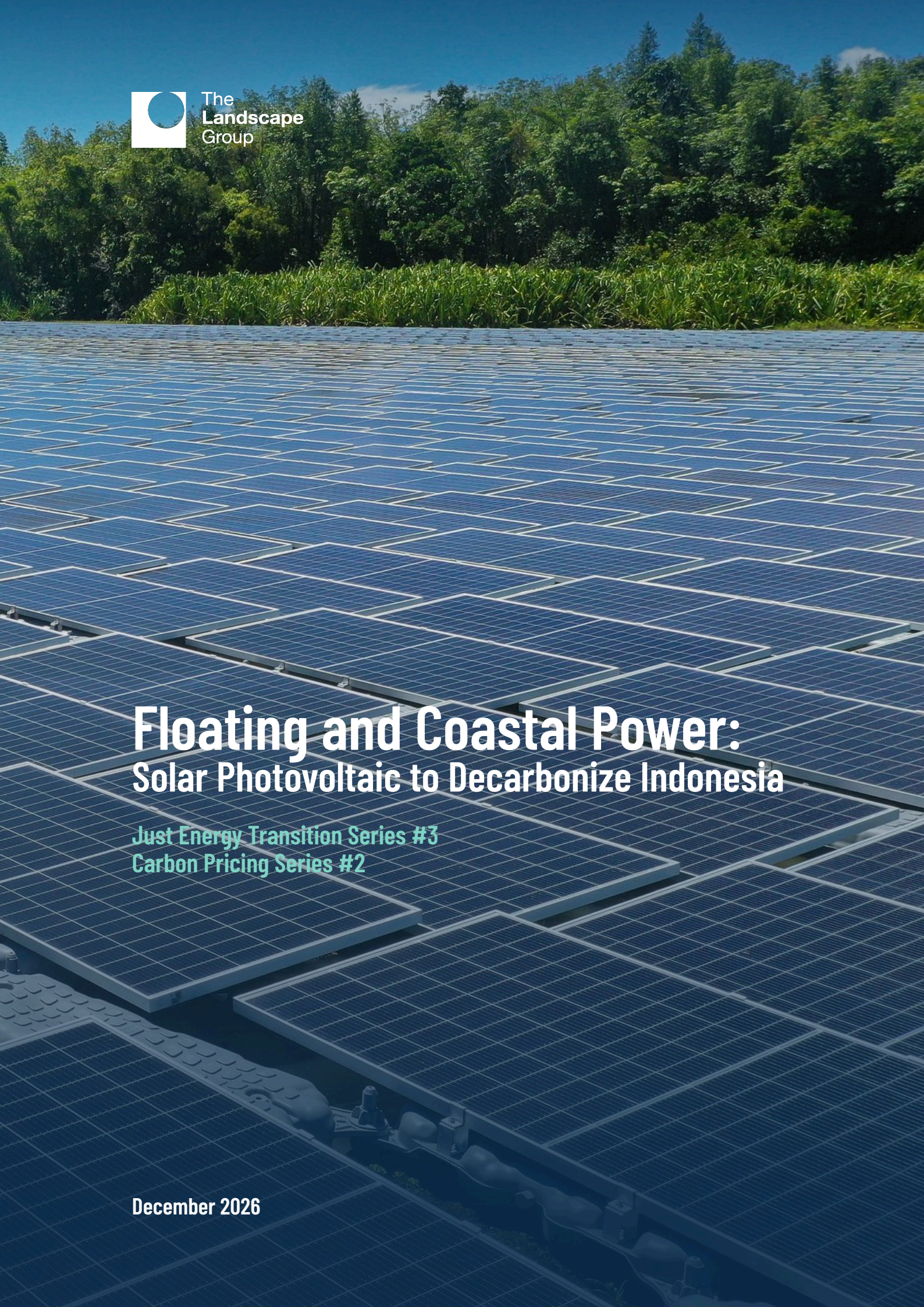

The Landscape Group

Floating and Coastal Power:
Solar Photovoltaic to Decarbonize Indonesia

Just Energy Transition Series #3
Carbon Pricing Series #2

December 2026

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Agus P. Sari
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Executive Summary

The 31st Conference of the Parties (COP31) ended without an overarching deal, but carbon markets survived. On November 11, 2026, the state electricity company Perusahaan Listrik Negara (PLN) signed an agreement under which Norway can buy up to 12 million tons of carbon dioxide equivalent (CO_2e) from PLN solar projects at $20 to $40 a ton. The agreement can start a much larger solar program.

The deal matters because state programs and a capped coal price built a coal-heavy power system. Coal supplied two-thirds of PLN's electricity in 2024, and captive coal plants emit another 135 million tons of carbon dioxide (CO_2) a year. Indonesia has 1.6 gigawatts (GW) of solar, while its 100 gigawatt-peak (GWp) program aims to add 33 GWp a year. PLN's Electricity Supply Business Plan (RUPTL) 2025–2034 adds more fossil than renewable capacity before 2030 and leaves most of that program out.

Reservoirs can host tens of gigawatts, calm seas far more, and about 300,000 hectares of idle shrimp ponds are cleared and open to the sea. Solar on piles is proven at scale, and floating solar at sea is in pilots. Carbon-negative coastal solar puts panels on stilts above restored mangroves and ponds, with four hectares of mangrove for each hectare of panels. The mangroves then absorb more carbon than the panels emit over their life, and the ponds give village households about $1,550 to $2,280 a year. Bali and Buru Island can use solar at sea to replace diesel, and Demak can host coastal solar among restored mangroves.

Carbon finance can pay for part of this, through bilateral deals under Article 6 now, transition credits for retiring diesel and coal, blue carbon credits for mangroves and, later, credits for a whole power sector. New carbon rules and a national registry give each form of solar a route to them. A domestic carbon tax would act mostly after 2040, so foreign carbon finance matters now. Working back from the 12 million tons, the agreement can anchor about 0.9 to 1.9 GWp of floating and coastal solar, and $1.0 to $2.6 billion of investment. It may need to extend beyond PLN to captive coal.

An illustrative financial plan applies carbon-negative coastal solar to a whole 890-megawatt captive coal fleet. Five GWp of coastal solar with 12 gigawatt-hours of batteries, built in phases from 2027 to 2038, supplies about 97 percent of the fleet's power. It needs about $9 to $11 billion. The full plan breaks even at a carbon price of $113 to $147 a ton under commercial finance, but cheaper batteries, blended finance and credits paid over the plant's life bring it to $39 to $56. Savings on Europe's carbon border charge help only if it covers electricity. The plan fits Indonesian law if the host licenses it as own-use supply and each ton is registered once.

The transition must also be just. Three coal provinces bear three-quarters of the domestic loss from coal but receive about 6 percent of the gains. Solar sites and transfers must reach them, retired plants need worker plans, and coastal villages need consent, secure tenure and fair income sharing. Carbon projects can make these safeguards a condition of credits. Five steps follow. Complete the transfer rules, share carbon revenue with project companies, open waters to solar, pilot carbon-negative coastal solar and prepare for sector-wide crediting.

Take Home Messages

Carbon agreements can finance the solar power that decarbonizes Indonesia's economy. COP31 ended without an overarching deal, but carbon markets came through intact. PLN agreed that Norway can buy up to 12 million tons of CO2e from its solar projects at $20 to $40 a ton, a template for a larger program.

Indonesia's power system remains coal-heavy, but its climate policy framework is broad and growing stronger. Coal supplies two-thirds of PLN's electricity, and emissions rose 55 percent from 2015 to 2024. RUPTL 2025–2034 adds more fossil than renewable capacity before 2030, and a domestic carbon price would act mostly after 2040.

Solar power now leads the world's energy transition and is moving onto water, but Indonesia has barely begun. Renewables overtook coal worldwide in 2025, solar costs fell 90 percent in fourteen years, and floating solar is moving to the sea. Indonesia has only 1.6 GW of solar, but its plans call for a sixtyfold expansion.

Coastal solar can carry Indonesia's solar expansion, and paired with mangroves it can remove more carbon than it emits. Reservoirs, calm seas and 300,000 hectares of idle shrimp ponds give solar room, and solar on piles is proven at scale. Panels on stilts above restored mangroves remove more carbon than they emit and give villages income, starting in Bali, Buru Island and Demak.

Solar can earn carbon finance as projects or across the whole power sector, and it earns most when it retires fossil plants. Floating and coastal solar pass the additionality test more easily than other solar, and mangroves add removal credits. Retiring diesel and coal plants creates transition credits, and sector-wide crediting can follow.

The Indonesia–Norway agreement can anchor 1 to 2 GWp of floating and coastal solar and $1 to $2.6 billion of investment. Carbon revenue covers a tenth to a half of that investment. Diesel replacement saves money, and the deal may need to extend to captive coal.

An illustrative financial plan shows that carbon-negative coastal solar can replace a captive coal fleet when carbon revenue, cheaper batteries and blended finance work together. Five GWp of coastal solar and 12 gigawatt-hours of batteries can replace an 890-megawatt captive coal fleet for $9 to $11 billion. It breaks even at $39 to $56 a ton with cheaper batteries, blended finance and longer crediting, and fits Indonesian law as own-use supply.

The transition must be just for coal provinces, plant workers and coastal villages. Three coal provinces bear three-quarters of the domestic loss from coal but receive about 6 percent of the gains, so solar sites and transfers must reach them. Each retired plant needs a worker plan, with retraining and a top-up to the Job Loss Guarantee. Villages can hold the ponds, nurseries and maintenance contracts, with consent, secure tenure and fair income sharing written into each carbon project and checked before credits are issued.

Five steps can turn the Norway agreement into a national solar program. Complete the transfer rules, share carbon revenue with project companies, open waters to solar, pilot carbon-negative coastal solar and prepare for sector-wide crediting.

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List of Abbreviations

ACR	American Carbon Registry
ADB	Asian Development Bank
AMDAL	Analisis Mengenai Dampak Lingkungan, environmental impact assessment
ART	Architecture for REDD+ Transactions
ARUKI	People's Alliance for Climate Justice
Bappenas	Badan Perencanaan Pembangunan Nasional, Ministry of National Development Planning
BMKG	Badan Meteorologi, Klimatologi, dan Geofisika, Meteorology, Climatology and Geophysics Agency
bn	billion
CBAM	Carbon Border Adjustment Mechanism
CNY	Chinese yuan
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CREA	Centre for Research on Energy and Clean Air
DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
EDGAR	Emissions Database for Global Atmospheric Research
EU	European Union
EU ETS	EU Emissions Trading System
FOLU	Forestry and Other Land Use
GDP	gross domestic product
GEDSI	gender equality, disability and social inclusion
GGGI	Global Green Growth Institute
GtCO2e	billion metric tons of carbon dioxide equivalent
GW	gigawatt
GWh	gigawatt-hour
GWp	gigawatt peak
ha	hectare
ICAO	International Civil Aviation Organization
ICAP	International Carbon Action Partnership
ICVCM	Integrity Council for the Voluntary Carbon Market
IDB	Inter-American Development Bank
IDXCarbon	Indonesia Carbon Exchange
IEA	International Energy Agency
IEEFA	Institute for Energy Economics and Financial Analysis
IESR	Institute for Essential Services Reform
IFRC	International Federation of Red Cross and Red Crescent Societies
IISD	International Institute for Sustainable Development
IPP	independent power producer
IRENA	International Renewable Energy Agency
IUPTLS	Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Sendiri, license for own-use electricity supply
IUPTLU	Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Umum, license for public electricity supply
JETP	Just Energy Transition Partnership
JKP	Jaminan Kehilangan Pekerjaan, Job Loss Guarantee
KKPRL	Kesesuaian Kegiatan Pemanfaatan Ruang Laut, sea-space suitability approval
kt, ktCO2	thousand metric tons, thousand metric tons of carbon dioxide
kV	kilovolt
kWh	kilowatt-hour
kWp	kilowatt peak
LCDI	Low Carbon Development Initiative
LCOE	levelized cost of electricity
LTS-LCCR	Long-Term Strategy for Low Carbon and Climate Resilience
MOPA	Mitigation Outcome Purchase Agreement
MRV	measurement, reporting and verification
Mt	million metric tons
MtCO2	million metric tons of carbon dioxide

MtCO2e	million metric tons of carbon dioxide equivalent
MW	megawatt
MWac	megawatt of alternating current output
MWh	megawatt-hour
MWp	megawatt peak
NDC	nationally determined contribution
NZE	net zero emissions
OJK	Otoritas Jasa Keuangan, Financial Services Authority
PLN	Perusahaan Listrik Negara, the state electricity company
PV	photovoltaics
PVPS	Photovoltaic Power Systems Programme
REDD+	reducing emissions from deforestation and forest degradation
RPJMN	Rencana Pembangunan Jangka Menengah Nasional, National Medium-Term Development Plan
RPJPN	Rencana Pembangunan Jangka Panjang Nasional, National Long-Term Development Plan
RUKN	Rencana Umum Ketenagalistrikan Nasional, National Electricity General Plan
RUPTL	Rencana Usaha Penyediaan Tenaga Listrik, Electricity Supply Business Plan
RUU EBET	Rancangan Undang-Undang Energi Baru dan Energi Terbarukan, bill on new and renewable energy
SPE-GRK	Sertifikat Pengurangan Emisi Gas Rumah Kaca, emission reduction certificate
SRUK	Sistem Registri Unit Karbon, national carbon unit registry system
STEPS	Standard for the Transformation of the Electric Power Sector
tCO2	metric ton of carbon dioxide
tCO2e	metric ton of carbon dioxide equivalent
TW	terawatt
TWh	terawatt-hour
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

1. Carbon Agreements for Solar Power

1.1 The Outcome of COP31

The 31st Conference of the Parties (COP31) to the United Nations Framework Convention on Climate Change (UNFCCC) in Antalya, Türkiye, ended on November 22, 2026 without its main political agreement, the Antalya Pact. It is the first COP since Copenhagen in 2009 to close without an overarching deal.[1] The talks ran into overtime and became the longest COP on record.[2]

Fossil fuels broke the talks. The Turkish presidency and Australia, which led the negotiations, put forward several drafts. Saudi Arabia, Russia and other oil producers opposed any mention of fossil fuels.[3] The final draft left fossil fuels out and promoted carbon capture instead.[4] A draft target of $120 billion in adaptation finance by 2035 was also removed.[5]

The coalition that rejected this text is the silver lining. About 130 countries wrote to the presidency that any deal must set a path away from fossil fuels.[6] The European Union, Norway, Panama, the Marshall Islands, Belize and Vanuatu rejected the weakened draft.[7] The summit failed because most countries held to the COP28 commitment to transition away from fossil fuels and would not accept less.

Work also moved ahead outside the cover decision. More than 20 countries published or announced fossil fuel phase-out plans. About 80 countries signed a pledge to raise electricity to 35 percent of energy use by 2035.[8] Earlier in 2026, the Santa Marta initiative had brought 57 countries together to cooperate on a fossil fuel phase-out.[9] Parties agreed that the Adaptation Fund will receive a share of revenue from the Article 6.4 carbon market, and they extended the Just Transition Work Programme by three years.[10] Carbon markets came through the summit intact. This matters for Indonesia, because Article 6 is the channel its new agreement with Norway uses.

1.2 Rising Emissions and Warming

Global greenhouse gas emissions are 34 percent higher than in 1995, the year of the first COP.[11] Fossil carbon dioxide (CO2) emissions reached a record 38.1 billion tons in 2025.[12] The United Nations Environment Programme (UNEP) puts total greenhouse gas emissions in 2025 at 58.4 billion tons of CO2 equivalent (GtCO2e), close to the 2024 level.[13]

1 Andrade, C., "COP31 without the Antalya Pact: Progress amid Political Division," *ClearBlue Markets*, November 25, 2026, https://www.clearbluemarkets.com/knowledge-base/cop31-without-the-antalya-pact-progress-amid-political-division, accessed on November 26, 2026.
2 Costa, M., and I. Walker, "Longest-Ever Cop Ends in Deadlock, but Side Deals on Energy and Finance Move Ahead," *Green Central Banking*, November 25, 2026, https://greencentralbanking.com/2026/11/25/cop-31-deadlock-side-deals-energy-finance-announced, accessed on November 26, 2026.
3 Andrade, *op. cit.* Marsi, F., "COP31: What Next after UN Climate Talks Collapse," *Al Jazeera*, November 23, 2026, https://www.aljazeera.com/news/2026/11/23/cop31-what-next-after-un-climate-talks-collapse, accessed on November 26, 2026.
4 Marsi, *op. cit.*
5 Andrade, *op. cit.*
6 Marsi, *op. cit.*
7 Andrade, *op. cit.*
8 Costa and Walker, *op. cit.*
9 Marsi, *op. cit.*
10 Andrade, *op. cit.*
11 Volcovici, V., and R. Valdmanis, "30 Years of Climate Talks: Progress, Pitfalls and a Planet in Peril," *Reuters*, November 8, 2025, republished by *The Weather Network*, https://www.theweathernetwork.com/en/news/climate/impacts/30-years-of-climate-talks-progress-pitfalls-and-a-planet-in-peril-cop30-brazil, accessed on November 26, 2026.
12 Hausfather, Z., and P. Friedlingstein, "Analysis: Fossil-Fuel CO2 Emissions to Set New Record in 2025, as Land Sink 'Recovers'," *Carbon Brief*, November 13, 2025, https://www.carbonbrief.org/analysis-fossil-fuel-co2-emissions-to-set-new-record-in-2025-as-land-sink-recovers/, accessed on November 26, 2026.
13 Dunne, D., G. Viglione, and R. McSweeney, "UNEP: Opportunity Has 'Been Lost' to Meet 1.5C Warming Limit without 'Overshoot'," *Carbon Brief*, October 21, 2026, https://

PRESSED FOR A PATH AWAY FROM FOSSIL FUELS

About 130 countries

Signed a letter to the presidency. The EU, Norway, Panama, the Marshall Islands, Belize and Vanuatu rejected the final draft for leaving fossil fuels out.

BLOCKED ANY REFERENCE TO FOSSIL FUELS

Saudi Arabia, Russia, other oil producers

Opposed fossil fuel language and pushed carbon capture instead. Under consensus rules, a small group can stop a deal.

20+

PHASE-OUT PLANS

Countries that published or announced national fossil fuel phase-out plans in Antalya

About 80

ELECTRIFICATION PLEDGE

Countries pledging that electricity reaches 35 percent of energy use by 2035

57

SANTA MARTA INITIATIVE

Countries cooperating on a voluntary fossil fuel phase-out since April 2026

2009

LAST COLLAPSE

Copenhagen was the last COP to end without an overarching agreement

Figure 1. COP31 ended without a deal, but the coalition for leaving fossil fuels is broad. Sources are Andrade, Marsi, and Costa and Walker, cited above.

+34 percent

SINCE THE FIRST COP

Rise in global greenhouse gas emissions since 1995

38.1 Gt

RECORD FOSSIL CO2

Fossil CO2 emissions in 2025, the highest on record

58.4 GtCO2e

ALL GREENHOUSE GASES

Total global emissions in 2025, close to the 2024 level

UNEP's Emissions Gap Report 2026, titled The Point of Return, finds that exceeding 1.5°C is now unavoidable. The task is to keep the overshoot small and short and to return to 1.5°C by 2100.[14] Current policies lead to 2.8°C of warming this century. Full delivery of all nationally determined contributions (NDCs), the national climate plans, brings this down to 2.6°C.[15] The lowest possible overshoot path peaks at 1.7 to 1.8°C around mid-century. It needs global emissions to fall 18 percent by 2030 and 45 percent by 2035 from 2025 levels. Full delivery of current NDCs cuts only 5 to 8 percent by 2030 and 11 to 15 percent by 2035.[16]

The pathways diverge quickly. Applied to the 2025 level of 58.4 GtCO2e, the lowest overshoot path brings global emissions to about 47.9 GtCO2e in 2030 and 32.1 GtCO2e in 2035. Full delivery of current NDCs leaves them near 50 to 52 GtCO2e in 2035.[17] Long-term warming is already about 1.34 to 1.41°C above pre-industrial levels, and 2024 was the first calendar year above 1.5°C.[18] Every five years of

carbonbrief.org/unep-opportunity-has-been-lost-to-meet-1-5c-warming-limit-without-overshoot, accessed on November 26, 2026.

14 United Nations Environment Programme, *Emissions Gap Report 2026: The Point of Return* (Nairobi: UNEP, 2026), as summarized in United Nations Environment Programme, "New UNEP Report Lays Out Emission Cuts Needed for Return to 1.5°C," press release, October 21, 2026, https://www.unep.org/news-and-stories/press-release/new-unep-report-lays-out-emission-cuts-needed-return-15degc, accessed on November 26, 2026. Dunne, Viglione, and McSweeney, *op. cit.*

15 Dunne, Viglione, and McSweeney, *op. cit.*

16 UNEP, *op. cit.*

17 Dunne, Viglione, and McSweeney, *op. cit.* UNEP, *op. cit.* The 2030 and 2035 levels apply UNEP's cuts of 18 and 45 percent, and of 11 to 15 percent for full NDC delivery, to the 2025 level. This is a Landscape Advisory calculation.

18 World Meteorological Organization, "WMO Report Documents Spiralling Weather and Climate Impacts," press release on the *State of the Global Climate 2024*, March 19, 2025, https://wmo.int/media/news/wmo-report-documents-spiralling-weather-and-climate-impacts, accessed on November 26, 2026.

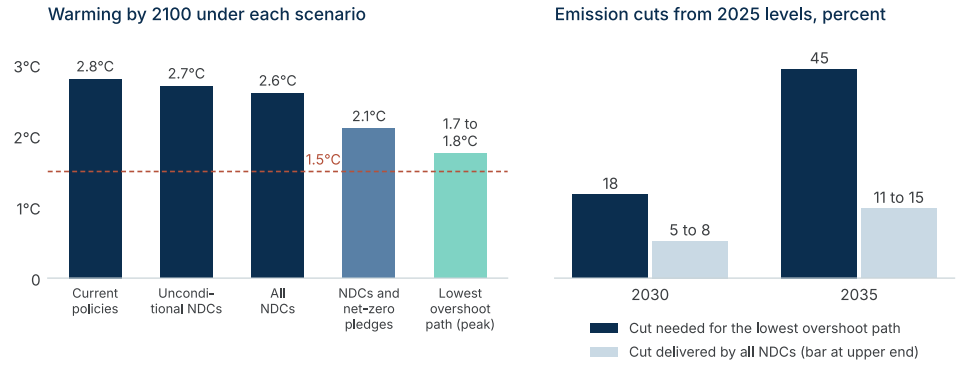

Figure 2. Every scenario except the lowest overshoot path ends far above 1.5°C, and current pledges deliver about a third of the cuts needed by 2035. Data from UNEP, Emissions Gap Report 2026, as reported by UNEP and by Dunne, Viglione, and McSweeney. The lowest overshoot bar shows the mid-century peak, with a return to 1.5°C by 2100.

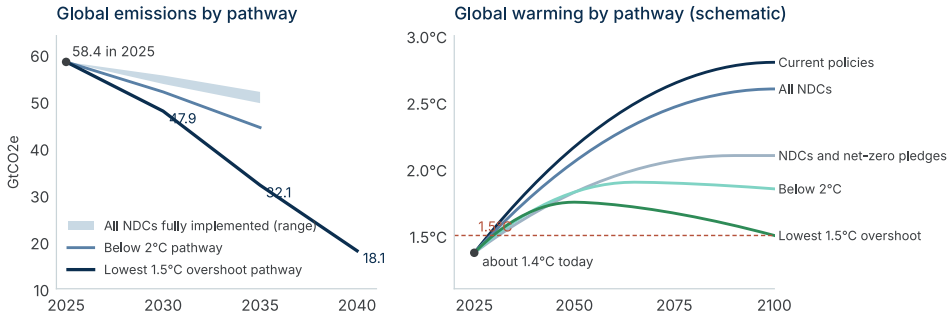

Figure 3. Emission and temperature trajectories under UNEP's scenarios. The emissions panel uses UNEP's 2025 level and percentage cuts for 2030, 2035 and 2040, converted to absolute values by Landscape Advisory. The temperature panel is a schematic drawn by Landscape Advisory through UNEP's stated peaks and 2100 end-points, starting from the estimate of the World Meteorological Organization (WMO) of current long-term warming. It follows the logic of the overshoot figures in the Emissions Gap Report 2026.

CO2 emissions at current levels adds about 0.1°C to peak warming.[19]

1.3 Climate Disasters in Asia

Pakistan's 2025 monsoon floods killed 1,037 people.[20] They affected nearly 7 million people and displaced more than 2.5 million for a time.[21] In early October 2025, heavy rain in eastern Nepal set off floods and landslides that killed at least 51 people within days, 37 of them in Ilam district.[22] The toll rose to 60 across ten districts.[23]

In late November 2025, cyclone-driven rain caused floods and landslides across Aceh, North Sumatra and West Sumatra. By

19 UNEP, *op. cit.*
20 International Federation of Red Cross and Red Crescent Societies, "Pakistan Monsoon Floods 2025, Operation Update #3 (MDRPK028)," *ReliefWeb*, figures as of November 30, 2025, https://reliefweb.int/report/pakistan/pakistan-monsoon-floods-2025-operation-update-3-mdrpk028, accessed on November 26, 2026.
21 Arab News, "Pakistan's 2025 Monsoon Floods Affected Nearly 7 Million People, IFRC Report," *Arab News*, June 1, 2026, https://www.arabnews.pk/node/2645631, accessed on November 26, 2026.

22 European Commission Directorate-General for European Civil Protection and Humanitarian Aid Operations, "Nepal, Floods and Landslides, Update (UN OCHA, NOAA-CPC)," *ECHO Daily Flash*, October 9, 2025, https://reliefweb.int/report/nepal/nepal-floods-and-landslides-update-un-ocha-noaa-cpc-echo-daily-flash-9-october-2025, accessed on November 26, 2026.
23 Nepal News, "Death Toll Climbs to 60 in Floods and Landslides across Nepal," *Nepal News*, October 6, 2025, https://english.nepalnews.com/?p=178805, accessed on November 26, 2026.

1,037 deaths

PAKISTAN, JUNE TO SEPTEMBER 2025

Monsoon floods affected nearly 7 million people

60 deaths

NEPAL, OCTOBER 2025

Floods and landslides in ten districts within days

1,140 deaths

SUMATRA, NOVEMBER 2025

Plus 163 missing in Aceh, North Sumatra and West Sumatra

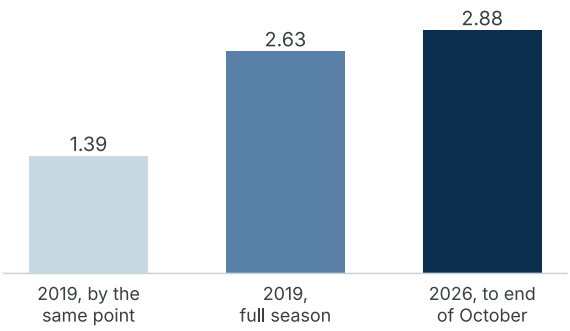

Figure 4. Recent floods and fires in the region. Death tolls from the International Federation of Red Cross and Red Crescent Societies (IFRC), the European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) and Nepal News, and the Indonesia Humanitarian Coordination Platform. Burned area from the Nusantara Atlas monitor, as reported by Agence France-Presse, cited above. The 2026 figure is a conservative estimate because smoke hides some burn scars.

December 28, the national disaster agency counted 1,140 dead and 163 missing.[24] In early December, about 2.1 million people were displaced across the three provinces, including 1.5 million in Aceh.[25]

In 2026, a strong El Niño that began in June dried out Indonesia's forests and peatlands. Scientists expect it to be one of the most intense on record.[26] Fires burned about 2.88 million hectares by the end of October. That exceeds the 2.63 million hectares of the whole 2019 season, previously the worst year in the same monitoring record.[27] By September 7, fire emissions had reached 76 million tons of carbon, on the same track as 2015.[28] Haze sickened hundreds of thousands of people and drifted into Malaysia and Singapore.[29]

1.4 The Indonesia–Norway Agreement

On November 11, 2026, Perusahaan Listrik Negara (PLN), the state electricity company, and the Global Green Growth Institute (GGGI), acting for Norway, signed a Mitigation Outcome Purchase Agreement (MOPA) at the Indonesia Pavilion in Antalya. Indonesia's Environment Minister Mohammad Jumhur Hidayat and Norway's Minister of Climate and Environment Sigrun Aasland witnessed the

24 Indonesia Humanitarian Coordination Platform, "Situation Report #6 on Floods, Flash Floods, and Landslides in Aceh, North Sumatra, and West Sumatra Provinces," *ReliefWeb*, December 29, 2025, https://reliefweb.int/report/indonesia/indonesia-ihcp-situation-report-6-floods-flash-floods-and-landslides-aceh-north-sumatra-and-west-sumatra-provinces-december-29-2025, accessed on November 26, 2026.
25 Tito, A., "Sumatra Floods Leave 776 Dead, Hundreds Missing, Millions Displaced," *Jakarta Globe*, December 4, 2025, https://jakartaglobe.id/news/sumatra-floods-leave-776-dead-hundreds-missing-millions-displaced, accessed on November 26, 2026.
26 Keating, C., "El Niño: Indonesia Fire Emissions in 2026 'On Track' to Match Record for This Century," *Carbon Brief*, September 11, 2026, https://carbonbrief.org/el-nino-indonesia-fire-emissions-in-2026-on-track-to-match-record-for-this-century, accessed on November 26, 2026.

27 Agence France-Presse, "Indonesia Forest Fires Burned through Nearly 2.9 Million Hectares," *The Jakarta Post*, November 11, 2026, citing the Nusantara Atlas monitor, https://www.thejakartapost.com/indonesia/2026/11/11/indonesia-forest-fires-burned-through-nearly-29-million-hectares, accessed on November 26, 2026.
28 Keating, *op. cit.*
29 Agence France-Presse, *op. cit.*

signing.[30] Norway can buy up to 12 million tons of carbon dioxide equivalent (CO2e) in emission reductions from PLN solar projects over ten years.[31] Delivery runs to 2038, and the price is $20 to $40 per ton.[32] At that range the agreement is worth $240 to $480 million.[33]

The agreement is Indonesia's first MOPA to put Article 6.2 of the Paris Agreement into practice. It is described as the largest carbon trade recorded with the UNFCCC Secretariat so far. It builds on an expression of intent the two countries signed at COP30 in Belém. GGGI's Carbon Transaction Facility backs it with money from Norway's fund and from Article 6 funds of Sweden and Singapore.[34]

The program starts with floating solar. It gives priority to projects paired with batteries, so that stored power can serve the evening peak.[35] Norway pays only for reductions that are achieved, verified, transferred and additional to what would have happened anyway.[36] Carbon revenue adds to electricity sales and helps projects that would not otherwise be viable.[37] Indonesia's environment ministry said in mid-November that technical rules for approving and recording transfers were still being completed.[38]

Indonesia already builds and runs floating solar on fresh water. The Cirata plant on a hydropower reservoir in West Java opened in November 2023 at 145 megawatts of alternating current output (MWac), or 192 megawatts peak (MWp), and PLN and Masdar plan a second phase of up to 500 megawatts (MW).[39] The 60 MWac Saguling plant, also on a reservoir in West Java, has a 25-year power purchase agreement and targets commercial operation in the second half of 2026.[40] A 50 MWac plant is planned on Lake Singkarak in West Sumatra.[41] Coastal and offshore solar is still at the assessment stage. The Institute for Essential Services Reform (IESR) estimates 89.37 gigawatts (GW) of floating solar potential on reservoirs and lakes and about 13.3 terawatts (TW) of technical potential offshore, mostly near the coastline. In late 2025 it

30 Hadi, A., "Indonesia, Norway Strike Carbon Credit Deal at COP31," *The Jakarta Post*, November 12, 2026, https://www.thejakartapost.com/business/2026/11/12/indonesia-norway-strike-carbon-credit-deal-at-cop31, accessed on November 26, 2026. Pattanaik, A., "Indonesia Secures Carbon Market Agreement with Norway at COP31," *Power Technology*, November 12, 2026, https://www.power-technology.com/news/indonesia-carbon-agreement-norway-cop31/, accessed on November 26, 2026.
31 Norway Ministry of Climate and Environment, "New Programme to Cut Emissions from Indonesia's Power Sector," news story, November 16, 2026, https://www.regjeringen.no/en/whats-new/new-programme-to-cut-emissions-from-indonesias-power-sector/id3192314/, accessed on November 26, 2026. Hadi, "Carbon Credit Deal at COP31," *op. cit.*
32 Hadi, "Carbon Credit Deal at COP31," *op. cit.* Reuters, "Norway to Buy Carbon Offsets from Indonesian Power Projects, Indonesia Says," *Reuters*, November 12, 2026, republished by *Yahoo News*, https://www.yahoo.com/news/science/articles/norway-buy-carbon-offsets-indonesian-022503862.html, accessed on November 26, 2026.
33 Landscape Advisory calculation. 12 million tons multiplied by $20 and by $40 per ton. The final value depends on the reductions actually verified and delivered.
34 Hadi, "Carbon Credit Deal at COP31," *op. cit.*
35 Elashi, M., "Norway Signs Carbon Credit Deals with Indonesia and Morocco to Help Fund Renewable Energy," *Euronews*, November 20, 2026, republished by *AOL*, https://www.aol.co.uk/articles/norway-signs-carbon-credit-deals-135552000.html, accessed on November 26, 2026.
36 Norway Ministry of Climate and Environment, *op. cit.* Elashi, *op. cit.*
37 Elashi, *op. cit.*
38 *Ibid.*
39 Masdar, "President of Indonesia Inaugurates Southeast Asia's Largest Floating Solar Plant," press release, November 9, 2023, https://masdar.ae/en/news/newsroom/president-of-indonesia-inaugurates-floating-solar-plant, accessed on November 26, 2026.
40 ACWA Power, "Saguling Floating PV," project page, *ACWA Power*, https://acwapower.com/en/what-we-do/projects/saguling-mw-floating-pv/, accessed on November 26, 2026.
41 Norman, W., "ACWA Power to Build 110MWac of Floating PV Projects in Indonesia," *PV Tech*, November 1, 2022, https://www.pv-tech.org/acwa-power-to-build-110mwac-of-floating-pv-projects-in-indonesia/, accessed on November 26, 2026.



