# “Potensi PLTS terapung di Indonesia”

Presentation for disampaikan pada Webinar “Surya Mengapung Wujudkan Transisi Bagi Indonesia”


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https://re100.eng.anu.edu.au/


Jakarta, 28 Mei 2025

# 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*



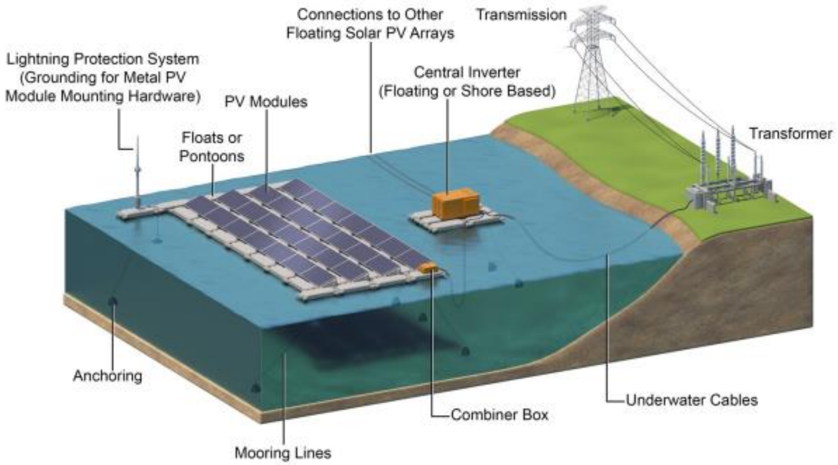



**Figure. Schematic of stand-alone FPV system**

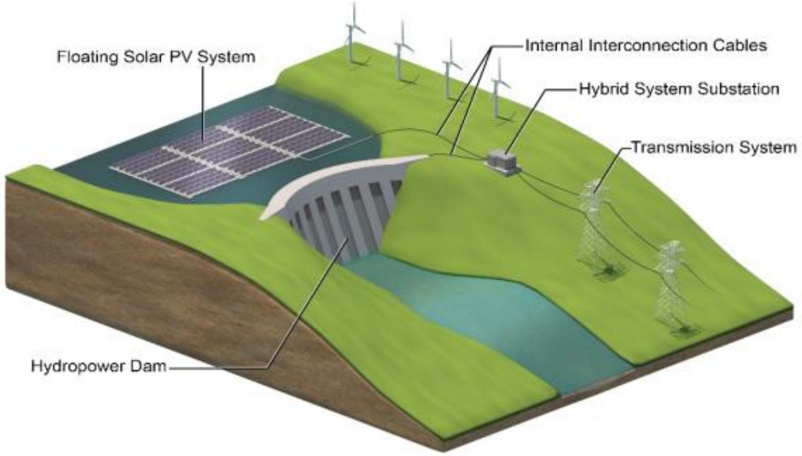



**Figure. Schematic of hybrid FPV-hydropower system**

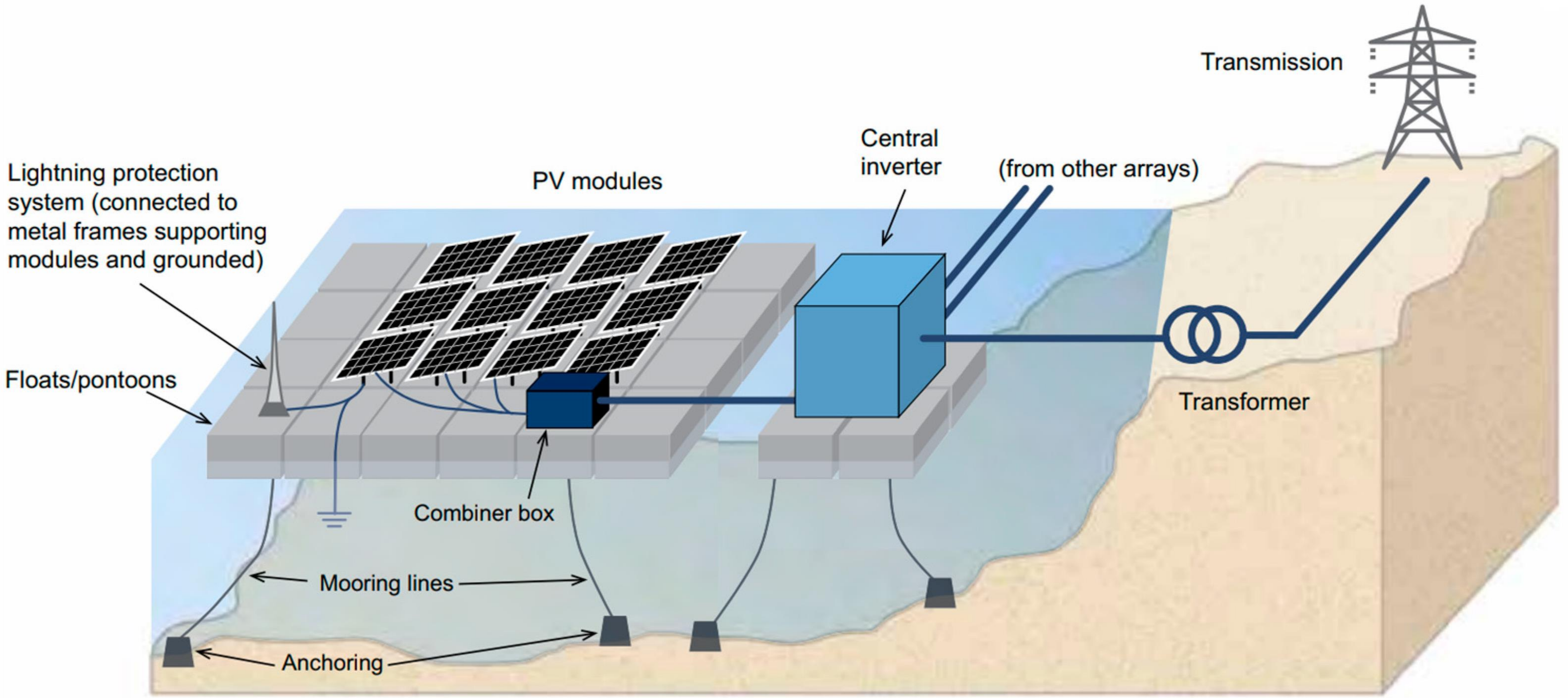
*Source: Lee et al. 2020*







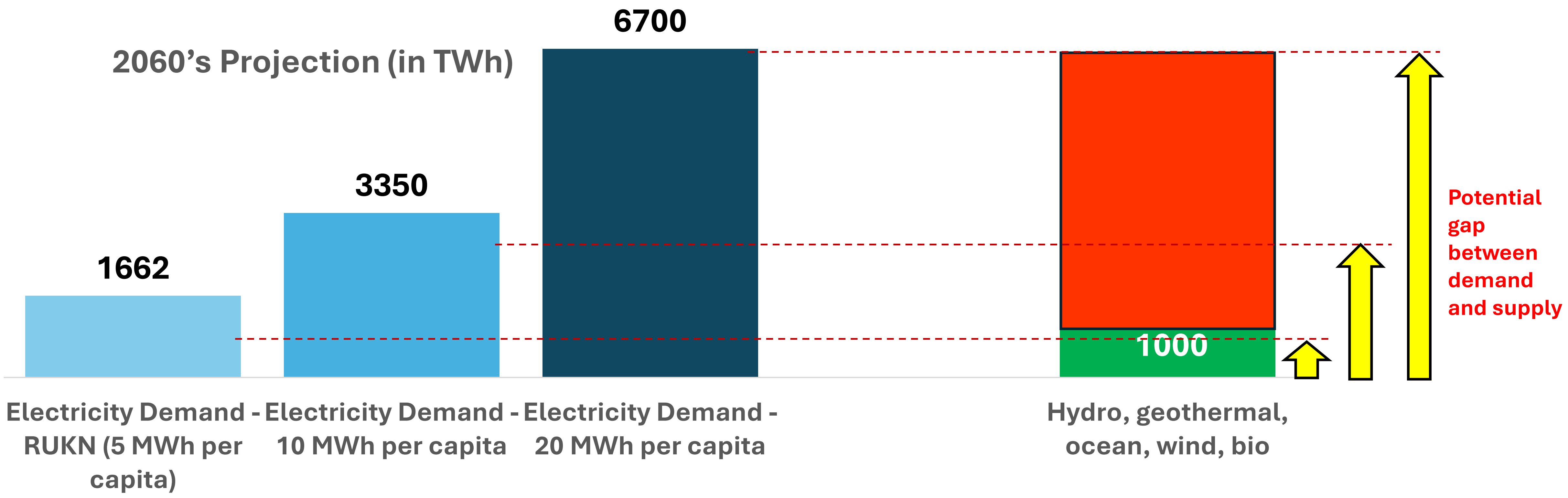
https://asiacleanenergyforum.adb.org/wp-content/uploads/2023/06/Sika-Gadzanku.pdf




*Source:* Solar Energy Research Institute of Singapore (SERIS) at the National University of Singapore.

# Inovasi sederhana panel surya terapung

# Indonesia's Projected Energy Demand







**Supply from hydro, geothermal, ocean, wind, bio (non-solar) is <u>not adequate</u> !**

Indonesia is likely to rely on solar energy!

Where to install the solar panels?

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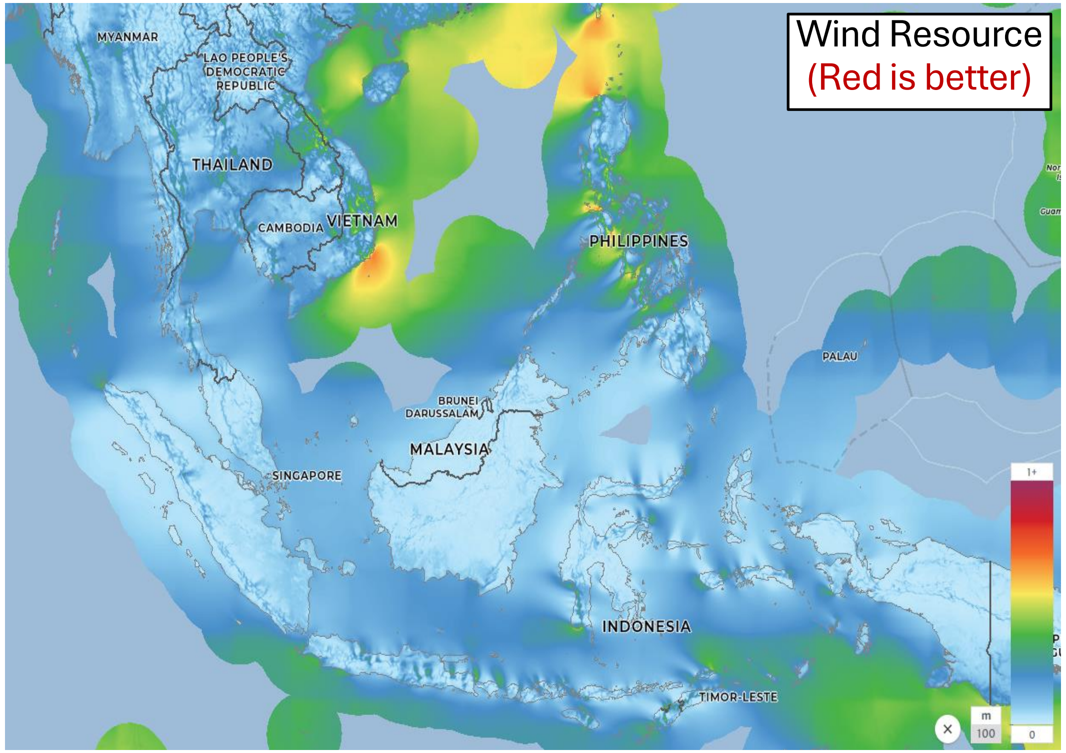
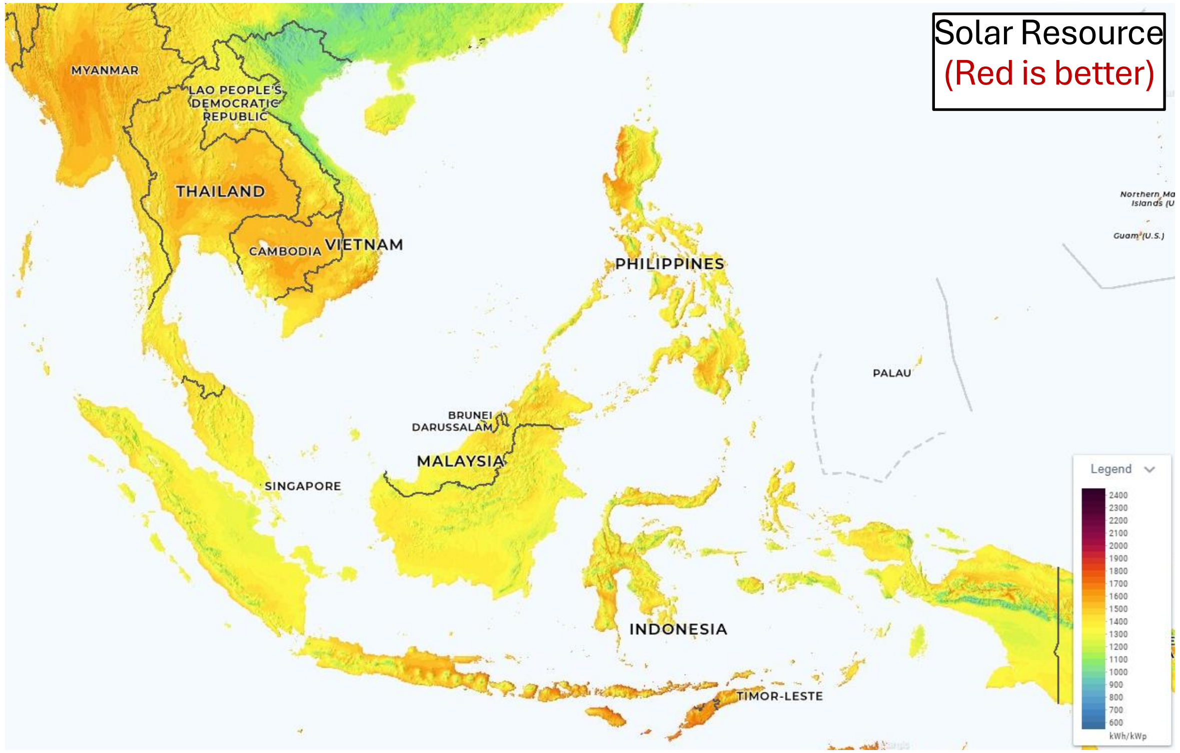
Where to install the solar panels?

