Relaxed)[8]	Lee et al. (Moderate)[8]	Lee et al. (Restricted)[8]
Exclusion	· Forest · Tree open · Farmland · Water bodies · Urban · Snow ice · Buildings · > 30° Slope	-	· Protected areas · Forest · Permanent wetlands · Croplands · Urban areas · > 5% Slope	· Protected areas · Water-bodies · Urban areas	· Protected areas · Water-bodies · Forested areas · Urban areas · > 5% Slope	· Protected areas · Water-bodies · Forested areas · Urban areas · Agricultural areas · > 5% Slope
Capacity density [MW/km^2]	87	-	45	36		
Competition w/ wind	Considered	-	-	Not considered		
Land-use data	GLCNMO ver3 15 arcsec (≒ 463.8m grid cell) Year: 2013	-	MCD12C1 Version 6 0.05 degree (≒5,600m grid cell) Year: 2016	ESA DUE GlobCover (300m grid cell) Year: 2009		

"–" indicates items for which the conditions could not be identified from each source.

Comparison of land use classification data

- GLCNMO ver.3 offers higher resolution than MCD12C1 and retains good accuracy for shrubland and grassland.
- Accuracy is enhanced via ground surveys and national agency collaboration.

	GLCNMO ver3	MCD12C1 Version 6	ESA DUE GlobCover
Base year	2013	2016	2009
Grid cell	15 arcsec (≒ 463.8m grid cell)	0.05 degree (≒ 5,600m grid cell)	300m grid cell
Accuracy	90.8% (Aggregated class) 74.8% (Detailed class)	73.6%(Global average)	73.1%
Note	Accuracy is low for mosaic-like surfaces with mixed land cover (Mixed forest, Tree open, Herbaceous with sparse tree/shrub, Cropland/Other vegetation mosaic) [50].	Shrubland and wetland classifications show particularly low accuracy (3.74% and 7.45%, respectively) [51].	Accuracy for wetlands, grasslands, and shrublands is reduced due to limitations of the satellite-mounted MERIS sensor [52].
Classification Approach	Satellite imagery, ground surveys, and national mapping agency expertise	Satellite imagery	Satellite imagery
Land use class	20	17	22

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