Figure 5. Terms and flow of the PLN–GGGI agreement. Sources are The Jakarta Post, Reuters, the Norway Ministry of Climate and Environment, and Elashi, cited above. Value is a Landscape Advisory calculation.

began a pre-feasibility study of offshore floating solar in Sulawesi.[42]

1.5 The Strategic Value of the Deal

Indonesia's power sector has become more coal-based and more carbon-intensive over the past decade. Coal now supplies about two-thirds of grid electricity, and coal plants serving industry add a second, fast-growing source of emissions outside the grid.[43] Section 2.1 sets out this trend in detail.

This carbon intensity is what makes the agreement valuable to Indonesia. Indonesia's emissions trading scheme caps coal plants at about 0.9 to 1.3 tons of CO2e per megawatt-hour (MWh), depending on their size and type.[44] Each MWh of solar that replaces coal therefore avoids about one ton of CO2. The Cirata floating solar plant, at 192 MWp, is reported to avoid 214,000 tons of CO2 a year.[45] At $20 to $40 per ton, a plant of that size could earn $4.3 to $8.6 million a year from carbon.[46] Cirata sells power to PLN at 5.8179 US cents per kilowatt-hour (kWh).[47] Carbon revenue on top of a

42 Institute for Essential Services Reform, "Request for Proposal (RFP) Pre-Feasibility Study for Offshore Floating Solar Photovoltaics (FSPV) in Sulawesi," *IESR*, 2025, https://iesr.or.id/en/?p=196054, accessed on November 26, 2026. pv magazine, "Indonesia Think Tank Seeks Partner for Offshore Floating Solar Study," *pv magazine*, December 1, 2025, https://www.pv-magazine.com/2025/12/01/indonesia-think-tank-seeks-partner-for-offshore-floating-solar-study/, accessed on November 26, 2026.
43 Ahdiat, A., "Indonesia's Electricity Generation Energy Mix 2015–2024," *Databoks*, Katadata, July 4, 2025, using data from RUPTL 2025–2034 published by the Ministry of Energy and Mineral Resources in June 2025, with 2024 covering January to October, https://databoks.katadata.co.id/en/energy/statistics/6867474f823f1/indonesias-electricity-generation-energy-mix-2015-2024, accessed on November 26, 2026. Vu, G. N. H., and D. Setyawati, *Indonesia's Captive Coal Giant: Better Data to Shape Industrial Competitiveness* (London: Ember, September 24, 2026), https://ember-energy.org/latest-insights/indonesias-captive-coal-giant-better-data-to-shape-industrial-competitiveness, accessed on November 26, 2026.

44 International Carbon Action Partnership, "Indonesian Economic Value of Carbon (Nilai Ekonomi Karbon) Trading Scheme," ETS factsheet, https://icapcarbonaction.com/en/ets-pdf-download/104, accessed on November 26, 2026.
45 Sukarso, A. P., "PLTS Terapung Cirata Lesson Learned," presentation, Institute for Essential Services Reform, December 2023, https://iesr.or.id/wp-content/uploads/2023/12/PLTS-Terapung-Cirata-Lesson-Learned-Adimas-Pradityo-Sukarso.pdf, accessed on November 26, 2026.
46 Landscape Advisory calculation. 214,000 tons multiplied by $20 and by $40 per ton.
47 Muliawati, F. D., "Sejarah! RI Punya PLTS Terapung Raksasa Terbesar di ASEAN," *CNBC Indonesia*, December 27, 2023, https://www.cnbcindonesia.com/news/20231227173748-4-500690/sejarah-ri-punya-plts-terapung-raksasa-terbesar-di-asean, accessed on November 26, 2026.

tariff at that level improves the case for new floating solar.

The agreement also prices carbon well above the domestic market. Indonesian carbon trades at about $4 to $5 per ton, and the government aims for $40.[48] The Norway price is four to ten times the domestic price and reaches the government's target at its upper end.

The agreement fits a wider pattern of bilateral carbon cooperation. Norway has signed Article 6.2 agreements with eight other countries, including Kenya, Senegal, Morocco and Switzerland.[49] Once Indonesia's authorization and recording rules work for Norway, the same system can serve other buyers. The deal also supports the investment Indonesia needs. Its Second NDC estimates $472.6 billion of investment for 2031 to 2035.[50] Cleaner grid power matters for industry too. Climate Action Tracker notes that the downstreaming agenda has increased carbon-intensive nickel and steel production, which exposes exporters to competitiveness risks.[51]

Two design points need attention. The first is scale. Twelve million tons over ten years averages 1.2 million tons a year, less than 0.1 percent of national emissions. Delivering it takes about 0.9 to 1.9 gigawatts peak (GWp) of solar, depending on the emission factor and on how fast plants come online, as Section 6 shows. That is roughly five to ten plants the size of Cirata.[52] The second is accounting. Reductions transferred under Article 6.2 count toward Norway's target, and Indonesia cannot also claim them.[53] Indonesia should therefore sell reductions beyond what it needs for its own unconditional NDC target, and set prices that reflect this. Table 1 summarizes the strategic value of the agreement for Indonesia.

1.6 A Template for Floating and Coastal Solar

COP31 showed that global consensus on fossil fuels will come slowly. Bilateral carbon finance can move faster, and the Norway agreement shows that the channel works for Indonesian solar power. This paper sets out how Indonesia can scale it from about 1 GWp to a national program of floating and coastal solar, backed by several buyers and by domestic reforms. At its largest, carbon-negative coastal solar can replace whole captive coal fleets in heavy industry, which needs blended finance and cheaper batteries as well as carbon revenue.

The sections that follow build the case in steps. Section 2 shows where Indonesia stands, with a power system that grew more coal-based and carbon-intensive under state programs and a capped coal price, a power plan that keeps fossil generation growing until after 2030,

48 Karyza, D., "Stricter Caps, Trusted Supply Key for RI to Hit $40 Carbon Price," *The Jakarta Post*, September 15, 2026, https://www.thejakartapost.com/business/2026/09/15/stricter-caps-trusted-supply-key-for-ri-to-hit-40-carbon-price, accessed on November 26, 2026.
49 Argus Media, "Cop: Norway, Indonesia Sign Paris Article 6.2 Deal," *Argus*, November 11, 2026, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2903065-cop-norway-indonesia-sign-paris-article-6.2-deal, accessed on November 26, 2026.
50 Luthsa, F., "COP31 and Indonesia's Economic Interests in the Low-Carbon Transition: Analysis," *Eurasia Review*, November 23, 2026, https://www.eurasiareview.com/23112026-cop31-and-indonesias-economic-interests-in-the-low-carbon-transition-analysis/, accessed on November 26, 2026.
51 Climate Action Tracker, "Indonesia: Policies and Action," December 8, 2025, https://climateactiontracker.org/countries/indonesia/2025-12-08/policies-action/, accessed on November 26, 2026.

52 Landscape Advisory calculation. Section 6 works back from 12 million tons at 0.68 to 1.0 ton per MWh and 1,360 kWh per kWp. Cirata is 192 MWp.
53 EconoTimes, "Norway Signs Carbon Deals to Fund Renewable Projects in Indonesia, Morocco," *EconoTimes*, November 2026, https://econotimes.com/Norway-Signs-Carbon-Deals-to-Fund-Renewable-Projects-in-Indonesia-Morocco-1780300, accessed on November 26, 2026.

Strategic dimension	Provision of the agreement	Value for Indonesia
New finance	Up to $240 to $480 million paid on delivery of verified reductions	Funds solar projects that would not otherwise be built, with no new public debt
Abatement per kilowatt-hour	Payment for each verified ton of CO2 that solar avoids	Each solar MWh that displaces coal avoids close to one ton, so Indonesia's high grid intensity becomes an asset
Price discovery	$20 to $40 per ton	Sets an international benchmark four to ten times the domestic price
Floating, coastal floating and stilted coastal solar	Initial focus on floating plants on reservoirs, paired with batteries	Uses reservoirs and existing grid links and serves the evening peak. The same model can extend to coastal floating solar in sheltered nearshore waters and to solar PV on stilts over coastal areas such as aquaculture and silvofishery ponds. Both avoid land conflict and sit close to coastal load centers and industrial estates
Market institutions	First MOPA under Article 6.2, with rules for authorization, recording and transfer	Builds the measurement, registry and authorization system Indonesia needs for further deals
Diplomatic position	Signed in Antalya while the main negotiations stalled	Shows Indonesia delivering concrete transition outcomes with a willing partner
Industrial competitiveness	Cleaner power on PLN's grid	Lowers the carbon footprint of power for export industries facing carbon border measures

Table 1. Strategic value of the Indonesia–Norway agreement. Sources are The Jakarta Post, Elashi, Karyza, the International Carbon Action Partnership (ICAP) and the Norway Ministry of Climate and Environment, cited above. Assessment by Landscape Advisory.

and the climate policies that now point toward clean power, including what a domestic carbon price can and cannot do. Section 3 sets Indonesia's solar record against the global boom in solar, floating solar and solar at sea. Section 4 explains the technologies of solar at sea, then makes the case for coastal solar, including carbon-negative coastal solar that pairs panels with mangroves and aquaculture, the role of coastal communities, the case of Bali and further sites such as Buru Island and Demak, where coastal solar can also restore livelihoods and protect the coast. Section 5 reviews how each form of solar can earn carbon finance, with and without the retirement of fossil plants, including the jurisdictional approach of the Standard for the Transformation of the Electric Power Sector (STEPS), and how each form of solar fits Indonesia's carbon rules and registry. Section 6 works back from the 12 million tons to the solar capacity, investment and financing structure the agreement can carry, and ranks solar against Indonesia's other renewables by the cost of cutting a ton of carbon. It also argues that the agreement may need to extend to captive coal. Section 7 sets out an illustrative financial plan for carbon-negative coastal solar that replaces a whole captive coal fleet, tests whether savings on the European Union's carbon border charge can close its cost gap, and reviews its fit with Indonesian law. Section 8 sets out how the program can be fair to the groups it affects, how to pay for it and how coastal solar carbon projects can protect them. Section 9 concludes.

2. Indonesia's Power and Climate Policy

2.1 The Rise of Coal Power

Coal's rise followed three government programs to speed up new power capacity, each with coal plants as the main source. Fast-Track Program I ran from 2006 to 2009, Fast-Track Program II from 2010 to 2014 and the 35 GW program from 2015 to 2019.[54] Cheap domestic coal reinforced the choice. Since March 2018, the price of coal sold to power plants for public supply has been capped at $70 per ton.[55] The government kept the cap, along with the rule that miners sell at least 25 percent of their output at home.[56] Plants built faster than demand grew, which left overcapacity in the Java-Bali and Sumatra systems.[57]

Indonesia's installed power capacity rose from 55.5 GW in 2015 to about 100.7 GW in 2024. Coal plants led the growth, rising from 27.2 GW to 53.8 GW. Gas capacity rose from 15.3 GW to 26.2 GW, and diesel capacity eased from 6.3 GW to 5.8 GW. Renewable capacity grew from 6.7 GW to 14.9 GW. Solar grew from 9 MW to about 0.9 GW in this count, and wind from 1 MW to 0.15 GW. Other counts of solar differ by date and coverage, as Section 3.5 shows.

Fossil plants still make up 85 percent of capacity.[58]

Generation grew even faster. Electricity produced or bought by PLN rose from 234.0 terawatt-hours (TWh) in 2015 to 343.9 TWh in 2024, an increase of 47 percent.[59] Coal's share of generation rose from 56.1 percent to 66.8 percent. Gas fell from 24.8 to 16.8 percent and oil from 8.3 to 3.0 percent. Renewables moved from 10.8 to 12.9 percent.[60] Wind and solar together supplied 0.5 percent of electricity in 2024, against 15 percent worldwide.[61]

Fossil generation rose from 190 TWh in 2013 to 285 TWh in 2023, and power-sector emissions rose by 86 million tons of CO2 over the same decade. Coal plants still ran at only about 49 percent of capacity in 2023.[62] Coal generation grew by another 12 TWh in 2024, making Indonesia the fifth-largest coal

54 Bagaskara, A., D. Arinaldo, F. Tumiwa, and R. R. Y. Wiranegara, *Delivering Power Sector Transition in Indonesia: Costs, Benefits, and Implications of Intervening the 13.8 GW Coal-Fired Power Plants Project Pipeline of Indonesia's State-Owned Utility* (Jakarta: Institute for Essential Services Reform, May 2023), https://iesr.or.id/wp-content/uploads/2023/05/IESR-2023.-Delivering-Indonesias-Power-Sector-Transition.pdf, accessed on November 26, 2026.
55 SSEK Law Firm, "Coal Prices for Domestic Power Producers in Indonesia," *SSEK Legal Updates*, April 2, 2018, https://ssek.com/?p=1102, accessed on November 26, 2026.
56 Ministry of Energy and Mineral Resources, "Coal Price for Electricity Stays at US$70 per Tonne," press release no. 484.Pers/04/SJI/2021, December 31, 2021, https://esdm.go.id/en/media-center/news-archives/coal-price-for-electricity-stays-at-us70-per-tonne, accessed on November 26, 2026.
57 Bagaskara, Arinaldo, Tumiwa, and Wiranegara, *op. cit.*

58 Ministry of Energy and Mineral Resources, *Statistik Ketenagalistrikan 2015* (Jakarta: Directorate General of Electricity, 2016), Table 3 and Tables 15 to 16, https://www.esdm.go.id/assets/media/content/Statistik_Ketenagalistrikan_2015.pdf, accessed on November 26, 2026. Alfathi, B. R., "85% Listrik Indonesia Berasal dari Energi Fosil," *GoodStats Data*, April 30, 2025, citing the Ministry of Energy and Mineral Resources, *Rencana Umum Ketenagalistrikan Nasional* 2025, https://data.goodstats.id/statistic/85-listrik-indonesia-berasal-dari-energi-fosil-g1Bb8, accessed on November 26, 2026. The 2015 total covers PLN, independent power producers and private power. The 2024 total is from the national electricity plan (RUKN) and includes captive plants.
59 Ministry of Energy and Mineral Resources, *Statistik Ketenagalistrikan 2015*, *op. cit.* PT PLN (Persero), *Statistik PLN 2024* (Jakarta: PLN, 2025), https://web.pln.co.id/statics/uploads/2025/09/Statistik-PLN-2024-Ind-Eng.pdf, accessed on November 26, 2026. The 2015 figure adds PLN's own production of 176,472 GWh and 57,510 GWh purchased from other producers.
60 Ahdiat, *op. cit.*
61 Ember, "Indonesia," country profile, last updated April 21, 2026, https://ember-energy.org/countries-and-regions/indonesia/, accessed on November 26, 2026.
62 Setiawan, D., and D. Setyawati, *Indonesia's Expansion of Clean Power Can Spur Growth and Equality* (London: Ember, August 14, 2024), https://ember-energy.org/latest-insights/indonesias-expansion-of-clean-power-can-spur-growth-and-equality/, accessed on November 26, 2026.

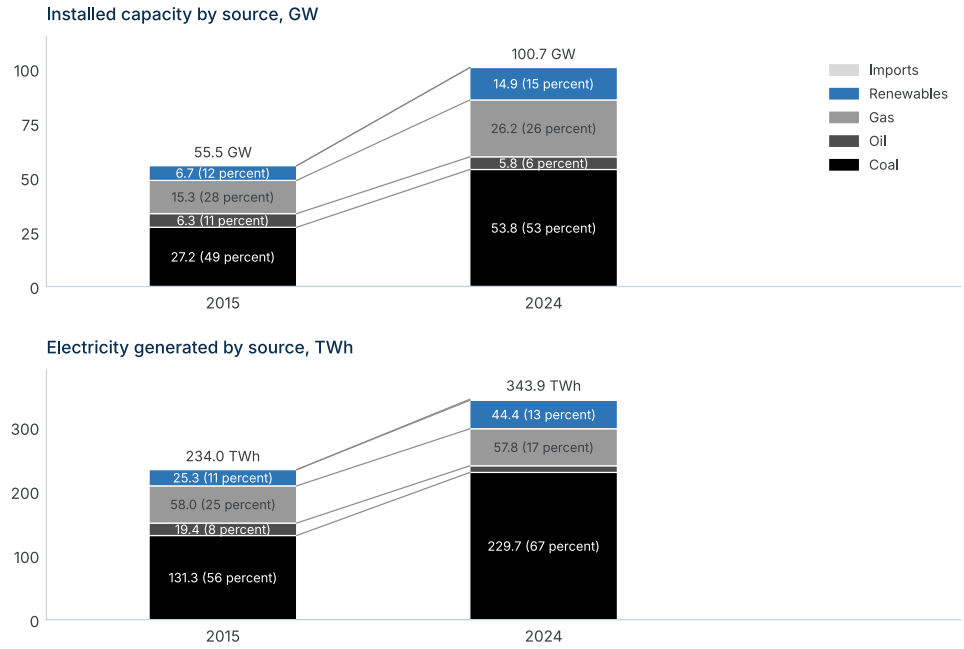

Figure 6. Indonesia's installed capacity and electricity generation by source, 2015 and 2024. Bars stack coal, oil, gas and renewables from the bottom, and lines join the edges of each source between the two years. Coal's share of generation rose from 56 to 67 percent, and its capacity nearly doubled. Imports supplied 0.5 percent of generation in 2024. Generation by source is derived from the shares and totals. Capacity data for 2015 are from the Ministry of Energy and Mineral Resources (national total including independent power producers (IPPs) and private power). Capacity data for 2024 are from the National Electricity General Plan (Rencana Umum Ketenagalistrikan Nasional, RUKN) 2025 as reported by Alfathi. Generation shares are from PLN's Electricity Supply Business Plan (Rencana Usaha Penyediaan Tenaga Listrik, RUPTL) 2025–2034 as compiled by Ahdiat, with 2024 covering January to October. Totals under each year are national capacity and PLN-system generation. Sources are the Ministry of Energy and Mineral Resources, Alfathi, PLN and Ahdiat, cited in this section.

power generator in the world.[63] Figure 6 shows how coal displaced gas and oil in both capacity and generation.

A second coal system runs outside the grid. Official data show 21 GW of captive capacity serving industry in 2023.[64] Ember estimates that captive plants supplied more than 161 TWh in 2025, that coal provided 83 percent of it, and that half went to nickel processing. These plants emitted about 135 million tons of CO2 in 2025, up from 120 million tons in 2024, equal to 48 percent of the emissions from grid-connected plants.[65]

The grid's carbon intensity has barely moved. Each kilowatt-hour carried about 696 g CO2e in 2015 and 680 g CO2e in 2024, on a lifecycle basis.[66] The 2024 figure is 44 percent above the world average of 471 g CO2e per kWh.[67] New coal plants absorbed the gains from gas and renewables, so the intensity stayed close to its 2015 level.

63 Ember, "Indonesia," *op. cit.*
64 Institute for Essential Services Reform, *Indonesia Energy Transition Outlook 2025* (Jakarta: IESR, December 2024), https://iesr.or.id/wp-content/uploads/2024/12/Indonesia-Energy-Transition-Outlook-2025-Digital-Version.pdf, accessed on November 26, 2026.
65 Vu and Setyawati, *Indonesia's Captive Coal Giant*, *op. cit.*
66 Ember, Yearly Electricity Data, via *Our World in Data*, as compiled by Sustainability Reference, "Indonesia Electricity: 680.25 g CO2e per kWh (2024), Series 2000–2024." The values are lifecycle intensities, https://sustainabilityreference.com/emission-factors/electricity/id, accessed on November 26, 2026.
67 *Ibid.*

53.8 GW
COAL CAPACITY, 2024
Almost double the 27.2 GW of 2015

66.8 percent
COAL IN GENERATION
Up from 56.1 percent in 2015

680 g
CO2E PER KWH
44 percent above the world average

0.5 percent
WIND AND SOLAR
Share of electricity in 2024, against 15 percent worldwide

2.2 Greenhouse Gas Emissions

National greenhouse gas emissions, excluding land use, rose from 853 million tons of CO2e (MtCO2e) in 2015 to 1,324 MtCO2e in 2024. That is an increase of 55 percent. Carbon dioxide alone rose from 512 million tons (Mt) to 812 Mt, up 59 percent.[68] Indonesia now accounts for about 2.5 percent of global greenhouse gas emissions.[69]

The power sector sits at the center of this growth. Multiplying PLN-system generation by the grid's carbon intensity gives about 163 MtCO2e in 2015 and 234 MtCO2e in 2024, a rise of 44 percent.[70] Captive plants emitted about 120 million tons of CO2 (MtCO2) in 2024 and 135 MtCO2 in 2025.[71] Power generation as a whole therefore emitted roughly 350 MtCO2e in 2024, more than a quarter of national emissions.

2.3 Indonesia's Climate Targets

Indonesia ratified the Paris Agreement through Law No. 16/2016.[72] Its first NDC pledged to cut emissions by 29 percent on its own and by 41 percent with international support by 2030, against business as usual. The Updated NDC of 2021 kept these targets and adopted the Paris rulebook. The Enhanced NDC of September 23, 2022 raised them to 31.89 percent and 43.20 percent.[73]

The Second NDC, submitted on October 27, 2025, moves to absolute emission levels. It uses 2019 as the reference year, when emissions were 1,145 MtCO2e. Indonesia expects emissions to peak by 2030. By 2035 they fall to 1,258 MtCO2e under the first scenario or hold at 1,489 MtCO2e under the higher-growth scenario. The plan keeps the target of net zero by 2060 or sooner, estimates an investment need of $472.6 billion, and uses Articles 5 and 6 of the Paris Agreement.[74] The forestry and land use sector has its own target, the Forestry and Other Land Use (FOLU) Net Sink 2030, set by Minister of Environment and Forestry Decree No. SK.168/2022.[75]

68 European Commission Joint Research Centre, EDGAR 2025 database, as compiled by Worldometers, "Indonesia Greenhouse Gas Emissions," *Worldometers*. The figures exclude land use, land-use change and forestry, https://www.worldometers.info/fr/greenhouse-gas-emissions/indonesia-greenhouse-gas-emissions/, accessed on November 26, 2026.
69 Climate Scorecard, "Indonesia Current Emission Levels," *Climate Scorecard*, September 2026, citing the EDGAR 2025 database of the European Commission, https://www.climatescorecard.org/2026/09/indonesia-current-emission-levels/, accessed on November 26, 2026.
70 Landscape Advisory calculation. 234.0 TWh at 696 g CO2e per kWh for 2015, and 343.9 TWh at 680 g CO2e per kWh for 2024. The intensities are lifecycle values from Ember, so combustion-only emissions are somewhat lower.
71 Vu and Setyawati, *Indonesia's Captive Coal Giant*, *op. cit.*

72 White & Case, "Indonesian Energy Transition: A Snapshot," *White & Case Insight*, https://www.whitecase.com/insight-alert/indonesian-energy-transition-snapshot, accessed on November 26, 2026.
73 Republic of Indonesia, *Enhanced Nationally Determined Contribution, Republic of Indonesia 2022* (Jakarta: Government of Indonesia, September 23, 2022), https://unfccc.int/sites/default/files/NDC/2022-09/23.09.2022_Enhanced%20NDC%20Indonesia.pdf, accessed on November 26, 2026.
74 Argus Media, "Indonesia, Malaysia Set New Emissions Reduction Targets," *Argus*, October 28, 2025, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2747041-indonesia-malaysia-set-new-emissions-reduction-targets, accessed on November 26, 2026.
75 The Landscape Group, "Indonesia Carbon Market Regulations," instrument list, status as of November 13, 2026, https://landscape.id/

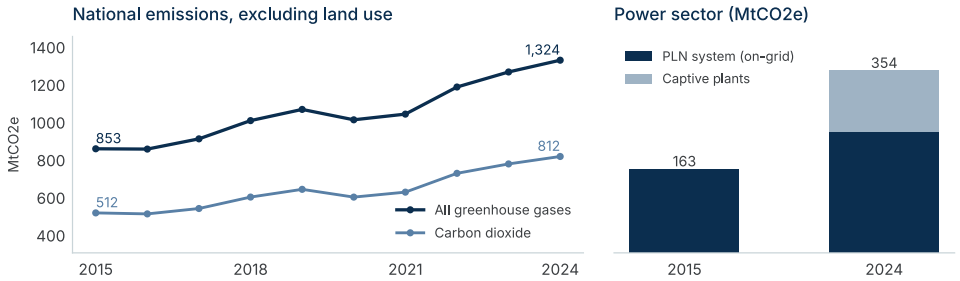

Figure 7. Indonesia's emissions, 2015 to 2024. National emissions from the Emissions Database for Global Atmospheric Research (EDGAR) 2025, excluding land use. Power-sector values for the PLN system are Landscape Advisory estimates from PLN-system generation and Ember's grid intensity. Captive emissions for 2024 are from Ember.

2016 Law No. 16/2016 ratifies the Paris Agreement. First NDC (29 and 41 percent).	**2017 to 2019** Bappenas launches the Low Carbon Development Initiative. LCDI report feeds RPJMN 2020–2024.	**2021** Updated NDC. LTS-LCCR 2050. Law No. 7/2021 with a carbon tax. Presidential Regulation No. 98/2021 on carbon pricing.	**2022** Enhanced NDC (31.89 and 43.20 percent). Presidential Regulation No. 112/2022 on renewables and the coal moratorium. Power-sector carbon trading rules. FOLU Net Sink 2030.
2023 Law No. 4/2023 and OJK Regulation No. 14/2023. IDXCarbon opens. JETP investment plan.	**2024** New rooftop solar rules. NDC implementation regulation.	**2025** Power transition roadmap. RUPTL 2025–2034. New National Energy Policy. Presidential Regulation No. 110/2025. Second NDC.	**2026** Forestry, waste and agriculture carbon rules. Carbon unit registry. Climate change bill in priority legislation. Norway Article 6.2 agreement.

Figure 8. Milestones in Indonesia's climate and energy policy, 2016 to 2026. Compiled by Landscape Advisory from the sources cited in this section.

Ministerial regulations on NDC implementation followed in 2024 and 2026.[76]

2.4 RUPTL 2025–2034 and the 100 GWp Program

RUPTL 2025–2034 was launched on May 26, 2025. It adds 69.5 GW. Of this, 42.6 GW (61 percent) is new and renewable energy, 10.3 GW (15 percent) is storage and 16.6 GW is fossil.[77] Solar is the largest single item at 17.1 GW.[78] Gas accounts for 10.3 GW of the fossil additions, more than twice the target in the Just Energy Transition Partnership (JETP) investment plan.[79]

carbon-market-regulations.html, accessed on November 26, 2026.
76 *Ibid.*
77 Hukumonline, "Bahlil Resmi Umumkan RUPTL Tahun 2025–2034," *Hukumonline*, May 26, 2025, https://www.hukumonline.com/berita/a/bahlil-resmi-umumkan-ruptl-tahun-2025-2034-lt68344d6f0dc8a, accessed on November 26, 2026.
78 Gurky, R. S., "ESDM Minister Announces PLN's 2025–2034 Electricity Supply Business Plan," *Petromindo*, May 27, 2025, https://www.petromindo.com/news/article/esdm-minister-announces-pln-s-2025-2034-electricity-supply-business-plan, accessed on November 26, 2026.
79 Hasan, K., and L. Myllyvirta, "Indonesia's RUPTL Outlines Faster Growth in Fossil Fuel Use, Downgrades Ambition for Clean Energy," *Centre for Research on Energy and Clean Air*, June 12, 2025, https://energyandcleanair.org/

The renewable share looks large over ten years, but most of it comes late. In 2025–2029 the plan adds 12.7 GW of fossil capacity (45 percent of additions), 12.2 GW of renewables (44 percent) and 3 GW of storage. In 2030–2034 renewables rise to 30.4 GW (73 percent) and storage to 7.3 GW.[80] Fossil generation grows by about 40 percent over the plan, from 295 to 407 TWh, while clean generation grows from 44 to 172 TWh. The Centre for Research on Energy and Clean Air (CREA) finds that renewable deployment is delayed until after 2030, against the JETP aim of peaking power emissions before 2030.[81]

Up to 2030, the new plan is more carbon-intensive than the plan it replaced. RUPTL 2021–2030 aimed for no new fossil capacity by 2030.[82] RUPTL 2025–2034 lowers the renewable capacity targeted for 2030 from 20.9 GW to 18.6 GW.[83] By 2030, fossil generation is about 10 percent higher than the previous plan targeted.[84] PLN's own projections show the same gap. Power-sector emissions reach 299 million tons of CO2 in 2025 under the new plan, against 270 million tons under the old plan, and 348 against 335 million tons in 2030.[85] Renewables supply 15.9 percent of generation in 2025 and 21.0 percent in 2030 under the new plan.[86] The old plan set 23.0 and 24.8 percent for the same years.[87] Figure 9 compares the two plans. The new plan adds most of its clean power after 2030, when its emissions level off at about 350 to 360 million tons. The years to 2030 are the years Indonesia has set for its national emissions peak, as Section 2.5 shows.

The 100 GWp solar program sits largely outside this plan. When first announced in 2025, it put about 80 GW in 80,000 villages at roughly 1 MW each, with about 20 GW in larger projects and around 320 gigawatt-hours (GWh) of storage.[88] At its launch at Gilimanuk, Bali, on August 25, 2026, the program set out eight parts, led by 30.97 GWp of utility-scale solar in the RUPTL, 24.13 GWp for new demand from industry, electric vehicles and induction stoves, 12.48 GWp to replace coal plants and 10.72 GWp of floating solar.[89] The Minister of Energy and Mineral Resources presents the

publication/indonesias-ruptl-outlines-faster-growth-in-fossil-fuel-use-downgrades-ambition-for-clean-energy/, accessed on November 26, 2026.

80 Bubb, M., M. Kasmali, S. Clugston, and K. Antonio, "Powering Indonesia's Future: Key Takeaways from the 2025–2034 RUPTL," *Hogan Lovells*, June 6, 2025, https://hlc.com/en/publications/powering-indonesias-future-key-takeaways-from-the-20252034-ruptl, accessed on November 26, 2026.

81 Hasan, K., N. Zahiruddin, and A. B. Swastika, *Indonesia's RUPTL 2025–2034: Fossils First, Renewables Later* (Helsinki: Centre for Research on Energy and Clean Air, September 11, 2025), https://energyandcleanair.org/publication/indonesias-ruptl-2025-2034-fossils-first-renewables-later/, accessed on November 26, 2026.

82 Tenggara Strategics, "Analysis: New RUPTL Signals Energy Security Prioritized over Green Transition," *The Jakarta Post*, June 3, 2025, https://www.thejakartapost.com/opinion/2025/06/03/analysis-new-ruptl-signals-energy-security-prioritized-over-green-transition.html, accessed on November 26, 2026.