# Solar and Wind Resources in Indonesia

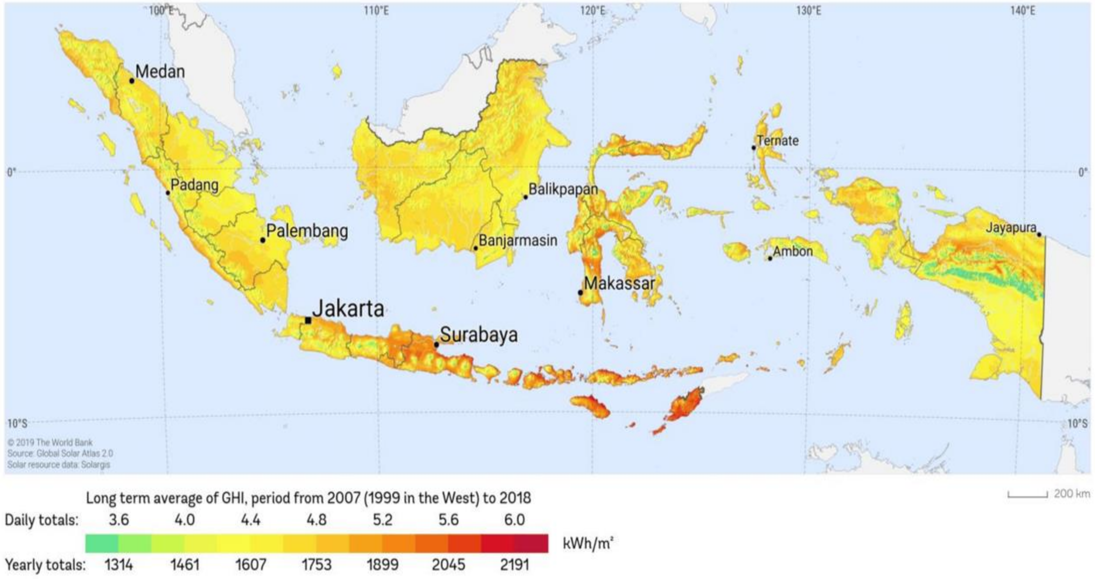



Source: https://globalwindatlas.info/en/

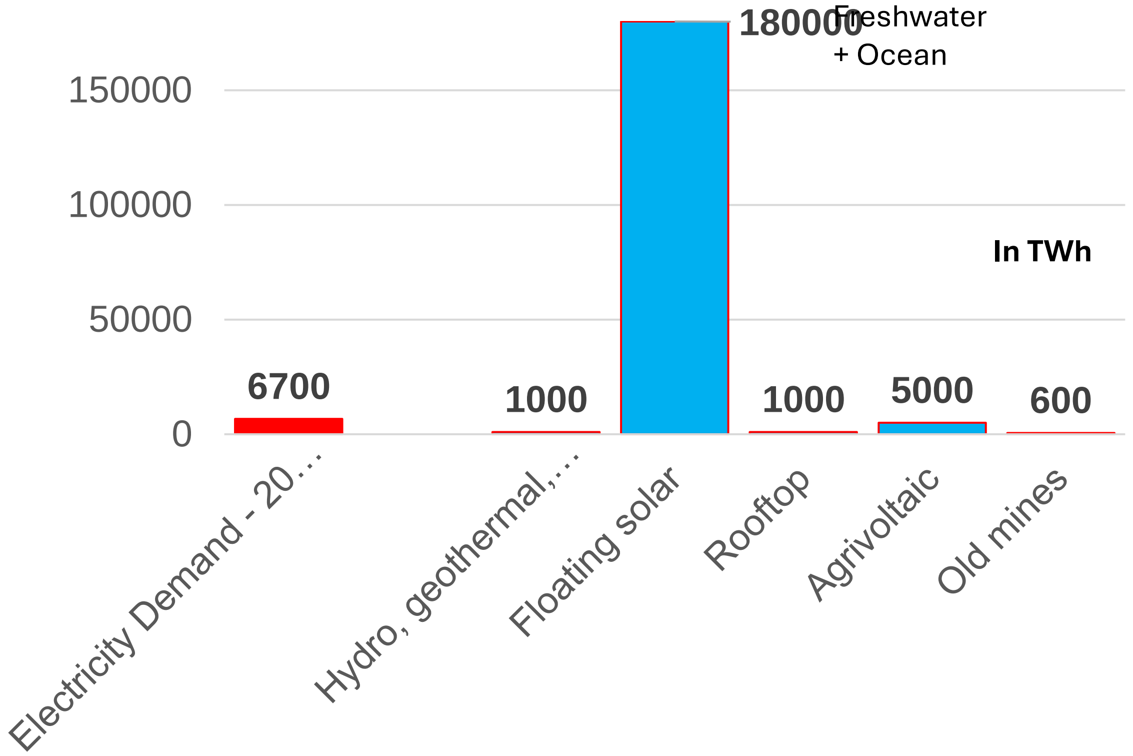



Source: https://globalsolaratlas.info/map

# Indonesia's Vast Solar Energy Potential

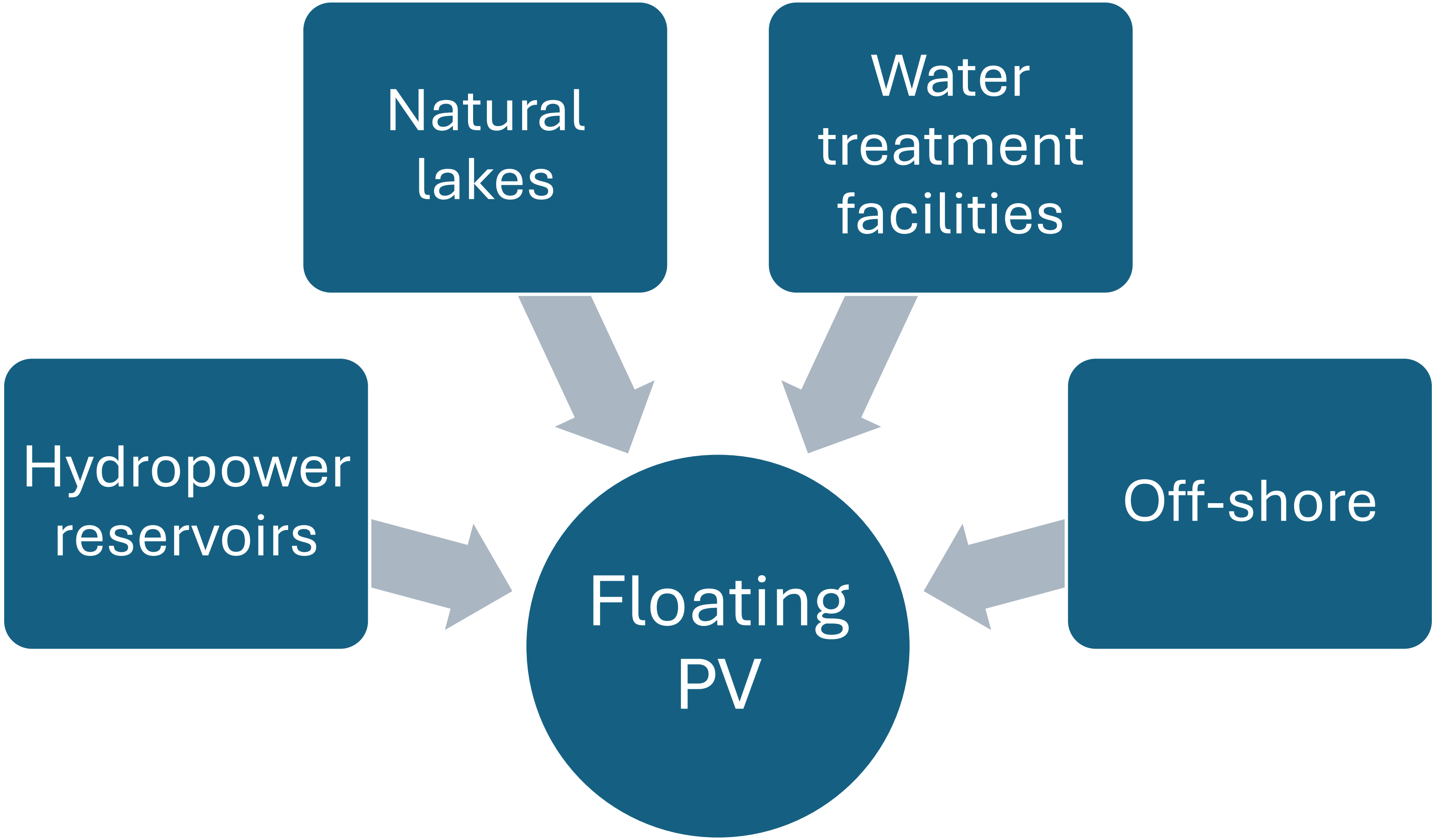



Indonesia's GHI: 4.8 kWh/m$^2$




Source: *Energies* **2021**, *14*(17), 5424; https://doi.org/10.3390/en14175424

**Floating PV Development Strategy**



# Faktor yang Mempengaruhi Keandalan PLTS:

1. Pemilihan Lokasi yang Tepat
2. Perawatan dan Pembersihan Rutin
3. Pemilihan Komponen Berkualitas
4. Monitoring Kinerja Sistem
5. Cadangan Energi dan Sistem Kontrol Otomatis

# Floating solar PV – risk to be managed

Japan's largest PV power plant, inaugurated by Kyocera in March 2018 at the Yamakura Dam in Ichihara City.

Kyocera's 13.7 MW floating project at the Yamakura Dam was damaged by 120mph winds the typhoon brought to the coastal city of Chiba.

Source: [PV-Magazine, 2019]

# Damaged floating solar PV

In India's state of Madhya Pradesh, the world's largest floating solar plant at Omkareshwar dam suffered severe damage during a storm on April 9. Footage captures the destructive impact as strong winds uprooted and damaged solar panels, disrupting operations.

The damaged floating plant is one of three developed near the dam. The storm that damaged it had winds reported at 50 kph, which is just over 31 mph.

A few days after it began operations.

Read more at: Times of India





## Storm damages world's biggest floating solar plant in Madhya Pradesh

TNN / Updated: Apr 15, 2024, 23:02 IST



NHDC assesses damage to the floating solar plant at Omkareshwar Dam after a storm. Despite setbacks, the plant is expected to resume power production, aiming for 100 MW by end-April. NHPC, employees, and various villages impacted.

The floating solar plant at Omkareshwar Dam after a storm

INDORE: The world's largest floating solar plant at Omkareshwar Dam has been badly damaged in a storm.

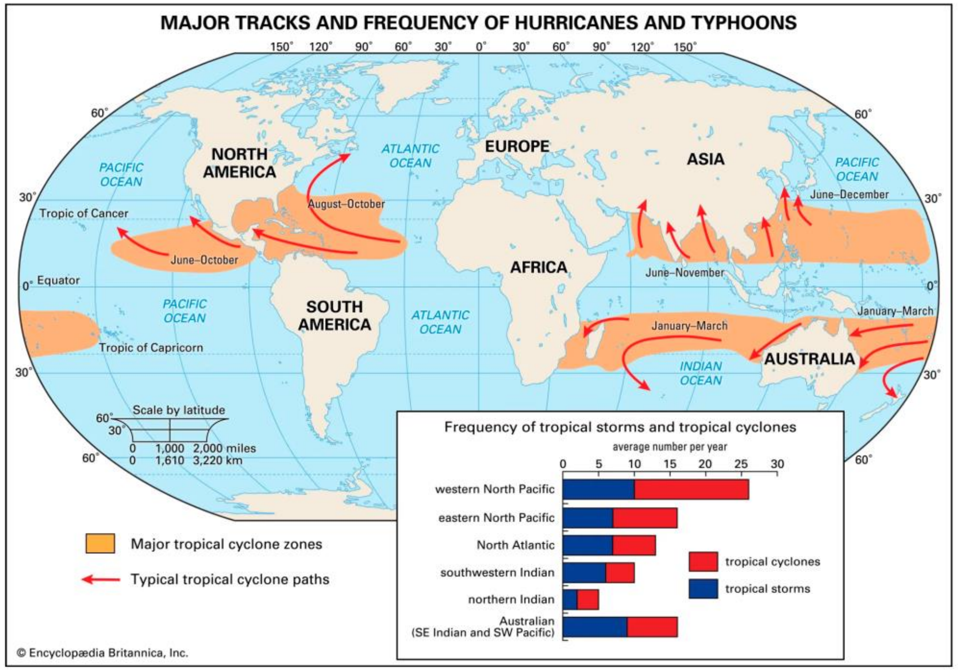
Narmada Hydroelectric Development Corporation (NHDC) has started evaluation of the damage, but is confident the plant will be back to producing power soon. Part of the plant went operational last week, and this is the section that took a hit.

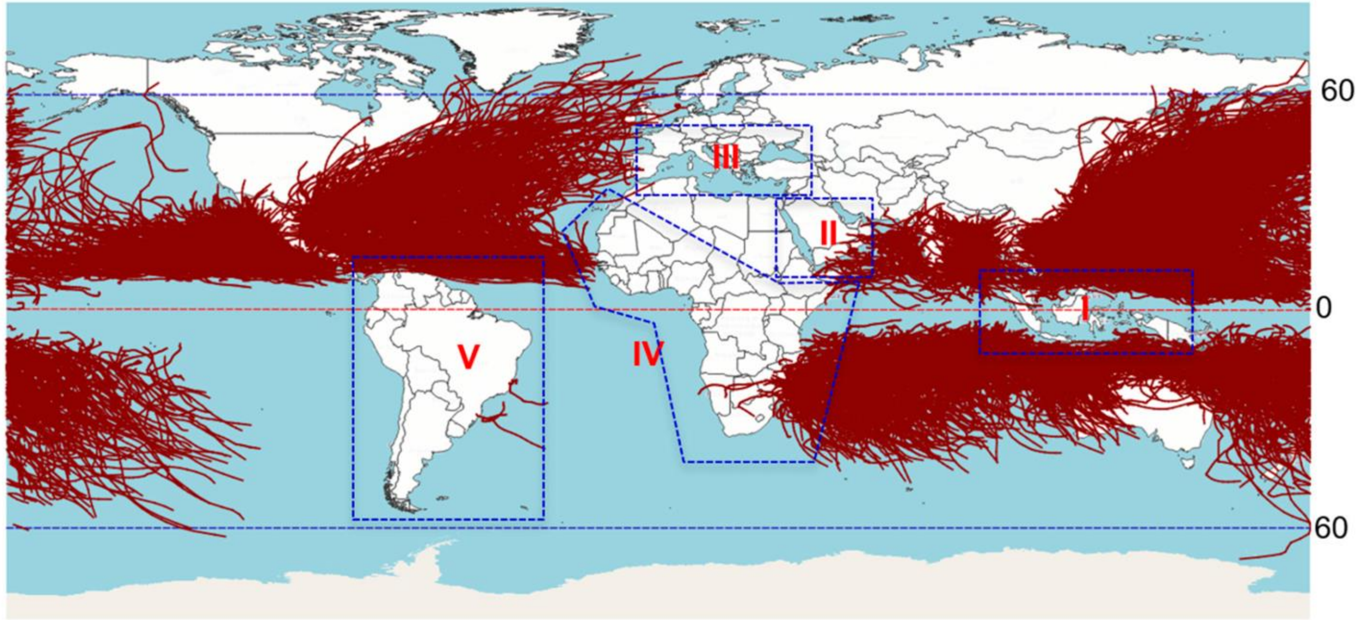
The floating plant, built on the backwaters of Omkareshwar Dam, was ready for launch but it was slammed around by 50kmph winds in a summer storm that hit on Tuesday.

Video

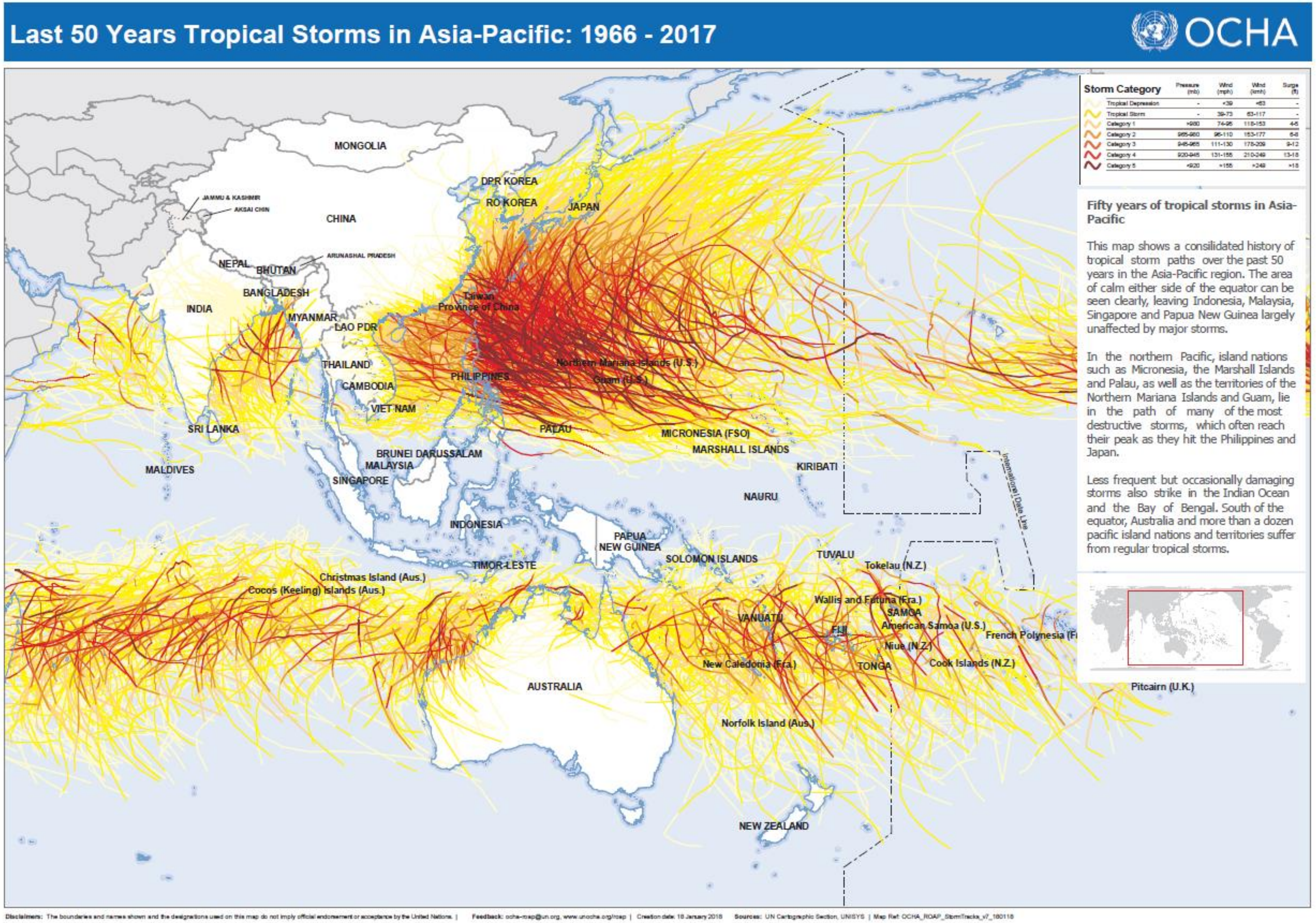
# POTENSI PLTS TERAPUNG “OFSHORE” DI INDONESIA

# Historical tropical storm around the globe




40 years of data (1980–2020) of historical tropical storm tracks (represented by red lines)




https://reliefweb.int/map/world/last-50-years-tropical-storms-asia-pacific-1966-2017

## Inland FPV

- **Static Freshwater bodies**
  - No waves
  - Limited wind
- **Inner waters**
  - Small to medium (1 m) waves
  - Water areas of 1-3 $km^2$
- **Larger inner waters**
  - Medium waves (>1 m)
  - Area > 3 $km^2$

## Marine FPV

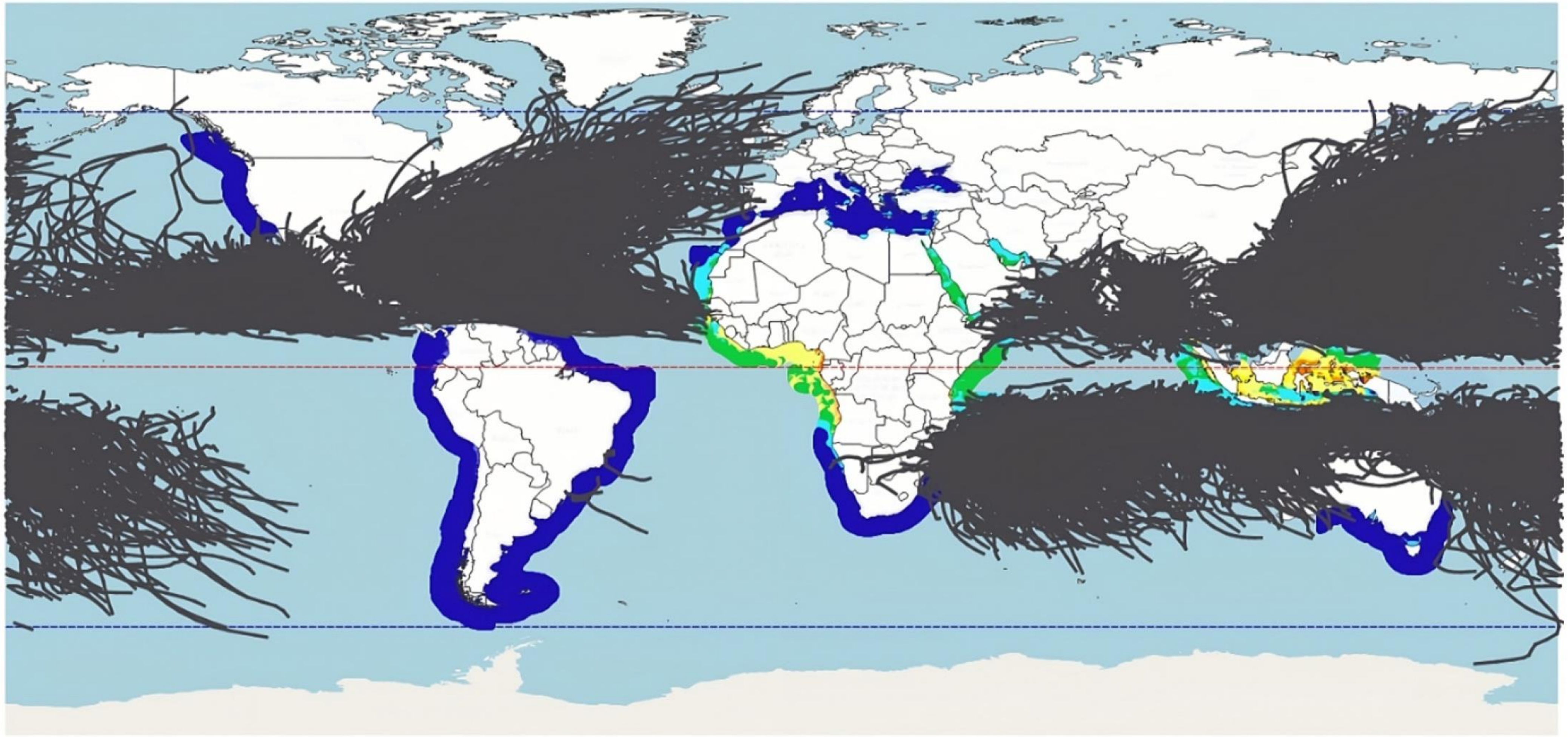
- **Nearshore FPV**
  - Reasonably sheltered area
  - Significant wave height < 2-3 m
- **Offshore FPV**
  - Unsheltered water
  - Significant wave height > 2-3 m

## Sea State Codes (SSC)

| SSC | Description | Significant Wave Height (m) |
|---|---|---|
| 0 | Calm (glassy) | 0 |
| 1 | Calm (rippled) | 0-0.1 |
| 2 | Smooth | 0.1-0.5 |
| 3 | Slight | 0.5-1.25 |
| 4 | Moderate | 1.25-2.5 |
| 5 | Rough | 2.5-4 |
| 6 | Very rough | 4-6 |
| 7 | High | 6-9 |
| 8 | Very high | 9-14 |
| 9 | Phenomenal | >14 |

*Figure 2. Categorization of FPV as suggested by Solar Power Europe [1] and the WMO sea state codes [4].*

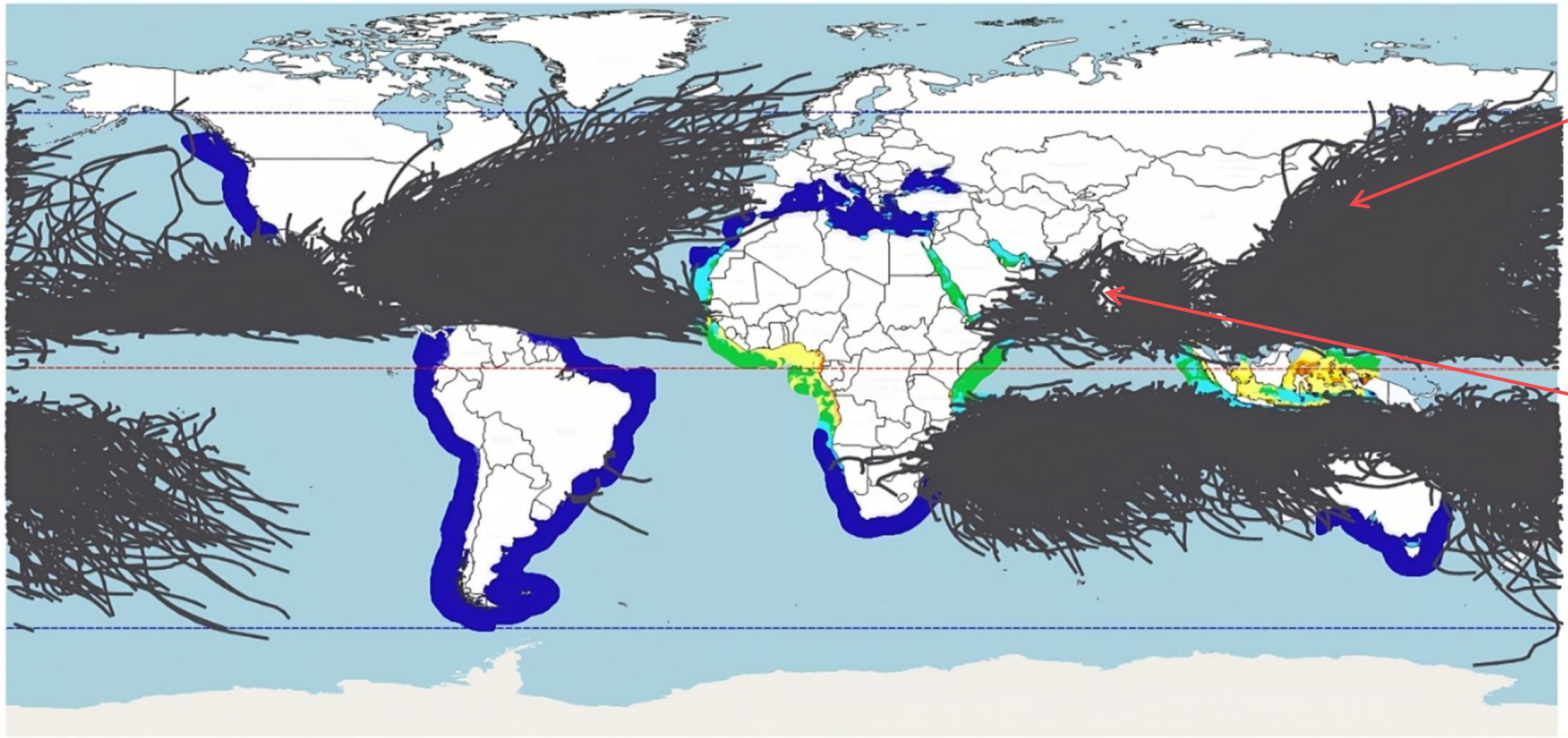
# Mapping potential sites for offshore floating solar PV



(c)

40 years of data (1980–2020) of historical tropical storm tracks (represented by grey lines)

# Mapping potential sites for offshore floating solar PV

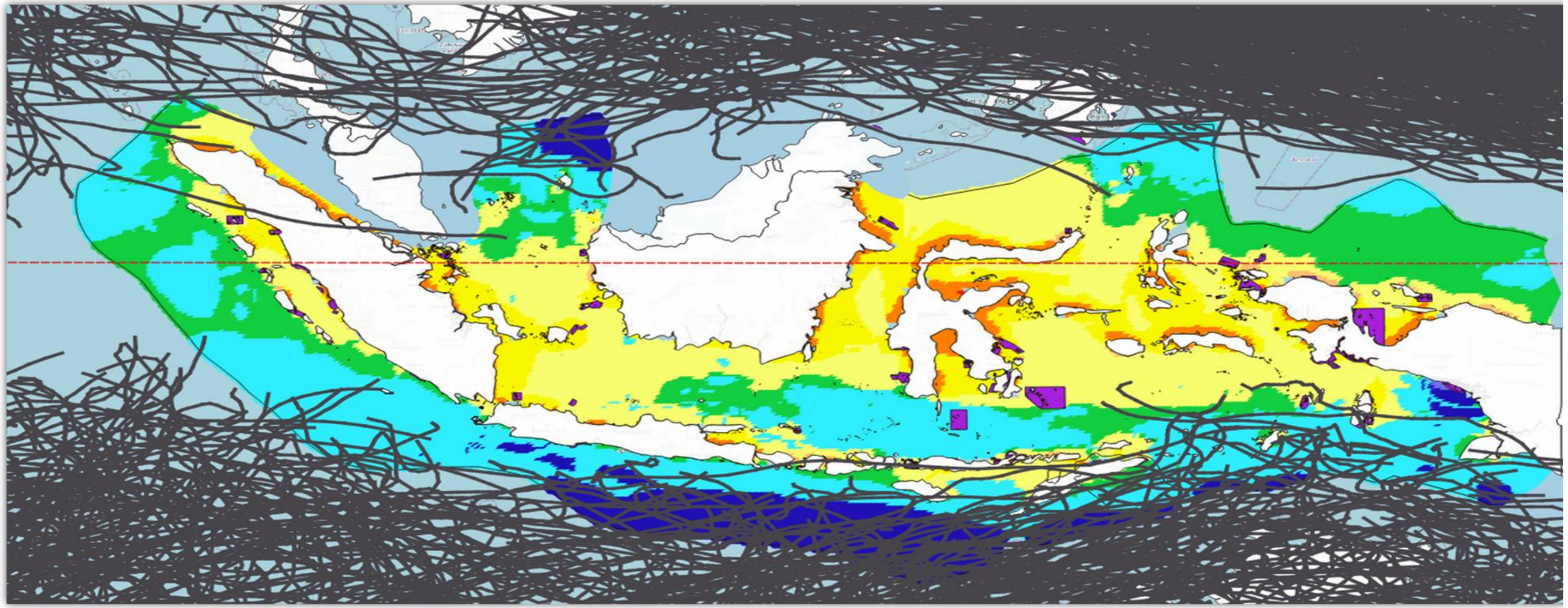


(c)

2019, storm hit floating solar PV (14 MW) at Yamakura Dam, Japan

2024, floating solar plant at Omkareshwar dam, Madhya Pradesh, India, suffered severe damage during a storm on April 9

# Indonesia's maritime floating solar PV potential



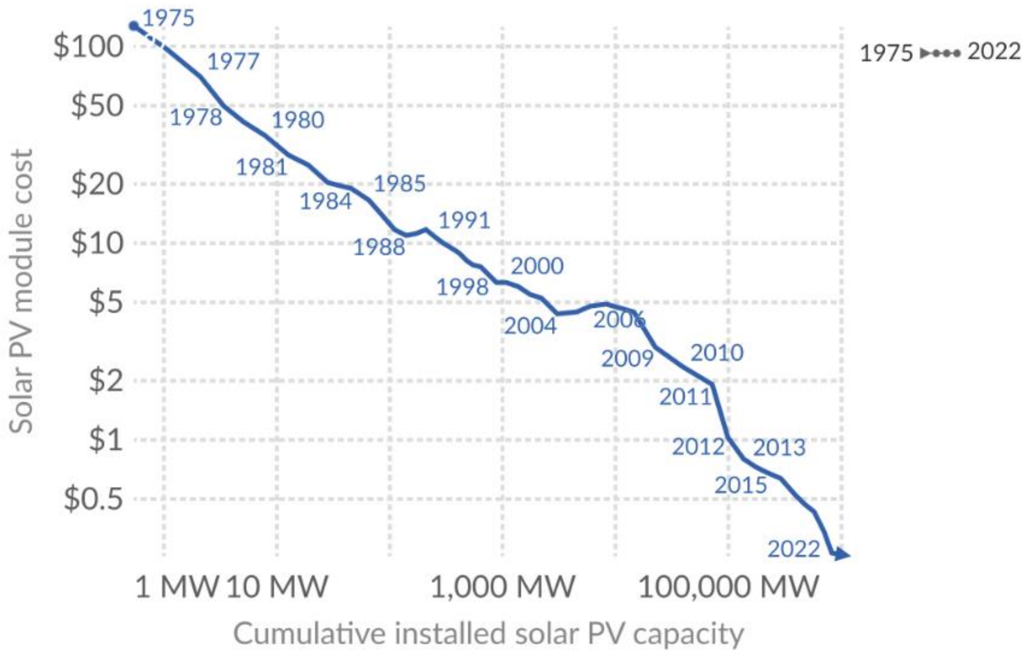
| Wave height | Wind speed 0 - 5 m/s | 5-10m/s | 10 - 15m/s | 15 - 20m/s | > 20m/s |
|---|---|---|---|---|---|
| 0 - 4 m | 0.1<br>0.02<br>0.03 | 140<br>28<br>37 | 635<br>127<br>167 | 0.1<br>0.02<br>0.03 | 1 |
| 4 - 6m | - | 22<br>4<br>6 | 1,576<br>315<br>414 | 71<br>14<br>19 | 3 |
| 6 - 8m | - | 2<br>0.3<br>0.4 | 970<br>194<br>255 | 752<br>150<br>198 | 19 |
| 8 - 10m | - | - | 161<br>32<br>42 | 914<br>183<br>240 | 4 |
| > 10m | - | - | - | 348 | 165 |

Note: In each cell, the numbers are (top to bottom): (i) area (thousands of km2); (ii) potential solar power (TW); and (iii) potential annual solar generation (thousands of TWh per annum).