83 Hasan, Zahiruddin, and Swastika, *Fossils First, Renewables Later*, *op. cit.*

84 Hasan and Myllyvirta, *op. cit.*

85 PT PLN (Persero), "Diseminasi RUPTL 2025–2034 per Regional: Beyond the Greenest RUPTL," presentation by the Electricity System Planning Division, Jakarta, June 2, 2025, http://www.hikkmi.org/assets/files/info/info_20250604120417.pdf, accessed on November 26, 2026.

86 Savitri, P. I., "PLN: Implementasi RUPTL Dongkrak Bauran EBT Jadi 34,3 Persen pada 2034," *Antara*, June 2, 2025, https://www.antaranews.com/berita/4872229/pln-implementasi-ruptl-dongkrak-bauran-ebt-jadi-343-persen-pada-2034, accessed on November 26, 2026.

87 PT PLN (Persero), "Diseminasi RUPTL 2021–2030," presentation by the Corporate Planning Directorate, Jakarta, October 5, 2021, https://web.pln.co.id/statics/uploads/2021/10/materi-diseminasi-2021-2030-publik.pdf, accessed on November 26, 2026.

88 Landscape Advisory, *100 GW Solar Power*, version 2.1, working paper (Jakarta: Landscape Advisory, 2026).

89 Sari, A. P., "Floating Power: Microgrids and Marine Floating Solar for Indonesia's Diesel Islands," presentation at the International Conference on Marine Floating Photovoltaics and Microgrids, Bali, September 23, 2026 (Jakarta: The Landscape Group, 2026).

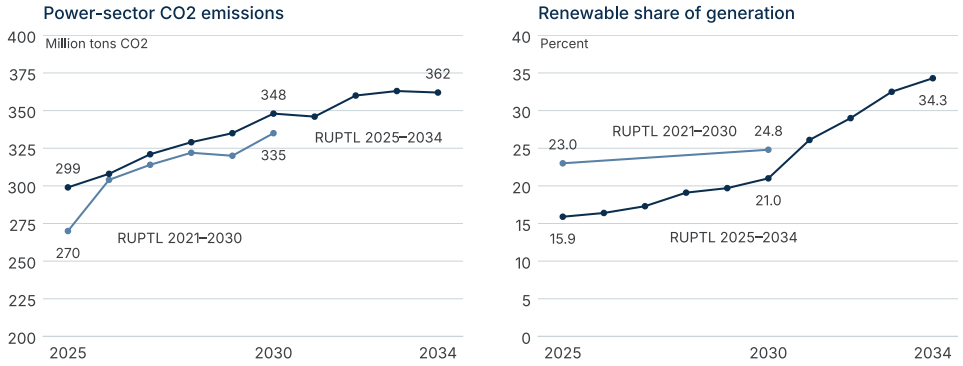

Figure 9. Power-sector carbon dioxide emissions and the renewable share of generation under RUPTL 2021–2030 and RUPTL 2025–2034. The new plan emits more in every year from 2025 to 2030 and has a lower renewable share in 2025 and 2030. Its renewable share passes the old plan's 2030 level only in 2031. Emissions are PLN's projections for both plans, with the new plan under its accelerated renewable energy development scenario. The renewable shares for RUPTL 2021–2030 are its low-carbon mix for 2025 and 2030. Sources are PLN (2025 and 2021) and Savitri, cited in this section.

program as a way to cut the use of diesel generation.[90] In his speech to the House of Representatives on August 14, 2026, the President set out a plan to replace 13 GW of diesel plants with solar, saving about Rp 73.9 trillion ($4.2 billion) a year.[91] Section 3.6 describes the launch.

The program far exceeds the 17.1 GW of solar in RUPTL 2025–2034.[92] Regulation requires that power plants connected to the grid be planned in the RUPTL. The Ministry of Energy and Mineral Resources has therefore said it will revise the RUPTL to include the program.[93] The Institute for Energy Economics and Financial Analysis (IEEFA) also urges that the program be built into future revisions, planning ground-mounted, floating and other solar together.[94] Until that revision, most of the program lacks the planning basis that PLN procurement requires.

Carbon agreements can move renewable deployment forward and secure it. A buyer that pays for verified emission cuts adds revenue to each project and pays only for capacity that is built and running. PLN estimates that the renewable expansion in its plan could generate about 250 million tons of CO2e in green attributes.[95] The Indonesia–Norway agreement described in Section 1.4 runs to 2038, with payments tied to tons delivered.

90 Tenggara Strategics, "Analysis: Indonesia Pushes 100 GW Solar Plan beyond RUPTL," *The Jakarta Post*, March 26, 2026, https://www.thejakartapost.com/opinion/2026/03/26/analysis-indonesia-pushes-100-gw-solar-plan-beyond-ruptl, accessed on November 26, 2026.
91 Tenggara Strategics, "Analysis: Indonesia's Solar Energy Bet: Cautious Optimism," *The Jakarta Post*, September 4, 2026, https://www.thejakartapost.com/opinion/2026/09/04/analysis-indonesias-solar-energy-bet-cautious-optimism, accessed on November 26, 2026. The 13 GW reported is larger than the 5.8 GW of diesel capacity in the national count for 2024 in Section 2.1, which may not cover all diesel units.
92 Tenggara Strategics, "100 GW Solar Plan beyond RUPTL," *op. cit.*
93 Savitri, P. I., "Kementerian ESDM Akan Revisi RUPTL PLN untuk Dukung PLTS 100 GW," *Antara*, June 9, 2026, https://www.antaranews.com/berita/5600285/kementerian-esdm-akan-revisi-ruptl-pln-untuk-dukung-plts-100-gw, accessed on November 26, 2026.
94 Fernandez, H. A., "Indonesia Urged to Integrate 100 GW Solar Plan into National Electricity Scheme," *Eco-Business*, September 1, 2026, on IEEFA, *Rethinking Indonesia's Electricity Economics to Reach the 100GW Solar Target* (August 2026), https://www.eco-business.com/ms/news/indonesia-urged-to-integrate-100-gw-solar-plan-into-national-electricity-scheme/, accessed on November 26, 2026.
95 Katadata, "Komitmen Transisi Energi, PLN Percepat Infrastruktur Hijau dan Pasar Karbon," *Katadata*, November 12, 2025, https://katadata.co.id/ekonomi-hijau/investasi-hijau/69144eb25b82a/komitmen-transisi-energi-pln-percepat-infrastruktur-hijau-dan-pasar-karbon, accessed on November 26, 2026.

Agreements of this kind give PLN a reason to bring solar forward into the years before 2030 and give the 100 GWp program a source of finance as it enters the revised RUPTL. Section 6 shows how much solar the Norway agreement can carry.

2.5 National Development Plans

The Ministry of National Development Planning (Bappenas) launched the Low Carbon Development Initiative (LCDI) in 2017. Its 2019 report placed greenhouse gas targets in the National Medium-Term Development Plan (RPJMN) 2020–2024. Bappenas also modeled net zero by 2045, 2050 and 2060. These scenarios showed average gross domestic product (GDP) growth of 6.1 to 6.5 percent alongside more jobs and cleaner air.[96] Low-carbon development is now built into the long-term plan (RPJPN) 2025–2045 and the RPJMN 2025–2029.[97] The long-term plan aims to cut greenhouse gas emission intensity by 93.5 percent from 2010 levels by 2045, on a path to net zero by 2060.[98]

The Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR) sets the same direction. It aims for national emissions to peak in 2030, anchored by a net sink in forestry and land use, and for net zero by 2060 or sooner.[99]

2.6 Energy Policy

The National Energy Policy, Government Regulation No. 40/2025, was signed on September 15, 2025 and replaced the 2014 policy. It sets the share of new and renewable energy in primary supply at 19 to 23 percent by 2030, 36 to 40 percent by 2040 and 70 to 72 percent by 2060.[100] It ties these targets to net zero by 2060.[101]

Presidential Regulation No. 112/2022 took effect on September 13, 2022. It bans new coal plants, with exceptions for plants already in the plan and for plants tied to industry or national strategic projects. Those exceptions must cut emissions by at least 35 percent within ten years and stop operating by 2050.[102] The regulation also replaced cost-based pricing with ceiling prices for renewable power, set by technology and plant size.[103]

Minister of Energy and Mineral Resources Regulation No. 10/2025 on the power-sector transition roadmap was signed on April 10, 2025.[104] It sets at least seven criteria

96 New Climate Economy, "Indonesia," *The New Climate Economy*, https://newclimateeconomy.net/content/indonesia, accessed on November 26, 2026.
97 Oxford Policy Management, "Low Carbon Development Initiative," factsheet, December 2024, https://www.opml.co.uk/sites/default/files/2025-05/factsheet-lcdi-dec-2024.pdf, accessed on November 26, 2026.
98 LPEM FEB UI, "Indonesia's Decarbonization Plans Diagnostic: A Policy Paper," *LPEM Working Paper* 080, August 2024, https://lpem.org/wp-content/uploads/2024/08/WP-LPEM-080_Indonesia_S_Decarbonization_Plans_Diagnostic_A_Policy_Paper.pdf, accessed on November 26, 2026.
99 Republic of Indonesia, *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050* (Jakarta: Government of Indonesia, 2021), https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf, accessed on November 26, 2026.
Climate Action Tracker, "Indonesia: Targets," September 28, 2026, https://climateactiontracker.org/countries/indonesia/2026-09-28/targets/, accessed on November 26, 2026.
100 pv magazine, "China Commissions World's Largest 1 GW Open-Sea Offshore Solar Project," *pv magazine*, December 29, 2025, https://www.pv-magazine.com/2025/12/29/china-commissions-worlds-largest-1-gw-open-sea-offshore-solar-project/, accessed on November 26, 2026.
101 Grantham Research Institute, "Government Regulation No. 40 of 2025 on National Energy Policy," *Climate Change Laws of the World*, https://climate-laws.org/document/government-regulation-no-40-of-2025-on-national-energy-policy_2e04, accessed on November 26, 2026.
102 Ali Budiardjo, Nugroho, Reksodiputro, "Long-Awaited Presidential Regulation Signals Transition to Greener Energy in Indonesia," *ABNR News*, 2022, https://www.abnrlaw.com/news/long-awaited-presidential-regulation-signals-transition-to-greener-energy-in-indonesia, accessed on November 26, 2026.
103 Herbert Smith Freehills, "Long-Awaited Reform of Indonesia's Renewable Energy Sector," *Legal 500*, https://legal500.com/firms/1561-herbert-smith-freehills-llp/global/news-and-developments/long-awaited-reform-of-indonesias-renewable-energy-sector, accessed on November 26, 2026.
104 Bisnis.com, "Celios Kritik Penyusunan Peta Jalan Pensiun Dini PLTU Minim

for the early retirement of coal plants.[105] The JETP investment plan of November 2023 caps on-grid power emissions at 250 MtCO2 in 2030 and targets a 44 percent renewable share.[106]

Distributed solar has its own rules. Minister of Energy and Mineral Resources Regulation No. 2/2024, in force since January 31, 2024, lifts the old limit of 100 percent of connected load for rooftop solar and replaces it with system quotas set by PLN.[107]

2.7 New Laws on Energy and Climate

The bill on new and renewable energy (Rancangan Undang-Undang Energi Baru dan Energi Terbarukan, RUU EBET) remains on the 2026 priority legislation list. Parliament agreed on September 22, 2026 to extend its deliberation.[108]

A climate change bill (RUU Pengelolaan Perubahan Iklim) entered the 2026 priority legislation list. The Ministry of Environment expects it to strengthen the legal basis for the green economy and for climate justice.[109] Commission XII reviewed the academic paper and draft with the ministry in early September 2026. The bill would be Indonesia's first comprehensive law on climate governance across sectors.[110] Civil society has prepared its own draft. The People's Alliance for Climate Justice (ARUKI) drafted a Climate Justice Bill (RUU Keadilan Iklim) and released its academic paper in August 2025.[111]

2.8 Carbon Tax and Carbon Trading

Law No. 7/2021 on the Harmonization of Tax Regulations created a carbon tax in Article 13. The rate must be at least the carbon market price, with a floor of Rp30 per kilogram of CO2e, or Rp30,000 per ton. The tax was scheduled to start on April 1, 2022 with coal power plants.[112] The Ministry of Finance is preparing a government regulation on the carbon tax roadmap and

Partisipasi Publik," *Bisnis.com*, May 11, 2025, https://ekonomi.bisnis.com/read/20250511/44/1876120/celios-kritik-penyusunan-peta-jalan-pensiun-dini-pltu-minim-partisipasi-publik, accessed on November 26, 2026.

105 Antara, "Menteri ESDM Atur Pensiun Dini PLTU lewat Peta Jalan Transisi Energi," *Antara*, April 2025, https://gorontalo.antaranews.com/berita/315649/menteri-esdm-atur-pensiun-dini-pltu-lewat-peta-jalan-transisi-energi, accessed on November 26, 2026.

106 Climate Action Tracker, "Indonesia: Policies and Action," December 10, 2024, https://climateactiontracker.org/countries/indonesia/2024-12-10/policies-action/, accessed on November 26, 2026.

107 Ministry of Energy and Mineral Resources, "Aturan Terbaru PLTS Atap Terbit, Kini Kapasitas Pemasangan Tidak Dibatasi," press release, March 2024, https://www.esdm.go.id/id/media-center/arsip-berita/aturan-terbaru-plts-atap-terbit-kini-kapasitas-pemasangan-tidak-dibatasi, accessed on November 26, 2026.

108 Kontan, "Paripurna DPR Sepakati Perpanjangan Waktu Pembahasan RUU EBET," *Kontan*, September 22, 2026, https://nasional.kontan.co.id/news/paripurna-dpr-sepakati-perpanjangan-waktu-pembahasan-ruu-ebet, accessed on November 26, 2026. Riyandanu, M. F., "RUU EBET Masuk Prolegnas DPR, ESDM Pastikan Power Wheeling Tak Masuk Pembahasan," *Katadata*, November 9, 2026, https://katadata.co.id/berita/energi/6af1e5b6b4b63/ruu-ebet-masuk-prolegnas-dpr-esdm-pastikan-power-wheeling-tak-masuk-pembahasan, accessed on November 26, 2026.

109 Ministry of Environment, "RUU Perubahan Iklim Masuk Prolegnas, KLH/BPLH Siap Perkuat Fondasi Hukum Ekonomi Hijau dan Keadilan Iklim di Indonesia," news release, August 14, 2026, https://www.kemenlh.go.id/news/detail/ruu-perubahan-iklim-masuk-prolegnas-klhbplh-siap-perkuat-fondasi-hukum-ekonomi-hijau-dan-keadilan-iklim-di-indonesia, accessed on November 26, 2026.

110 Ayuningtyas, A. D., "RUU Perubahan Iklim Tuai Pro dan Kontra, Apindo Siapkan Masukan ke DPR," *Katadata*, October 30, 2026, https://katadata.co.id/ekonomi-hijau/investasi-hijau/6ae41479147b0/ruu-perubahan-iklim-tuai-pro-dan-kontra-apindo-siapkan-masukan-ke-dpr, accessed on November 26, 2026.

111 Mongabay Indonesia, "Mengapa Undang-Undang Keadilan Iklim Urgen," *Mongabay Indonesia*, August 15, 2025, https://mongabay.co.id/2025/08/15/mengapa-undang-undang-keadilan-iklim-urgen/, accessed on November 26, 2026. Perpustakaan DPR RI, "Mengisi Kewajiban Korporasi dalam RUU Perubahan Iklim," e-paper digest of *Kompas*, August 24, 2026, https://perpustakaan.dpr.go.id/epaper/index/detail/id/20936, accessed on November 26, 2026.

112 Salsabila, F. A., "Ketika Penerapan Pajak Karbon Masih Tertunda," *DDTCNews*, October 12, 2026, https://news.ddtc.co.id/komunitas/kolaborasi/1823223/ketika-penerapan-pajak-karbon-masih-tertunda, accessed on November 26, 2026.

intends to use the market price as the reference.[113]

Presidential Regulation No. 110/2025, signed on October 10, 2025, is now the umbrella for carbon pricing. It replaced Presidential Regulation No. 98/2021.[114] It covers a domestic trading system, a carbon levy as a compliance backstop and results-based payments linked to Article 6.[115] It recognizes units certified under international standards such as Verra and Gold Standard, and it facilitates trade between countries under Article 6.[116] It also links carbon policy to economic planning through carbon allocations, quotas and reserves.[117]

The power sector has run an emissions trading scheme since 2023 under Minister of Energy and Mineral Resources Regulation No. 16/2022. By 2024 it covered 146 coal power installations with intensity caps.[118] Law No. 4/2023 and Financial Services Authority (OJK) Regulation No. 14/2023 created the legal basis for the carbon exchange, which opened in September 2023.[119] Since January 2025, Indonesia has authorized selected projects for international transfer under Article 6, including about 1.78 MtCO2e from PLN-affiliated power projects.[120] In 2026 new rules arrived for forestry, waste, agriculture, the carbon unit registry and the accreditation of validators and verifiers. Table 2 lists the main instruments.[121]

The market has stayed small. Trading on the carbon exchange slowed soon after it opened in September 2023,[122] the carbon tax has yet to take effect, and power-sector units have traded at about $2 to $4 a ton.[123] The national carbon unit registry, Sistem Registri Unit Karbon (SRUK), went live on July 9, 2026, starting with four forestry projects.[124] Landscape Advisory's modeling finds that a tax of about $2 a ton cuts only 5.8 percent of power-sector emissions over 2025–2060. A tax that rises to $50 a ton by 2060 cuts the new coal built over the period from 183 GW to 38 GW and raises about $268 billion, but more than 90 percent of its cuts come after 2040, and captive coal should

113 Simanjuntak, A. K. M., "Pajak Karbon Tak Kunjung Berlaku, Kemenkeu Beberkan Alasannya," *DDTCNews*, 2026, https://news.ddtc.co.id/berita/nasional/1815284/pajak-karbon-tak-kunjung-berlaku-kemenkeu-beberkan-alasannya, accessed on November 26, 2026.
114 Badan Pemeriksa Keuangan, "Peraturan Presiden (Perpres) Nomor 110 Tahun 2025," *JDIH BPK* database, https://peraturan.bpk.go.id/Details/334733/perpres-no-110-tahun-2025, accessed on November 26, 2026.
115 International Carbon Action Partnership, "Indonesian Economic Value of Carbon (Nilai Ekonomi Karbon) Trading Scheme," ETS detail page, https://icapcarbonaction.com/en/ets/indonesian-economic-value-carbon-nilai-ekonomi-karbon-trading-scheme, accessed on November 26, 2026.
116 Detikfinance, "Aturan Karbon Direvisi, Ini 3 Manfaat buat Ekonomi RI," *Detikfinance*, October 2025, https://finance.detik.com/ekonomi-hijau/d-8163466/aturan-karbon-direvisi-ini-3-manfaat-buat-ekonomi-ri, accessed on November 26, 2026.
117 Coordinating Ministry for Food Affairs, "Presiden Prabowo Sahkan Perpres No. 110 Tahun 2025 Jadi Pondasi Pertumbuhan Hijau Indonesia," press release No. 88/SES.M.PANGAN.4/SP/10/2025, October 20, 2025, https://mail.kemenkopangan.go.id/assets/images/artikel/24550_presiden-prabowo-sahkan-perpres-no-110-tahun-2025-jadi-pondasi-pertumbuhan-hijau-indonesia_20251031155027.pdf, accessed on November 26, 2026.
118 ICAP, *op. cit.*
119 Otoritas Jasa Keuangan, "Carbon Exchange Organizer," *OJK*, https://ojk.go.id/en/Fungsi-Utama/Pasar-Modal/Pelaku-Pasar-Modal/Pages/Penyelenggara-Bursa-Karbon.aspx, accessed on November 26, 2026.
120 ICAP, ETS detail page, *op. cit.*
121 The Landscape Group, *op. cit.*
122 Yustika, M., "Two Years after Launch, Indonesia's Carbon Market Struggles to Find Momentum," briefing note, Institute for Energy Economics and Financial Analysis, October 15, 2025, https://ieefa.org/resources/two-years-after-launch-indonesias-carbon-market-struggles-find-momentum, accessed on November 26, 2026.
123 International Institute for Sustainable Development, *Implementing Carbon Pricing in Southeast Asia* (Winnipeg: International Institute for Sustainable Development, 2026). Yustika, *op. cit.*
124 Firmansyah, M., and B. P. Jatmiko, "RI Luncurkan Sistem Registri Unit Karbon Nasional, Empat Proyek Mulai Diperdagangkan," *Kompas.com*, July 10, 2026, https://lestari.kompas.com/read/2026/07/10/095200286/ri-luncurkan-sistem-registri-unit-karbon-nasional-empat-proyek-mulai, accessed on November 26, 2026.

Instrument	Issuer	Sector	Main provision
Law No. 7/2021 on the Harmonization of Tax Regulations, Article 13	Parliament	Tax	Carbon tax with a floor of Rp30 per kg CO2e
Law No. 4/2023 on the Development and Strengthening of the Financial Sector	Parliament	Finance	Legal basis for carbon trading through an exchange
Presidential Regulation No. 110/2025	President	Cross-sector	Umbrella for carbon pricing and national emission control, replacing Presidential Regulation No. 98/2021
Coordinating Minister for Maritime Affairs and Investment Regulation No. 5/2022	Coordinating Ministry	Governance	Steering committee for carbon pricing
Minister of Environment and Forestry Regulation No. 21/2022	Environment and Forestry	Cross-sector	Procedures for carbon pricing
Minister of Environment and Forestry Regulation No. 12/2024 and Minister of Environment Regulation No. 7/2026	Environment	Cross-sector	Implementation of the NDC
Minister of Environment Regulation No. 10/2026	Environment	Registry	Carbon unit registry system (SRUK), launched July 9, 2026
Minister of Energy and Mineral Resources Regulation No. 16/2022	Energy and Mineral Resources	Power generation	Emission caps and trading for power plants
Minister of Environment and Forestry Decree No. SK.168/2022	Environment and Forestry	Forestry and land use	FOLU Net Sink 2030
Minister of Forestry Regulation No. 6/2026	Forestry	Forestry	Carbon offsets in forestry, replacing Minister of Environment and Forestry Regulation No. 7/2023
Minister of Environment Regulation No. 11/2026	Environment	Waste	Carbon trading in the waste sector
Minister of Agriculture Regulation No. 18/2026	Agriculture	Agriculture	Carbon offsets in agriculture, issued October 6, 2026
OJK Regulation No. 14/2023, OJK Regulation No. 10/2026 and OJK Board of Commissioners Member Regulation No. 6/2026	Financial Services Authority	Carbon exchange	Rules for trading on IDXCarbon, amended in July 2026
National Accreditation Committee Regulation No. 1/2026	National Accreditation Committee	Cross-sector	Competence standards for validators and verifiers

Table 2. Carbon pricing instruments in Indonesia, by sector. Source is The Landscape Group, "Indonesia Carbon Market Regulations," status as of November 13, 2026, cited above.

be covered from the start.[125] Carbon finance from abroad can bring solar forward before a domestic price takes hold.

2.9 A Firm Footing for Floating Solar

Indonesia's targets, plans and markets now point the same way. The NDC and the National Energy Policy set the direction. RUPTL 2025–2034 makes solar the largest addition to the grid. Presidential Regulation No. 112/2022 sets prices for renewable power, and Minister of Energy and Mineral Resources Regulation No. 10/2025 sets the path for retiring coal. Presidential Regulation No. 110/2025 and Article 6 let Indonesia earn carbon revenue from the emission cuts that solar delivers.

125 Results of Landscape Advisory's modeling of carbon pricing in Indonesia.

3. Solar Power in the World and in Indonesia

511 GW
SOLAR ADDED IN 2025
About three-quarters of all new renewable capacity

33.8 percent
RENEWABLES IN POWER
Ahead of coal for the first time in 100 years

75 percent
DEMAND GROWTH
Share of new electricity demand met by solar in 2025

$0.043
SOLAR COST PER KWH
Global average for new utility-scale plants in 2024

3.1 Renewables Overtaking Coal

The world added a record 692 GW of renewable capacity in 2025, a rise of 15.5 percent in one year. Total renewable capacity reached 5,149 GW, and renewables made up 85.6 percent of all new power capacity.[126] Renewables now account for 49 percent of the world's installed capacity.[127]

Solar led this growth. The world added 511 GW of solar in 2025, of which 510 GW was solar photovoltaics (PV). That is about three-quarters of all renewable additions, and it lifted global solar capacity to about 2.4 TW.[128] China added 315 GW, India 37 GW and the United States 34 GW. Germany and Brazil followed with 15.1 GW and 11.6 GW.[129] SolarPower Europe, which counts panel capacity in direct current, puts 2025 additions at 664 GW and the global fleet above 3 TW.[130]

Generation tells the same story. Solar generation rose by a record 636 TWh in 2025, or 30 percent, to 2,778 TWh. Solar alone met 75 percent of the growth in world electricity demand, and solar and wind together met 99 percent of it.[131] Renewables supplied 33.8 percent of world electricity and coal 33.0 percent. This is the first time in a century that renewables have overtaken coal. Fossil generation fell by 0.2 percent.[132] Solar now supplies 8.7 percent of world electricity, close to nuclear at 8.9 percent.[133] Global solar generation was only 256 TWh in 2015, so it has grown more than tenfold in a decade.[134]

3.2 Falling Solar Costs

New utility-scale solar cost an average of $0.043 per kWh in 2024. That is 90 percent less than the $0.417 per kWh of 2010, and 41 percent below the cheapest fossil fuel option.[135] Installed costs fell to

126 Emirates News Agency, "Renewables Account for 85.6% of Global Expansion in 2025: IRENA Report," *WAM*, April 1, 2026, https://www.wam.ae/en/article/bzhx524-renewables-account-for-856-global-expansion-2025, accessed on November 26, 2026.
127 Jowett, P., "Global Solar Additions Reached Record 511 GW in 2025, Says IRENA," *pv magazine*, April 2, 2026, https://pv-magazine-usa.com/2026/04/02/global-solar-additions-reached-record-511-gw-in-2025-says-irena/, accessed on November 26, 2026.
128 *Ibid.*
129 Energy Institute, "Global Renewable Capacity Hits Record 5.1 TW," *New Energy World*, April 8, 2026, https://ei-dev.energyinst.org/knowledge/new-energy-world/article?id=140214, accessed on November 26, 2026.
130 SolarPower Europe, "New Report: Global Solar Market Hits New Record of 664 GW Installation in 2025, as Global Solar Fleet Passes 3 TW," press release, June 22, 2026, https://www.solarpowereurope.org/press-releases/new-report-global-solar-market-hits-new-record-of-664-gw-installation-in-2025-as-global-solar-fleet-passes-3-tw, accessed on November 26, 2026.
131 Fulghum, N., W. Suárez, K. Altieri, and K. Rangelova, *Global Electricity Review 2026* (London: Ember, April 21, 2026), https://ember-energy.org/latest-insights/global-electricity-review-2026/, accessed on November 26, 2026.
132 *Ibid.*
133 Ember, "World," country and region profile, last updated May 27, 2026, https://ember-energy.org/countries-and-regions/world/, accessed on November 26, 2026.
134 Fulghum, Suárez, Altieri, and Rangelova, *op. cit.*
135 International Renewable Energy Agency, *Renewable Power Generation Costs in 2024* (Abu Dhabi: IRENA, 2025), https://www.irena.

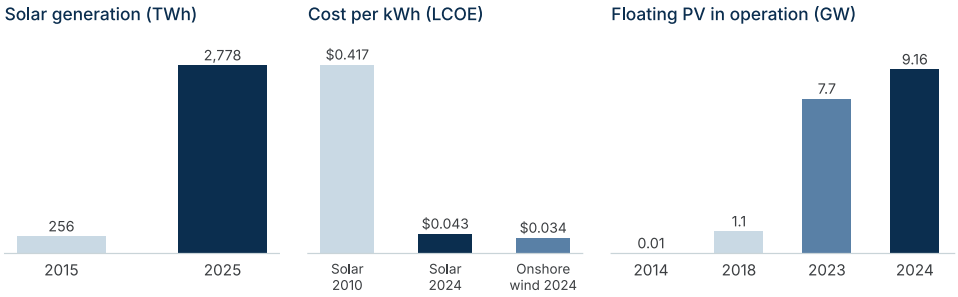

Figure 10. Global solar trends. Solar generation from Ember, levelized costs of new utility-scale plants from IRENA, and floating PV in operation from the World Bank and the IEA Photovoltaic Power Systems Programme (PVPS). The 2018 floating figure is for September of that year. All sources are cited in the text.

$691 per kW, down 87 percent since 2010. Cheaper modules and inverters explain 60 percent of the fall, and cheaper construction another 30 percent. Solar in China and India cost $0.033 and $0.038 per kWh. Only onshore wind, at $0.034 per kWh, was cheaper on average.[136] Costs have now leveled off after a decade of steep declines, which the International Renewable Energy Agency (IRENA) reads as a sign of a mature market.[137]

The pace still falls short of what the climate needs. Even with record additions, the world remains more than 6 TW short of the renewable capacity that a 1.5°C pathway requires by 2030.[138] SolarPower Europe expects global solar capacity to reach 6.6 TW by 2030 in its middle scenario.[139]

3.3 Floating Solar on Lakes and Reservoirs

Floating solar places panels on pontoons on lakes, reservoirs and other calm water. It needs no land, and the water cools the panels.

Global floating capacity grew from 10 MW at the end of 2014 to 1.1 GW by September 2018.[140] It reached 7.7 GW in 2023 and 9.16 GW at the end of 2024, after 1.5 GW of additions that year.[141] Asia held almost 90 percent of floating capacity in 2023, and China alone held half. The Netherlands and France are the largest markets outside Asia.[142]

Wood Mackenzie expects floating capacity to reach 77 GW by 2033, with 81 percent in Asia and the Pacific. It names India, China and Indonesia as the three largest markets by installed and planned capacity.[143] Growth has been slower than such forecasts. Annual additions fell from 1.77 GW in 2023 to 1.5 GW in 2024.[144] The solar program of the International Energy

org/-/media/Files/IRENA/Agency/Publication/2025/Jul/IRENA_TEC_RPGC_in_2024_2025.pdf, accessed on November 26, 2026.
136 *Ibid.*
137 *Ibid.*
138 TaiyangNews, "IRENA: Global Solar PV Additions Exceeded 510 GW in 2025," *TaiyangNews*, April 2026, https://taiyangnews.info/business/irena-global-solar-pv-additions-exceeded-510-gw-in-2025, accessed on November 26, 2026.
139 SolarPower Europe, *op. cit.*

140 PV Tech, "Floating Solar Surpasses 1GW Globally: World Bank," *PV Tech*, reporting World Bank and Solar Energy Research Institute of Singapore, *Where Sun Meets Water: Floating Solar Market Report* (Washington, DC: World Bank, 2018), https://www.pv-tech.org/floating-solar-surpasses-1gw-globally-world-bank, accessed on November 26, 2026.
141 Bhambhani, A., "IEA PVPS: Global Floating Solar Capacity Reaches 9.16 GW in 2024," *TaiyangNews*, February 10, 2026, https://taiyangnews.info/technology/iea-pvps-global-floating-solar-capacity-exceeds-9-gw-in-2024, accessed on November 26, 2026.
142 *Ibid.*
143 PV Tech, "Floating Solar to Reach 77GW by 2033, Led by APAC Region," *PV Tech*, 2024, on Wood Mackenzie, *Floating Solar Landscape 2024*, https://www.pv-tech.org/floating-solar-to-reach-77gw-by-2033-led-by-apac-region, accessed on November 26, 2026.
144 Bhambhani, *op. cit.*

Agency (IEA) notes that models for floating yield, degradation and maintenance still lack reliable field data, and that standards are still being written.[145] Better data and shared standards would lower the risk that lenders see in floating projects.

3.4 Solar at Sea

Coastal and offshore solar comes in two forms. The first sets panels on platforms fixed to piles in shallow water. The second floats panels on the sea itself. Both use sea space where land is scarce or costly, and both can share space with fish farming.