- Red areas are best (calmer) followed by orange, yellow, and green, while blue areas are the stormiest. Pale blue corresponds to maritime areas far from land that were not considered in this analysis.
- Purple areas represent marine protected areas.
- The dark gray line shows the history of tropical storms.

# PERBANDINGAN KEEKONOMIAN ENERGI FOSIL DAN SURYA


Dengan asumsi per kg batubara dapat menghasilkan 2 - 4 kWh, harga $100/ton. Maka biaya bahan bakar mencapai 2 – 5 cent per kWh.

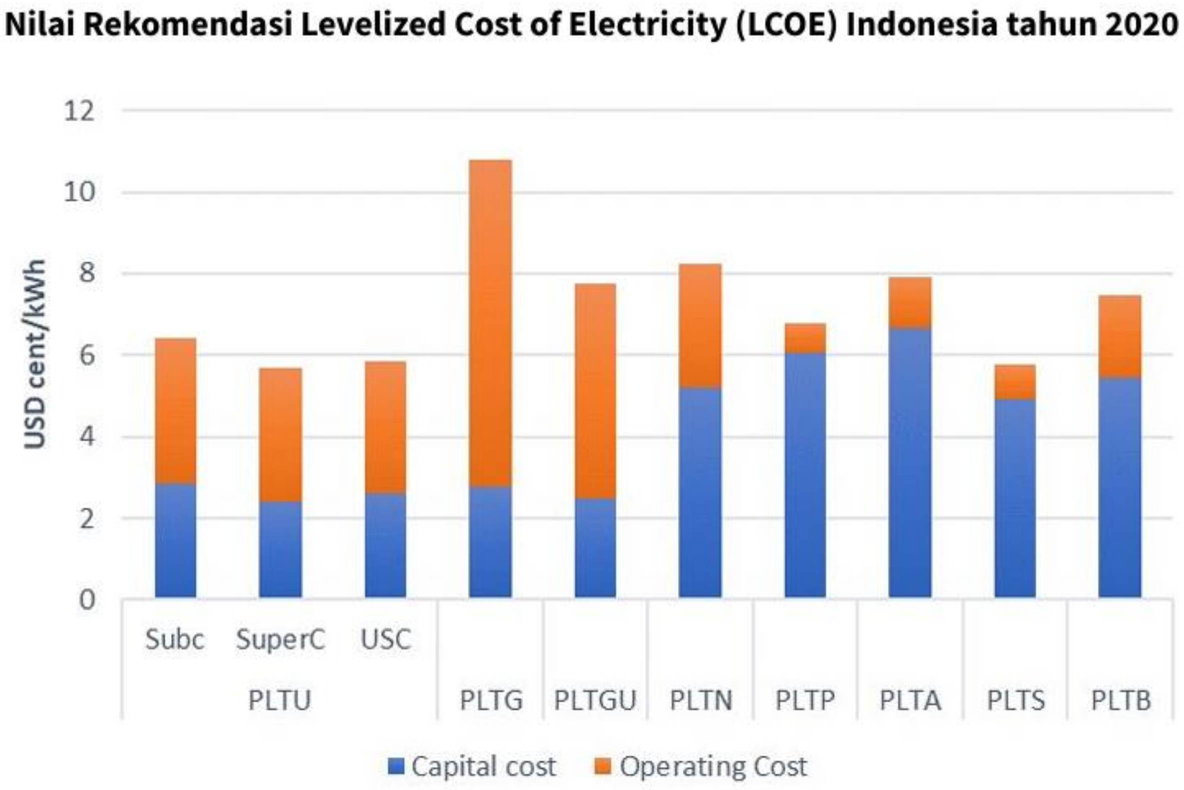



**Data source:** IRENA (2023); Nemet (2009); Farmer and Lafond (2016)



Dengan asumsi harga system PLTS terapung $1000- 1200/kWp, biaya setara 5 – 6 cent per kWh.

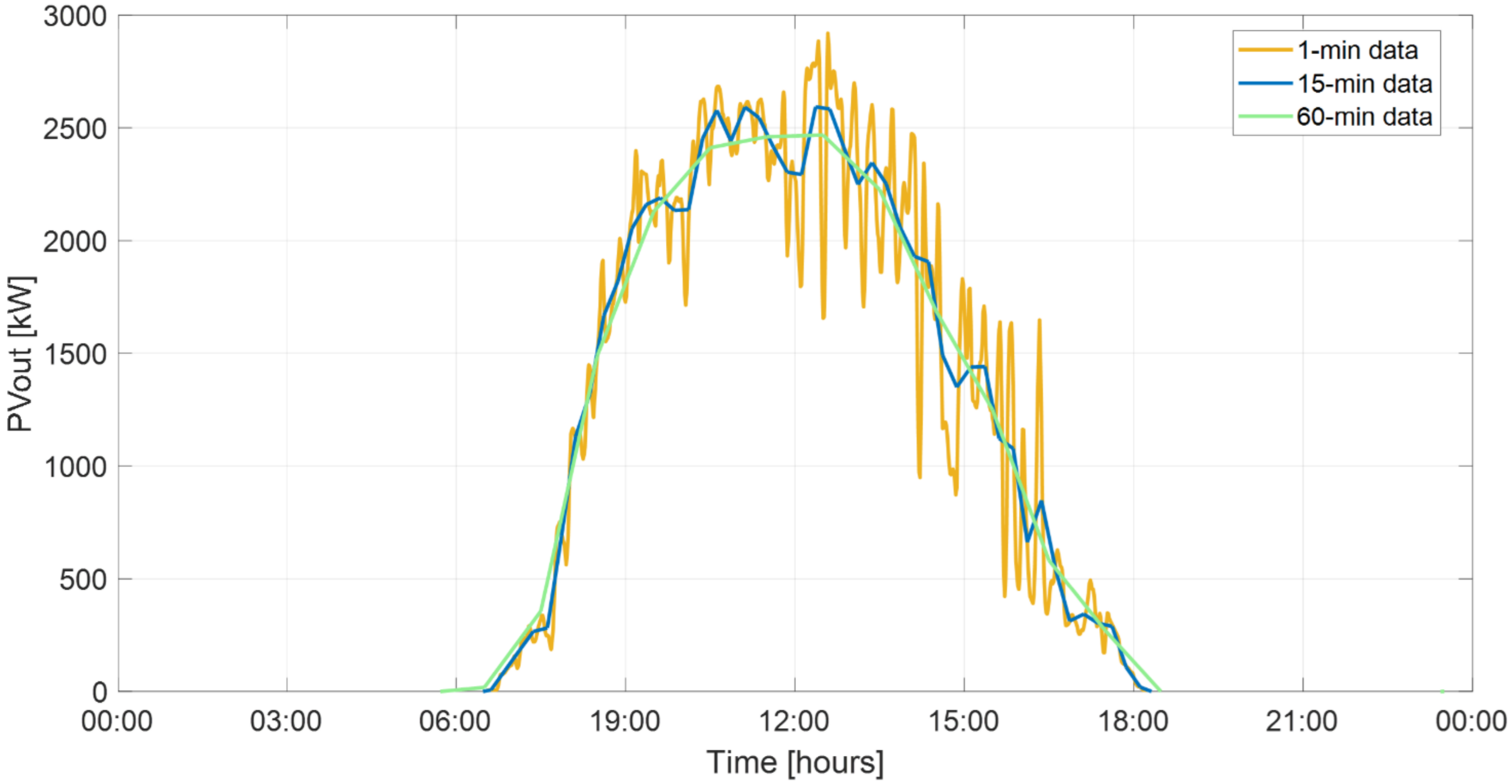
# Biaya pembangkit thermal dengan bahan bakar fosil sangat bergantung pada biaya operasi (gabungan biaya O&M dan bahan bakar)




- Kisaran LCOE pembangkit termal sangat bergantung pada operasi sedangkan pembangkit energi terbarukan sangat besar di biaya investasi awal
- Biaya operasi dapat berfluktuasi (terutama dari biaya bahan bakar), namun di Indonesia dilindungi dengan kebijakan *price cap* batubara di USD 70/ton dan gas di USD 6/mmbtu di *plant gate*
- Biaya investasi energi terbarukan memberikan tren penurunan harga yang lebih dapat diprediksi

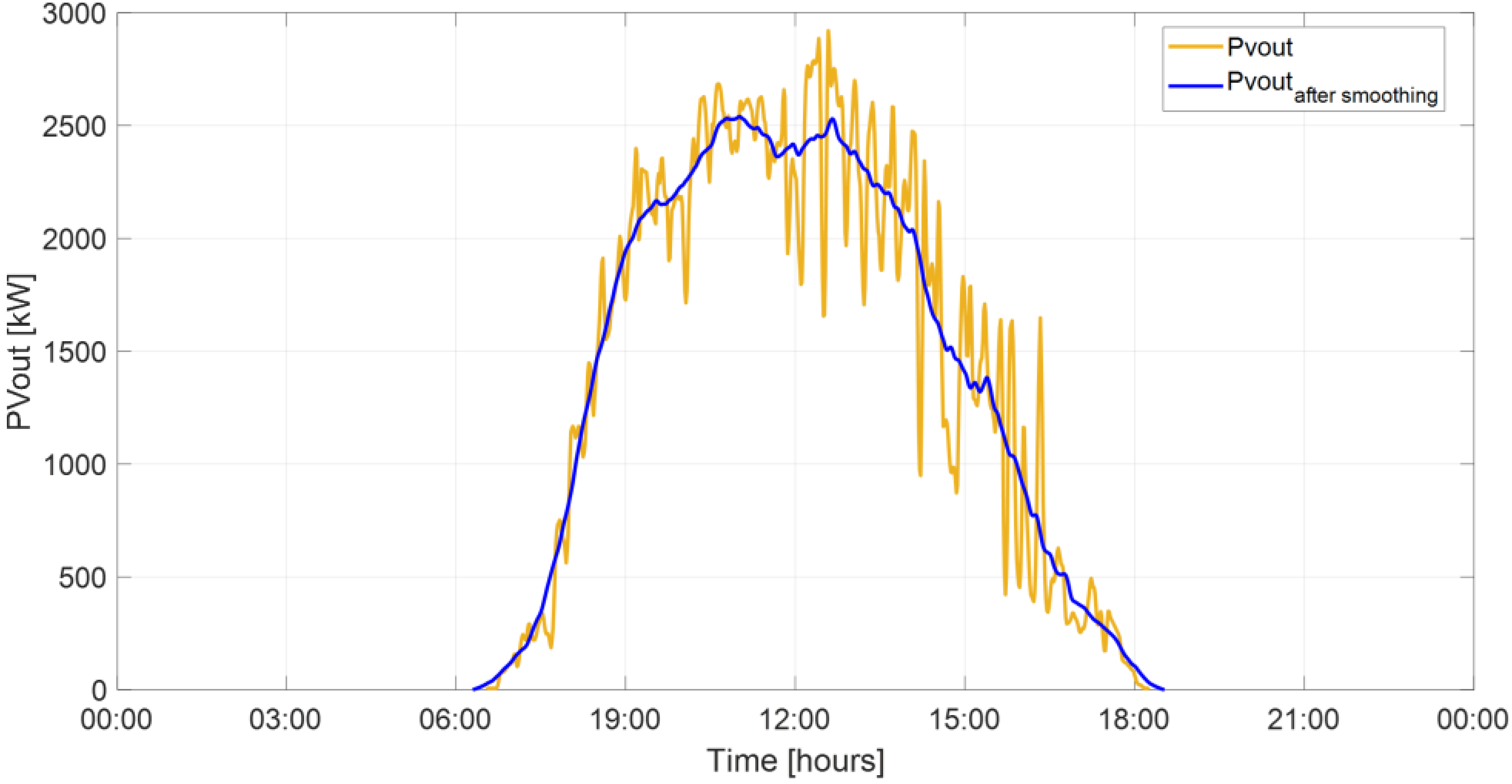
Sumber: IESR

# ILUSTRASI OUTPUT PLTS 1 MENIT VS 15 MENIT VS 60 MENIT




https://solargis.com/resources/blog/best-practices/4-reasons-why-pv-project-designers-need-1-minute-data