Pile-mounted solar has already reached gigawatt scale in China. CHN Energy's 1 GW HG14 plant off Dongying, Shandong, reached full grid connection in late December 2025. It sits 8 km from shore in water 1 to 4 meters deep and covers about 1,223 hectares.[146] Its 2,934 platforms stand on steel truss frames with four piles each, and its panels tilt at 15 degrees to resist force-11 gales and winter ice.[147] It includes a battery system of 100 MW and 200 MWh and connects to shore through a 66 kilovolt (kV) cable.[148] It is expected to produce about 1.78 TWh a year.[149] Fish are farmed beneath the panels, which gives the site a second source of income.[150]

China's first pile-mounted offshore plant, the 400 MW Yantai Zhaoyuan farm in Laizhou Bay, reached full output in May 2025.[151] A 1.8 GW plant on steel-pipe piles in the Bohai Sea off Changli, Hebei, is under construction for completion by mid-2026. Experts expect China's offshore solar to pass 100 GW by 2030.[152] Jiangsu alone plans 60 offshore solar projects of 27.3 GW. It targets 10 GW on the grid by 2027 and up to 20 GW by 2030, with batteries equal to at least 10 percent of capacity for two hours.[153] A 440 MW offshore floating plant in Taiwan was commissioned in November 2024.[154]

Floating solar at sea is younger. Sinopec began operating a 7.5 MW floating plant in full seawater at its Qingdao refinery in July 2025. It is expected to produce 16.7 GWh a year, and Sinopec plans to expand it to 23 MW.[155] In Europe, Oceans of

145 PV Tech, "Technical Knowledge Gaps 'Slowing Floating PV Adoption': IEA PVPS," *PV Tech*, April 24, 2025, on IEA PVPS Task 13, *Floating Photovoltaic Power Plants: A Review of Energy Yield, Reliability, and Maintenance* (2025), https://www.pv-tech.org/technical-knowledge-gaps-slowing-floating-pv-adoption-iea-pvps, accessed on November 26, 2026.
146 pv magazine, "China Commissions," *op. cit.*
147 CGTN, "China's First Gigawatt Offshore Solar Project Fully Grid-Connected," *CGTN*, December 27, 2025, https://news.cgtn.com/news/2025-12-27/China-s-first-gigawatt-offshore-solar-project-fully-grid-connected-1JrXCu7jJtK/share_amp.html, accessed on November 26, 2026.
148 Balkan Green Energy News, "China Completes Grid Connection of World's Largest Open Sea PV Plant," *Balkan Green Energy News*, December 31, 2025, https://balkangreenenergynews.com/china-completes-grid-connection-of-worlds-largest-open-sea-pv-plant/, accessed on November 26, 2026.
149 SolarQuarter, "China Connects World's Largest 1 GW Open-Sea Solar Power Plant to Grid in Shandong Province," *SolarQuarter*, January 3, 2026, https://solarquarter.com/2026/01/03/china-connects-worlds-largest-1-gw-open-sea-solar-power-plant-to-grid-in-shandong-province/, accessed on November 26, 2026.
150 pv magazine, "China Commissions," *op. cit.*
151 Zheng, X., "China's First Pile-Foundation Fixed Offshore Solar Power Project Connects to Grid," *China Daily*, May 27, 2025, https://www.chinadaily.com.cn/a/202505/27/WS68355231a310a04af22c1c48.html, accessed on November 26, 2026.
152 pv magazine, "China Advances 1.8 GW Offshore PV Project as Part of Wider Solar Strategy," *pv magazine Australia*, 2025, https://www.pv-magazine-australia.com/?p=14278, accessed on November 26, 2026.
153 pv magazine, "China's Jiangsu Province Launches 27.3 GW Offshore Solar Plan," *pv magazine*, January 2, 2025, https://www.pv-magazine.com/2025/01/02/chinas-jiangsu-province-launches-27-3-gw-offshore-solar-plan, accessed on November 26, 2026.
154 pv magazine, "CHN Energy Starts Connecting 1 GW of Offshore Solar in China," *pv magazine*, November 15, 2024, https://www.pv-magazine.com/2024/11/15/chn-energy-starts-connecting-1-gw-of-offshore-solar-in-china/, accessed on November 26, 2026.
155 Sinopec, "Sinopec Launches China's First Floating Offshore PV Project, Advancing

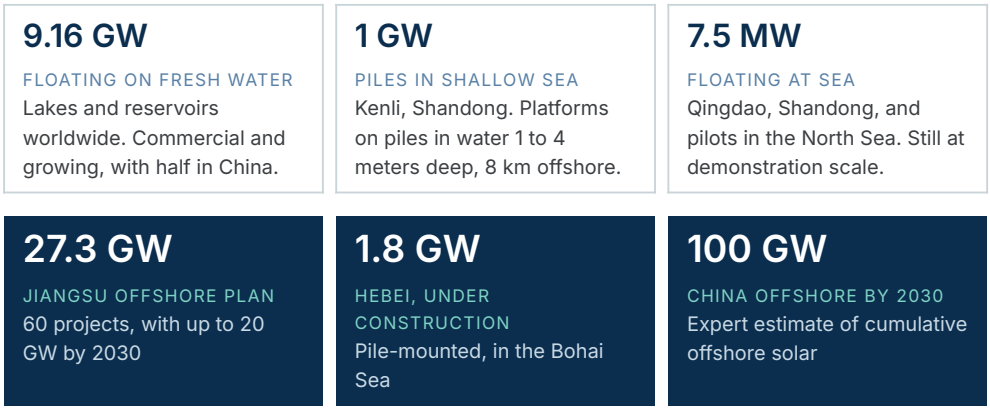

Figure 11. Three ways to put solar on water, and the scale of China's plans for the sea. Sources are IEA PVPS, CHN Energy, Sinopec, the Jiangsu provincial government and pv magazine, cited in the text.

Energy placed the first floating solar unit at sea in the Dutch North Sea in 2019, with 8.5 kW.[156] In the summer of 2025 it installed a larger floating plant inside the Hollandse Kust Noord offshore wind farm, sharing the wind farm's grid connection.[157] SolarDuck and RWE installed a 0.5 MWp pilot, Merganser, 12 km off Scheveningen in 2024.[158] These projects test moorings and structures in rough seas. Indonesia's calm equatorial waters would demand less of them.

3.5 Indonesia's Solar Capacity

Indonesia passed 1 GW of solar for the first time in 2025. The Ministry of Energy and Mineral Resources counted 1.49 GW at the end of the year, after 546 MW of additions. Rooftop systems on commercial and industrial buildings drove most of the growth.[159] Capacity had stood at only 717.71 MW in August 2024. The 145 MW Cirata plant, opened in November 2023, nearly tripled on-grid solar capacity on its own.[160]

IESR counts 1.59 GW at the end of the first quarter of 2026. That is about 1.5 percent of the country's power capacity and 0.3 percent of its electricity. Rooftop systems make up 0.9 GW, utility-scale plants 0.33 GW, captive plants 0.3 GW and systems in remote areas about 0.06 GW.[161] Renewables supplied 15.75

Green Energy Innovation," press release, *PR Newswire*, July 4, 2025, https://www.prnewswire.com/ae/news-releases/sinopec-launches-chinas-first-floating-offshore-pv-project-advancing-green-energy-innovation-302498184.html, accessed on November 26, 2026. pv magazine, "Sinopec Launches China's First Commercial Offshore Floating PV Project," *pv magazine*, July 4, 2025, https://www.pv-magazine.com/2025/07/04/sinopec-launches-chinas-first-commercial-offshore-floating-pv-project/, accessed on November 26, 2026.

156 Balkan Green Energy News, "Floating Solar Farm Ready to Be Merged with North Sea Offshore Wind Park," *Balkan Green Energy News*, August 14, 2025, https://balkangreenenergynews.com/floating-solar-farm-ready-to-be-merged-with-north-sea-offshore-wind-park/, accessed on November 26, 2026.

157 CrossWind, "Offshore Solar Project Completed," news release, May 2026, https://www.crosswindhkn.nl/news/2026/05/offshore-solar-project-afgerond/, accessed on November 26, 2026.

158 Offshore, "SolarDuck, RWE Successfully Install Offshore Floating Solar Pilot Merganser off Dutch Coast," *Offshore*, July 4, 2024, https://offshore-mag.com/renewable-energy/article/55093743/solarduck-rwe-successfully-install-offshore-floating-solar-pilot-merganser-off-dutch-coast, accessed on November 26, 2026.

159 pv magazine, "Indonesia's Solar Capacity Reaches 1.49 GW," *pv magazine*, February 4, 2026, https://www.pv-magazine.com/2026/02/04/indonesias-solar-capacity-reaches-1-49-gw/, accessed on November 26, 2026.

160 PV Tech, "Solar Manufacturing Mounts in Indonesia, yet Deployment Remains 'Underutilised', Says Report," *PV Tech*, on IESR, *Indonesia Energy Transition Outlook 2025*, https://www.pv-tech.org/solar-manufacturing-mounts-in-indonesia-yet-deployment-remains-underutilised-says-report, accessed on November 26, 2026.

161 pv magazine, "Indonesia Could Reach 96.7 GW of Solar by 2029 with Policy Reforms," *pv magazine*, November 19, 2026, on IESR, *Indonesia Solar Energy Outlook 2027*, https://www.pv-magazine.com/2026/11/19/indonesia-could-reach-96-7-gw-of-solar-by-2029-with-policy-reforms/, accessed on November 26, 2026.

Project	Location	Capacity	Structure	Status
Guohua HG14, CHN Energy	Dongying, Shandong, China	1 GW	Piles, steel truss	Fully connected December 2025
Yantai Zhaoyuan, CGN	Laizhou Bay, Shandong, China	400 MW	Piles	Full output May 2025
Changli demonstration	Bohai Sea, Hebei, China	1.8 GW	Steel-pipe piles	Under construction, mid-2026 target
Jiangsu offshore plan	Nantong, Yancheng, Lianyungang, China	27.3 GW	Mostly piles	Planned, 10 GW by 2027
Offshore floating plant	Taiwan	440 MW	Floating	Commissioned November 2024
Qingdao refinery, Sinopec	Qingdao, Shandong, China	7.5 MW	Floating, seawater	Operating since July 2025
Hollandse Kust Noord, Oceans of Energy	Dutch North Sea	Pilot	Floating, in a wind farm	Installed summer 2025
Merganser, SolarDuck and RWE	Dutch North Sea	0.5 MWp	Floating platforms	Installed 2024

Table 3. Selected coastal and offshore solar projects. Sources are cited in the text of Section 3.4.

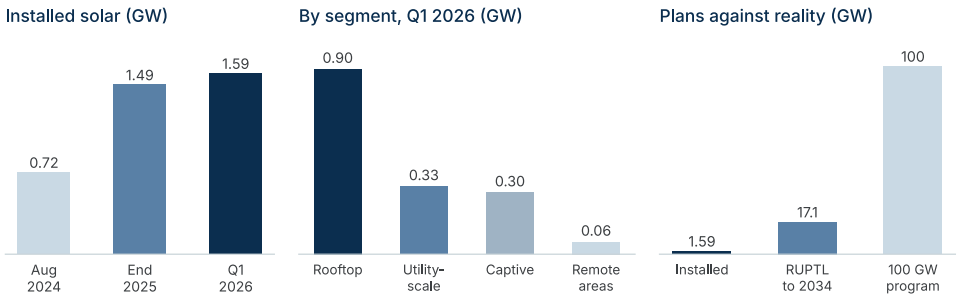

Figure 12. Indonesia's solar capacity against its plans. Capacity for August 2024 and the first quarter of 2026 is from IESR, and for the end of 2025 from the Ministry of Energy and Mineral Resources. The RUPTL figure is the solar addition planned for 2025 to 2034. All sources are cited in the text.

percent of the energy mix in 2025, short of the revised target of 17 to 19 percent.[162]

Utility-scale solar has lagged its plans. PLN's plan lists 988.4 MW of solar due to start operating in 2026, but IESR warns that delivery depends on PLN's procurement methods, which have changed little.[163] IESR estimates that only about 30 percent of the solar projects in the RUPTL are scheduled to operate in 2025 to 2029.[164] Rooftop solar now runs on quotas. The first round, in January 2026, opened 485 MW.[165]

162 SMM, "Indonesia Adds 546 MW Solar in 2025," *SMM PV News*, February 5, 2026, https://news.metal.com/en/newscontent/103756004-SMM-PV-News-Indonesia-Adds-546-MW-Solar-in-2025, accessed on November 26, 2026.

163 pv magazine, "1.49 GW," *op. cit.*

164 Riyandanu, M. F., "IESR: Kapasitas PLTS RI Baru 1,59 GWp, Butuh Percepatan Capai Target 100 GWp," *Katadata*, November 19, 2026, https://katadata.co.id/berita/energi/6afef813b9677/iesr-kapasitas-plts-ri-baru-1-59-gwp-butuh-percepatan-capai-target-100-gwp, accessed on November 26, 2026.

165 SMM, *op. cit.*

3.6 Indonesia's Solar Plans

Plans have grown quickly. RUPTL 2021–2030 included 4,680 MW of solar. RUPTL 2025–2034 raised this to 17.1 GW, the largest single item among 42.6 GW of new renewable capacity.[166] The government then launched the 100 GWp solar program on August 25, 2026. It aims to add about 33 GWp a year for three years.[167] The target is about the size of Indonesia's entire installed capacity of 100.7 GW in 2024, as Section 2.1 showed.

The first bundle covers about 5.3 GWp at 15 locations, mixing ground-mounted, rooftop and floating plants.[168] Seven projects of about 4.7 GWp are ready for tender. Floating solar dominates the list. Jatiluhur is the largest at 1,688 MWp, followed by an expansion at Cirata of 1,250 MWp. Jatigede (636 MWp), Madura with batteries (605 MWp), Gilimanuk (300 MWp), Buleleng (118 MWp) and a land bank site (69 MWp) complete the list. Independent power producers will compete in tenders, and the sovereign wealth fund Danantara will step in where prices are not competitive.[169] The ministry will revise the RUPTL to include the program.[170]

IESR finds that Indonesia could reach 96.7 GW of solar by 2029 if utility-scale tenders, rooftop solar, diesel replacement and rural electrification all move at once, with reforms to regulation and the grid.[171] Manufacturing is also growing. Foreign investment would give Indonesia capacity for 200,000 tons of polysilicon, 11 GW of wafers, 17 GW of cells and 19 GW of modules.[172]

3.7 Floating and Coastal Solar in Indonesia

Rules on reservoirs have opened the way for floating solar. Minister of Public Works and Housing Regulation No. 6/2020 let floating solar cover only 5 percent of a reservoir's surface.[173] Minister of Public Works and Housing Regulation No. 7/2023 raised the limit to 20 percent, and more with a recommendation from the Dam Safety Commission. At 20 percent, existing dams could host 8,788 MW and new dams 4,760 MW.[174] In September 2024 the Ministry of Public Works approved floating solar on its reservoirs, which the energy ministry says opens about 14 GW.[175]

Projects are following. Cirata has run since 2023, and Saguling and Singkarak are being built or planned, as Section 1.4 described. Construction of the 100 MWac Karangkates plant in East Java

166 Bisnis.com, "RI Mau Bangun PLTS 17,1 GW, Berkah untuk Industri Panel Surya?," *Bisnis.com*, May 27, 2025, https://ekonomi.bisnis.com/read/20250527/257/1880389/ri-mau-bangun-plts-171-gw-berkah-untuk-industri-panel-surya, accessed on November 26, 2026.
167 Gupta, M., "Indonesia Launches 100 GWp Solar Program, Opens 4.7 GWp Tender Pipeline," *SolarQuarter*, September 2, 2026, https://solarquarter.com/2026/09/02/indonesia-launches-100-gwp-solar-program-opens-4-7-gwp-tender-pipeline/, accessed on November 26, 2026.
168 Gupta, *op. cit.* Mercom India, "Indonesia Launches 5.3 GW Solar Projects, Eyes 100 GW in Three Years," *Mercom India*, August 27, 2026, https://mercomindia.com/indonesia-launches-5-3-gw-solar-projects-eyes-100-gw-in-three-years, accessed on November 26, 2026.
169 Gupta, *op. cit.*
170 Savitri, "Revisi RUPTL," *op. cit.*
171 pv magazine, "96.7 GW," *op. cit.*
172 PV Tech, "Solar Manufacturing," *op. cit.*
173 Kompas.com, "Potensi PLTS Terapung di Indonesia," *Kompas.com*, June 10, 2023, https://lestari.kompas.com/read/2023/06/10/150000486/potensi-plts-terapung-di-indonesia?page=all, accessed on November 26, 2026.
174 Katadata, "Kementerian ESDM Dapet Restu Garap PLTS Terapung di 259 Waduk RI," *Katadata*, July 2024, https://katadata.co.id/ekonomi-hijau/energi-baru/66865a553a61a/kementerian-esdm-dapet-restu-garap-plts-terapung-di-259-waduk-ri, accessed on November 26, 2026.
175 Ministry of Energy and Mineral Resources, "Kementerian PUPR Beri Lampu Hijau Optimalisasi PLTS Terapung di Permukaan Waduk," press release No. 510.Pers/04/SJI/2024, September 12, 2024, https://esdm.go.id/id/media-center/arsip-berita/kementerian-pupr-beri-lampu-hijau-optimalisasi-plts-terapung-di-permukaan-waduk, accessed on November 26, 2026.

Project	Location	Capacity	Status
Cirata	West Java	145 MWac (192 MWp)	Operating since November 2023
Saguling	West Java	60 MWac	Under construction, operation due in the second half of 2026
Singkarak	West Sumatra	50 MWac	Planned
Karangkates	East Java	100 MWac	Construction began February 2026
Tembesi	Batam, Riau Islands	46 MWp	Financed March 2025, operation due in the second quarter of 2026
Duriangkang	Batam, Riau Islands	2.2 GWp	Agreed in 2021, not yet under construction
Jatiluhur	West Java	1,688 MWp	Ready for tender under the 100 GWp program
Cirata expansion	West Java	1,250 MWp	Ready for tender under the 100 GWp program
Jatigede	West Java	636 MWp	Ready for tender under the 100 GWp program

Table 4. Floating solar projects in Indonesia. Sources are Masdar, ACWA Power, PV Tech, Power Technology, VOI, pv magazine, Construction Review and SolarQuarter, cited in Sections 1.4, 3.6 and 3.7.

began in February 2026.[176] The 46 MWp Tembesi plant in Batam, financed in March 2025, slipped its start of operations to the second quarter of 2026.[177] The 2.2 GWp Duriangkang plant in Batam, first agreed in 2021, has not started construction. The project passed to EDP Renewables when it acquired Sunseap.[178] Table 4 lists these projects.

Coastal and offshore solar has no operating plant in Indonesia. The only formal work so far is the IESR pre-feasibility study of offshore floating solar in Sulawesi, described in Section 1.4. China's experience offers a direct model. Its largest sea plants stand on piles in water 1 to 4 meters deep, close to shore, with fish farming below. Indonesia has long, shallow and sheltered coastlines, many of them already used for fish and shrimp ponds. Pile-mounted solar over such waters, and floating solar in calm bays, could add capacity near coastal cities and industrial estates without taking farmland or forest.

176 Power Technology, "Construction Begins on Karangkates Floating Solar Plant at Indonesian Dam," *Power Technology*, February 26, 2026, https://www.power-technology.com/newsletters/construction-begins-on-karangkates-floating-solar-plant-at-indonesian-dam, accessed on November 26, 2026.
177 VOI, "Had Planned for COD 2025, First Operation of PLTS Tembesi Resigned to Quarter II-2026," *VOI*, 2025, https://voi.id/en/amp/533060, accessed on November 26, 2026.
178 pv magazine, "Sunseap Announces 2.2 GW Floating PV Project at Indonesian Water Reservoir," *pv magazine*, July 21, 2021, https://www.pv-magazine.com/2021/07/21/sunseap-announces-2-2-gw-floating-pv-project-at-indonesian-water-reservoir/, accessed on November 26, 2026.
Construction Review, "Indonesia's $2bn Duriangkang Floating Solar Farm: World's Largest 2.2GW Solar Construction in Limbo," *Construction Review*, 2026, https://constructionreviewonline.com/news/worlds-largest-floating-solar-farm-to-be-constructed-in-indonesia/, accessed on November 26, 2026.

4. Coastal Solar Photovoltaic

4.1 Reservoirs and Seas

Freshwater floating solar has clear limits. Reservoirs under the Ministry of Public Works can host about 14 GW at the 20 percent cover rule, as Section 3.7 showed. IESR puts the potential on all reservoirs and lakes at 89.37 GW.[179] Both figures are small next to the sea. Indonesia has a vast maritime area that almost never sees strong winds or large waves. Floating solar there could generate more than 200,000 TWh a year, nearly 600 times the electricity on PLN's system in 2024.[180] IESR puts the technical potential of offshore solar at about 13.3 TW, mostly near the coast.[181] Indonesia's coastline runs to about 99,000 km.[182]

The national program already looks to the water. The 100 GWp program launched at Gilimanuk, Bali, on August 25, 2026, includes 10.72 GWp of floating solar, about a tenth of the total.[183]

4.2 Coastal Solar Technologies

Coastal solar uses the same panels, inverters and cables as a solar farm on land, but it stands on or above water, and that changes the engineering. Water and sea breezes can keep panels cooler, which raises their output. Field tests in the Netherlands and Singapore found that open floating structures, which let wind pass under the panels, ran cooler than closed structures that cover the water. The best Dutch system ran 3.2 degrees Celsius cooler than a nearby system on land.[184] Coastal solar also needs no land to be bought or cleared. The sea is a harsher place to work, however. Salt, humidity, waves, tides and marine growth wear down structures, cables and panels, so every part must be built for marine conditions and serviced from boats or walkways.[185]

Solar on water comes in three designs. Freshwater floating solar sits on pontoons on reservoirs and lakes. It is commercial and bankable, and it costs about 6.2 US cents per kWh, with capital costs of about $890 per kW. Offshore floating solar rides the waves on floats or flexible membranes moored to the seabed. It is at the pilot stage, with costs below 10 cents per kWh in a third of offshore zones and below 6 cents at the best Southeast Asian sites. Pile-mounted solar stands on steel platforms in water 1 to 5 meters deep. It is commercial at gigawatt scale in China.[186]

Pile-mounted solar fixes platforms of panels on steel piles driven into the seabed. At the 1 GW HG14 plant off Dongying, each platform measures 60 by 35 meters and stands on four

179 IESR, "Request for Proposal," *op. cit.*
180 Silalahi, D. F., A. Blakers, M. Stocks, B. Lu, C. Cheng, and L. Hayes, "Indonesia's Vast Solar Energy Potential," *Energies* 14, no. 17 (2021): 5424, https://www.mdpi.com/1996-1073/14/17/5424, accessed on November 26, 2026. The comparison with 343.9 TWh of PLN-system supply in 2024 is a Landscape Advisory calculation.
181 pv magazine, *op. cit.*
182 The Jakarta Post, "RI Targets Supply Chain Issues to Get in on Global Seaweed Rush," *The Jakarta Post*, March 24, 2023, https://www.thejakartapost.com/business/2023/03/24/ri-targets-supply-chain-issues-to-get-in-on-global-seaweed-rush.html, accessed on November 26, 2026.
183 Sari, "Floating Power," *op. cit.*
184 Dörenkämper, M., A. Wahed, A. Kumar, M. de Jong, J. Kroon, and T. Reindl, "The Cooling Effect of Floating PV in Two Different Climate Zones: A Comparison of Field Test Data from the Netherlands and Singapore," *Solar Energy* 219 (2021): 15–23.
185 Huang, L., H. Elzaabalawy, M. Sarhaan, A. Sherif, H. Ding, B. Ou, D. Yang, and B. Cerik, "Developing Reliable Floating Solar Systems on Seas: A Review," *Ocean Engineering* 322 (April 2025): 120525. Bugeja, R., L. Mule' Stagno, C. Godin, W. Luo, and X. Zhang, "Advancements and Challenges in Floating Photovoltaic Installations Focusing on Technologies, Opportunities, and Future Directions," *Energies* 18, no. 22 (November 10, 2025): 5908, https://www.mdpi.com/1996-1073/18/22/5908, accessed on November 26, 2026.
186 Sari, "Floating Power," *op. cit.*

steel piles that reach 23 meters below the surface, 17 meters of them in the seabed. Builders assemble the panels and frames on land, tow them out and lift them onto the piles. The steel carries anti-corrosion coatings for a service life of more than 30 years.[187] China's first fixed offshore solar plant also protects its piles with an electric current that stops corrosion.[188] The HG14 plant cost about 8.1 billion Chinese yuan (CNY) including its battery, or about $1,100 to $1,200 per kW depending on the exchange rate, which Landscape Advisory estimates at about 8 US cents per kWh.[189] Fixed platforms do not move with the waves, so they are stable and easy to service. They work best in shallow water, such as tidal flats and pond areas, and they leave the water below open for ponds, fish and mangroves. This makes them the natural design for carbon-negative coastal solar.

Moored floating solar sets panels on floats or flexible membranes anchored to the seabed. In sheltered bays and near the shore it can use designs close to those on reservoirs, which DNV's recommended practice for floating solar covers.[190] At sea the loads rise. Membrane designs can be swamped by small waves, while rigid platforms built for the open sea are rated for waves of 8 to 12 meters. Most offshore systems use taut moorings, and fouling, corrosion and the motion of large arrays remain open problems. Open-sea pilots so far range from 20 kWp to 0.5 MWp.[191] DNV's recommended practice leaves offshore sites out of its scope, and in 2026 DNV added standards for floats and for keeping arrays in place.[192]

4.3 Strengths, Limits and Feasibility

The designs suit different waters, and Table 5 compares them with solar on land. A study for Hainan found fixed offshore solar competitive in water up to 30 meters deep, while floating systems at sea cost more because their structures and installation are more complex.[193] Landscape Advisory's coastal solar study compares five options. Nearshore floating solar costs least but needs calm, sheltered bays. Offshore floating solar has more room but costs more to build and maintain. Pile-mounted solar suits tidal flats, with ponds or mangroves alongside. Hybrids mix these designs across water depths, and onshore solar on reclaimed land serves as a cost benchmark.[194]

Each design affects the water in its own way. Floating arrays shade the water, which can reduce algae but also change habitats. Effects on nutrients were negligible where floats covered less than about half of the water surface.[195] Pile-mounted platforms stand above the water and

187 Huawei Digital Power, "World's Largest Open-Sea Offshore PV Project: A Green Model of Offshore Innovation," April 2, 2026, https://digitalpower.huawei.com/en/blogs/dongying-offshore-pv-project, accessed on November 26, 2026.
188 Wang, F., and B. Lin, "Application of Cathodic Protection System for Offshore Photovoltaic Pile Foundation," *Journal of Shandong University (Engineering Science)* 56, no. 1 (February 3, 2026): 142, https://gxbwk.njournal.sdu.edu.cn/EN/Y2026/V56/I1/142, accessed on November 26, 2026.
189 Sari, "Floating Power," *op. cit.*
190 DNV, *DNV-RP-0584 Design, Development and Operation of Floating Solar Photovoltaic Systems*, recommended practice, edition March 2021, amended October 2021, https://dnv.com/energy/standards-guidelines/dnv-rp-0584-design-development-and-operation-of-floating-solar-photovoltaic-systems, accessed on November 26, 2026.
191 Bugeja, Mule' Stagno, Godin, Luo, and Zhang, *op. cit.*
192 DNV, *DNV-RP-0584*, *op. cit.* DNV, "DNV Launches Coordinated Standards to Improve Safety and Reliability of Floating Solar," news release, 2026, https://www.dnv.com/news/2026/dnv-launches-coordinated-standards-to-improve-safety-and-reliability-of-floating-solar/, accessed on November 26, 2026.
193 Bugeja, Mule' Stagno, Godin, Luo, and Zhang, *op. cit.*
194 Landscape Advisory, "Carbon-Negative Coastal Solar," *Landscape 360* Highlighted Publication, November 6, 2026, drawing on Landscape Advisory, *Offshore Solar PV Feasibility Study* (Jakarta: Landscape Advisory, 2026).
195 Bugeja, Mule' Stagno, Godin, Luo, and Zhang, *op. cit.*

Feature	Ground-mounted solar	Pile-mounted solar	Nearshore floating solar	Offshore floating solar
Site	Cleared land	Tidal flats, ponds and shallow seas	Sheltered bays, lagoons and reservoirs	Open sea
Structure	Frames on ground footings	Platforms on steel piles in the seabed	Floats or membranes on moorings	Rigid platforms or membranes on taut moorings
Maturity	Commercial	Commercial at gigawatt scale in China	Commercial on fresh water, early on the coast	Pilots of up to 0.5 MWp
Indicative cost	Benchmark	About $1,100 to $1,200 per kW, or 8 cents per kWh, at HG14	About $890 per kW and 6.2 cents per kWh on fresh water	Below 10 cents per kWh in a third of zones
Cooling	None	Some, from sea breezes	Some to strong with open designs	Some, from sea breezes
Main risks	Competition for land	Corrosion, steel use and a fixed footprint on the seabed	Mooring loads and shading of the water	Waves, fouling and wear on moorings
Fit with ponds and mangroves	Low	High	Medium	Low

Table 5. Ground-mounted, pile-mounted and floating solar compared. Landscape Advisory, drawing on the sources cited in Sections 3.4, 4.2 and 4.3.

let light, tides and fish pass beneath. Both designs need the sea-space approval and must follow the mangrove rules in Section 4.10.

Indonesia's seas favor both designs. The Meteorology, Climatology and Geophysics Agency (BMKG) notes that Indonesia lies on the equator outside the usual tracks of tropical cyclones.[196] Cyclones do form to the south. From 1990 to 2023, 217 formed in southern Indonesian waters, most of them south of Nusa Tenggara and in the Timor, Sawu and Arafura Seas, so sites in the south and east, including Bali and Nusa Tenggara, need site-specific wind and wave design.[197] Tidal flats, idle ponds and sheltered bays suit pile-mounted and nearshore floating solar, which are proven at scale. Open-sea floating solar should start with pilots. Platforms can be assembled in port and towed to the site, as at HG14, and their modules must meet the local content rules in Section 7.10. For carbon-negative coastal solar, pile-mounted platforms over ponds and young mangroves are the proven choice, and the rest of this section builds on them.

4.4 Fish Farming under Solar

China combines solar with aquaculture at large scale. The 2 GW fishery-solar project at Zhanhua, Binzhou, in Shandong covers about 66,000 mu, or about 4,400 hectares. Its third phase was connected to the grid in May 2026.[198] DMEGC

196 Badan Meteorologi, Klimatologi, dan Geofisika, "Is Indonesia Tracked by Tropical Cyclone?" Tropical Cyclone Warning Centre Jakarta, n.d., https://web-meteo.bmkg.go.id/en/component/content/article/37-siklon-tropis/286-near-indonesia-cyclone-season, accessed on November 26, 2026.

197 Nur, A. S., A. Wibowo, Supriatna, and S. B. Tampubolon, "Spatial Pattern of Tropical Cyclone in South Indonesia during 1990–2023," *Jurnal Geografi Lingkungan Tropik* 8, no. 2 (2024), https://scholarhub.ui.ac.id/jglitrop/vol8/iss2/1, accessed on November 26, 2026.

198 Mysteel, "World's Largest Fishery-Solar Complementary Power Project's Phase Three Connects to Grid," *Mysteel*, May 26, 2026, https://www.mysteel.net/news/5125338-flash-worlds-largest-fishery-solar-complementary-power-projects-phase-three-connects-to-grid, accessed on November 26, 2026. One mu is one fifteenth of a hectare.

connected the first 940 MW of a fishery-solar project in November 2024.[199] PowerChina is building China's first offshore pile-mounted fishery-solar project in Jimo, Qingdao, with 1.15 GW in two phases.[200] The 1 GW HG14 plant off Dongying also farms fish beneath its panels.[201]

Partial shade can help some farmed species. In a trial in Tainan, Taiwan, floating panels shaded 40 percent of a pond. Shrimp grew to 16.26 g in the shaded pond against 9.69 g in the open pond, and afternoon dissolved oxygen was higher. Milkfish growth did not differ.[202] Shading also lowers summer water temperatures in sea cucumber ponds in China, which can prevent heat deaths.[203] In the North Sea, Oceans of Energy and a seaweed company combined offshore solar with seaweed farming in the same area.[204]

199 DMEGC Solar, "DMEGC Solar Completes 940MW Fishery-PV Complementary Project," *PV Tech* industry update, November 21, 2024, https://www.pv-tech.org/industry-updates/dmegc-solar-completes-940mw-fishery-pv-complementary-project/, accessed on November 26, 2026.
200 Huasun Energy, "Huasun Powered Offshore PV-Fishery Project Nears Grid Connection," *PV Tech* industry update, https://www.pv-tech.org/industry-updates/huasun-powered-offshore-pv-fishery-project-nears-grid-connection/, accessed on November 26, 2026.
201 pv magazine, "China Commissions," *op. cit.*
202 Chang, P.-H., C.-H. Shih, and W.-C. Kao, "Optimizing the Fishery and Solar Power Symbiosis Model for Sustainable Marine Resource Management: Evaluating the Effects of Solar Shading on the Growth and Water Quality of *Litopenaeus vannamei* and *Chanos chanos*," *Water* 15, no. 18 (2023): 3260, https://www.mdpi.com/2073-4441/15/18/3260, accessed on November 26, 2026.
203 pv magazine, "Photovoltaics for Sea Cucumber Aquaculture," *pv magazine*, February 18, 2025, https://www.pv-magazine.com/2025/02/18/photovoltaics-for-sea-cucumber-aquaculture, accessed on November 26, 2026.
204 CORDIS, "Seaweed and Solar Energy Join Hands at Sea," *CORDIS*, European Commission, https://cordis.europa.eu/article/id/428677-seaweed-and-solar-energy-join-hands-at-sea, accessed on November 26, 2026.

4.5 Former Shrimp Ponds

Indonesia has the world's largest mangrove forests, 3,455,628 hectares in the 2025 National Mangrove Map.[205] It has also lost more than one million hectares over four decades to land conversion, development and coastal erosion.[206] Brackish water ponds, or *tambak*, cover about 660,000 hectares of former mangrove land.[207] About 60 percent of the country's shrimp ponds lie fallow, and the government has proposed reviving more than 300,000 hectares of them.[208]

These idle ponds suit coastal solar. They are already cleared, flat and connected to tidal water, so arrays can be built without cutting a single tree. Government Regulation No. 27/2025 on the protection and management of mangrove ecosystems prohibits converting mangroves to other uses and promotes silvofishery, which combines aquaculture with mangrove planting.[209] The Ministry of Environment has committed to

205 RRI, "Indonesia's Mangrove Coverage Expands to 3.45 Million Hectares," *RRI*, January 19, 2026, https://rri.co.id/en/national/2115122/indonesia-s-mangrove-coverage-expands-to-3-45-million-hectares, accessed on November 26, 2026.
206 Antara, "Ministry Commits to Rehabilitate 769,824 Hectares of Mangroves," *Antara*, August 2025, https://en.antaranews.com/news/372301/homepage-v2.html, accessed on November 26, 2026.
207 World Economic Forum, "How to Save Indonesia's Mangroves," *World Economic Forum*, April 2015, https://www.weforum.org/stories/2015/04/how-to-save-indonesias-mangroves/, accessed on November 26, 2026.
208 The Fish Site, "Indonesia Plans to Revitalise 300,000 Hectares of Fallow Shrimp Farms," *The Fish Site*, https://thefishsite.com/articles/indonesia-plans-to-revitalise-300-000-hectares-of-fallow-shrimp-farms, accessed on November 26, 2026. Mongabay, "Indonesia to Revive Idle Shrimp Farms to Spare Mangroves from Clearing," *Mongabay*, December 2019, https://news.mongabay.com/2019/12/indonesia-shrimp-fisheries-mangroves-deforestation-aquaculture-farms/, accessed on November 26, 2026.
209 Kompas.com, "Kemenhut: Alih Fungsi Lahan Mangrove Dilarang, Silvofishery Jadi Alternatif," *Kompas.com*, August 20, 2025, https://lestari.kompas.com/read/2025/08/20/203300586/kemenhut–alih-fungsi-lahan-mangrove-dilarang-silvofishery-jadi-alternatif, accessed on November 26, 2026.

rehabilitating 769,824 hectares of mangroves.[210]

The scale is large. If the 300,000 hectares of idle ponds were developed at four hectares of mangrove for each hectare of panels, as Section 4.6 explains, they would hold about 60,000 hectares of arrays. At 0.82 MWp per hectare, that is about 49 GWp of solar, close to half of the 100 GWp program, together with 240,000 hectares of restored mangroves.[211]

4.6 Carbon-Negative Coastal Solar

Landscape Advisory is testing whether solar arrays built on the coast can replace captive coal plants that serve heavy industry, and whether mangroves, shrimp silvofishery or seaweed can turn the whole site into a net carbon sink.[212] In the design, panels stand high on stilts above the replanted mangroves and the ponds. Rows are spaced so that enough light reaches the trees below. Below the waterline, mangrove roots shelter fish, and the ponds raise fish, shrimp and shellfish. Every hectare of panels comes with four hectares of mangrove, which keeps the site carbon-negative.[213] The piles are built for salt water, waves and earthquakes, as at the 1 GW HG14 plant, and drones, satellites and soil samples track the carbon while sensors track the pond water.[214]

Silvofishery practice already uses an 80 to 20 split between mangroves and ponds, which gives the four-to-one ratio that the carbon balance needs.[215] Fishers in Cilacap, for example, rehabilitate mangroves on 65 percent of their land and keep 35 percent as ponds.[216] Where water is deeper, panels can also float in calm bays, with seaweed lines between the rows.[217]

The ponds and the water between the arrays produce food. Ponds with more than 80 percent mangrove cover yield about 414 kg of wild shrimp per hectare a year, against 171 kg in ponds with none.[218] A silvofishery in North Sumatra harvests milkfish, tiger prawns and mud crabs side by side.[219] Mud crabs live among mangrove roots and are a high-value silvofishery crop.[220] In the Blanakan silvofishery in Subang, West Java, households farm fish and shrimp among the mangroves and earn about $1,513 per hectare a year.[221] Seaweed grown between floating rows needs no feed, fertilizer or land.[222] Indonesia produced 10.80 million tons of seaweed in 2024, so the skills and markets already exist.[223]

210 Antara, "769,824 Hectares," *op. cit.*
211 Landscape Advisory calculation. 300,000 ha divided in a ratio of one to four gives 60,000 ha of arrays and 240,000 ha of mangroves. The array density of 0.82 MWp per ha follows the HG14 plant, 1 GW on 1,223 ha.
212 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
213 Sari, A. P., *Power from the Coast: Carbon-Negative Coastal Solar PV for Indonesia's Heavy Industry*, investor summary (Jakarta: The Landscape Group, November 2026).
214 *Ibid.*
215 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
216 Mongabay Indonesia, "Makin Sulit Tangkap Kepiting Bakau, Nelayan Cilacap Mulai Kembangkan Silvofishery," *Mongabay Indonesia*, November 28, 2024, https://mongabay.co.id/2024/11/28/makin-sulit-tangkap-kepiting-bakau-nelayan-cilacap-mulai-kembangkan-silvofishery/, accessed on November 26, 2026.
217 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
218 *Ibid.*
219 *Ibid.*
220 Triyanto, "Pengembangan Silvofishery Kepiting Bakau (*Scylla serrata*) dalam Pemanfaatan Kawasan Mangrove di Kabupaten Berau, Kalimantan Timur," *Prosiding Seminar Nasional Limnologi VI* (2012): 739–751, https://karya.brin.go.id/id/eprint/36522/1/Prosiding_2012_Triyanto_739-751.pdf, accessed on November 26, 2026.
221 Sumarga, E., D. Rosleine, G. B. Hutajulu, R. P. Plaurint, Tsabita, M. Basyuni, S. H. Larekeng, M. F. Taqiyudin, N. N. Shohihah, and H. M. Ali, "Quantification of Ecosystem Services from Mangrove Silvofishery," *Global Journal of Environmental Science and Management* (July 2024), https://doaj.org/article/1d8719f707bd4428877683fe57e1a4ee, accessed on November 26, 2026.
222 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
223 Antara, "Indonesia Prioritizes Seaweed amidst Surging Global Demand," *Antara*,



Figure 13. Carbon-negative coastal solar. Panels stand on stilts above replanted mangroves. Below the waterline, mangrove roots shelter fish, and shellfish grow on lines in the pond. Every hectare of panels comes with four hectares of mangrove. Landscape Advisory design concept, illustrative and not to scale, from Sari, *Power from the Coast*, cited above.

+48 t	7–24 t	4 to 1	414 kg
SOLAR ONLY	MANGROVES	DESIGN RULE	WILD SHRIMP
Life-cycle CO2 per hectare of panels a year	CO2 removed per hectare a year	Hectares of mangrove for each hectare of panels	Per hectare a year in ponds with over 80 percent mangrove cover

Shellfish can be grown on lines and racks in the same waters.

4.7 Aquaculture and Communities

The ponds give coastal communities a direct stake in the project. Coastal solar uses shores and shallow waters that villages already farm and fish, so the project needs their trust as much as it needs a permit. Aquaculture offers the way in. A household working two hectares of ponds can earn about $1,550 to $2,280 a year from fish, shrimp and its share of carbon income, and at 1 GWp about 2,440 households could each work two hectares.[224] The project also creates local jobs in mangrove nurseries, planting, monitoring, boat crews and panel cleaning, with village groups as partners.[225] Under the proposed terms, 40 percent of blue carbon credit revenue goes to the villages.[226]

The same households can look after the site. Silvofishery farmers already plant and tend the mangroves around their ponds, as in Cilacap and Blanakan.[227] In a coastal solar project, village groups can be contracted to run the nurseries, replant and protect the mangrove belts, watch the ponds and water quality, and keep the panels clean and the site secure. Government Regulation No. 27/2025 supports this model. The government's

2025, https://en.antaranews.com/news/343550/indonesia-prioritizes-seaweed-amidst-surging-global-demand, accessed on November 26, 2026.
224 Sari, *Power from the Coast*, *op. cit.*
225 *Ibid.*
226 *Ibid.*
227 Mongabay Indonesia, "Cilacap," *op. cit.* Sumarga, Rosleine, Hutajulu, Plaurint, Tsabita, Basyuni, Larekeng, Taqiyudin, Shohihah, and Ali, *op. cit.*

mangrove program under the regulation includes silvofishery, ecotourism, mangrove nurseries and the strengthening of village institutions.[228] Paid stewardship turns the mangrove carbon from a promise into a measured result, and it gives the people living beside the arrays a reason to protect them.

Trust has to be built before construction. The design should start from free, prior and informed consent in each village, with a written income-sharing agreement, a complaints process and an updated environmental impact assessment (AMDAL).[229] Arrays should avoid fishing grounds and shipping lanes.[230] Landscape Advisory proposes that the pilot begin in a bay where a village group already cares for the mangroves, so that the community can serve as nursery, partner and early example for the later phases.[231] Done this way, the community supports the project because it shares in the power, the food and the carbon.

4.8 The Carbon Balance

Solar emits about 43 g CO2 per kWh over its life cycle, mostly in manufacturing.[232] The review by the United Nations Economic Commission for Europe (UNECE) gives a range of 8 to 83 g per kWh for photovoltaics.[233] At 0.82 MWp per hectare and 1,360 kWh per kilowatt peak (kWp) a year, one hectare of panels emits about 48 tons of CO2 a year over its life. Mangroves remove 7 to 24 tons per hectare a year in global reviews, and restored stands in Indonesia have measured 18 to 56 tons.[234] Seven-year-old mangroves planted on an abandoned pond in Lubuk Kertang, North Sumatra, held 51 to 57 tons of carbon per hectare in biomass, which equals about 27 to 30 tons of CO2 per hectare a year.[235] Indonesian mangroves store an average of 1,083 tons of carbon per hectare, most of it in the soil.[236]

The balance depends on the layout. Solar alone emits a net 48 tons per hectare of panels a year. One hectare of mangroves for each hectare of panels still leaves the site emitting 24 to 41 tons. Only the four-to-one silvofishery layout can fall below zero, at between 48 tons removed and 20 tons emitted per hectare of panels.[237] Seaweed also takes up carbon. *Eucheuma denticulatum* absorbs 16 to 68 tons of carbon per hectare a year.[238] Most of that carbon returns to the air once the seaweed is harvested and used, so the balance does not count it.

228 Ministry of Environment, "Dua PP Baru Perkuat Tata Kelola Lingkungan: KLH/BPLH Tegaskan Rencana 30 Tahun dan Perlindungan Mangrove Jadi Fondasi Masa Depan," press release, July 7, 2025, https://www.kemenlh.go.id/news/detail/dua-pp-baru-perkuat-tata-kelola-lingkungan-klhbplh-tegaskan-rencana-30-tahun-dan-perlindungan-mangrove-jadi-fondasi-masa-depan, accessed on November 26, 2026.
229 Sari, *Power from the Coast*, *op. cit.*
230 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
231 Sari, *Power from the Coast*, *op. cit.*
232 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
233 United Nations Economic Commission for Europe, *Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources* (Geneva: UNECE, 2022), as summarized in *Energy Industry Review*, https://energyindustryreview.com/?p=10349, accessed on November 26, 2026.
234 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
235 Amelia, R., M. Basyuni, A. Alfinsyahri, N. Sulistiyono, B. Slamet, Y. Bimantara, S. S. H. Harahap, M. Harahap, I. M. Harahap, S. S. Al Mustaniroh, S. D. Sasmito, and V. B. Arifanti, "Evaluation of Plant Growth and Potential of Carbon Storage in the Restored Mangrove of an Abandoned Pond in Lubuk Kertang, North Sumatra, Indonesia," *Forests* 14, no. 1 (2023): 158, https://www.mdpi.com/1999-4907/14/1/158, accessed on November 26, 2026. 51.18 to 56.79 Mg C per ha over seven years, multiplied by 44/12 to convert carbon to CO2, is a Landscape Advisory calculation.
236 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
237 *Ibid.*
238 Mongabay Indonesia, "Silvofishery, Harmoni Vegetasi Hutan Mangrove dan Budidaya Perikanan," *Mongabay Indonesia*, August 29, 2023, https://www.mongabay.co.id/2023/08/29/silvofishery-harmoni-vegetasi-hutan-mangrove-dan-budidaya-perikanan/, accessed on November 26, 2026.

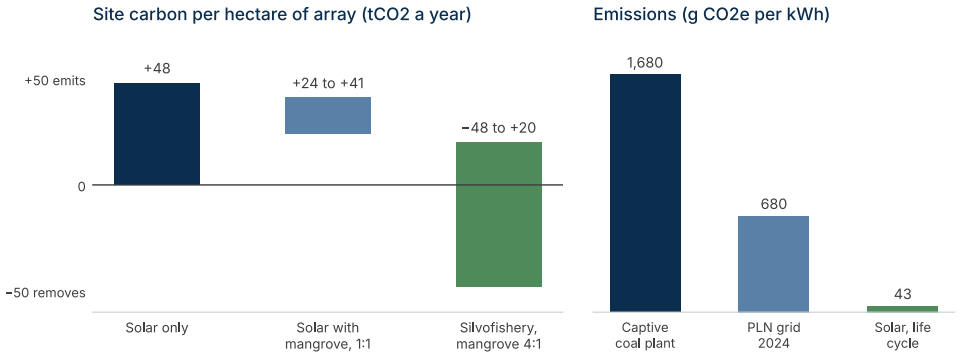

Figure 14. The site's own carbon balance and the emissions it displaces. Left, panels' life-cycle emissions less mangrove uptake, per hectare of panels. Right, emissions per kWh of a reference captive coal plant, of the PLN grid in 2024 and of solar over its life cycle. Sources are Landscape Advisory and Ember, cited in the text.

Share of coal replaced	25 percent	50 percent	100 percent
Solar capacity	1.1 GWp	2.2 GWp	4.3 GWp
Array area	1,330 ha	2,650 ha	5,300 ha
Mangroves at four to one	5,300 ha	10,600 ha	21,200 ha
Coal CO2 avoided a year	2.5 Mt	5.0 Mt	9.9 Mt
Mangrove uptake a year	37–127 kt	74–254 kt	148–509 kt
Total emission reductions a year	2.5–2.6 Mt	5.0–5.2 Mt	10.1–10.4 Mt

Table 6. Scale of carbon-negative coastal solar at three levels of coal displacement. Indicative Landscape Advisory estimates for the 890 MW reference fleet at 0.82 MWp per hectare and 1,360 kWh per kWp, to be replaced by site modeling.

The site breaks even once each hectare of mangrove absorbs 12 tons of CO2 a year, and restored mangroves in Indonesia absorb more. At 18 to 24 tons per hectare, the site's electricity carries a net footprint of minus 22 to minus 43 g CO2 per kWh, against 1,675 g from the reference coal fleet.[239]

The site balance is only part of the gain. Each hectare of panels produces about 1,115 MWh a year. On the PLN grid at 680 g CO2e per kWh, that avoids about 758 tons of CO2 a year. Against a captive coal plant at about 1.68 tons per MWh, it avoids about 1,870 tons.[240] The mangroves make the plant itself carbon-negative, and the electricity cuts emissions elsewhere on top of that.

Table 6 shows the scale needed to replace a reference captive coal fleet of 890 MW. The fleet produces about 5,910 GWh and emits 6.5 to 9.9 million tons of CO2 a year, and the table uses the upper figure.[241] Replacing all of it on energy alone would take about 4.3 GWp of solar on 5,300 hectares, with 21,200 hectares of mangroves.

Several revenues can be stacked without counting the same ton twice. Mangrove restoration credits sold for about $26 per ton in 2023 and near $30 in 2025. Transition credits for curtailing coal break even at $8 to $16 per ton. Green bonds under OJK Regulation No. 18/2023 can fund the build.[242] Fish, shrimp, crabs and

239 Sari, *Power from the Coast*, *op. cit.*
240 Landscape Advisory calculation. 0.82 MWp per ha times 1,360 kWh per kWp gives about 1,115 MWh per ha a year. The grid intensity is from Section 2.1. The captive coal figure is from Landscape Advisory, "Carbon-Negative Coastal Solar," cited above.

241 Sari, *Power from the Coast*, *op. cit.*
242 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*

Item	Pilot, 2027 to 2028	Phase 1, 2029 to 2031	Phase 2, by 2032	Phase 3, by 2035
Loads served	Utilities and support	Support and auxiliaries	Main plants, with batteries	Main plants, with batteries
Solar, MWp	50	500	1,000	2,000
Batteries, GWh	None	0.5	1	4
Solar output, GWh a year	68	680	1,360	2,720
Share of fleet power	1.2 percent	11.5 percent	20.4 to 22.9 percent	37.4 to 43.3 percent
CO2 avoided, Mt a year	0.07 to 0.11	0.75 to 1.14	1.32 to 2.26	2.43 to 4.29
Array area, ha	61	610	1,220	2,440
Mangroves and ponds, ha	240	2,440	4,880	9,760
CO2 absorbed by mangroves, kt a year	1.7 to 5.9	17 to 59	34 to 117	68 to 234
Solar capex, $ million	44 to 56	438 to 563	876 to 1,126	1,752 to 2,253
Households with ponds	120	1,220	2,440	4,880

Table 7. Phases of a carbon-negative coastal solar program for a captive coal fleet of 890 MW. Landscape Advisory screening model. Capex excludes batteries, grid and cable works. Households at 2 ha each. Source is Sari, *Power from the Coast*, cited above.

seaweed add income for coastal villages within the project.

4.9 Heavy Industry and the Carbon Border Tax

The first application is heavy industry that runs on captive coal. Landscape Advisory has screened a project with a large industrial producer whose exports are covered by the Carbon Border Adjustment Mechanism (CBAM) of the European Union (EU). The producer's emissions rose from about 4 MtCO2e in 2022 to about 11 Mt in 2024, and planned output would double them by 2028 at 2023 intensity. Captive coal power makes 60 to 90 percent of these emissions.[243]

CBAM raises the stakes. Since January 2026, EU importers pay for the carbon in covered goods. Importers pay 2.5 percent of the charge in 2026, 48.5 percent in 2030 and the full charge from 2034. Producers without verified data pay on EU default values with a markup of 10 percent in 2026 and 30 percent from 2028. Before 2028 the EU will decide whether to count the electricity used to make the goods it covers. Coal power would then add to the bill, while solar supplied by a direct line counts as zero. Indonesian carbon prices cannot yet be deducted.[244]

Solar can carry a large share of the load in phases. Coal units stay on at their lowest safe output as backup for cloudy days, so 1 GWp without batteries supplies 16 to 22 percent of the fleet's power. On the worst three cloudy days of the modeled year, solar output falls to 61 percent of its average.[245] Table 7 shows a path from a 50 MWp pilot in 2027 to 2 GWp with 4 GWh of batteries by 2035, when solar supplies 37 to 43 percent of the fleet's power. Solar power would cost 7 to 9 US cents per kWh before batteries on cautious assumptions, while recent offers are 5.5 to 6.5 cents.[246]

Each ton of carbon is counted once, where it earns the most. The solar ton can either lower the producer's own emissions, which CBAM and buyers measure, or be sold as a

243 Sari, *Power from the Coast*, *op. cit.*

244 *Ibid.*
245 *Ibid.*
246 *Ibid.*

credit, but not both, as Section 7.9 explains. The mangrove ton becomes a blue carbon credit for sale in the Indonesian market through the national carbon unit registry, SRUK, under Presidential Regulation No. 110/2025, in the voluntary market, or abroad under Article 6. Closing a coal unit early can earn transition credits, but only for tons the producer does not claim itself, and the unit's emission permits must be cancelled.[247]

Mangrove credits are worth far more than Indonesian carbon prices. Indonesian emission permits traded at about $0.76 per ton and Indonesian credits at about $3.66 in 2023, while mangrove restoration credits sold for $26 to $30 in 2023 to 2025. At 1 GWp, 4,880 hectares of mangrove absorb 34 to 117 thousand tons of CO2 (ktCO2) a year, worth $0.9 to $3.5 million.[248] Credits must follow Verra's tidal wetland method or the Indonesian method, plant only on bare ponds and flats that would not regrow on their own, register in SRUK, and rest on the free, prior and informed consent of each village with a written income-sharing agreement.[249]

Coastal villages share the gain. A household working two hectares of ponds can earn about $1,550 to $2,280 a year from fish, shrimp and its share of carbon income, which is 60 to 88 percent of a year's provincial minimum wage. At 1 GWp, 2,440 households could each work two hectares.[250] At 2 GWp, power sales bring in about $155 to $231 million a year. Mangrove credits, transition credits from one retired coal unit and village ponds add about $24 to $34 million more. If the EU adds power to CBAM, the producer and its buyers avoid a further $11 to $57 million a year.[251] A nine-month study in seven parts would prepare a 50 MWp pilot for financing in 2027.[252]

4.10 Permits, Mangrove Rules and Site Risks

Any use of coastal waters needs a sea-space suitability approval, known as Kesesuaian Kegiatan Pemanfaatan Ruang Laut (KKPRL), from the Ministry of Marine Affairs and Fisheries. It is a basic requirement for a business license, alongside environmental approval.[253] Government Regulation No. 27/2025 protects mangroves both inside and outside forest areas, so arrays must not clear standing mangroves. They go over existing ponds, flats and newly planted mangroves.[254] Cyclone and seismic loads, shipping lanes and fishing grounds limit where arrays can go.[255] At full replacement of a large coal fleet, a mangrove belt of about 21,000 hectares may exceed the suitable coast near the plant.[256] Storage should be sized only where it pays, because solar with batteries at full baseload loses money.[257] Data on yields, degradation and maintenance in floating systems remain thin, so early projects should publish their monitoring results.[258]

4.11 Bali

Bali has set itself a net zero target for 2045, 15 years ahead of the

247 *Ibid.*
248 *Ibid.*
249 *Ibid.*
250 *Ibid.*
251 *Ibid.*
252 *Ibid.*
253 Ministry of Marine Affairs and Fisheries, "Sosialisasi PP 28 Tahun 2025: Kebijakan Umum dan Bisnis Proses Kesesuaian Kegiatan Pemanfaatan Ruang Laut," presentation, 2026, https://dpb.unpad.ac.id/wp-content/uploads/2026/06/Sosialisasi-PP-28-Tahun-2025-Kebijakan-Umum-dan-Bisnis-Proses-Kesesuaian-Kegiatan-Pemanfaatan-Ruang-Laut.pdf, accessed on November 26, 2026.
254 Kompas.com, "Alih Fungsi," *op. cit.*
255 Landscape Advisory, "Carbon-Negative Coastal Solar," *op. cit.*
256 *Ibid.*
257 *Ibid.*
258 PV Tech, "Technical Knowledge Gaps," *op. cit.*

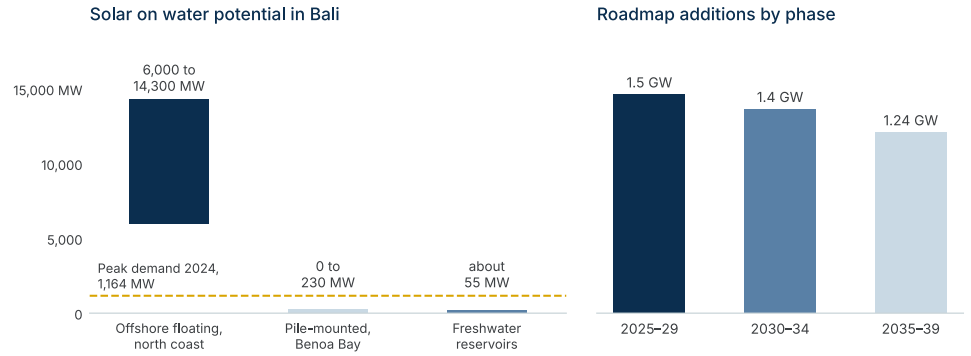

Figure 15. Bali's potential for solar on water and its roadmap. Left, Landscape Advisory screening estimates of solar on water against peak demand in 2024. Right, renewable capacity added in the first three phases of the Bali Net Zero Emissions (NZE) 2045 electricity roadmap. Sources are Sari (2026) and Hartatik (2025), cited in the text.

national target. The provincial government declared it on August 4, 2023, with a goal of 100 percent renewable energy on Nusa Penida before 2030.[259] The electricity roadmap, launched with IESR on July 15, 2025, adds 1.5 GW of renewable capacity in 2025 to 2029, 1.4 GW in 2030 to 2034 with 400 MWh of storage, and 1.24 GW in 2035 to 2039. Bali's renewable potential is 22.04 GW, of which 21 GW is solar, and demand reaches 44.71 TWh by 2045.[260]

Bali needs new supply soon. The Celukan Bawang coal plant and the cable from Java carry two-thirds of Bali's electricity, while the gas turbines run only a quarter of the time. Without new plants, supply falls below peak demand from 2030. Peak demand reached 1,164 MW in 2024.[261] Every gas and diesel plant on the island loses money on each kWh it produces, even with state support.[262] The island's dependence on the cable was exposed on May 2, 2025. A fault cut the four Java–Bali cable circuits, which normally carry about 270 MW, to zero.[263] The blackout hit 80 percent of the province.[264] The energy ministry said the event showed the importance of each island producing its own power.[265]

Bali's solar resource is mostly at sea. Offshore floating solar accounts for 14.3 GW of Bali's 21.2 GW of solar potential. Landscape Advisory's screening finds 6 to 14 GW of offshore floating potential in a band 0.5 to 2.5 km off the calm north coast, between Gilimanuk and Tulamben. That is five to twelve times Bali's peak demand. Reservoirs add only about 55 MW. Pile-mounted solar is close to zero, because the only candidate is Benoa Bay, a conservation area since 2019.[266] In Bali, coastal solar therefore means

259 Institute for Essential Services Reform, "Declare Bali Net Zero Emission 2045: Bali Government Targets 100 Percent Renewable Energy in Nusa Penida before 2030," *IESR*, August 4, 2023, https://iesr.or.id/en/2023/08/04, accessed on November 26, 2026.
260 Hartatik, "Bali Launches Clean Electricity Roadmap, Steps towards Net-Zero 2045," *Tanahair.net*, July 16, 2025, https://tanahair.net/?p=12231, accessed on November 26, 2026.
261 Sari, "Floating Power," *op. cit.*
262 *Ibid.*
263 Lestarini, A. H., "Gangguan Kabel Bawah Laut Jawa-Bali Jadi Biang Kerok Listrik Padam," *Metro TV News*, May 3, 2025, https://www.metrotvnews.com/read/NgxCDDl0-gangguan-kabel-bawah-laut-jawa-bali-jadi-biang-kerok-listrik-padam, accessed on November 26, 2026.
264 Antara, "Electricity Supply on Bali Almost Back to Normal after Blackout," *Antara*, May 2025, https://en.antaranews.com/news/353777/homepage-v2.html, accessed on November 26, 2026.
265 Antara, "Bali Needs Geothermal Power to Avoid Future Outages: Official," *Antara*, May 5, 2025, https://en.antaranews.com/news/354041/bali-needs-geothermal-power-to-avoid-future-outages-official, accessed on November 26, 2026.
266 Sari, "Floating Power," *op. cit.*

2030	6–14 GW	1,000 MWp	$60
BALI RUNS SHORT Supply falls below peak demand without new plants	OFFSHORE POTENTIAL Off the calm north coast, five to twelve times peak demand	BALI TARGET Five clusters under the 100 GWp program	CARBON BREAK-EVEN Per ton, to replace diesel on Nusa Penida

offshore floating solar on the north coast, while mangrove restoration protects the south. Bali has about 2,144 hectares of mangroves, of which the Ngurah Rai Grand Forest Park holds about 1,373 hectares.[267]

The 100 GWp program has made Bali its starting point. Bali's target is 1,000 MWp in five clusters with 3,300 MWh of batteries. The first project, 300 MWp with 1,000 MWh of batteries, is at Gilimanuk.[268] Offshore floating solar can replace Bali's diesel plants. At Pesanggaran, a 50 MW diesel plant whose build-operate-transfer contract ends in 2030, 154 MWp of floating solar on the north coast and a 200 MWh battery would cost $229 million, at 13.5 US cents per kWh. It saves $18 million while the diesel runs to 2030, and it saves money overall if solar after 2030 is valued at 12.2 cents per kWh, close to the cost of new supply. On Nusa Penida, the 12.4 MW Kutampi diesel plant could be replaced by 32 MWp of solar and a 90 MWh battery, at 18.4 cents per kWh. Replacement saves money once diesel costs more than 20.6 cents per kWh. It avoids 441,000 tons of CO2 between 2030 and 2043, and transition credits make it viable at about $60 per ton, or about $8 per ton if the solar goes on land.[269]

Bali is the template for Indonesia's diesel islands. The country has 5,819 MW of diesel capacity, mostly on islands and remote grids. PLN's cost of diesel power rose from Rp4,746 per kWh in 2020 to Rp8,748 in 2023.[270] Replacing the whole fleet would take 14 to 16 GW of solar and 43 to 51 GWh of batteries over about seven years, for $20 to $27 billion, paid back in six to eight years from avoided fuel and subsidy.[271] Floating and coastal solar can carry much of this, because many diesel islands have little flat land but calm water close to the load.