# PV OUT WITH AND WITHOUT SMOOTHING

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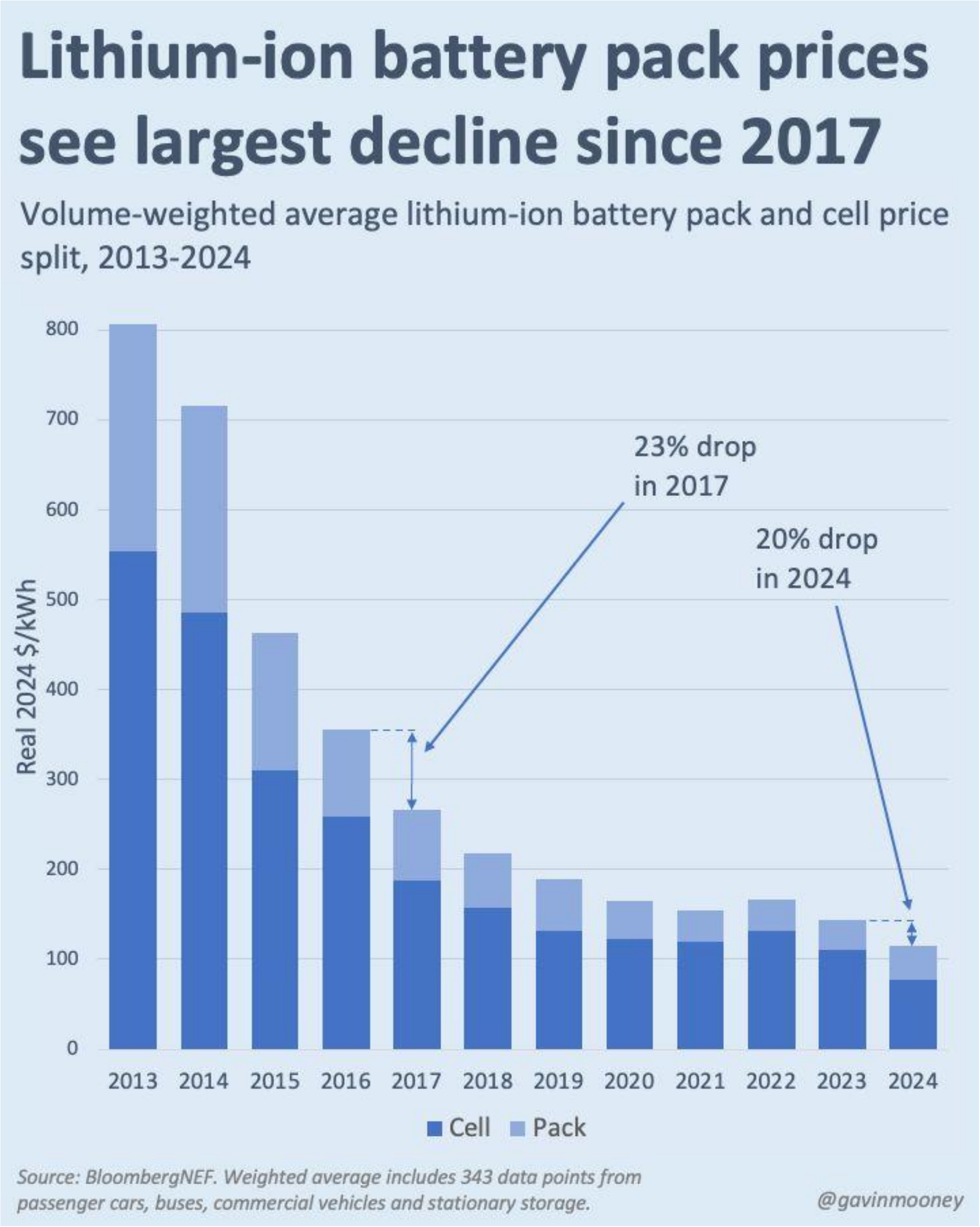
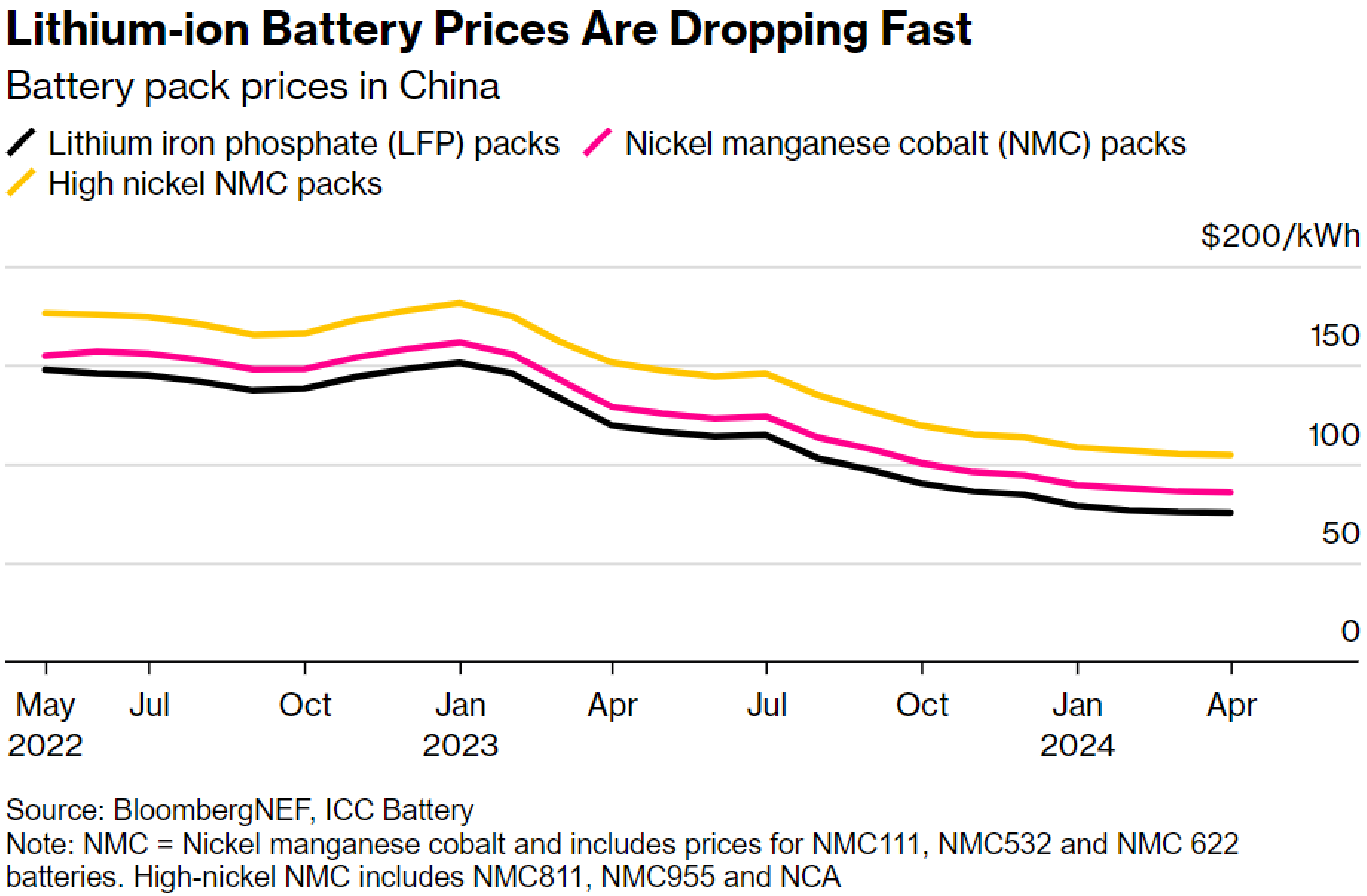
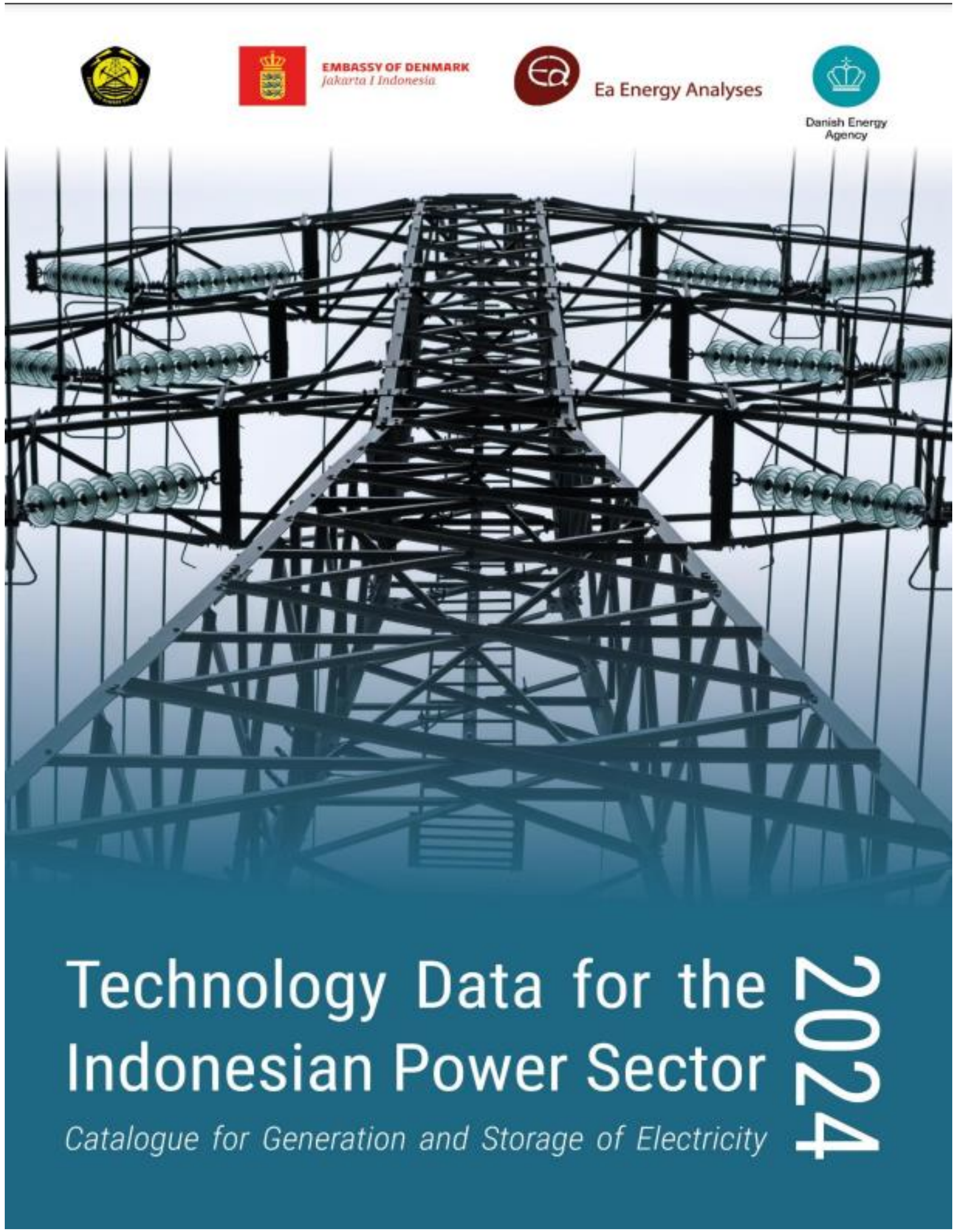

Lithium-ion battery pack prices see largest decline since 2017
Volume-weighted average lithium-ion battery pack and cell price split, 2013-2024
Real 2024 $/kWh
800
700
600
500
400
300
200
100
0
23% drop in 2017
20% drop in 2024
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
Cell
Pack
Source: BloombergNEF. Weighted average includes 343 data points from passenger cars, buses, commercial vehicles and stationary storage.
@gavinmooney


Lithium-ion Battery Prices Are Dropping Fast
Battery pack prices in China
Lithium iron phosphate (LFP) packs
Nickel manganese cobalt (NMC) packs
High nickel NMC packs
$200/kWh
150
100
50
0
May 2022
Jul
Oct
Jan 2023
Apr
Jul
Oct
Jan 2024
Apr
Source: BloombergNEF, ICC Battery
Note: NMC = Nickel manganese cobalt and includes prices for NMC111, NMC532 and NMC 622 batteries. High-nickel NMC includes NMC811, NMC955 and NCA




## Technology

| Technology | PV Floating, utility-scale, grid connected | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2050 | Uncertainty (2023) | | Uncertainty (2050) | | Note | Ref |
| **Energy/technical data** | | | | Lower | Upper | Lower | Upper | | |
| Generating capacity for total power plant (MWe) | 30 | 80 | 100 | | | | | A | 1 |
| Electricity efficiency, net (%), name plate | - | - | - | | | | | B | |
| Electricity efficiency, net (%), annual average | - | - | - | | | | | B | |
| Forced outage (%) | - | - | - | | | | | | |
| Planned outage (weeks per year) | - | - | - | | | | | | |
| Technical lifetime (years) | 27 | 30 | 35 | 25 | 30 | 28 | 42 | | 1 |
| Construction time (years) | 0.5 | 0.5 | 0.5 | 0.3 | 1.0 | 0.2 | 1.0 | | 1 |
| Space requirement (1000 $m^2$/MWe) | 8.3 | 7.5 | 6.7 | 7.2 | 10.0 | 5.0 | 9.0 | V | 9 |
| ***Additional data for non thermal plants*** | | | | | | | | | |
| Capacity factor (%), theoretical | 21.1 | 21.7 | 22.8 | 14.0 | 22.0 | 16.0 | 23.0 | M,L | 1,2,4 |
| Capacity factor (%), incl. outages | 21.0 | 21.6 | 22.7 | 14.0 | 22.0 | 16.0 | 23.0 | M,L,X | 1,2,4 |
| **Ramping configurations** | | | | | | | | | |
| Ramping (% per minute) | - | - | - | - | - | - | - | C | |
| Minimum load (% of full load) | - | - | - | - | - | - | - | C | |
| Warm start-up time (hours) | - | - | - | - | - | - | - | C | |
| Cold start-up time (hours) | - | - | - | - | - | - | - | C | |
| **Environment** | | | | | | | | | |
| PM 2.5 (gram per $Nm^3$) | 0 | 0 | 0 | | | | | | |
| $SO_2$ (degree of desulphuring, %) | 0 | 0 | 0 | | | | | | |
| $NO_X$ (g per GJ fuel) | 0 | 0 | 0 | | | | | | |
| $CH_4$ (g per GJ fuel) | 0 | 0 | 0 | | | | | | |
| $N_2O$ (g per GJ fuel) | 0 | 0 | 0 | | | | | | |
| **Financial data** | | | | | | | | | |
| Nominal investment (M$/MWe) | 1.20 | 0.74 | 0.48 | 1.15 | 1.90 | 0.25 | 0.60 | E,R,S | 1,3,8,11,12 |
| - of which equipment | 90% | 86% | 82% | | | | | | 1,3,6 |
| - of which installation | 10% | 14% | 18% | | | | | W | 1,3,6 |
| Fixed O&M ($/MWe/year) | 9,000 | 7,500 | 6,100 | 4,500 | 13,500 | 3,100 | 9,200 | Q | 3 |
| Variable O&M ($/MWh) | 0 | 0 | 0 | | | | | | |
| Start-up costs ($/MWe/start-up) | 0 | 0 | 0 | | | | | | |
| **Technology specific data** | | | | | | | | | |
| Global horizontal irradiance (kWh/m2/y) | 1,700 | 1,700 | 1,700 | 1,300 | 2,200 | 1,300 | 2,200 | F,M | 1,2,7 |
| DC/AC sizing factor (Wp/W) | 1.20 | 1.20 | 1.20 | | | | | G | 1,5 |
| Transposition Factor for fixed tilt system | 1.01 | 1.01 | 1.01 | | | | | H | 7 |
| Performance ratio | 0.90 | 0.95 | 0.97 | | | | | I | 1,4,5 |
| PV module conversion efficiency (%) | 0.21 | 0.23 | 0.26 | | | | | T | 1,3,5 |
| Inverter lifetime (years) | 12.50 | 15.00 | 15.00 | | | | | | 1,5 |