4.12 Buru, Demak and Similar Coasts

Buru Island in Maluku shows the diesel case. Maluku had 409 MW of generating capacity in 2024, and 99 percent of it burned fossil fuels. Diesel engines made up 249 MW, or 61 percent.[272] Buru's three main power systems had a combined peak load of about 9.5 MW in 2022.[273] The RUPTL plans 5 MW of

267 Antara Bali, "Pemprov Bali Libatkan Desa Adat Tanam dan Pantau Mangrove," *Antara Bali*, https://bali.antaranews.com/berita/350448/pemprov-bali-libatkan-desa-adat-tanam-dan-pantau-mangrove, accessed on November 26, 2026. Mongabay Indonesia, "Menyusuri Taman Hutan Raya Ngurah Rai sambil Belajar Lingkungan," *Mongabay Indonesia*, May 19, 2019, https://mongabay.co.id/2019/05/19/menyusuri-taman-hutan-raya-ngurah-rai-sambil-belajar-lingkungan/, accessed on November 26, 2026.
268 Sari, "Floating Power," *op. cit.*

269 *Ibid.*
270 Landscape Advisory, "Accelerating Diesel Retirement," *Landscape 360* Highlighted Publication, November 6, 2026, drawing on Sari, A. P., and M. Kurniawan, *Decentralized Renewables: Towards a Reformed Electricity Market in Indonesia* (Jakarta: Landscape Advisory, 2026).
271 *Ibid.*
272 Listrik Indonesia, "Menteri Bahlil Ultimatum PLN Ganti Semua Diesel dengan EBT," *Listrik Indonesia*, April 7, 2025, https://listrikindonesia.com/detail/16193/menteri-bahlil-ultimatum-pln-ganti-semua-diesel-dengan-ebt, accessed on November 26, 2026.
273 Nugroho, A., "Dorong Perekonomian, Tol Listrik Sepanjang 180,9 Kms di Pulau Buru Dibangun," *Listrik Indonesia*, April 1, 2022, https://listrikindonesia.com/detail/9507/dorong-perekonomian-tol-listrik-sepanjang-

solar with batteries at Namlea, a 10 MW biomass plant by 2029, the 20 MW Wapsalit geothermal plant by 2028 and a 12 MW hydropower plant by 2030.[274] Landscape Advisory has identified about 3,000 hectares of coast on Buru that could host carbon-negative coastal solar.[275] At four hectares of mangrove for each hectare of panels, that area holds about 490 MWp. A few tens of megawatts with batteries would replace the island's diesel. The rest could power new industry, cold storage for fisheries and the mining area that the government is reorganizing.[276]

Demak on the north coast of Central Java shows the case of land lost to the sea. The village of Bedono sinks by about 20 centimeters a year, and two of its hamlets, Rejosari Senik and Tambaksari, are now under water.[277] Sixty-five households from Tambaksari were moved in 1999, and 201 households from Rejosari Senik in 2006. Only one family stayed in Senik, that of Pasijah, known as Mak Jah, and her husband Rokani.[278] Across the Sayung coast, abrasion has taken about 1,710 hectares of ponds, and hundreds of hectares of rice fields can no longer be planted because they stay flooded.[279] Figure 16 shows the drowned area from space.[280] Mak Jah has planted about 15,000 mangroves a year for two decades and grows seedlings for others to plant.[281] Solar panels on stilts can stand among her mangroves across the former hamlet. The site lies close to the Java grid near Semarang, so its power can replace coal on the grid without new long lines. Ponds and a share of the carbon income can give former residents a reason to come back to the coast as its keepers.

Many coasts share these conditions. Sea levels on Indonesia's coasts rose an average of 4.25 millimeters a year from 1992 to 2024, and villages along Java's north coast are losing land to the sea.[282] Indonesia also has about 300,000 hectares of idle shrimp ponds, as Section 4.5 showed, and hundreds of islands that still run on diesel.[283] A site suits carbon-negative coastal solar when three conditions meet. The coast is degraded or its ponds are idle, there is a need for power from diesel or

1809-kms-di-pulau-buru-dibangun, accessed on November 26, 2026.

274 Thertina, M. R., "Rencana Puluhan Megawatt EBT di Pulau Buru di Tengah Pembenahan Tambang Emas," *Katadata*, September 15, 2026, https://katadata.co.id/ekonomi-hijau/investasi-hijau/6aa92f076156e/rencana-puluhan-megawatt-ebt-di-pulau-buru-di-tengah-pembenahan-tambang-emas, accessed on November 26, 2026.

275 Landscape Advisory calculation. Site identification by Landscape Advisory. At four hectares of mangrove for each hectare of panels and 0.82 MWp per hectare of panels, 3,000 hectares hold about 600 hectares of panels, or about 490 MWp.

276 Thertina, "EBT di Pulau Buru," *op. cit.*

277 Kompas, "Bedono, the Village That's Vanishing," *Kompas*, March 20, 2017, https://www.kompas.id/baca/english/2017/03/20/bedono-the-village-thats-vanishing, accessed on November 26, 2026. Mongabay Indonesia, "Keluarga Mak Jah 'Penyintas Terakhir Dusun Rejosari': Kami akan Tetap Tanam Mangrove," *Mongabay Indonesia*, December 28, 2024, https://mongabay.co.id/2024/12/28/keluarga-mak-jah-penyintas-terakhir-dusun-rejosari-kami-akan-tetap-tanam-mangrove/, accessed on November 26, 2026.

278 Mongabay Indonesia, "Keluarga Mak Jah," *op. cit.*

279 Asiyah, S., M. G. Rindarjono, and C. Muryani, "Analisis Perubahan Permukiman dan Karakteristik Permukiman Kumuh Akibat Abrasi dan Inundasi di Pesisir Kecamatan Sayung Kabupaten Demak Tahun 2003–2013," *Jurnal GeoEco* 1, no. 1 (January 2015): 83–100, https://jurnal.uns.ac.id/GeoEco/article/download/8900/7934, accessed on November 26, 2026.

280 European Space Agency, Copernicus Sentinel-2 Level-2A image S2B_49MDN_20261014, acquired October 14, 2026, accessed through Element 84, *Earth Search*, https://earth-search.aws.element84.com/v1, accessed on November 26, 2026. OpenStreetMap contributors, place records for Tambaksari, Rejosari, Mondoliko, Morosari and Timbulsloko, Sayung, Demak, retrieved through *Nominatim*, https://nominatim.openstreetmap.org, accessed on November 26, 2026.

281 Reuters, "Last House in the Sea: Java Woman Battles Rising Waters with Mangroves," *Malay Mail*, April 20, 2025, https://malaymail.com/news/life/2025/04/20/last-house-in-the-sea-java-woman-battles-rising-waters-with-mangroves/173687, accessed on November 26, 2026.

282 *Ibid.*

283 The Fish Site, *op. cit.* Landscape Advisory, "Accelerating Diesel Retirement," *op. cit.*

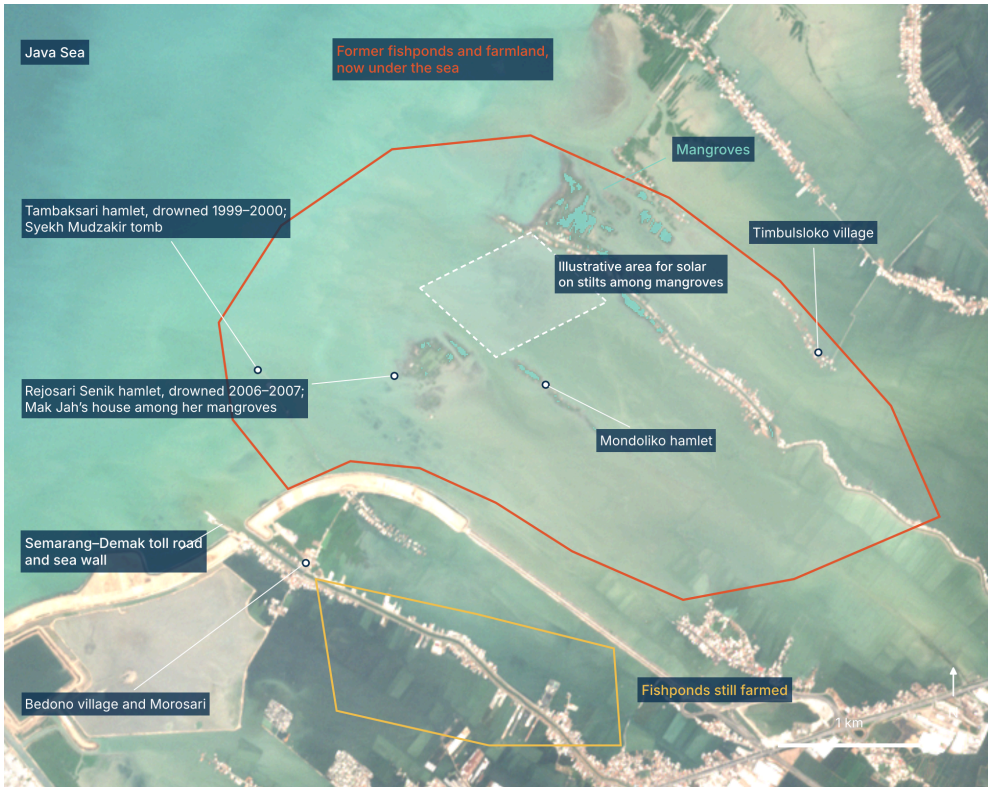

Figure 16. The drowned coast of Bedono, Demak, seen by Sentinel-2 on October 14, 2026. The red outline marks former fishponds and farmland that are now under the sea, read from the image, where the old pond walls and village lines still show below the water. Mangroves, in mint, survive in patches around the drowned hamlets, including the stand that Mak Jah has planted around her house in Rejosari Senik. Ponds behind the toll-road sea wall are still farmed. The dashed outline is illustrative only and shows how solar on stilts could stand among replanted mangroves in the drowned area. Mangroves are mapped from the image's vegetation index, and hamlet locations are from OpenStreetMap. Contains modified Copernicus Sentinel data 2026, processed by Landscape Advisory. Sources are the European Space Agency, OpenStreetMap contributors, Asiyah, Rindarjono and Muryani, and Mongabay Indonesia, cited in this section.

the grid, and a community can tend the mangroves and ponds. Mapping these sites across the archipelago is a task for the next stage of work.

Coastal solar in Demak would give the families displaced by the sea new income and work, because ponds under the panels can be farmed again and village groups can be paid to plant and guard the mangroves, as Section 4.7 described. Some 70,000 people and 6,000 hectares of aquaculture ponds in Demak are exposed to the sea.[284]

The mangrove belt that comes with the panels also protects the coast. Along 20 kilometers of the Demak coast, the Building with Nature program combined mangrove restoration with engineering from 2015 to 2021, which helped avoid further flooding and erosion.[285] Solar, ponds and mangroves together can make Bedono and its neighbors more resilient to storms, high tides and rising seas.

284 United Nations Office for Disaster Risk Reduction, "Q&A with Apri Susanto Astra, Coordinator of Nature-Based Solutions Programme, Wetlands International Indonesia," in *Words into Action: Implementation Guide for Land Use and Urban Planning*, https://www.undrr.org/words-into-action/implementation-guide-land-use-and-urban-planning/qa-apri-susanto-astra, accessed on November 26, 2026.

285 Wetlands International, "Securing Eroding Delta Coastlines of the Northern Coastal Java: Lessons Learned of the Building with Nature Indonesia Implementation and Upscaling," *UN Decade on Ecosystem Restoration*, August 2025, https://www.decadeonrestoration.org/ar/node/9581, accessed on November 26, 2026.

5. Carbon Finance for Solar Photovoltaic

5.1 The Additionality of Solar Credits

Carbon credits from grid-connected solar have lost standing in the voluntary market. In August 2024, the Integrity Council for the Voluntary Carbon Market (ICVCM) found that eight renewable energy methodologies, covering 32 percent of the voluntary market and 236 million unretired credits, failed its Core Carbon Principles on additionality.[286] The council judged them insufficiently rigorous in testing whether projects would have gone ahead without carbon revenue, but it left the door open to more robust methods.[287] In May 2026 it gave conditional approval to Verra's revised method, VMR0017, for future wind, solar, geothermal, small hydro and tidal projects. A project qualifies only if a benchmark analysis shows that carbon revenue decisively lifts its returns to the financial viability benchmark, and storage can be included under set conditions.[288]

Indonesia has its own route. Emission reduction certificates (Sertifikat Pengurangan Emisi Gas Rumah Kaca, SPE-GRK) are issued in the national registry and traded on the Indonesia Carbon Exchange (IDXCarbon). International trading opened on January 20, 2025, with 1.78 MtCO2e authorized from five PLN power plants.[289] IDXCarbon lists separate products for renewable energy units for domestic buyers and for units authorized for international trade.[290] Volumes remain small. In April 2026, 10 projects were listed, with about 3.1 MtCO2e available.[291] Domestic credits traded at about $3.66 per ton in 2023.[292] The bilateral route pays far more. The Indonesia–Norway agreement buys emission cuts from solar at $20 to $40 per ton, as Section 1.4 described.

5.2 Credits for Floating and Coastal Solar

The higher cost of floating and coastal solar works in their favor under the new tests. Offshore floating solar costs about $1,200 per kW against about $790 for solar on land.[293] Carbon revenue therefore changes the economics more, which is exactly what the benchmark analysis under VMR0017 must show.[294] Solar replacing diesel on islands is additional for a further reason. Diesel power costs $0.29 to $0.65 per kWh, which makes a strong additionality case even where most standards no longer credit plain

286 S&P Global Commodity Insights, "Renewable Energy Projects 'Fail to Meet High-Integrity Label': ICVCM," *S&P Global*, August 6, 2024, https://www.spglobal.com/energy/en/news-research/latest-news/natural-gas/080624-renewable-energy-projects-fail-to-meet-high-integrity-label-icvcm, accessed on November 26, 2026.
287 Argus Media, "Renewable Energy Carbon Credits Not Eligible for CCP," *Argus Media*, August 2024, https://argusmedia.com/en/news-and-insights/latest-market-news/2595135-renewable-energy-carbon-credits-not-eligible-for-ccp, accessed on November 26, 2026.
288 Integrity Council for the Voluntary Carbon Market, "Integrity Council Announces New Batch of Assessment Decisions," *ICVCM*, May 11, 2026, https://icvcm.org/?p=18159, accessed on November 26, 2026.
289 Otoritas Jasa Keuangan, Ministry of Environment and Indonesia Stock Exchange, "Inauguration of Indonesia International Carbon Trading," joint press release, January 20, 2025, https://www.ojk.go.id/en/berita-dan-kegiatan/siaran-pers/Documents/Pages/Inauguration-of-Indonesia-International-Carbon-Trading/12%20[Joint%20Press%20Release]%20Peresmian%20Perdagangan%20Karbon%20Luar%20Negeri_EN.pdf, accessed on November 26, 2026.
290 IDXCarbon, carbon unit product classification, *IDXCarbon*, https://www.idxcarbon.co.id/document/share/186/4185502e-93d0-431a-aca1-ecbf93104d82, accessed on November 26, 2026.
291 IDXCarbon, *Monthly Report, April 2026* (Jakarta: Indonesia Stock Exchange, 2026), https://www.idxcarbon.co.id/document/share/163/d7f039b2-b2c7-4c94-ba3c-77aef23ddcfc, accessed on November 26, 2026.
292 Sari, *Power from the Coast*, *op. cit.*
293 Sari, "Floating Power," *op. cit.*
294 ICVCM, "New Batch," *op. cit.*

solar.[295]

The mangroves in carbon-negative coastal solar generate a second, separate credit. Verra's VM0033 methodology covers tidal wetland and seagrass restoration, including mangroves.[296] The ICVCM has also approved Isometric's Mangrove Restoration Protocol as high integrity, noting its rigorous additionality test and dynamic baseline.[297] Mangrove restoration credits sold for $26 to $30 per ton in 2023 to 2025, against $3.66 for domestic credits.[298] To be credible, planting must take place on bare ponds and flats that would not regrow on their own, with a buffer of credits held in reserve, legal protection for the mangroves, and the consent of each village.[299]

5.3 Transition Credits

Transition credits pay for the emissions avoided when a fossil plant closes early and clean power replaces it. Gold Standard published its JUST: Coal Decommissioning methodology on March 12, 2026. It pairs the early closure of a coal plant with a specific grid-connected renewable plant, uses conservative baselines set by an ambitious performance benchmark, and requires a just transition plan.[300] On March 24, 2026, Gold Standard and Sustainable Energy for All launched JUST: Fossil Fuel Generators, for replacing diesel and other fossil generators with renewable power.[301] Gold Standard requires a credible decommissioning plan, permanent shutdown and replacement capacity that keeps power reliable. Transition credits must never justify new fossil investment or reward closures that would have happened anyway.[302]

On November 3, 2026, Verra announced that its VM0052, Accelerated Retirement of Coal-fired Power Plants Using a Just Transition, had become the first transition methodology approved by the ICVCM.[303] Version 1.1 applies to coal plants built before the end of 2021 with power purchase agreements of at least 20 years signed before the end of 2023, and with profits in each of the previous three years. Replacement renewables, which may be solar with or without storage, must export to the grid and replace all of the retired plant's annual output.[304] Some environmental groups warn that unresolved weaknesses in the method could lead to weak credits.[305] The IEA

295 Landscape Advisory, "Accelerating Diesel Retirement," *op. cit.*
296 Verra, *VM0033 Methodology for Tidal Wetland and Seagrass Restoration*, version 2.1, September 4, 2023, https://verra.org/methodologies/vm0033/, accessed on November 26, 2026.
297 Eco-Business, "ICVCM Approves Another Carbon Credit Standard, Mangrove Restoration Rules as High Integrity," *Eco-Business*, https://www.eco-business.com/news/icvcm-approves-another-carbon-credit-standard-mangrove-restoration-rules-as-high-integrity/, accessed on November 26, 2026.
298 Sari, *Power from the Coast*, *op. cit.*
299 *Ibid.*
300 Gold Standard, *Joined-Up Sustainable Transition (JUST): Coal Decommissioning*, GS4GG PAA M400-05, version 1.0, March 12, 2026, https://globalgoals.goldstandard.org/standards/459_v1.0_PAA-M400-05_JUST-Coal-Decommissioning.pdf, accessed on November 26, 2026.
301 Gold Standard, "First Methodology to Support Just Transition Away from Fossil Fuel Generators Launched by Gold Standard and Sustainable Energy for All," media release, March 24, 2026, https://goldstandard.org/news/just-transition-fossil-fuel-generators-launched, accessed on November 26, 2026.
302 Gold Standard, "The Carbon Market's Next Mission: Paying to Shut Fossil Fuels Down," *Gold Standard*, https://www.goldstandard.org/news/the-carbon-markets-next-mission-paying-to-shut-fossil-fuels-down, accessed on November 26, 2026.
303 Verra, "Verra Secures First ICVCM Approval for Transition Credits from Early Coal Retirement," press release, November 3, 2026, https://verra.org/verra-secures-first-icvcm-approval-for-transition-credits-from-early-coal-retirement/, accessed on November 26, 2026.
304 Saptakee S., "Verra's VM0052 Wins ICVCM Approval to Boost Coal Retirement Carbon Credits," *Carbon Credits*, November 5, 2026, https://carboncredits.com/?p=49177, accessed on November 26, 2026.
305 Carbon Pulse, "Environmental Group Warns ICVCM Approval of Coal Transition Credits Risks Undermining Climate Action," *Carbon Pulse*, November 6, 2026, https://carbon-pulse.com/568511/, accessed on November 26, 2026.

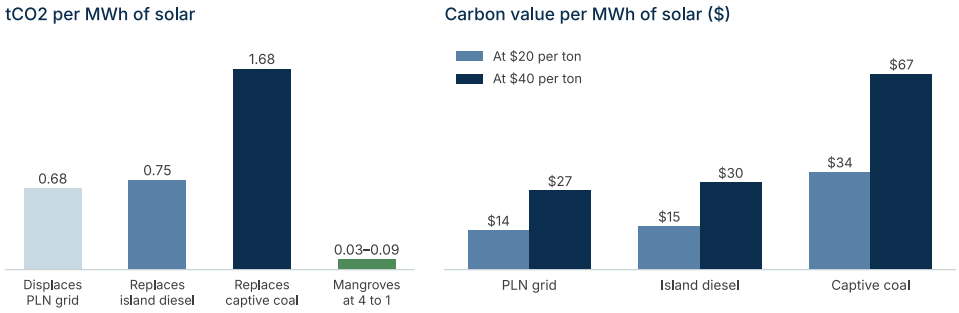

Figure 17. Emissions avoided and carbon value per MWh of solar, by what the solar replaces. The grid value uses PLN's 2024 intensity of 680 g CO2e per kWh. Diesel uses 0.75 tons of CO2 (tCO2) per MWh and captive coal 1.68, from Landscape Advisory. Mangroves at four hectares per hectare of panels absorb 7 to 24 tCO2 per hectare a year. The $20 to $40 range is the price in the Indonesia–Norway agreement. Landscape Advisory calculation.

counts six transition credit methodologies as of April 2026, including drafts by Sustainability Economics and a Paris Agreement Crediting Mechanism method under development by the Rockefeller Foundation, the World Bank, the Asian Development Bank (ADB) and the Inter-American Development Bank (IDB).[306]

These methods fit Indonesia's fleet in different ways. VM0052 and JUST: Coal Decommissioning suit PLN's grid-connected coal plants under long-term contracts. JUST: Fossil Fuel Generators suits island diesel, where replacing Kutampi on Nusa Penida breaks even at about $60 per ton, as Section 4.11 showed.[307] Captive coal needs a method of its own. Landscape Advisory's Retiring Early study finds that transition credits for captive plants break even at $8 to $16 per ton.[308] Figure 17 shows why retirement matters. A MWh of solar that replaces captive coal avoids more than twice the CO2 of a MWh that simply feeds the grid, so it earns more than twice the carbon value at any price.

5.4 Crediting Routes

Table 8 sets out the routes. Without retirement, solar earns credits only where it proves additionality, through VMR0017, SPE-GRK or a bilateral Article 6.2 deal. With retirement, it earns transition credits under VM0052, JUST: Coal Decommissioning or JUST: Fossil Fuel Generators. Coastal solar adds blue carbon credits from its mangroves in either case.

5.5 Sector-Wide Crediting with STEPS

The Standard for the Transformation of the Electric Power Sector (STEPS) is a sector-wide carbon crediting standard. It rewards host countries for investment, planning and policies that make power sector emissions peak sooner and fall faster. Environmental Resources Trust at Winrock International develops it, building on its work on the American Carbon Registry (ACR) and on the Architecture for REDD+ Transactions (ART), a jurisdictional program for reducing emissions from deforestation and forest degradation (REDD+) in tropical forests.[309]

306 International Energy Agency, *Financing the Modernisation of Power Systems beyond Coal: The Role of Transition Credits in Southeast Asia* (Paris: IEA, 2026), https://iea.blob.core.windows.net/assets/f2c3700c-519d-49c3-823d-de0e385500b9/FinancingtheModernisationofPowerSystemsBeyondCoal.pdf, accessed on November 26, 2026.
307 Sari, "Floating Power," *op. cit.*
308 Sari, *Power from the Coast*, *op. cit.*

309 Environmental Resources Trust, "About STEPS," *STEPS*, Winrock International, https://

Activity	Retirement	Main routes	Key condition
Ground and rooftop solar on the grid	No	Verra VMR0017, SPE-GRK, Article 6.2 deals	Benchmark test shows carbon revenue decisively improves returns
Freshwater floating solar	No	Verra VMR0017, SPE-GRK, Article 6.2 deals	Same test, helped by higher costs
Offshore floating and pile-mounted coastal solar	No	Verra VMR0017, SPE-GRK, Article 6.2 deals	Same test, helped by costs of about $1,200 per kW
Mangroves in carbon-negative coastal solar	Not needed	Verra VM0033, Isometric Mangrove Restoration Protocol, SPE-GRK in SRUK	Planting on bare ponds and flats, buffer, legal protection, village consent
Solar and batteries replacing island diesel	Yes, diesel	Gold Standard JUST: Fossil Fuel Generators	Verified decommissioning, reliable supply, just transition plan
Solar replacing grid coal under a power purchase agreement	Yes, coal	Verra VM0052, Gold Standard JUST: Coal Decommissioning	Plant built before 2022, long-term contract, profitable, renewables replace all output
Coastal solar replacing captive coal	Yes, coal	Transition credits under a captive-specific method, as in Retiring Early	Emission permits cancelled, each ton claimed once
All forms, across a province or the nation	Optional	STEPS, jurisdictional	Sector-wide emissions fall below the crediting baseline

Table 8. Carbon crediting routes for solar, floating solar and coastal solar in Indonesia. Landscape Advisory compilation from the sources cited in Sections 5.1 to 5.5.

Winrock began the work in 2023 as the crediting body for the Energy Transition Accelerator of the U.S. Department of State, the Bezos Earth Fund and the Rockefeller Foundation, to credit sector-wide transition strategies in developing countries, states or regions.[310]

STEPS accounts for all electricity generation and its CO2 emissions in a jurisdiction, rather than project by project. That covers grid-connected plants, captive generation, distributed generation, and imports and exports. The interventions it rewards include grid-connected and distributed renewables, the retirement or reduced dispatch of fossil plants, grid infrastructure and storage. The draft was open for public comment from April 30 to July 1, 2026.[311] ACR is piloting it with the governments of the Dominican Republic and Chile.[312] In July 2026, the International Civil Aviation Organization (ICAO) found STEPS credits eligible for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the aviation carbon market, the first sector-wide approach to qualify beyond jurisdictional REDD+.[313]

www.stepsclimate.org/about-steps/, accessed on November 26, 2026.

310 Rockefeller Foundation, "U.S. Department of State, Bezos Earth Fund, and the Rockefeller Foundation Announce Winrock International as the Crediting Body for Energy Transition Accelerator," press release, April 11, 2023, https://rockefellerfoundation.org/?p=59630, accessed on November 26, 2026.

311 Environmental Resources Trust, "Global Public Comment Period Announced for the Standard for the Transformation of the Electric Power Sector (STEPS)," *STEPS*, April 30, 2026, https://www.stepsclimate.org/2026/04/30/ert-announces-global-public-comment-period-for-steps/, accessed on November 26, 2026.

312 ACR, "Material Change Assessment Form," submitted to the ICAO Technical Advisory Body, April 2026, https://www.icao.int/sites/default/files/environmental-protection/CORSIA/TAB/2026/ACR_MCA-form_April2026.pdf, accessed on November 26, 2026.

313 ACR, "ACR Scope of Eligibility for Global Aviation's Carbon Market Expanded to Include Electric Power Sector Credits," news release, July 21, 2026, https://acrcarbon.org/news/

The Kinetic Coalition is building demand. Companies make advance commitments to buy energy transition credits, and the expected revenue helps host countries or asset owners raise finance up front. The coalition is exploring STEPS for early coal retirement, faster renewables, and grid and storage improvements.[314]

A jurisdictional approach has clear strengths and real risks. It limits leakage within the jurisdiction, avoids plant-by-plant counterfactuals, links credits to sector-wide policy, and gives ownership of the credits to the host government. Setting baselines is difficult, additionality has to be judged at the level of policy, set-up can be slow and costly, political change can disrupt programs, and the fair sharing of revenue is unresolved. Project credits can be nested within the jurisdictional account to reduce the risk of double counting.[315]

STEPS fits Indonesia for four reasons, on Landscape Advisory's reading. First, it counts captive generation, and Indonesia had nearly 20 GW of captive coal in 2024, mainly for processing critical minerals.[316] Project methods such as VM0052 do not reach these plants because they have no long-term contracts with PLN. Second, the 100 GWp program spreads capacity over rooftops, off-grid sites for productive use, frontier regions and industrial estates, as well as utility-scale plants.[317] Many of these sites are too small to credit one by one. Third, it rewards the policies that Section 2 described, from the revised RUPTL to coal retirement under Minister of Energy and Mineral Resources Regulation No. 10/2025. Fourth, it can work below the national level. Island grids such as Nusa Tenggara or Maluku, or a province with its own target such as Bali, could serve as pilot jurisdictions, with imports from Java handled through adjustments to the emission rate.[318]

5.6 Stacking the Routes

The routes work best in sequence. Bilateral Article 6.2 agreements such as the one with Norway can pay for solar now. Gold Standard's generator method can finance diesel replacement on islands. VM0052 and the coal decommissioning methods can fund the retirement of PLN coal plants, and a captive-specific method can do the same for industry. Blue carbon credits can reward the mangroves in coastal solar from the first year. A STEPS pilot, at the national level or in an island jurisdiction, can then gather these results into one sector-wide account.

Integrity depends on clean accounting. Every credit should be registered in SRUK under Presidential Regulation No. 110/2025, with an Article 6 authorization and a corresponding adjustment when it is sold abroad.[319] Each ton can count in only one place, whether toward the NDC, under the Norway agreement, by an industrial producer or under STEPS. Nesting the project credits within the jurisdictional account, and keeping a single registry, will keep the different routes from claiming the same ton twice.[320]

acr-scope-of-eligibility-for-global-aviations-carbon-market-expanded-to-include-electric-power-sector-credits/, accessed on November 26, 2026.
314 Kinetic Coalition, "Our Approach," *Kinetic Coalition*, https://www.kinetic-coalition.org/our-approach/, accessed on November 26, 2026.
315 IEA, *Financing the Modernisation*, *op. cit.*
316 *Ibid.*
317 Sari, "Floating Power," *op. cit.*
318 IEA, *Financing the Modernisation*, *op. cit.*
319 Sari, *Power from the Coast*, *op. cit.*
320 IEA, *Financing the Modernisation*, *op. cit.*

5.7 Solar under Indonesia's Carbon Rules

Indonesia's carbon rules give each form of solar a place. Presidential Regulation No. 110/2025 sets the framework for domestic trading and for transfers abroad under Article 6.[321] The national carbon unit registry, SRUK, went live on July 9, 2026, to record projects and units, and its first traded units came from four forestry projects.[322] The Ministry of Energy and Mineral Resources is drafting the energy-sector rule under the regulation. It will cover units certified nationally as SPE-GRK and units with international certification, and the ministry will approve all energy carbon projects. The ministry sees energy projects that could yield about 22.49 million tons of CO2 a year, worth about Rp2.2 trillion.[323]

Grid-connected ground and rooftop solar can earn SPE-GRK or international units, measured against the grid's emission factor. Floating solar on reservoirs follows the same path, and the Norway agreement shows how its units can be sold abroad under Article 6.2. Coastal solar earns energy units for the panels and separate blue carbon units for the mangroves, each registered in SRUK. Where solar replaces diesel or coal, transition units can follow once a method is approved, as Section 5.3 described.

The government presents its market under the principle of high integrity and real impact. At COP31 it launched the Indonesia Climate and Carbon Partnership, with support packages for measurement, carbon integrity and Article 6 cooperation. None of the 14 projects it offered to buyers there was a renewable power project.[324] Solar projects that use approved methods, independent verification, authorization and corresponding adjustments can fill that gap and meet the integrity standard the government has set.

321 ICAP, ETS detail page, *op. cit.*
322 Antara, "Indonesia Reaffirms Commitment to High-Integrity Carbon Market," *Antara News*, June 25, 2026, https://en.antaranews.com/news/420401/indonesia-reaffirms-commitment-to-high-integrity-carbon-market, accessed on November 26, 2026. Firmansyah and Jatmiko, *op. cit.*
323 Ayuningtyas, A. D., "ESDM Godok Aturan Perdagangan Karbon Energi, Bidik Harga Karbon Lebih Tinggi," *Katadata*, September 17, 2026, https://katadata.co.id/ekonomi-hijau/investasi-hijau/6aaba3d9d1929/esdm-godok-aturan-perdagangan-karbon-energi-bidik-harga-karbon-lebih-tinggi, accessed on November 26, 2026.

324 Ministry of Environment, "Indonesia Luncurkan Kemitraan Iklim dan Karbon, Buka Jalan Investasi Hijau dari Desa ke Pasar Global," press release, Antalya, November 16, 2026, https://kemenlh.go.id/news/detail/indonesia-luncurkan-kemitraan-iklim-dan-karbon-buka-jalan-investasi-hijau-dari-desa-ke-pasar-global, accessed on November 26, 2026.

6. The Norway Agreement as an Anchor

Item	Low case	Central case	High case
Emission factor, tCO2e per MWh	1.0, coal margin	0.68, grid average	0.68, grid average
Years of delivery to 2038	10	10	7, phased
Solar output needed, TWh	12.0	17.6	17.6
Solar output a year, TWh	1.20	1.76	2.52
Solar capacity, GWp	0.88	1.30	1.85
Solar capex, $ billion	0.78–1.06	1.16–1.56	1.65–2.22
Batteries at 1 MWh per MWp, $ billion	0.19	0.29	0.41
Total investment, $ billion	0.97–1.25	1.45–1.85	2.06–2.63
Project development, $ million	29–63	44–93	62–132
Carbon revenue, $ million	240–480	240–480	240–480
Carbon revenue as share of investment	19–49 percent	13–33 percent	9–23 percent

Table 9. Back-calculation from 12 MtCO2e to capacity, investment and carbon revenue. Landscape Advisory calculation. Solar capex of $890 per kW for freshwater floating solar and $1,200 per kW for offshore floating or pile-mounted solar, and batteries at $220 per kWh, from Sari, "Floating Power," cited above. Project development is assumed at 3 to 5 percent of total investment, covering feasibility studies, surveys, permits, environmental assessment, community consent and MRV design. Excludes grid connections and cables.

6.1 Solar Capacity for 12 Million Tons

Working backwards from the agreement shows how much solar it can carry. Norway can buy up to 12 million tons of CO2e from PLN solar projects, with delivery running to 2038 at $20 to $40 per ton.[325] The tons a MWh of solar earns depend on the emission factor that verification applies. At PLN's grid average of 680 g CO2e per kWh, 12 million tons require about 17.6 TWh of solar output. If the factor reflects the coal plants that solar pushes off the margin, at about 1 ton per MWh, they require about 12 TWh.[326]

The solar capacity follows from the yield and the years of delivery. At 1,360 kWh per kWp a year, as in Section 4.8, plants running for the full ten years need 0.88 GWp at the coal factor or 1.30 GWp at the grid average. If plants come online in phases and deliver for seven years on average within the window, the grid case needs about 1.85 GWp.[327] Table 9 sets out the three cases. Floating solar already has a pipeline of this size. The tender-ready projects at Jatiluhur, Cirata and Jatigede alone add up to about 3.6 GWp.[328]

6.2 Investment and Carbon Revenue

Investment follows from the capacity. Freshwater floating solar costs about $890 per kW, and offshore floating or pile-mounted solar about $1,200 per kW. Batteries cost about $220 per kWh.[329] With one MWh of storage per MWp, an assumption in line with the agreement's priority on batteries, the central case needs $1.45 to $1.85

325 Norway Ministry of Climate and Environment, *op. cit.* Hadi, "Carbon Credit Deal at COP31," *op. cit.*
326 Landscape Advisory calculation. 12 million tons divided by 0.68 and by 1.0 ton per MWh. The grid average is from Section 2.1. A coal plant emits about 1,001 g CO2 per kWh on a global average, from Landscape Advisory, "Carbon-Negative Coastal Solar," cited above.

327 Landscape Advisory calculation. Annual output is total output divided by 10 or 7 years. Capacity is annual output divided by 1,360 kWh per kWp. Battery losses would raise the capacity needed slightly.
328 Gupta, *op. cit.*
329 Sari, "Floating Power," *op. cit.*

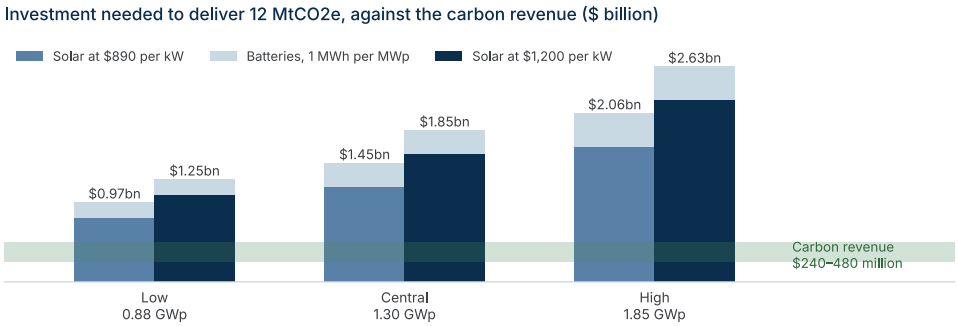

Figure 18. Investment needed to deliver 12 MtCO2e under the Indonesia–Norway agreement, in three cases, against the agreement's carbon revenue of $240 to $480 million. Left bars use freshwater floating costs, right bars offshore floating or pile-mounted costs. Landscape Advisory calculation from Table 9.

billion. The full range runs from about $1 billion in the low case to $2.6 billion in the high case. Project development, from feasibility studies and site surveys to permits, community consent and measurement, reporting and verification (MRV) design, adds about $30 to $130 million on Landscape Advisory's assumption of 3 to 5 percent of investment.[330] The carbon revenue of $240 to $480 million covers 9 to 49 percent of the investment, depending on the case.

6.3 Carbon Revenue and the Cost Gap

Per unit of power, carbon revenue is large. At the grid average, each MWh earns $13.60 to $27.20 at $20 to $40 per ton. Freshwater floating solar costs about 6.2 US cents per kWh, so carbon covers 22 to 44 percent of its cost. Pile-mounted solar at about 8 cents gets 17 to 34 percent.[331] Coal generation costs rose 46 percent to Rp930, or about 5.2 cents per kWh, in 2025.[332] Carbon revenue therefore closes the gap of about 1 cent per kWh between freshwater floating solar and coal, and goes most of the way for coastal solar. Solar with batteries costs more. Replacing the Pesanggaran diesel plant with floating solar and a battery costs 13.5 cents per kWh, so carbon revenue alone cannot carry it, and the case rests on the high cost of the diesel it replaces.[333] This is also the point that proves additionality. Carbon revenue makes the difference between a project that PLN can afford to buy from and one it cannot.

6.4 The Marginal Abatement Cost Curve

Figure 19 places floating and coastal solar among Indonesia's other renewable options. It is a marginal abatement cost curve. Each bar is one option. Its width shows the emissions it cuts each year, and its height shows the cost of cutting one ton. The options run from the cheapest on the left to the dearest on the right. The cost per ton is the levelized cost of electricity (LCOE) of the renewable option minus the cost of the power it replaces, divided by the emissions it avoids per MWh.[334] LCOE is the better measure for this purpose than capital cost, because it

330 Landscape Advisory calculation. See the note to Table 9.
331 Sari, "Floating Power," *op. cit.* $13.60 to $27.20 per MWh divided by $62 and $80 per MWh is a Landscape Advisory calculation.
332 Fernandez, "100 GW Solar Plan," *op. cit.*

333 Sari, "Floating Power," *op. cit.*
334 Landscape Advisory calculation. Cost per ton equals LCOE minus the cost of the replaced power, in $ per MWh, divided by tCO2e avoided per MWh. Emission reductions equal capacity times full-load hours times the emission factor.

also counts how much power a plant produces, how long it lasts, what it costs to run and the fuel it saves.

The inputs come from published sources. The solar options follow the eight parts of the 100 GWp program and the Bali options described in Section 4.11. Utility-scale solar combines the program's RUPTL, new demand and industrial estate parts, and solar with batteries on land combines its off-grid and frontier parts, which replace diesel.[335] Hydro, geothermal, onshore wind and bioenergy follow the additions in RUPTL 2025–2034, which are 11.7 GW, 5.2 GW, 7.2 GW and 0.9 GW.[336] Offshore wind is not in the RUPTL. The curve uses 5 GW, the capacity for which an EU study has prepared windfarm designs.[337] Most LCOEs come from the government's 2024 technology catalog, in 2023 values at a 10 percent cost of capital.[338] The diesel options use the costs in the Bali case, and coastal solar uses the cost in Landscape Advisory's coastal solar study.[339] Grid options replace coal power at 5.2 US cents per kWh, and diesel options replace diesel at 24 cents.[340] The emission factors are those of Figure 17.[341]

Together the 13 options cut about 243 MtCO2e a year. Replacing diesel with solar and batteries saves money before any carbon revenue, at about $130 to $140 per ton below zero, because diesel costs so much. Ground solar, hydro and coastal solar over mangroves cost $10 to $17 per ton, below the Norway price. Coastal solar cuts the most carbon per gigawatt of any solar option, about 2.4 MtCO2e a year, because it replaces captive coal and its mangroves absorb carbon as well. Geothermal and hydro cut even more per gigawatt, because they run most hours of the year. Freshwater floating solar at $34 and rooftop solar at $37 sit within the Norway range. Geothermal at $51 and onshore wind at $59 need a higher price, and offshore floating solar, bioenergy and offshore wind need far more. About 188 MtCO2e a year is available at $40 per ton or less. The 1.2 million tons a year that the agreement buys uses less than 1 percent of it.

Four points qualify these results. The catalog's costs are higher than the project quotes in Section 6.3. Freshwater floating solar costs $75 per MWh in the catalog against about $62 in the Bali case, so the curve may overstate its cost per ton. LCOE also leaves out the batteries and grid upgrades that large amounts of solar and wind need, while geothermal and hydro need none. Where solar only reduces how much a coal plant runs, without retiring it, the saving is mostly fuel, so the cost per ton would be higher. And the diesel bars compare solar

335 Sari, "Floating Power," *op. cit.*
336 Heynes, G., "Indonesian Government Ratifies Plans for 42.6GW of Renewable Energy Capacity," *PV Tech*, June 2, 2025, https://www.pv-tech.org/indonesian-government-ratifies-plans-for-42-6gw-of-renewable-energy-capacity/, accessed on November 26, 2026.
337 European Union, *Offshore Wind Opportunities in Indonesia*, executive summary (Jakarta: Delegation of the European Union to Indonesia, 2024), https://www.eeas.europa.eu/sites/default/files/documents/2024/Offshore%20Wind%20Opportunities%20in%20Indonesia%20-%20Executive%20Summary.pdf, accessed on November 26, 2026.
338 Danish Energy Agency and Directorate General of Electricity, *Technology Cost Perspectives in the Indonesian Power Sector: A Comparative Techno-Economic Analysis* (Copenhagen and Jakarta: Danish Energy Agency, May 2024), https://ens.dk/media/5064/download, accessed on November 26, 2026.
339 Sari, "Floating Power," *op. cit.* Sari, *Power from the Coast*, *op. cit.*
340 Fernandez, "100 GW Solar Plan," *op. cit.* Sari, "Floating Power," *op. cit.*

341 Landscape Advisory calculation. The catalog gives no LCOE for rooftop solar or for offshore floating solar. Rooftop uses the catalog's capital cost of $1,200 per kW and running cost of $4.9 per kW a year at 10 percent over 25 years, giving $77 per MWh. Offshore floating solar off Bali uses $1,200 per kW, running costs of 1.5 percent of capital cost and 1,400 kWh per kWp, giving $107 per MWh.

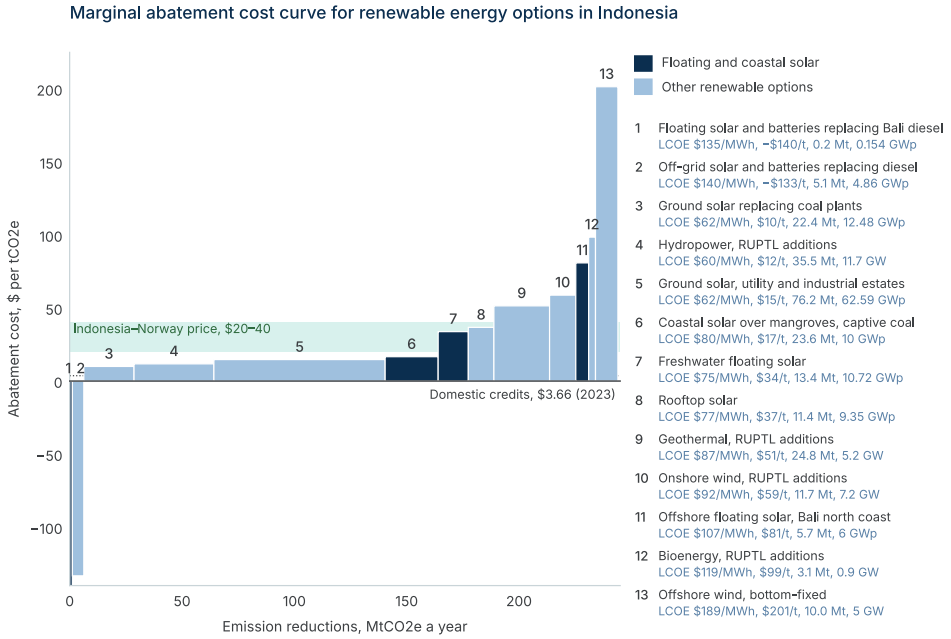

Figure 19. Marginal abatement cost curve for 13 renewable energy options in Indonesia. Bar width shows emission reductions a year and bar height the cost per ton. Dark blue bars are floating and coastal solar. The band marks the $20 to $40 price in the Indonesia–Norway agreement, and the dotted line the 2023 price of domestic credits. LCOEs from the 2024 Indonesian technology catalog, the Bali case and Landscape Advisory. Capacities from the 100 GWp program and RUPTL 2025–2034. Landscape Advisory calculation.

with diesel at 24 cents per kWh. Individual plants can run more cheaply, so a specific replacement can still need carbon revenue, as Kutampi on Nusa Penida does at about $60 per ton in Section 4.11. Biogas from palm oil mill effluent, biomass co-firing in coal plants and ocean energy are left out for lack of comparable Indonesian cost data.

6.5 The Project Company

The agreement buys from PLN solar projects.[342] Private developers and investors can take part as partners in PLN project companies, as Masdar did with PLN Nusantara Power at Cirata.[343] Under the 100 GWp program, independent power producers will compete in tenders, and Danantara will step in where prices are not competitive. International developers are expected to partner with local companies.[344] Figure 20 shows a structure that brings these pieces together.

Four features would make the structure bankable, on Landscape Advisory's proposal. First, the power purchase agreement or a side agreement should give the project company a clear share of the carbon revenue, since PLN is the seller under the agreement. Second, the carbon payments should flow into the project's accounts and count toward debt service, which raises the amount lenders can lend. Third, part of the expected carbon revenue could be paid in advance against verified delivery schedules, which turns a stream of payments that starts after commissioning into money for construction. Fourth, concessional finance can absorb the risks that private lenders will not yet

342 Hadi, "Carbon Credit Deal at COP31," *op. cit.*
343 Masdar, *op. cit.*
344 Gupta, *op. cit.*

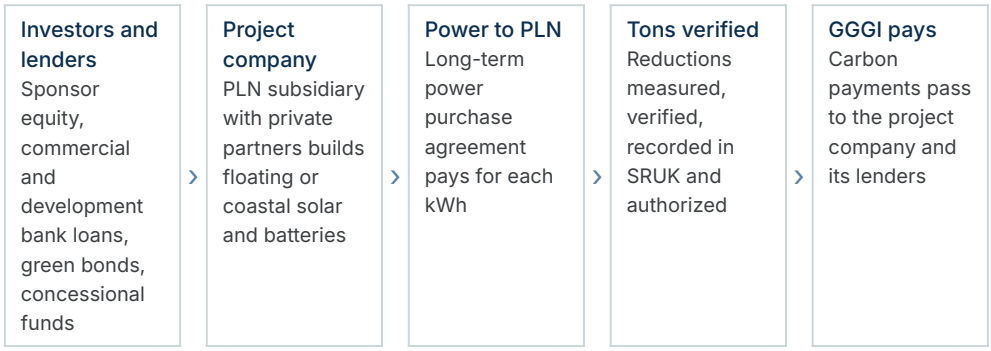

Figure 20. A financing structure for solar under the Indonesia–Norway agreement. Landscape Advisory proposal.

take, such as the marine risks of coastal solar. Green bonds under OJK Regulation No. 18/2023 and blended finance can complete the capital stack.[345] GGGI's Carbon Transaction Facility, backed by Norway and by Article 6 funds of Sweden and Singapore, already provides the buyer.[346]

6.6 A Template for More Solar

The 12 million tons are small against the 100 GWp program, which the government expects to avoid 140 million tons of CO2 a year.[347] The agreement's value lies in proving the route. The first tons will test measurement, authorization, corresponding adjustments and payment through SRUK. Once they work, the same project companies and contracts can sell to other buyers, add blue carbon credits from the mangroves in coastal solar as separate units, and, where solar replaces diesel or coal, earn transition credits as Section 5 described. Each ton must still be counted once, so mangrove removals and transition credits must stay outside the tons sold to Norway unless the parties agree otherwise. The agreement involves PLN, yet much of Indonesia's coal burns outside PLN's grid. Captive plants serving industry emitted about 135 million tons of CO2 in 2025, up from 120 million tons in 2024.[348] The bilateral agreement, or a new one with Norway or other buyers, may need to cover solar that replaces captive coal, with the same authorization and corresponding adjustments. Section 7 applies this structure at the scale of a whole captive coal fleet.

345 Sari, *Power from the Coast*, *op. cit.*
346 Hadi, "Carbon Credit Deal at COP31," *op. cit.*
347 Sari, "Floating Power," *op. cit.*

348 Vu and Setyawati, *Indonesia's Captive Coal Giant*, *op. cit.*

7. An Illustrative Financial Plan

7.1 The Plan

Section 6 sized the solar that the Norway agreement can carry. This section goes further and sets out an illustrative financial plan for carbon-negative coastal solar on the scale of a whole captive coal fleet. It uses the reference fleet of Section 4.9, three captive coal plants of 890 MW that produce about 5,910 GWh a year at about 1.68 tons of CO2 per MWh.[349] The host is a large industrial producer that runs on its own coal power. All costs and incomes are in 2026 US dollars, in real terms.

Table 6 sized the solar on energy alone at about 4.3 GWp. Serving the fleet's load at night as well needs more, because batteries lose some power and some daytime output goes unused. An hourly screening model finds that 5 GWp of coastal solar with 12 GWh of four-hour batteries supplies about 97 percent of the fleet's power, or about 5,745 GWh a year.[350] One small coal unit stays in reserve for long cloudy spells and runs for the remaining 3 percent. The solar avoids about 9.65 million tons of CO2 a year. Its panels cover about 6,100 hectares, with about 24,390 hectares of mangroves and ponds at four to one, worked by about 12,200 households at two hectares each. The mangroves absorb another 0.17 to 0.59 million tons a year.

7.2 Phases and Investment

Table 10 phases the build-out to follow Landscape Advisory's coastal solar study to 2 GWp by 2035, then adds 3 GWp and most of the batteries by 2038. Its shares run above Table 7 because only one coal unit stays in reserve, and its CO2 uses the upper emission factor.[351] The first phases serve utilities and support loads in daytime and need few batteries. Phase 4 replaces night-time coal and carries most of the cost, because it needs 8 GWh of batteries and links to coastal sites far from the industrial estate.

7.3 Transmission

The coast near the industrial estate can host about 0.5 to 0.9 GWp on stilts, and degraded land nearby can host more.[352] The rest must come from coastal sites 100 to 150 kilometers away, some across the sea. The plan therefore carries two kinds of transmission. Lines and substations for sites within about 40 kilometers cost about $0.15 to $0.25 billion. High-voltage overhead lines in Indonesia cost about Rp4.5 to 5 billion per circuit kilometer, and a new substation in Europe costs about €12 million.[353] Two high-voltage direct current links for the 3 GWp of distant sites cost about $1.4 to $1.9 billion, mostly for converter stations and subsea cable.[354]

349 Sari, *Power from the Coast*, *op. cit.*
350 Landscape Advisory calculation. Landscape Advisory hourly screening of a flat 675 MW load against a solar profile of 1,360 kWh per kWp a year, with daily cloud variation calibrated to the worst three-day output in Landscape Advisory's coastal solar study, four-hour batteries and 88 percent round-trip efficiency. About 9 percent of solar output is curtailed. The screening gives 12 percent of fleet power at 0.5 GWp with 0.5 GWh, 23 percent at 1 GWp with 1 GWh and 45 percent at 2 GWp with 4 GWh, close to the coastal solar study's 11.5, 20 to 23 and 37 to 43 percent.

351 Sari, *Power from the Coast*, *op. cit.*
352 *Ibid.*
353 Mulyana, R. N., "Jaringan Tol Listrik Akan Membentang di Sumatra," *Kontan*, May 10, 2019, https://insight.kontan.co.id/news/jaringan-tol-listrik-akan-membentang-di-sumatra, accessed on November 26, 2026. European Union Agency for the Cooperation of Energy Regulators, *Unit Investment Cost Indicators for Energy Infrastructure Categories* (Ljubljana: ACER, July 4, 2023), https://www.acer.europa.eu/Publications/ACER_UIC_indicators_table.pdf, accessed on November 26, 2026.
354 ACER, *Unit Investment Cost Indicators*, *op. cit.* Chatzivasileiadis, S., D. Ernst, and G. Andersson, "The Global Grid," *Renewable Energy* 57 (2013): 372–383, https://arxiv.org/

Phase	Years	Solar, GWp	Batteries, GWh	Share of fleet power	CO2 avoided a year	Mangroves and ponds	Added investment
Pilot	2027–2028	0.05	None	1 percent	0.1 Mt	240 ha	$0.05–0.06 bn
Phase 1	2029–2031	0.5	0.5	12 percent	1.1 Mt	2,440 ha	$0.61–0.77 bn
Phase 2	by 2032	1	1	23 percent	2.3 Mt	4,880 ha	$0.62–0.77 bn
Phase 3	by 2035	2	4	45 percent	4.5 Mt	9,760 ha	$1.64–1.95 bn
Phase 4	by 2038	5	12	97 percent	9.65 Mt	24,390 ha	$6.04–7.38 bn
Total	2027–2038	5	12	97 percent	9.65 Mt	24,390 ha	$8.95–10.93 bn

Table 10. Build-out of carbon-negative coastal solar to replace the reference captive coal fleet. Landscape Advisory screening model. Solar, batteries and mangroves are cumulative. Households work two hectares each, so the full plan involves about 12,200 households. Investment includes solar on stilts at $876 to $1,126 per kWp, batteries at $220 per kWh, transmission, mangrove restoration at $1,640 to $3,900 per hectare and project development at 4 percent. Phases to 2 GWp follow Landscape Advisory's coastal solar study.

Transmission then totals $1.55 to $2.15 billion, or 17 to 20 percent of the investment. The cost would fall if part of the solar could stand on degraded land near the estate, which costs less to build than stilts at sea.

The other capital costs follow the earlier sections. Solar on stilts costs $876 to $1,126 per kWp before batteries and grid works.[355] Batteries cost about $220 per kWh in the Bali case, while global turnkey battery systems averaged $117 per kWh in 2025, before installation and grid connection.[356] Mangrove restoration in Indonesia costs about $1,640 to $3,900 per hectare.[357]

7.4 Annual Costs

Table 11 turns the investment into annual costs. With commercial finance at 8 percent real, capital recovery comes to $0.89 to $1.07 billion a year. Solar is recovered over 25 years, batteries over 15 years so that they can be replaced once, transmission over 40 years and mangroves over 30 years.[358]

pdf/1207.4096, accessed on November 26, 2026. Landscape Advisory calculation. Near sites assume about 300 to 400 circuit kilometers of overhead lines at Rp4.5 to 5 billion each, at Rp16,500 per dollar, and six to eight substations at about €12 million each. Distant sites assume two links of about 1.5 GW and 120 kilometers each, half of it subsea, with subsea direct current cable at about €1.1 million per kilometer and four converter stations at about €250 to €350 million each after inflation, plus 15 percent for marine works and contingency, at $1.10 per euro. A feasibility study will replace these screening estimates.

355 Sari, *Power from the Coast*, *op. cit.*

356 Sari, "Floating Power," *op. cit.* Energy-Storage.news, "Battery Storage System Prices Continue to Fall Sharply, BNEF and Ember Reports Find," *Energy-Storage.news*, December 16, 2025, https://www.energy-storage.news/battery-storage-system-prices-continue-to-fall-sharply-bnef-and-ember-reports-find/, accessed on November 26, 2026.

357 World Bank, "Planting Mangrove Forests Is Paying Off in Indonesia," feature story, December 1, 2023, https://www.worldbank.org/en/news/feature/2023/11/30/planting-mangrove-forests-is-paying-off-in-indonesia, accessed on November 26, 2026. van Zanten, B., L. M. Brander, J.-P. Castaneda, D. Herrera, D. Kaczan, B. M. Brown, I. A. Smith, and B. Jongman, "Integrated Spatial Cost-Benefit Analysis of Large-Scale Mangrove Conservation and Restoration in Indonesia," *Frontiers in Environmental Science* 13 (2025): 1459034, https://www.frontiersin.org/articles/10.3389/fenvs.2025.1459034/full, accessed on November 26, 2026.

358 Landscape Advisory calculation. Capital recovery factors at 8 percent real, with project development at 4 percent of solar, battery and transmission capital. Operation and maintenance at 1.5 percent of capital a year for solar, from the coastal solar study, and assumed at 2 percent for batteries and 1.5 percent for transmission. Mangrove upkeep, monitoring and verification are assumed at 5 percent of restoration cost a year, well above the $7.87 per hectare a year that conserving

Item	Low case	High case
Solar, capital recovery	427	549
Batteries, capital recovery	321	321
Transmission, capital recovery	135	188
Mangrove restoration, capital recovery	4	8
Operation and maintenance of solar, batteries and lines	142	169
Mangrove upkeep, monitoring and verification	2	5
Total cost	1,030	1,239
Power sold to the host at 6 cents per kWh	345	345
Solar and transition credits at $20 or $40, paid for ten years and spread over 25	121	243
Mangrove credits, project share of 60 percent	3	11
Total project income	469	598
Mangrove credits, village share of 40 percent	2	7
Fish, shrimp and shellfish ponds, to village households	17	21
Total income of the scheme	488	626

Table 11. Annual costs and incomes of the full plan at 5 GWp and 12 GWh, $ million a year, under commercial finance. Landscape Advisory screening model. Low-case costs use the low solar, transmission and mangrove costs, and high-case costs the high ones. Low-case incomes use credits at $20, mangroves absorbing 7 tCO2 per hectare at $26 and ponds at $700 per hectare. High-case incomes use credits at $40, 24 tCO2 per hectare at $30 and ponds at $850 per hectare.

Operation and maintenance add $0.14 to $0.17 billion. Mangrove upkeep, monitoring and verification cost $2 to $5 million a year. In total, the system costs $1.03 to $1.24 billion a year, or 17.9 to 21.6 cents per kWh delivered.

7.5 Income

Power sales are the largest income. The host pays for solar power what its captive coal power costs now. IEEFA puts the cost of captive coal power at about 6 US cents per kWh, so 5,745 GWh a year earns about $345 million.[359] The host's actual cost depends on its coal contracts and will be set in the feasibility study.

Carbon credits from the solar come next. The 9.65 million tons a year that the solar avoids can earn credits at the Indonesia–Norway price of $20 to $40, which is $193 to $386 million a year.[360] Where a coal unit closes early, these tons can be issued as transition credits under methods such as Verra's VM0052, as Section 5 showed.[361] The plan assumes credits for ten years, the length of the agreement, which spread over the plant's 25-year life is worth $121 to $243 million a year. This volume is about eight times the 12 million tons that Norway buys over ten years, so the plan needs more buyers. Other governments under Article 6, airlines under CORSIA and the domestic market can take part.[362]

mature mangroves costs, according to van Zanten and colleagues.
359 Peh, G., *The Coal Cost of Aluminum* (Lakewood, OH: Institute for Energy Economics and Financial Analysis, October 11, 2023), https://ieefa.org/resources/coal-cost-aluminum, accessed on November 26, 2026.

360 Hadi, "Carbon Credit Deal at COP31," *op. cit.*
361 Verra, "First ICVCM Approval," *op. cit.*
362 ACR, "Scope of Eligibility," *op. cit.*

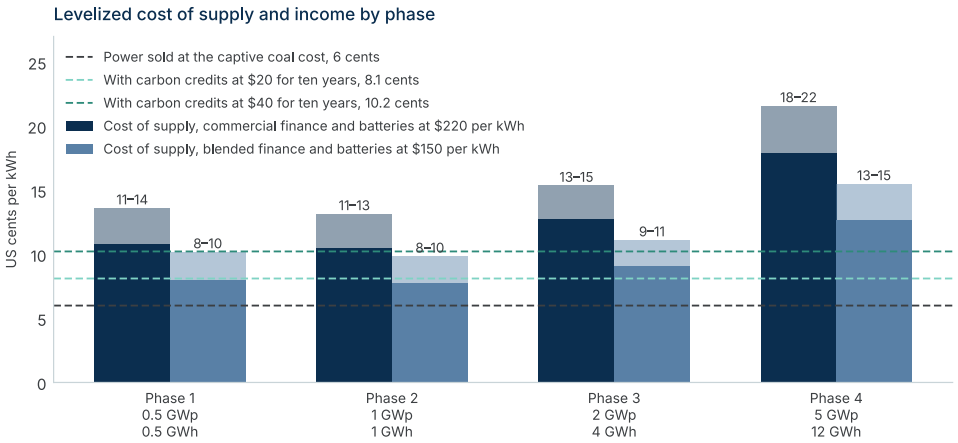

Figure 21. Levelized cost of supply by phase, cumulative, against the income per kWh from power sales and from carbon credits paid for ten years. Darker parts of each bar show the low case and lighter parts the range to the high case. Landscape Advisory screening model.

The mangroves and ponds add smaller sums that matter most to villages. The 24,390 hectares of mangroves absorb 0.17 to 0.59 million tons of CO2 a year. At $26 to $30 a ton, that is worth $4 to $18 million a year, and 40 percent goes to village groups.[363] The ponds earn $700 to $850 per hectare a year, or $17 to $21 million in all.[364] Each household working two hectares earns about $1,550 to $2,280 a year from ponds and its share of carbon.

7.6 Day and Night Supply

Figure 21 shows the cost of supply as the plan grows. Under commercial finance, Phases 1 and 2 cost about 11 to 14 cents per kWh. Power sales and carbon credits at $40 bring in about 10 cents, so the early phases need carbon at about $42 to $72 a ton over ten years. With blended finance and cheaper batteries, they cost 8 to 10 cents per kWh and need $19 to $45, within or near the Norway price.[365] Phase 4 raises the cost to 18 to 22 cents per kWh, because it adds 8 GWh of batteries and the long links to distant sites. Under commercial finance, the full plan breaks even only at a carbon price of $113 to $147 a ton over ten years.

7.7 Levers to Close the Gap

Table 12 tests three levers. Batteries at $150 per kWh, which allows for installation on top of today's global turnkey prices, cut the cost by about 2 cents per kWh.[366] Blended finance that lowers the real cost of capital from 8 to 5 percent cuts it by about 4 cents. Together they bring the full plan to 12.7 to 15.5 cents per kWh. Credits paid over the plant's whole life instead of ten years lower the break-even carbon price further. With both levers and life-long crediting, the full plan breaks even at $39 to $56 a ton, close to the upper end of the Norway price.

A higher cost of captive coal than 6 cents per kWh would also narrow the gap, as would a domestic carbon price closer to the government's $40 target.[367] The plan can also stop at Phase 3 and keep coal units as backup at night until battery prices fall further, which keeps the cost per

363 Sari, *Power from the Coast*, *op. cit.*
364 *Ibid.*
365 Landscape Advisory calculation. Break-even carbon prices assume credits for ten years and power sold at 6 cents per kWh. The early phases include transmission to sites within about 40 kilometers.

366 Energy-Storage.news, "Battery Storage System Prices," *op. cit.*
367 Karyza, *op. cit.*

Case	Investment	Cost of supply	Break-even, ten-year credits	Break-even, 25-year credits
Commercial finance, batteries at $220 per kWh	$9.0–10.9 bn	17.9–21.6 cents	$113–147	$71–92
Batteries at $150 per kWh	$8.1–10.1 bn	15.9–19.5 cents	$93–127	$58–80
Blended finance at 5 percent real	$9.0–10.9 bn	14.4–17.2 cents	$91–122	$50–67
Both levers together	$8.1–10.1 bn	12.7–15.5 cents	$72–103	$39–56

Table 12. Cost of supply and break-even carbon price of the full plan under four finance cases. Landscape Advisory screening model. Cost of supply is in US cents per kWh delivered. Break-even carbon prices are in dollars per ton of CO2, with power sold at 6 cents per kWh and the project's share of mangrove credits.

kWh near 13 to 15 cents under commercial finance and 9 to 11 cents with the levers. Section 7.8 tests one more source of value, savings on the CBAM charge.

7.8 CBAM Savings

The host sells products covered by the CBAM of the EU to Europe. EU importers pay for the emissions embedded in these goods at the price of allowances in the EU Emissions Trading System (EU ETS). The certificate price for the first quarter of 2026 was €75.36, or about $87, per ton of CO2.[368] The charge phases in as free allowances for European producers phase out. Importers pay 2.5 percent of the full charge in 2026, 48.5 percent in 2030 and the full charge from 2034.[369]

Under the rules in force today, clean power does not lower the host's CBAM charge. The regulation defines indirect emissions as those from producing the electricity used to make goods, wherever that electricity is generated.[370] Power from the host's own coal plants therefore counts as indirect. For most goods that CBAM covers, including the host's, the charge applies only to direct emissions, so the importer pays nothing on the electricity. Only cement and fertilizers carry a charge on electricity today.[371] The Commission plans a report in 2027 on extending CBAM to indirect emissions from the other goods.[372] Until then, clean power helps the host mainly by lowering the reported footprint of its products.