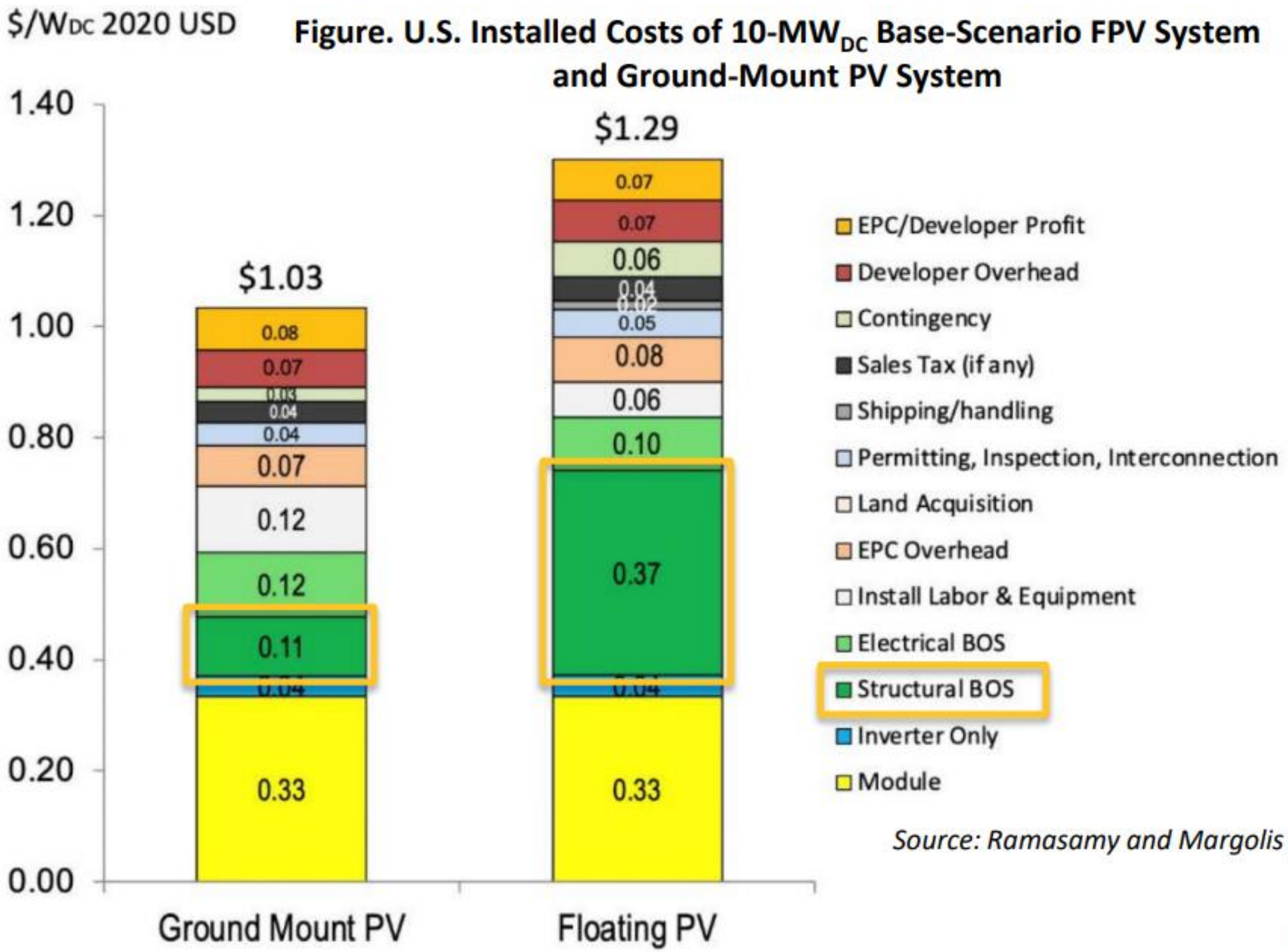
# Cost Structure of Floating PV

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.*

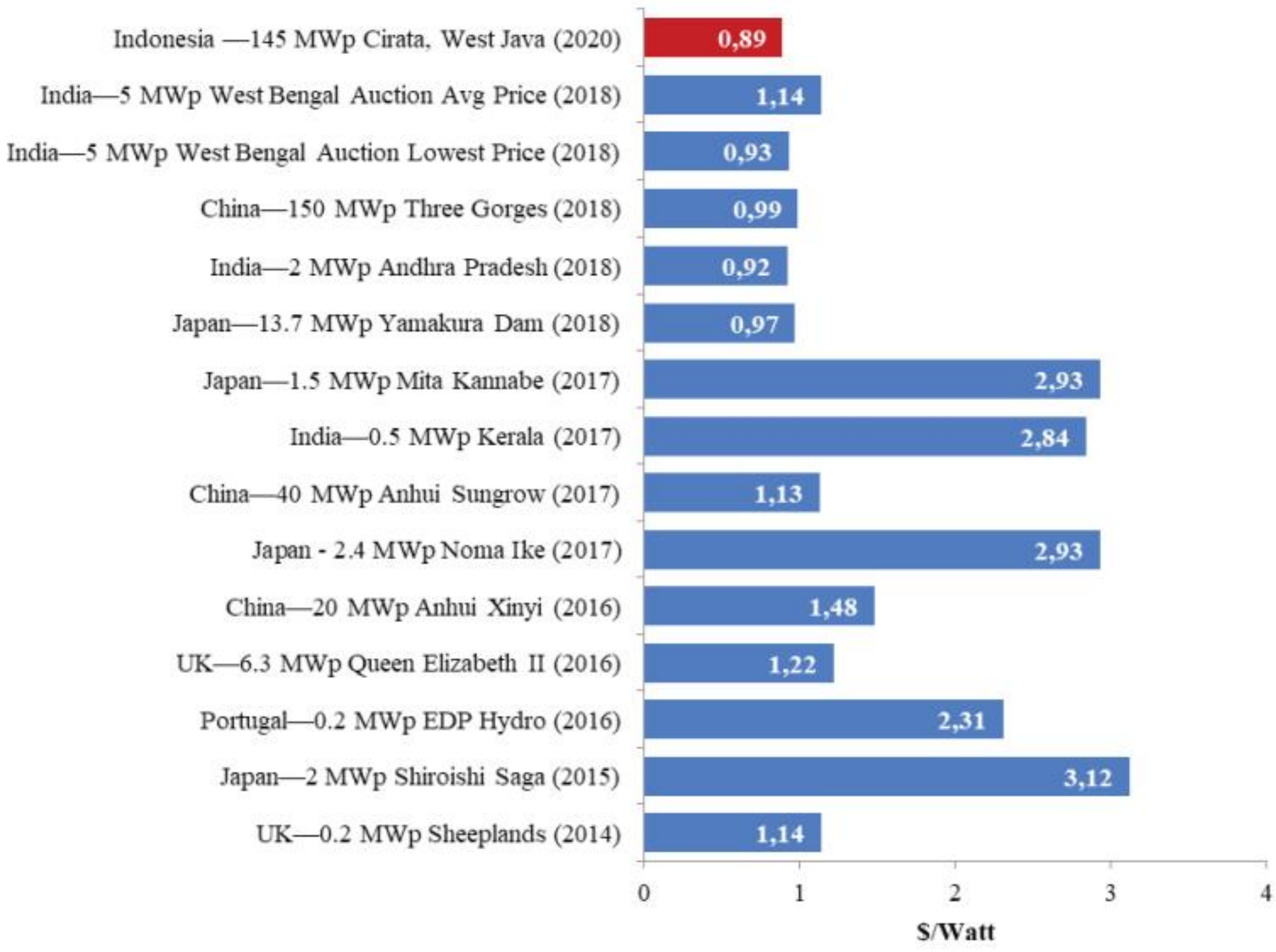
Levelized cost of electricity (LCOE) estimated to be 20% higher for FPV system compared to ground-mount PV.

- *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).*




*Source: Ramasamy and Margolis (2021)*

# Project cost of Floating Solar PV ($/Watt)



# Terimakasih

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# FURTHER READING

- 100% Renewable Electricity in Indonesia, https://doi.org/10.3390/en17010003
- Global Atlas of Marine Floating Solar PV Potential, https://www.mdpi.com/2673-9941/3/3/23
- Indonesia's Vast Off-river Pumped Hydro Energy Storage Potential, https://www.mdpi.com/1996-1073/15/9/3457
- Indonesia's Vast Solar Energy Potential, https://www.mdpi.com/1996-1073/14/17/5424
- Pumped hydro energy storage to support 100% renewable energy. https://iopscience.iop.org/article/10.1088/2516-1083/adaabd
- Heatmaps to Guide Siting of Solar and Wind Farms. *Energies* 2025, *18*(4), 891; https://doi.org/10.3390/en18040891
- A global atlas of pumped hydro systems that repurpose existing mining sites, https://www.sciencedirect.com/science/article/abs/pii/S0960148124001782?via%3Dihub
- A review of pumped hydro energy storage, https://iopscience.iop.org/article/10.1088/2516-1083/abeb5b
- Global Atlas of Closed-Loop Pumped Hydro Energy Storage, https://doi.org/10.1016/j.joule.2020.11.015

*Prog. Energy* **7** (2025) 022004 https://doi.org/10.1088/2516-1083/adaabd

Progress in Energy

**TOPICAL REVIEW**

# Pumped hydro energy storage to support 100% renewable energy

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**E-mail:** andrew.blakers@anu.edu.au

**Keywords:** hydro, storage, renewable energy, pumped hydro energy storage, solar energy, wind energy


Open access: https://iopscience.iop.org/article/10.1088/2516-1083/adaabd

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*Article*

# Indonesia's Vast Off-River Pumped Hydro Energy Storage Potential

**David Firnando Silalahi *, Andrew Blakers, Bin Lu and Cheng Cheng**

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*Energies* **2022**, *15*(9), 3457;
https://doi.org/10.3390/en15093457

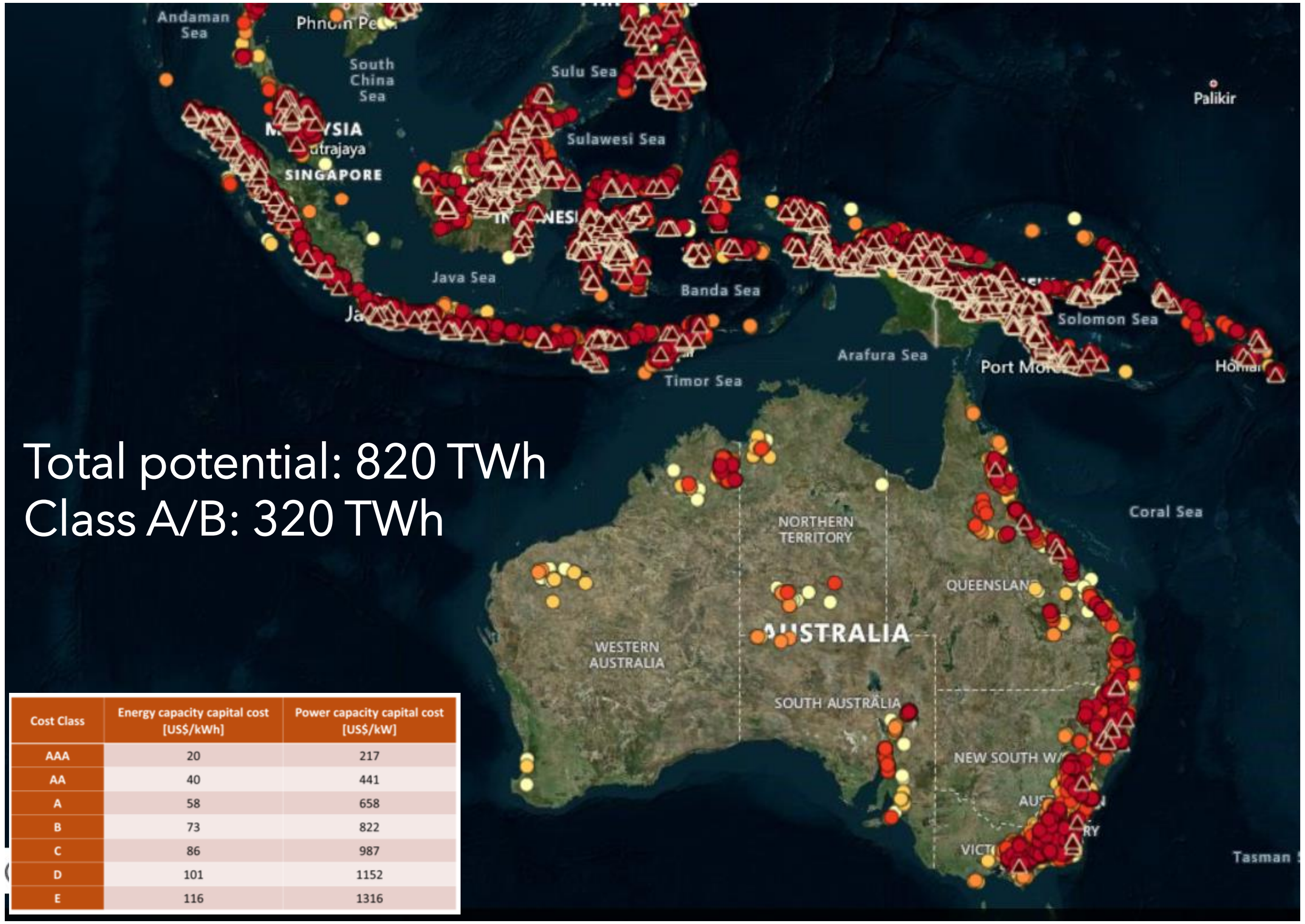
**Abstract:** Indonesia has vast solar energy potential, far more than needed to meet all its energy requirements without the use of fossil fuels. This remains true after per capita energy consumption rises to match developed countries, and most energy functions are electrified to minimize the use of fossil fuels. Because Indonesia has relatively small energy potential from hydro, wind, biomass, geothermal and ocean energy, it will rely mostly on solar for its sustainable energy needs. Thus, Indonesia will require large amounts of storage for overnight and longer periods. Pumped hydro comprises 99% of global energy storage for the electricity industry. In this paper, we demonstrate that Indonesia has vast practical potential for low-cost off-river pumped hydro energy storage with low environmental and social impact; far more than it needs to balance a solar-dominated energy system.

**Keywords:** off-river pumped hydro; energy storage; potential; low cost; green-field; solar PV

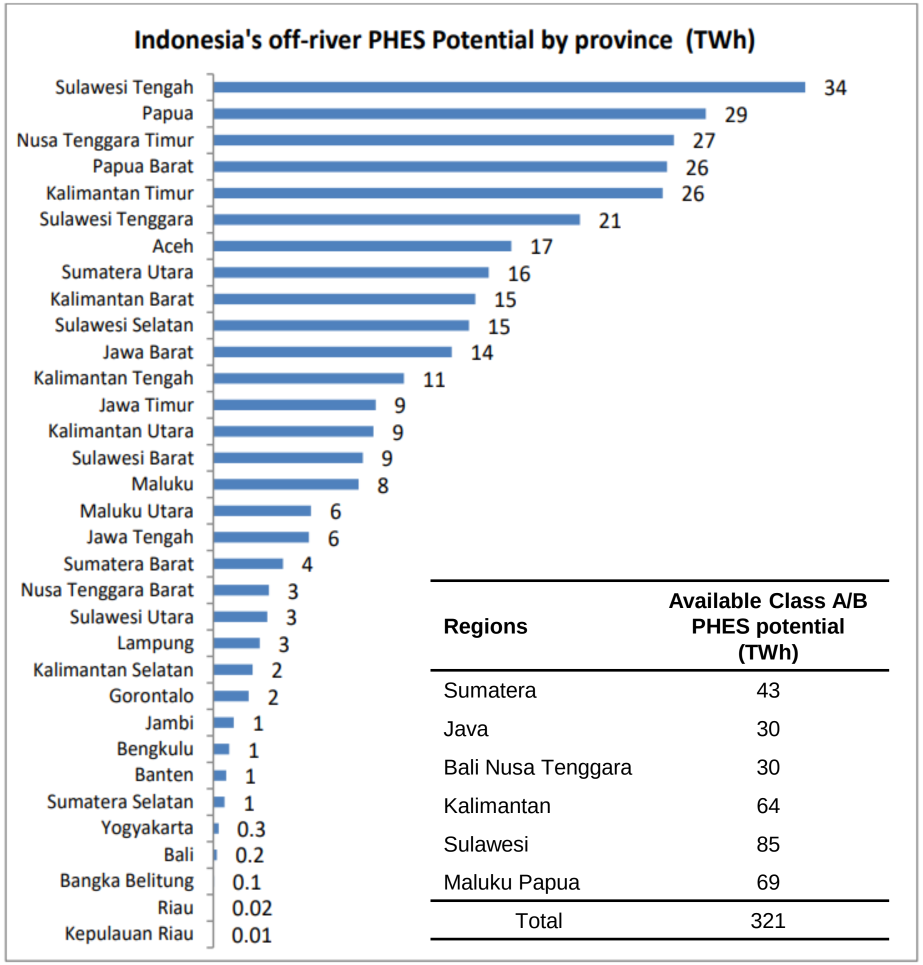


**Part 2: Assessment of Indonesia's practical off-river pumped hydro energy storage potential.**

# Indonesia's Vast Off-River PHES Potential




| Cost Class | Energy capacity capital cost [US$/kWh] | Power capacity capital cost [US$/kW] |
|---|---|---|
| AAA | 20 | 217 |
| AA | 40 | 441 |
| A | 58 | 658 |
| B | 73 | 822 |
| C | 86 | 987 |
| D | 101 | 1152 |
| E | 116 | 1316 |




| Regions | Available Class A/B PHES potential (TWh) |
|---|---|
| Sumatera | 43 |
| Java | 30 |
| Bali Nusa Tenggara | 30 |
| Kalimantan | 64 |
| Sulawesi | 85 |
| Maluku Papua | 69 |
| Total | 321 |

*Source: Energies* **2022**, *15*(9), 3457; **https://doi.org/10.3390/en15093457**

# Heatmap to Guide Siting of Solar and Wind Farms

Published 13 Feb 2025

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## Heatmaps to Guide Siting of Solar and Wind Farms

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**Abstract:** The decarbonization of the electricity system coupled with the electrification of transport, heat, and industry represents a practical and cost-effective approach to deep decarbonization. A key question is as follows: where to build new solar and wind farms? This study presents a cost-based approach to evaluate land parcels for solar and wind farm suitability using colour-coded heatmaps that visually depict favourable locations. An indicative cost of electricity is calculated and classified for each pixel by focusing on key factors including the resource availability, proximity to transmission infrastructure and load centres, and exclusion of sensitive areas. The proposed approach mitigates the subjectivity associated with traditional multi-criteria decision-making methods, in which both the selection of siting factors and the assignment of their associated weightings rely highly on the subjective judgements of experts. The methodology is applied to Australia, South Korea, and Indonesia, and the results show that proximity to high-voltage transmission and load centres is a key factor affecting site selection in Australia and Indonesia, while connection costs are less critical in South Korea due to its smaller land area and extensive infrastructure. The outcomes of this study, including heatmaps and detailed statistics, are made publicly available to provide both qualitative and quantitative information that allows comparisons between regions and within a region. This study aims to empower policymakers, developers, communities, and individual landholders to make informed decisions and, ultimately, to facilitate strategic renewable energy deployment and contribute to global decarbonization.

**Keywords:** solar photovoltaics; wind energy; GIS analysis; heatmap; resource assessment

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### 1. Introduction

#### 1.1. Background and Motivation

Approximately three-quarters of global greenhouse gas emissions arise from fossil fuels [1]. A highly credible and economical pathway to achieve rapid and deep emission reductions involves the decarbonization of electricity through the deployment of solar and wind energy, coupled with the electrification of land transport using electric vehicles and heating through electric heat pumps and furnaces [2]. Emissions from fossil fuels used in the chemical industry (metals, chemicals, materials, synthetic aviation and shipping fuels) can also be addressed by solar and wind through electrolysis to produce clean hydrogen.