If CBAM comes to cover electricity, the savings can be large. Each ton of CO2 that the solar avoids in goods sold to Europe would save about $87

368 European Commission, "Price of CBAM Certificates," *Taxation and Customs Union*, https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism/price-cbam-certificates_en, accessed on November 26, 2026. Eurometal, "European Commission Provides Critical CBAM Cost Component," *Eurometal*, April 2026, https://eurometal.net/european-commission-provides-critical-cbam-cost-component/, accessed on November 26, 2026.
369 CBAM Guide, "CBAM and ETS Free Allocation: Phase-Out Schedule 2026–2034," *CBAM Guide*, https://cbamguide.com/learn/free-allocation/, accessed on November 26, 2026.
370 European Parliament and Council of the European Union, "Regulation (EU) 2023/956 of 10 May 2023 Establishing a Carbon Border Adjustment Mechanism," *Official Journal of the European Union* L 130 (May 16, 2023): 52–104, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023R0956, accessed on November 26, 2026.
371 Kolum, "Technical Study on Indirect Emissions: Default Values, PPA Evidence, and the Question of Extension," *Kolum CBAM Weekly*, June 2026, https://www.kolum.earth/en/cbam/weekly/2026-06-02, accessed on November 26, 2026.
372 Meyn, S., and J. Voskoboinikova, "EU: Commission Proposes to Extend CBAM Scope and Adopts Implementing Legislation," *Linklaters Sustainable Futures*, January 2026, https://sustainablefutures.linklaters.com/post/102me4c/eu-commission-proposes-to-extend-cbam-scope-and-adopts-implementing-legislation, accessed on November 26, 2026.

Finance case	Credits	Cost gap before CBAM savings, $ million a year	Share of output sold in Europe
Commercial finance, batteries at $220 per kWh	None	682–883	81–105 percent
Commercial finance, batteries at $220 per kWh	Ten years	561–640	78–107 percent
Both levers, batteries at $150 per kWh and blended finance at 5 percent	None	382–534	45–64 percent
Both levers, batteries at $150 per kWh and blended finance at 5 percent	25 years	148–189	29–33 percent

Table 13. Share of the host's output sold in Europe needed for the full plan to break even, if CBAM covers electricity at the full charge. Landscape Advisory screening model. The cost gap is total cost less power sold at 6 cents per kWh, the project's share of mangrove credits and, where shown, solar and transition credits on all 9.65 million tons. The share sold in Europe solves for savings at $87.2 per ton on tons kept to lower the CBAM charge, net of the credits those tons give up. Shares above 100 percent mean that CBAM savings alone cannot close the gap. Low and high values follow the low and high cases of Tables 11 and 12.

once the full charge applies. If all of the host's output went to Europe, the 9.65 million tons avoided each year would save about $840 million a year, close to the cost gap of the plan under commercial finance. The savings scale with the share of output sold in Europe. A ton kept to lower the CBAM charge cannot also be sold as a credit, as Section 7.9 explains, so the host would keep the tons in goods sold to Europe and sell the rest as credits.[373]

Table 13 shows the share of output that the host would need to sell in Europe for the plan to break even. Under commercial finance, the plan needs about 80 percent or more of its output in Europe, with or without credits. With cheaper batteries and blended finance, it needs about 45 to 65 percent without credits and about 30 percent with credits paid over the plant's life. Shares this large would require the host to turn much of its sales toward Europe. CBAM can make the plan pay its way only if the EU extends it to electricity and the host turns its sales toward Europe. Without both, it adds value at the margin, and the plan still rests on carbon credits, cheaper batteries and blended finance.

7.9 Counting Tons and Sharing Income

The host faces one choice for each ton avoided by its solar power. It can sell the ton as a credit, or keep it to lower its own reported emissions, its CBAM charge and the footprint of its products. It cannot do both.[374] Selling the solar tons earns the carbon income in Table 11 but gives up the border tax savings on the same tons. The mangrove tons are sold as blue carbon credits in either case. Transition credits apply only to coal units that close early, and the retired units' emission permits must be cancelled.[375]

The financing follows the structure in Section 6.5. A project company owns the solar, batteries and lines and sells power to the host under a long-term contract, in one of the licensed forms that Section 7.10 sets out. An illustrative capital stack for the $9 to

373 Landscape Advisory calculation. Savings are 9.65 million tons a year times the share of output sold in Europe times $87.2 per ton, the first-quarter 2026 certificate price of €75.36. Tons in goods sold outside Europe earn credits at the Table 11 values. The cost gap is total cost less power sales and the project's share of mangrove credits.

374 Sari, *Power from the Coast*, *op. cit.*
375 *Ibid.*

$11 billion could combine equity from the developer and the host of about a quarter, commercial loans and green bonds under Financial Services Authority Regulation No. 18/2023 of about a third, concessional and blended loans from development banks and climate partners of about a third, and advance payments from carbon buyers for the rest.[376] That mix brings the cost of capital close to the 5 percent case in Table 12. Village groups hold their pond rights and receive 40 percent of the mangrove credit income under written agreements, as Section 4.7 described. The pilot and Phase 1 can start now, while battery prices fall and the carbon markets for the later phases grow.

7.10 Regulatory Compliance

Indonesia's electricity law separates supply for public use from supply for the supplier's own use.[377] A company that generates more than 500 kW for its own use needs a license for own-use supply, the Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Sendiri (IUPTLS).[378] Selling power to consumers, by contrast, takes place within a business area held by a single company with a license for public supply (IUPTLU).[379] The structure in Section 7.9, where a project company sells power to the host, therefore needs one of two forms. The host can hold the IUPTLS for the solar, batteries and lines, and lease or buy the plant from the project company. Or the operator of the industrial estate can obtain a business area and sell power under an IUPTLU. The first form is simpler, because the host already supplies itself from its coal plants.

Renewables policy supports the plan. Presidential Regulation No. 112/2022 allows coal plants tied to industry only if they cut their emissions by at least 35 percent within ten years and stop operating by 2050.[380] The first three phases supply about 45 percent of the fleet's power by 2035, so the plan gives the host a route to meet that rule. Local content rules apply to the equipment. Minister of Energy and Mineral Resources Regulation No. 11/2024 cut the minimum local content for solar power plants to 20 percent.[381] Its allowance for imported modules covers only projects with power contracts signed by the end of 2024 that start commercial operation by June 30, 2026.[382] The plan's modules must therefore meet the local content rules, which Indonesia's growing module industry, described in Section 3.6, can serve. Coastal sites also need sea-space approval and must leave standing mangroves untouched, as Section 4.10 showed. Grid-connected sites such as Demak and Bali need a place in the revised RUPTL, as Section 2.4 showed.

376 Sari, *Power from the Coast*, *op. cit.* Landscape Advisory calculation. Illustrative shares. With equity at about 12 percent real, commercial debt at about 6 percent and concessional loans at about 1.5 percent, the blended real cost of capital is about 5 to 6 percent, close to the 5 percent in Table 12.
377 Republic of Indonesia, *Law No. 30/2009 on Electricity*, September 23, 2009, https://jdih.esdm.go.id/storage/document/UU%2030%202009.pdf, accessed on November 26, 2026.
378 Directorate General of Electricity, "FAQ Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Sendiri (IUPTLS)," Ministry of Energy and Mineral Resources, https://gatrik.esdm.go.id/assets/uploads/download_index/files/0d0f0-faq-izin-usaha-penyediaan-tenaga-listrik-untuk-kepentingan-sendiri-iuptls-.pdf, accessed on November 26, 2026.
379 Republic of Indonesia, *Government Regulation No. 14/2012 on Electricity Supply Business Activities*, January 2012, https://jdih.esdm.go.id/storage/document/PP%20No.%2014%20Thn%202012.pdf, accessed on November 26, 2026.
380 ABNR, *op. cit.*
381 Reuters, "Indonesia Eases Local Content Requirement for Solar Power Plants to 20%, Official Says," *Business Recorder*, August 12, 2024, https://brecorder.com/news/amp/40317093, accessed on November 26, 2026.
382 VOI, "The Government Sets a Time Limit for the Relaxation of TKDN PLTS," *VOI*, August 13, 2024, https://voi.id/en/amp/407232, accessed on November 26, 2026.

Area	Main rule	What the plan must do
Electricity supply	Law No. 30/2009 on Electricity and Government Regulation No. 14/2012	The host holds an own-use license (IUPTLS) for the solar, batteries and lines, or the estate obtains a business area and an IUPTLU
Captive coal	Presidential Regulation No. 112/2022	Cut fleet emissions by at least 35 percent within ten years and stop coal by 2050; the plan reaches 45 percent of fleet power by 2035
Local content	Minister of Energy and Mineral Resources Regulation No. 11/2024	Use modules and equipment that meet the local content minimum, 20 percent for solar plants
Sea space and mangroves	Government Regulations No. 28/2025 and No. 27/2025	Obtain sea-space approval (KKPRL) and place panels over ponds, flats and new mangroves only
Grid-connected sites	RUPTL 2025–2034 and its revision	Include sites that feed the PLN grid, such as Demak and Bali, in the revised plan
Carbon credits abroad	Presidential Regulation No. 110/2025 and Minister of Environment Regulation No. 10/2026	Obtain authorization, record units in SRUK and apply corresponding adjustments
Power-sector emissions trading	Minister of Energy and Mineral Resources Regulation No. 16/2022	Sell either unused allowances or credits for each ton, never both
Carbon tax	Law No. 7/2021, Article 13	No present obligation; the plan lowers future exposure

Table 14. Compliance of the plan with Indonesian electricity, renewables, climate and carbon rules. Landscape Advisory review of the rules cited in Sections 2, 4 and 7.

Climate and carbon rules decide how the tons are counted. Presidential Regulation No. 110/2025 governs carbon trading at home and transfers abroad under Article 6.[383] Every unit sold abroad must be authorized and recorded in the national carbon unit registry (SRUK).[384] Tons transferred with a corresponding adjustment count toward the buyer's target, and Indonesia cannot also claim them.[385] The power-sector trading scheme under Minister of Energy and Mineral Resources Regulation No. 16/2022 was set to give emission caps to coal plants outside PLN's business area and to plants for own use by the end of 2024.[386] Once the host's fleet holds caps, solar power leaves it with unused allowances. The host can sell those allowances or sell credits for the same tons, but not both. The carbon tax in Law No. 7/2021 has not yet been applied, so the plan lowers a future cost rather than a present one.[387] The mangrove credits follow the same registry rules.

No rule blocks the plan. It complies when the host holds the own-use license or the estate holds a business area, when its modules meet the local content rules and its sites hold sea-space approval, and when each ton appears once in the registry, as a sold credit, an unused allowance or a lower CBAM charge. Table 14 summarizes these conditions. Pending laws on renewable energy and the carbon tax could change some of them.

383 ICAP, ETS detail page, *op. cit.*
384 The Landscape Group, *op. cit.*
385 EconoTimes, *op. cit.*
386 Directorate General of Electricity, "Kementerian ESDM Terbitkan Aturan Acuan Nilai Ekonomi Karbon Subsektor Listrik," *Buletin Ketenagalistrikan*, March 2023, https://gatrik.esdm.go.id/assets/uploads/buletin/files/a808f-maret_compressed-3-.pdf, accessed on November 26, 2026.
387 Salsabila, *op. cit.* Simanjuntak, *op. cit.*

8. A Just Transition

8.1 The Meaning of Just

The partnership that Indonesia signed in 2022 is a Just Energy Transition Partnership, and the first word carries as much weight as the megawatts. Its Just Transition Framework, prepared with the United Nations Development Programme (UNDP), rests on equity, human rights, gender equality and accountability, and commits the transition to leave no one behind.[388] The framework builds on safeguards that Indonesia already applies, such as the environmental impact assessment (AMDAL) and land acquisition and resettlement plans, and adds a standard for economic diversification. The International Partners Group set aside a grant of about $200 million for just transition work, including capacity building, studies and pilots.[389] Progress has been slow. Climate Action Tracker finds that the social side of the transition remains underdeveloped and that most of the finance comes as loans, with little in grants.[390] Finance has also been slow to arrive. By September 2026, approved JETP financing stood at $3.92 billion, against a pledge of $21.4 billion.[391]

The solar program in this paper touches four groups. Coal provinces and the firms that supply their mines lose jobs and income as coal declines. Workers at the coal and diesel plants that solar replaces need new work. Coastal villages host the panels on the shores and waters that they farm and fish. Women, young people and informal workers stand to gain or lose more than others in each of these groups. This section sets out what each group faces and how the program can treat it fairly. Table 15 summarizes the measures, and Section 8.7 sets out the safeguards for coastal solar carbon projects.

8.2 Coal Provinces

Indonesia burns most of its coal in Java and mines it elsewhere. East Kalimantan, South Kalimantan and South Sumatra produce about 80 percent of the country's coal, which reached a record 836 million tons in 2024. Coal mining makes up 35.8 percent of East Kalimantan's regional economy, 29.6 percent of South Kalimantan's and 15.9 percent of South Sumatra's.[392] The World Bank ranks these three provinces as the most vulnerable to the coal transition, measured by their exposure to coal assets, their dependence on them and their capacity to adapt.[393] Nationally, coal made up about 3.6 percent of the economy in 2022, and in some

388 Shimomura, N., "Just Transition: A Pivotal Measure for Fair Energy Transition in Indonesia," *The Jakarta Post*, December 23, 2023, https://www.thejakartapost.com/opinion/2023/12/23/just-transition-a-pivotal-measure-for-fair-energy-transition-in-indonesia.html, accessed on November 26, 2026.
389 Larasati, L. K., and T. Mafira, "Highlights from Indonesia's JETP Comprehensive Investment and Policy Plan," Climate Policy Initiative, December 5, 2023, https://www.climatepolicyinitiative.org/highlights-from-indonesias-jetp-comprehensive-investment-and-policy-plan/, accessed on November 26, 2026.
390 Climate Action Tracker, "Indonesia: Policies and Action," *op. cit.*
391 JETP Secretariat, "JDU Newsletter First Edition," September 8, 2026, https://jetp.id/news/jdu-newsletter-first-edition, accessed on November 26, 2026. JETP Secretariat, "Just Energy Transition Partnership Indonesia," homepage, n.d., https://jetp.id, accessed on November 26, 2026.

392 Energy News, "Indonesia Records 836 Mt Coal Output in 2024 Despite Falling Revenues," 2025, https://energynews.pro/en/indonesia-records-836-mt-coal-output-in-2024-despite-falling-revenues, accessed on November 26, 2026. Statista, "Share of Coal Mining in GRDP by Province, Indonesia" (Hamburg: Statista, 2024).
393 Tas, E. O., E. Canpolat, M. Cole, A. Setyowati, and J. Woodhouse, *Spatial Analysis of Coal Transition Vulnerability in Indonesia*, Policy Research Working Paper 11188 (Washington, DC: World Bank, August 19, 2025), https://hdl.handle.net/10986/43616, accessed on November 26, 2026.

regencies mining makes up as much as 80 percent of the local economy.[394]

Landscape Advisory traced how the closure of coal plants in Java reaches the coal provinces. The loss travels through two channels. Lower coal exports, which Indonesian policy does not control, cut provincial income from the mid-2020s. Indonesian plant retirement adds a domestic loss from 2038 under the JETP pathway, or from 2048 under the slower phase-down of the RUKN. By 2060, about 1.15 million full-time-equivalent jobs are lost across both channels, almost all of them in the mines and in the transport, trade, equipment and service firms that supply them. East Kalimantan bears 47 percent of the domestic loss, South Sumatra 26 percent, the 31 provinces with neither mines nor retiring plants 24 percent, and South Kalimantan, which mostly exports, 3 percent. For the country as a whole the loss stays below about 0.3 percent of GDP in any year, while GDP in 2060 is 7.6 percent higher than under business as usual.[395]

The gains do not land where coal is lost. Under the JETP pathway, the supply chains of new clean power support about 42.5 million job-years over 2025–2060, against 10.7 million lost in coal. The three coal provinces receive about 6 percent of these gains and bear 76 percent of the domestic loss, while five Java provinces take about 69 percent of the gains. A power project that buys its civil works, cement and quarrying locally keeps about 40 percent of its supply-chain value in the host province, against about 2 percent when it buys on the national pattern.[396] Floating and coastal solar can help close this gap. The national program can place part of its pipeline on the coasts and reservoirs of East Kalimantan and South Sumatra, buy civil works and services there and train local workers to build and run the plants. South Sumatra needs early attention, because its economy is less diversified than East Kalimantan's and less able to absorb the loss.[397]

Sawahlunto in West Sumatra shows the cost of planning late. Mining fell from 51 percent of the city's economy in 1995 to 5 percent by 2017. Thousands of residents left, informal workers made up nearly half the labor force by 2023, and the livelihood programs that followed were too small to make up for the decline.[398]

8.3 Plant Workers

Most of the jobs at risk lie in the mines and the firms that supply them, not at the plants.[399] The plant jobs are fewer, but they end on a known date. Each coal unit and diesel generator that solar replaces employs operators, mechanics, fuel handlers and contract staff. The phased plan in Section 7 retires the reference fleet's coal units over about a decade, so the owner knows years in advance which units will close and when. That lead time allows a worker plan for each unit. Staff can retrain for solar, battery and grid operation, or for the mangrove and pond work around the arrays. Workers near retirement can receive a pension bridge, and those

394 Vazi, B., I. Sepia, P. Gass, R. M. Sundari, A. D. A. Firmansyah, S. Oktavilia, S. H. Azyzia, and R. Prayogi, *Navigating Inclusive Just Transitions in Indonesia*, policy brief (Winnipeg: International Institute for Sustainable Development, November 2025), https://www.iisd.org/system/files/2025-11/just-transition-coal-indonesia-summary.pdf, accessed on November 26, 2026.
395 Results of Landscape Advisory's modeling of the subnational effects of coal retirement in Indonesia.
396 Results of Landscape Advisory's modeling of the subnational effects of coal retirement in Indonesia.
397 Tas, *Coal Transition Vulnerability*, *op. cit.*
398 *Ibid.*
399 Results of Landscape Advisory's modeling of the subnational effects of coal retirement in Indonesia.

who leave can receive severance and help finding new work. On remote islands, the staff who run diesel generators can run the solar and battery systems that replace them. Workers who still lose their jobs have a national safety net. Under Government Regulation No. 6/2025, the Job Loss Guarantee (JKP) pays 60 percent of wages for up to six months, on wages capped at 5 million rupiah, or at most 3 million rupiah a month.[400] Skilled plant workers who earn more than the cap receive a smaller share of their pay, so the worker plan should top up the benefit and keep paying for training until each worker finds a new job.

Carbon finance can make this plan a condition of payment. Gold Standard's JUST methods for coal plants and for diesel and other fossil generators require a just transition plan before a closure earns credits, as Section 5.3 explains.[401] Buyers under Article 6 can ask for the same plan for every retirement they finance. The plan should be agreed with workers and their unions before the closure date is fixed, and its results should be reported with the credits.

8.4 Coastal Communities

Coastal solar uses shores and shallow waters that villages already farm and fish, so their consent and their share of income decide whether the program is fair. Section 4.7 sets out the starting point. Each village gives free, prior and informed consent, signs a written income-sharing agreement, and has a complaints process and an updated environmental impact assessment.[402] Under the proposed terms, 40 percent of blue carbon credit revenue goes to village groups, and a household working two hectares of ponds can earn about $1,550 to $2,280 a year, which is 60 to 88 percent of a year's provincial minimum wage, as Section 4.9 shows. The full plan in Section 7 involves about 12,200 households.

Villages can also take active roles in the project. A village enterprise or cooperative can hold the pond plots, run the mangrove nursery and take maintenance contracts for the arrays, as Section 4.7 describes. Village members can sit on the committee that hears complaints and help monitor the mangroves for the carbon credits. These roles give households paid work and a voice in how the site is run.

The risks are as real as the gains. Arrays can block boats and fishing grounds, pond tenure is often informal and disputed, and payments can flow to a few village leaders instead of the households that do the work. The program can map who uses each pond and fishing ground before design, keep channels open for boats, record tenure in the income-sharing agreement, and pay village shares through open accounts that households can check. In Demak, the families that lost their ponds and homes to the sea can be first in line for pond plots and site jobs, so that the project restores income to the people who lost it.

8.5 Women, Young People and Informal Workers

The World Bank finds that the coal transition will fall hardest on groups with the least protection. Women in

400 Interesse, G., "Indonesia Updates Job Loss Program: What Employers Need to Know," *ASEAN Briefing*, April 18, 2025, on Government Regulation No. 6/2025 amending Government Regulation No. 37/2021 on the Job Loss Guarantee Program, https://www.aseanbriefing.com/news/indonesia-updates-job-loss-program-what-employers-need-to-know/, accessed on November 26, 2026.
401 Gold Standard, *JUST: Coal Decommissioning*, *op. cit.* Gold Standard, "First Methodology," *op. cit.*

402 Sari, *Power from the Coast*, *op. cit.*

coal communities are often shut out of the income that mining brings. Young people in low-skilled support jobs, and informal workers more broadly, lack formal contracts, social protection and access to retraining. Indigenous communities face risks to their land and livelihoods.[403] IISD adds that women in coal regions earn less than men, and it recommends gender equality, disability and social inclusion (GEDSI) focal points in the agencies that run the transition.[404]

Coastal solar can offer these groups paid work. In Demak, Mak Jah has planted mangroves for two decades and grows seedlings for others to plant.[405] The program can contract village nurseries for seedlings, set targets for women, local youth and former informal workers in technician training, and report these results to the buyers of its carbon credits.

8.6 Paying for a Just Transition

Indonesia already has the channels to pay for a just transition. The 2025 budget carries Rp192 trillion in revenue-sharing funds, Rp447 trillion in general allocation funds, Rp184 trillion in special allocation funds and Rp71 trillion in the Village Fund. These transfers take years to redirect, and the domestic coal loss begins in the late 2030s, so the 2030s are the time to prepare them. Support should follow each province's supply of coal to Indonesian power plants, which places South Sumatra ahead of South Kalimantan despite its smaller coal economy.[406]

Carbon pricing can add to these funds. Landscape Advisory's modeling finds that a tax rising to $50 a ton raises an average of about $7.4 billion a year over 2025–2060, enough to match the whole JETP pledge roughly every three years. Returning 35 percent of the revenue to households covers two to four times the carbon cost in their electricity bills. Tariffs peak in 2035–2037, years before revenue peaks in 2044, so household support should come early. The revenue falls once coal is gone, so it should fund one-time needs such as retraining, grids and storage.[407]

The solar program brings its own money as well. The village share of mangrove credits funds coastal communities. A fixed share of each transition credit sale can fund retraining, severance and regional diversification for the plants it retires. CBAM savings accrue to the host, which can fund a worker plan for its own coal units. The $200 million JETP grant can pay for the first worker plans, village tenure mapping and training programs, and Norway and later buyers can add their own grants.[408]

8.7 Safeguards for Coastal Solar Carbon Projects

A coastal solar project that sells carbon credits must meet the safeguards of the standards that certify them. Under the ICVCM's Core Carbon Principles, projects must assess and reduce risks to Indigenous Peoples and local communities, obtain their free, prior and informed consent and show how they share benefits.[409] An ICVCM

403 Tas, *Coal Transition Vulnerability*, *op. cit.*
404 Vazi, *Inclusive Just Transitions*, *op. cit.*
405 Mongabay Indonesia, "Keluarga Mak Jah," *op. cit.*
406 Republic of Indonesia, *Law No. 62/2024 on the 2025 State Budget*, 2024. The special allocation funds combine Rp37 trillion of physical and Rp147 trillion of non-physical allocations. The timing of the loss and the ranking of provinces are results of Landscape Advisory's modeling of the subnational effects of coal retirement in Indonesia.
407 Results of Landscape Advisory's modeling of carbon pricing in Indonesia.
408 Larasati and Mafira, *op. cit.*
409 Integrity Council for the Voluntary Carbon Market, "Fact Sheet: Integrity Council for the Voluntary Carbon Market," n.d., https://www.icvcm.org/wp-content/uploads/2024/

Group	What changes	Measures
Coal provinces and their supply chains	Lost coal sales spread to transport, trade and service firms, and East Kalimantan and South Sumatra bear most of the domestic loss	Solar sites, local purchasing and training in coal provinces; transfers that follow domestic coal supply, prepared in the 2030s; diversification before closures
Workers at retired coal units and diesel generators	Jobs end on a known date	A worker plan for each unit, agreed with unions; retraining for solar, batteries, grids and ponds; pension bridges, severance and a top-up to the Job Loss Guarantee
Coastal villages	Shores and waters host solar arrays	Free, prior and informed consent; written income sharing; village enterprises holding ponds, nurseries and maintenance contracts; tenure mapping; open channels for boats; open accounts for village shares
Women, young people and informal workers	Less protection and fewer formal jobs	Nursery and processing contracts; training targets; GEDSI focal points; results reported to credit buyers
Displaced coastal families	Ponds and homes lost to the sea	First call on pond plots and site jobs
Electricity users	Tariffs rise if carbon is priced, peaking in 2035–2037	Household support from carbon revenue, paid early

Table 15. Groups affected by the solar program and the measures to treat them fairly. Landscape Advisory, drawing on Tas, *Coal Transition Vulnerability*, on Vazi, *Inclusive Just Transitions*, on Landscape Advisory's modeling, and on Sections 4 and 7.

review in October 2025 called for stronger protections, clearer rules for fair benefit sharing and more inclusive consent.[410] Under Article 6.4, a sustainable development tool adopted in October 2024 assesses each activity's social and environmental impacts and monitors them after registration, and a separate procedure lets affected people file grievances.[411] Transition credits under Gold Standard's JUST methods also require a just transition plan.[412]

The project can turn these rules into commitments that a verifier checks. Before design, it can map who uses each pond, mangrove and fishing ground, and identify those most at risk, such as fishers without title, women and customary communities. It can obtain written consent in each village and accept a refusal. It can avoid moving anyone and replace any lost pond access with a plot or income. It can write the 40 percent village share of blue carbon revenue and household pond income into the project documents and pay them through open accounts. It can run a complaints process that the developer does not control. It can monitor household income, jobs for women and young people and access to fishing grounds alongside the carbon, and have the same verifier check them. Credits are then issued only while the project keeps these commitments.

09/CCP-Fact-Sheet-FINAL-01-8-24.pdf, accessed on November 26, 2026.

410 Integrity Council for the Voluntary Carbon Market, *Continuous Improvement Work Program Report: Sustainable Development Benefits and Safeguards*, version 1 (London: Integrity Council for the Voluntary Carbon Market, October 2025), https://icvcm.org/wp-content/uploads/2025/10/CIWP-SD-Benefits-Safeguards_Report.pdf, accessed on November 26, 2026.

411 Article 6.4 Mechanism Supervisory Body, "Draft Tool: Article 6.4 Sustainable Development Tool, Version 02.0," A6.4-SBM021-AA-A03, United Nations Framework Convention on Climate Change, May 2026, https://unfccc.int/sites/default/files/resource/A6.4-SBM021-AA-A03.pdf, accessed on November 26, 2026. Article 6.4 Mechanism Supervisory Body, "Procedure: Appeal and Grievance Processes under the Article 6.4 Mechanism, Version 01.0," A6.4-SB011-A03, United Nations Framework Convention on Climate Change, https://unfccc.int/sites/default/files/resource/a64-sb011-a03.pdf, accessed on November 26, 2026.

412 Gold Standard, *JUST: Coal Decommissioning*, *op. cit.*

9. Concluding Note

Global climate talks stalled at COP31, but the tools to cut emissions kept working. The coalition of about 130 countries that refused a deal without fossil fuels, and the carbon markets that came through the summit intact, leave a clear path for countries that act together. The Indonesia–Norway agreement is one such path. It puts a price of $20 to $40 per ton on the emission cuts from Indonesian solar power, starting with floating solar.

Indonesia needs this finance because its power system has grown more dependent on coal. Three state programs since 2006 built mostly coal plants, and a capped coal price kept them cheap to run. Coal now supplies two-thirds of PLN's electricity, power-sector emissions rose by 86 million tons of CO2 in the decade to 2023, and captive coal plants add a second, fast-growing source of emissions for industry. Each kWh of solar therefore cuts more carbon in Indonesia than in most countries. The policy framework points toward clean power, from the Second NDC to carbon pricing and the 100 GWp solar program. RUPTL 2025–2034 lags behind it. The plan adds more fossil than renewable capacity before 2030, emits more each year to 2030 than the plan it replaced and leaves most of the 100 GWp program out. Carbon agreements can pull renewable deployment forward into those years. Solar is the cheapest new power in most of the world, yet Indonesia has only about 1.6 GW of it, so the gap between policy and delivery is wide.

Floating and coastal solar can close much of that gap. Reservoirs can host tens of gigawatts, and Indonesia's calm seas far more. Former shrimp ponds offer cleared, flat coastal land connected to the sea. Solar on piles is proven at gigawatt scale in China, while floating solar on the open sea is still in pilots. Built on stilts above restored mangroves and productive ponds, with four hectares of mangrove for each hectare of panels, coastal solar can remove more carbon than its panels emit over their life. The ponds give coastal villages income and a stake in the project, and the villages in turn care for the mangroves and the panels. In Bali, solar at sea off the north coast can replace diesel and meet demand that will outgrow supply from 2030. Buru Island can replace its diesel the same way, and the drowned hamlets of Demak, where the Sayung coast has lost about 1,710 hectares of ponds, can turn land lost to the sea into a site for solar among the mangroves that Mak Jah has planted for two decades, restoring income for displaced families and protecting the coast.

Carbon finance can help pay for this, and it pays most when solar replaces fossil plants. Bilateral deals can fund solar now. Transition credits can fund the retirement of diesel, grid coal and captive coal, and blue carbon credits can reward the mangroves. A jurisdictional approach such as STEPS can bring these results together across the whole power sector. Indonesia's carbon rules, its registry and its emphasis on high integrity give each form of solar a route to these credits. A domestic carbon price would act mostly after 2040, so carbon finance from abroad matters most before then. The 12 million tons of the Norway agreement can anchor about 1 to 2 GWp of floating and coastal solar and $1 to $2.6 billion of investment. The agreement involves PLN, but it may need to extend to captive coal plants, which emitted about 135 million tons of CO2 in 2025. Carbon

revenue covers a significant share of that investment and closes the gap between floating solar and coal. Across all of Indonesia's renewables, diesel replacement, ground solar, hydro and coastal solar cut carbon most cheaply, and freshwater floating solar falls within the Norway price.

Carbon-negative coastal solar can also replace a whole captive coal fleet. For an 890 MW fleet, 5 GWp of coastal solar with 12 GWh of batteries and links to distant coastal sites would cost about $9 to $11 billion and supply about 97 percent of the fleet's power. The daytime phases come close to paying their way at the Norway price. Replacing night-time coal needs much more carbon revenue under commercial finance. Cheaper batteries, blended finance and credits paid over the plant's life bring the full plan close to the upper end of the Norway price, while the mangroves and ponds give about 12,200 households a steady income. Savings on CBAM can close the rest of the gap only if the EU extends the charge to the electricity used to make the host's products and the host sells much of its output in Europe, so the plan rests first on carbon credits, cheaper batteries and blended finance. The plan fits Indonesian law when the host holds the license for own-use supply, its equipment meets the local content rules and each ton is recorded once, as a sold credit, an unused allowance or a lower CBAM charge. Captive coal plants must cut their emissions by 35 percent within ten years under Presidential Regulation No. 112/2022, and the plan gives the host a way to do it.

The transition must also be just. Three coal provinces, East Kalimantan, South Kalimantan and South Sumatra, would bear about three-quarters of the domestic loss from retiring coal plants but receive about 6 percent of the gains from clean power. The program can place part of its solar in coal provinces and buy locally there. It can give each retired coal unit and diesel generator a worker plan agreed with unions, and build coastal solar on village consent, written income sharing and secure tenure, with paid work for women and young people. Indonesia can prepare its regional transfers in the 2030s, before the domestic loss begins. Each coastal solar carbon project can make consent, benefit sharing and an independent complaints process conditions of its credits. Carbon finance can pay for this through the village share of mangrove credits, a share of each transition credit sale and the $200 million JETP grant for just transition work.

Indonesia can take five steps to turn the agreement into a national program. First, complete the rules for authorizing, recording and transferring units in SRUK, so that the first tons reach Norway on time. Second, give project companies a contractual share of the carbon revenue, and pair it with blended finance from development banks and climate partners, so that private developers and lenders can finance projects under the agreement. Third, open the reservoirs, idle ponds and calm coastal waters to floating and coastal solar through clear rules on sea space and mangroves. Fourth, with each village's consent, start pilots of carbon-negative coastal solar where villages already care for their mangroves, as in Demak, pilots of coastal solar that replace diesel on islands such as Buru, and a pilot of floating solar that replaces diesel in Bali. Fifth, prepare for sector-wide crediting under a jurisdictional approach, so that the same system can serve more buyers and carry the 100 GWp program further.

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