In 2023, new installations of solar photovoltaics (PV) and wind accounted for 80% of the global net additions in electricity generation capacity, continuing their dominance of new capacity additions since 2020 [3–5]. Therefore, the aforementioned decarbonization

**Table 4.** Summary of solar PV potential in Sumatra, Java, and Kalimantan under low-cost, overhead transmission scenario.

| Cost Classes | Sumatra | Java | Kalimantan |
|---|---|---|---|
| Class A: <USD 30/MWh | - | - | - |
| Class B: USD 30–40/MWh | - | 1145 GW | - |
| Class C: USD 40–50/MWh | 10,363 GW | 6698 GW | 9193 GW |
| Class D: USD 50–60/MWh | 13,708 GW | 471 GW | 7253 GW |
| Class E: >USD 60/MWh | 3488 GW | 1 GW | 1041 GW |
| Total | 27,559 GW | 8316 GW | 17,487 GW |
| Population (millions) | 61 | 152 | 17 |

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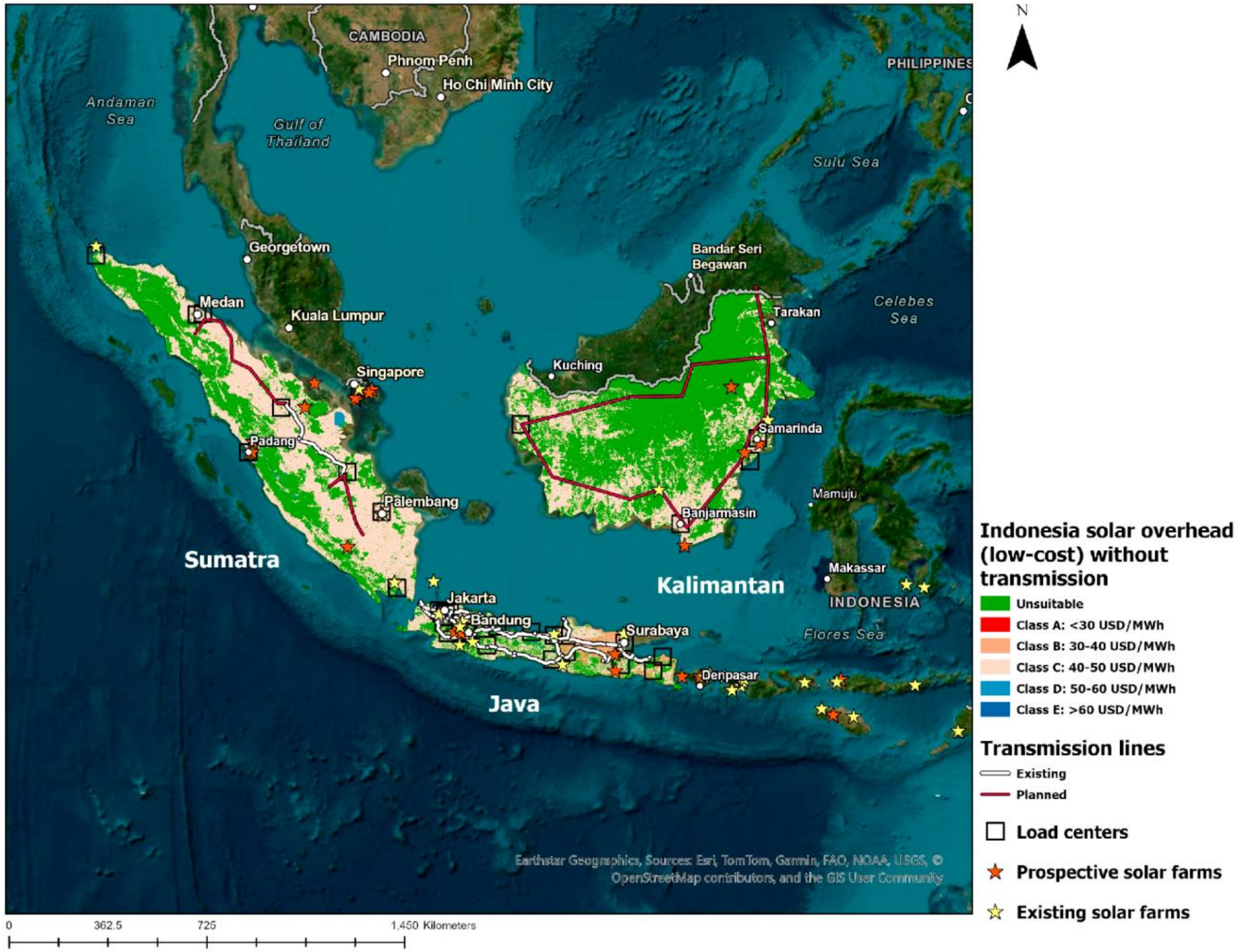
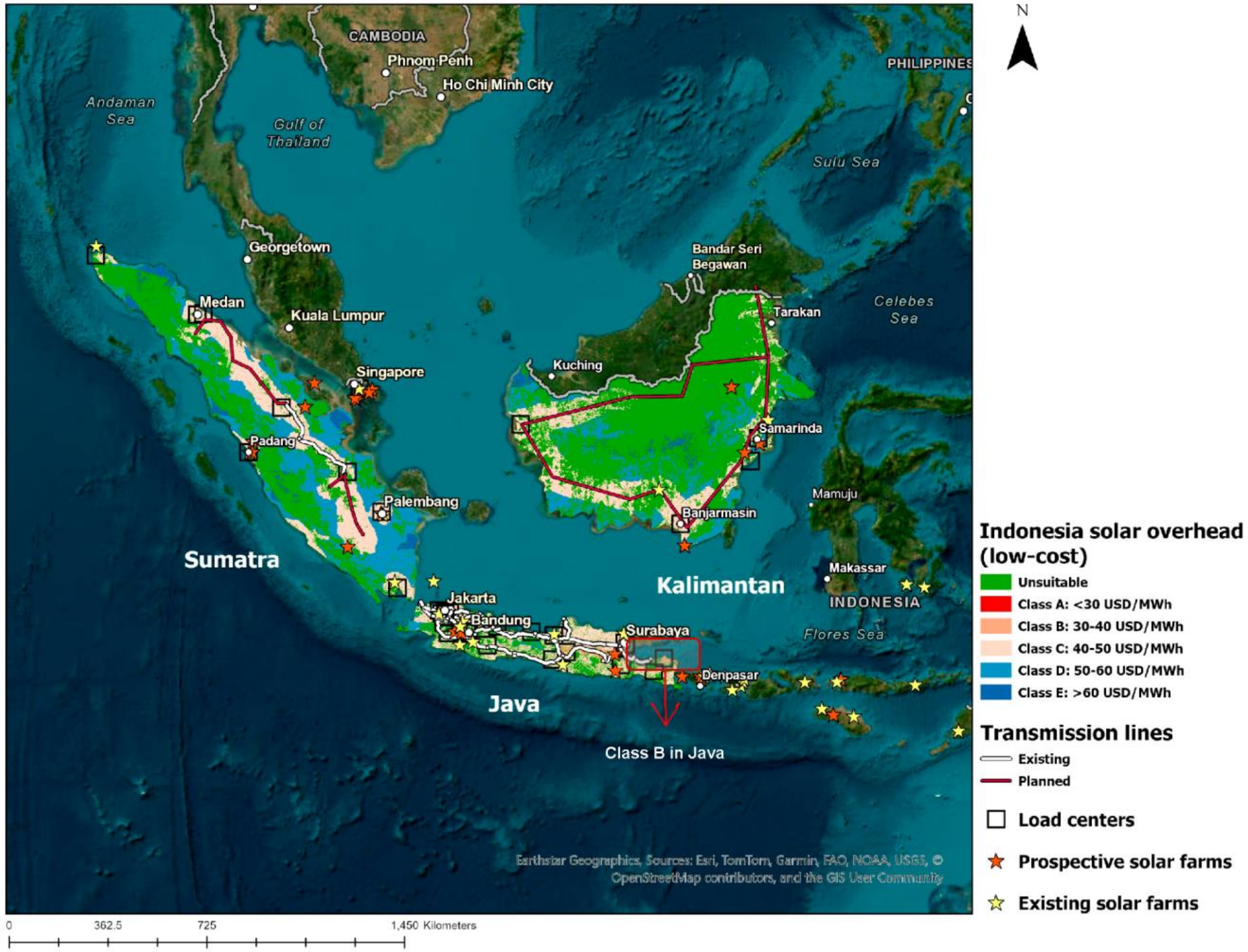
# Indonesia solar overhead low-cost heatmap and comparative heatmap without the effect of transmission



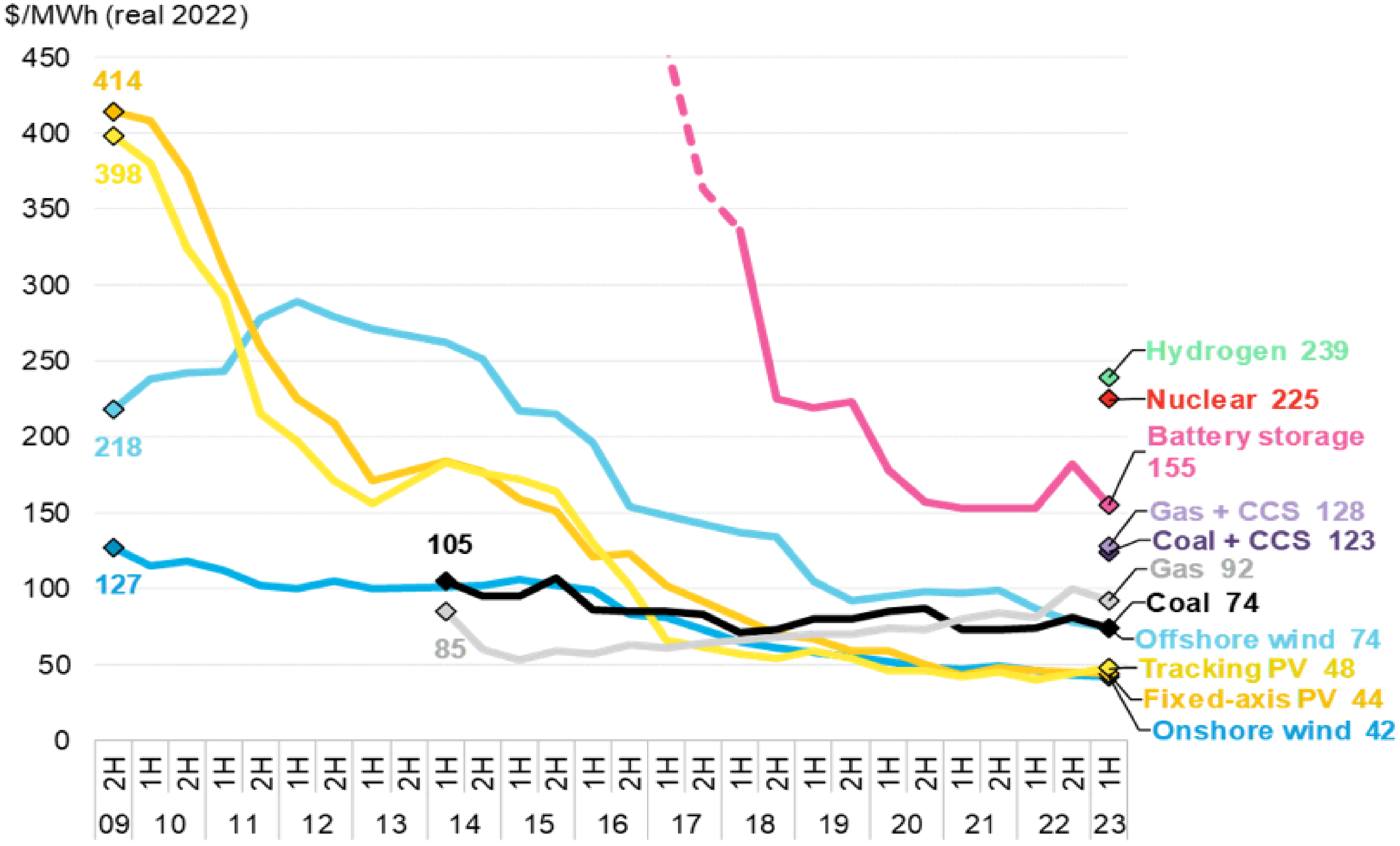

(a)




(b)

# Solar and wind are the most affordable sources of clean energy

**Figure 1: Global levelized cost of electricity benchmarks, 2009-2023**




Source: Bloomberg NEF

# Potential of Floating Solar PV in Indonesia

## Indonesia Results

| Waterbody Type | Sensitivities | | Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Minimum Shore Distance (m) | Maximum Shore Distance (m) | Suitable Waterbody Area ($km^2$) | Fixed Tilt: Monofacial | | | Fixed Tilt: Bifacial | | |
| | | | | Capacity (MW) | Generation (GWh/year) | Average Net Capacity Factor (%) | Capacity (MW) | Generation (GWh/year) | Average Net Capacity Factor (%) |
| Reservoirs (including hydropower and non-hydropower reservoirs) | 0 (Close to Shore) | 500 | 273 | 27,341 | 39,150 | 16.3% | 27,341 | 41,108 | 17.2% |
| | | 1,000 | 340 | 34,000 | 48,604 | 16.3% | 34,000 | 51,034 | 17.1% |
| | | 2,000 | 340 | 34,000 | 48,604 | 16.3% | 34,000 | 51,034 | 17.1% |
| | 50 (Median) | 500 | 212 | 21,246 | 30,444 | 16.4% | 21,246 | 31,967 | 17.2% |
| | | 1,000 | 278 | 27,792 | 39,741 | 16.3% | 27,792 | 41,728 | 17.1% |
| | | 2,000 | 304 | 30,406 | 43,411 | 16.3% | 30,406 | 45,581 | 17.1% |
| | 100 (Far From Shore) | 500 | 163 | 16,282 | 23,335 | 16.4% | 16,282 | 24,501 | 17.2% |
| | | 1,000 | 227 | 22,727 | 32,492 | 16.3% | 22,727 | 34,117 | 17.1% |
| | | 2,000 | 253 | 25,282 | 36,079 | 16.3% | 25,282 | 37,883 | 17.1% |
| Natural Waterbody | 0 (Close to Shore) | 500 | 2,604 | 260,425 | 357,115 | 15.7% | 260,425 | 374,971 | 16.4% |
| | | 1,000 | 3,296 | 329,563 | 448,455 | 15.5% | 329,563 | 470,878 | 16.3% |
| | | 2,000 | 3,296 | 329,563 | 448,455 | 15.5% | 329,563 | 470,878 | 16.3% |
| | 50 (Median) | 500 | 2,031 | 203,115 | 278,210 | 15.6% | 203,115 | 292,120 | 16.4% |
| | | 1,000 | 2,719 | 271,897 | 369,059 | 15.5% | 271,897 | 387,511 | 16.3% |
| | | 2,000 | 3,362 | 336,217 | 451,573 | 15.3% | 336,217 | 474,152 | 16.1% |
| | 100 (Far From Shore) | 500 | 1,539 | 153,920 | 210,464 | 15.6% | 153,920 | 220,987 | 16.4% |
| | | 1,000 | 2,223 | 222,322 | 300,785 | 15.4% | 222,322 | 315,824 | 16.2% |
| | | 2,000 | 2,864 | 286,435 | 383,012 | 15.3% | 286,435 | 402,163 | 16.0% |
| All Suitable Waterbodies | 0 (Close to Shore) | 500 | 2,878 | 287,766 | 396,265 | 15.7% | 287,766 | 416,078 | 16.5% |
| | | 1,000 | 3,636 | 363,563 | 497,059 | 15.6% | 363,563 | 521,912 | 16.4% |
| | | 2,000 | 3,636 | 363,563 | 497,059 | 15.6% | 363,563 | 521,912 | 16.4% |
| | 50 (Median) | 500 | 2,244 | 224,361 | 308,654 | 15.7% | 224,361 | 324,087 | 16.5% |
| | | 1,000 | 2,997 | 299,689 | 408,800 | 15.6% | 299,689 | 429,240 | 16.4% |
| | | 2,000 | 3,666 | 366,622 | 494,984 | 15.4% | 366,622 | 519,733 | 16.2% |
| | 100 (Far From Shore) | 500 | 1,702 | 170,202 | 233,799 | 15.7% | 170,202 | 245,488 | 16.5% |
| | | 1,000 | 2,450 | 245,049 | 333,277 | 15.5% | 245,049 | 349,941 | 16.3% |
| | | 2,000 | 3,117 | 311,717 | 419,092 | 15.3% | 311,717 | 440,046 | 16.1% |

Source: FPV Technical Potential Assessment for Southeast Asia

# Potential of Floating Solar PV in Indonesia

**Table 1.** Floating PV Potentials higher than 1 MWp in Indonesia.

| Province | Number of reservoirs (sites) | Area of Reservoir (ha) | Floating PV Potential (MWp) |
|---|---|---|---|
| Aceh | 15 | 7,983.39 | 231.52 |
| Bali | 5 | 2,764.95 | 80.18 |
| Banten | 9 | 2,221.85 | 64.43 |
| Bengkulu | 4 | 303.22 | 8.79 |
| DI Yogyakarta | 1 | 145.84 | 4.23 |
| DKI Jakarta | 1 | 79.78 | 2.31 |
| Gorontalo | 2 | 2,276.72 | 66.02 |
| Jambi | 6 | 6,014.01 | 174.41 |
| Jawa Barat | 21 | 21,662.33 | 628.21 |
| Jawa Tengah | 23 | 15,331.71 | 444.62 |
| Jawa Timur | 38 | 5,644.05 | 163.68 |
| Kalimantan Barat | 58 | 28,461.03 | 825.37 |
| Kalimantan Selatan | 21 | 7,818.18 | 226.73 |
| Kalimantan Tengah | 42 | 7,773.94 | 225.44 |
| Kalimantan Timur | 28 | 40,239.23 | 1,166.94 |
| Kalimantan Utara | 2 | 79.93 | 2.32 |
| Kepulauan Riau | 5 | 2,448.77 | 71.01 |
| Lampung | 10 | 3,084.23 | 89.44 |
| Maluku | 5 | 1,354.22 | 39.27 |
| Maluku Utara | 14 | 3,399.97 | 98.60 |
| Nusa Tenggara Barat | 15 | 4,293.09 | 124.50 |
| Nusa Tenggara Timur | 12 | 2,610.92 | 75.72 |
| Papua | 103 | 58,198.58 | 1,687.76 |
| Papua Barat | 15 | 22,859.90 | 662.94 |
| Riau | 31 | 18,906.24 | 548.28 |
| Sulawesi Selatan | 17 | 93,151.20 | 2,701.39 |
| Sulawesi Tengah | 11 | 42,356.70 | 1,228.34 |
| Sulawesi Tenggara | 1 | 51.21 | 1.49 |
| Sulawesi Utara | 6 | 5,632.11 | 163.33 |
| Sumatera Barat | 8 | 23,727.96 | 688.11 |
| Sumatera Selatan | 19 | 17,334.50 | 502.70 |
| Sumatera Utara | 7 | 115,514.35 | 3,349.91 |
| TOTAL | **555** | **563,724.11** | **16,347.99** |

As result, the country has 5,807 potential reservoirs for FPV and 26 hydropower plants with a reservoir area with a potential utilization of more than 1 MW. Those sites are suitable for 3 GW floating power plants and 2.8 GW hydropower. And those sites can reduce $CO_2$ emissions by 2,911,197 tonnes per year.

Source: Hybrid Floating Photovoltaic - Hydropower Potential Utilization in Indonesia

# Potential of Floating Solar PV in Indonesia

**Table 2.** Potential reservoirs with hydropower for floating PV higher than 1 MWp

| No | Name | DAM Commercial Operation Year | Area Reservoir (Ha) | River | Province | Hydropower Capacity (MW) | FPV potential (MWp) | FPV Electricity Production (TWh/year) | Emission reduction (Tonne $CO_2$/year) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Pengga | 1994 | 554.55 | Dodokan | Nusa Tenggara Barat | 0.40 | 16.12 | 22.59 | 15,319 |
| 2 | Pelaperado | 2004 | 71.95 | Parado | Nusa Tenggara Barat | 0.305 | 2.09 | 2.93 | 1,986 |
| 3 | Mamak | 1992 | 261.46 | Mamak | Nusa Tenggara Barat | 0.55 | 7.60 | 10.65 | 7,222 |
| 4 | Tiu Kulit | 1994 | 62.54 | Tiu Kulit | Nusa Tenggara Barat | 0.08 | 1.82 | 2.55 | 1,730 |
| 5 | Sumi | 1999 | 102.29 | Sumi | Nusa Tenggara Barat | 0.2 | 2.97 | 4.16 | 2,822 |
| 6 | Sengguruh | 1988 | 150.39 | Brantas | Jawa Timur | 29.00 | 4.37 | 6.12 | 4,153 |
| 7 | Karangkates/S utami | 1973 | 1357.20 | Brantas | Jawa Timur | 105.00 | 39.45 | 55.29 | 37,489 |
| 8 | Wlingi | 1977 | 65.15 | Brantas | Jawa Timur | 54.00 | 1.89 | 2.65 | 1,796 |
| 9 | Wonorejo | 1999 | 357.68 | Gondang | Jawa Timur | 6.02 | 10.40 | 14.58 | 9,883 |
| 10 | Bening/widas | 1984 | 465.67 | Bening | Jawa Timur | 0.5 | 13.54 | 18.98 | 12,867 |
| 11 | Jatigede | 2015 | 3588.41 | Cimanuk | Jawa Barat | 110.00 | 104.31 | 146.20 | 99,124 |
| 12 | Gunung Rowo | 1925 | 50.92 | Gunung wadi | Jawa Tengah | 22.50 | 1.48 | 2.07 | 1,406 |
| 13 | Jatiluhur | 1967 | 6798.31 | Citarum | Jawa Barat | 187.50 | 197.63 | 277.00 | 187,805 |
| 14 | Bili Bili | 1999 | 885.09 | Jeneberang | Sulawesi Selatan | 24.00 | 25.73 | 36.06 | 24,451 |
| 15 | Batu Tegi | 2002 | 1335.26 | Sekampung | Lampung | 28.00 | 38.82 | 54.41 | 36,890 |
| 16 | Kalola | 1995 | 654.66 | Kalola | Sulawesi Selatan | 0.15 | 19.03 | 26.67 | 18,084 |
| 17 | Riam Kanan | 1973 | 6129.32 | Barito | Kalimantan Selatan | 30 | 178.18 | 249.74 | 169,322 |
| 18 | Larona (Batu Besi) | 1978 | 58480.62 | Larona | Sulawesi Selatan | 166 | 1700.02 | 2,382.75 | 1,615,503 |
| 19 | Kotapanjang | 1997 | 9135.02 | Kampar Kanan | Riau | 114 | 265.55 | 372.19 | 252,348 |
| 20 | Wadas Lintang | 1987 | 1300.00 | Badegolan | Jawa Tengah | 16 | 37.79 | 52.97 | 35,911 |
| 21 | Mrica | 1988 | 631.21 | Serayu | Jawa Tengah | 185 | 18.35 | 25.72 | 17,438 |
| 22 | Sempor | 1978 | 193.12 | Cingcingguling | Jawa Tengah | 1.1 | 5.61 | 7.86 | 5,331 |
| 23 | Kedung Ombo | 1984 | 3009.29 | Uter & Serang | Jawa Tengah | 22.5 | 87.48 | 122.61 | 83,131 |
| 24 | Selorejo | 1970 | 334.44 | Konto | Jawa Timur | 4.5 | 9.72 | 13.62 | 9,237 |
| 25 | Cirata | 1988 | 5393.29 | Citarum | Jawa Barat | 1008 | 156.78 | 219.74 | 148,986 |
| 26 | Saguling | 1984 | 4016.93 | Citarum | Jawa Barat | 700.72 | 116.77 | 163.66 | 110,965 |
| TOTAL | | | | | | 2,816 | 3065 | 4,293.80 | 2,911,197 |

Source: Hybrid Floating Photovoltaic - Hydropower Potential Utilization in Indonesia

# Floating solar PV - schematic

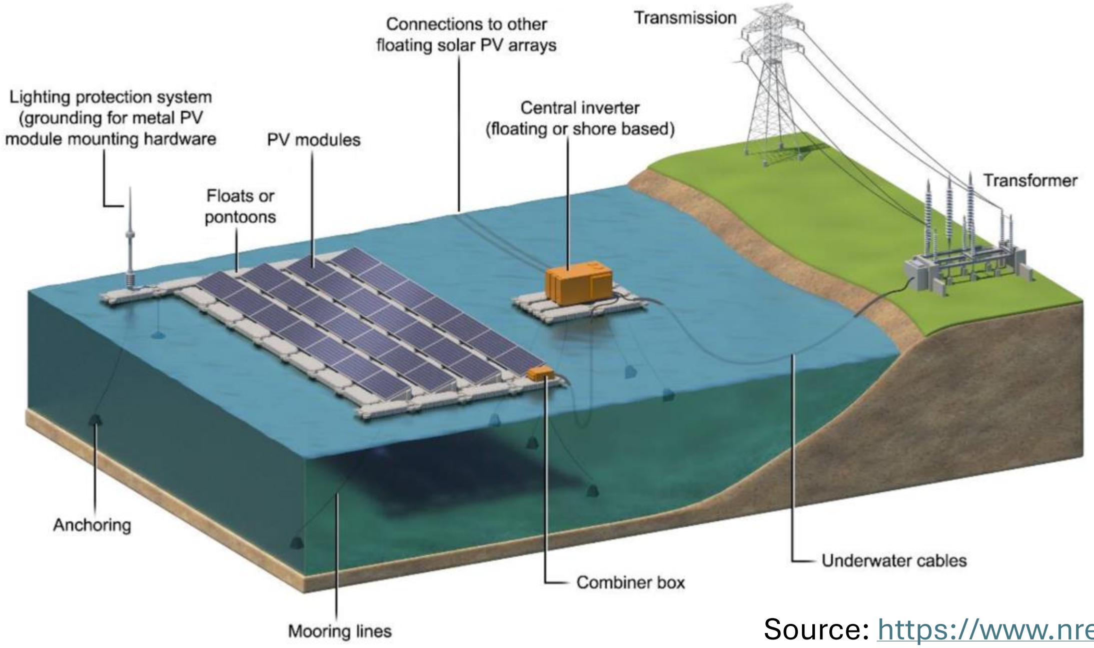
**Floating PV :** ***Solar PV sited floating on waterbodies such as reserovirs, lakes, seas***

**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).

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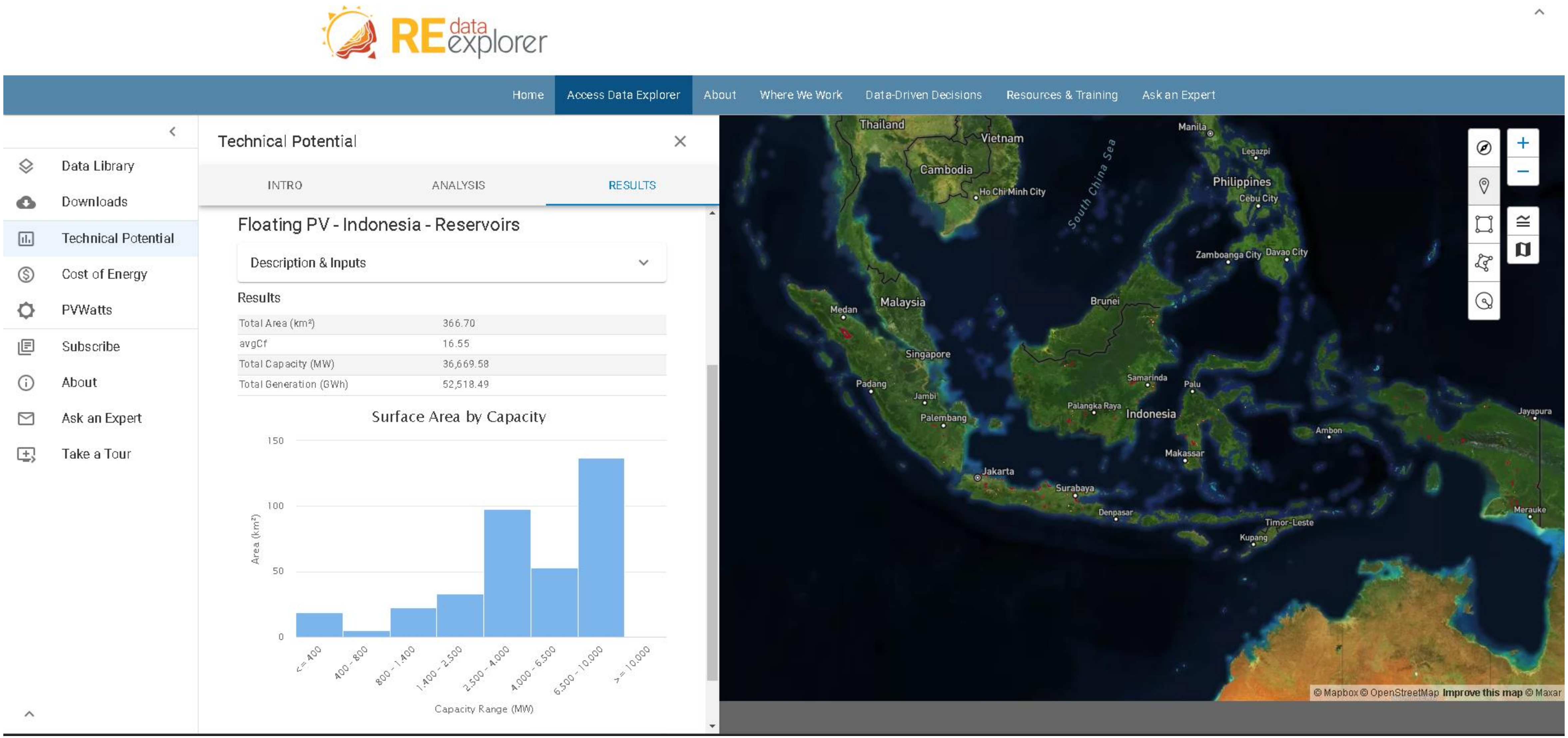
# RE data explorer - NREL

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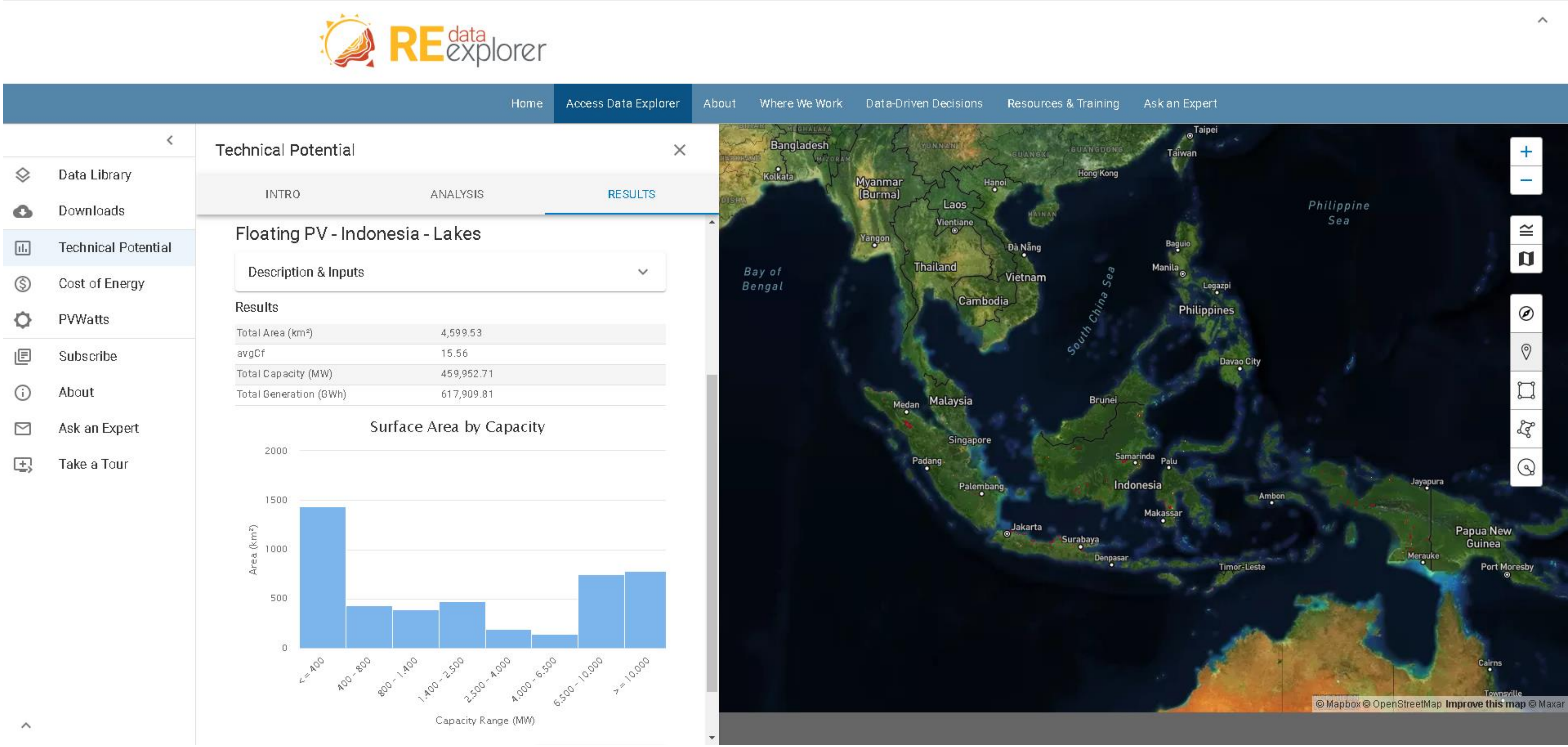


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