Indonesia Solar Energy Outlook 2025

The rising importance of solar energy in leading Indonesia's energy transition

IESR
Institute for Essential Services Reform

Imprint

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Foreword

Soon, the sun will be shining at the end of the tunnel!

Globally, solar photovoltaic (PV) is the most popular form of renewable energy. More than 85% of all renewable energy installations in 2023 were solar PV, which reached 444 GW around the world. The world's total solar PV capacity has reached 1.6 TW. Installing solar PV panels is faster than a year ago due to lower solar module and system costs, higher electricity needs after the pandemic, and government policies to reduce emissions. Solar PV is expected to reach a total capacity of 6.7 TW by the end of 2030, with around 5.1 TW of new solar capacity added during 2024-2030. This capacity aligns with the target to triple the world's renewable energy capacity by 2030, which was agreed upon at COP28 last year. The goal is to reach 11.5 TW of total renewable energy capacity.

However, Indonesia needs to catch up with the global solar PV trend. Despite having a huge resource potential of 3.3 to 20 TW, solar PV installed capacity has yet to reach 1 GW. It is time for Indonesia to catch up to Vietnam, the Philippines, Malaysia, Cambodia, and Singapore regarding energy capacity. While other countries in the region are increasing their renewable energy goals and the amount of renewable energy they use, especially solar PV, Indonesia's policymakers and utilities are still not ready to increase the amount of solar PV they use. PLN wants to install 2.3 GW of new solar PV by 2025 and 4.7 GW by 2030, but it is still moving slowly toward its goal. So, the government's plan to add 3.6 GW of PV to rooftops by 2025 was met with resistance from the utility companies and some important government agencies, which were worried that the cost of generation would go up and the government would have to pay more to subsidize electricity. Cirata's 145 MW floating solar PV was the most impressive installation. It was the biggest floating solar plant in Southeast Asia and was put into service in November 2023.

Over the past two years, we have witnessed a downturn in the solar PV industry. However, this trend is reversing, and the future of solar PV in Indonesia looks promising. In the long term, solar PV will play a crucial role in transitioning the power system to carbon-free energy by 2050. It is projected that between 350 GW and 550 GW of solar PV will be installed by 2050. In the short term, however, we think emerging demands will lead to more solar PV capacity in the next three years.

The growth of solar energy in Indonesia will come from several robust sources. Firstly, PLN's RUPTL plans to significantly increase the capacity of renewable energy to meet rising demand, including 7.9 GW of solar by 2033. Secondly, rooftop PV is expected to add 5 GW in the next five years due to recent changes in rules by MEMR. Thirdly, Indonesian companies will build and export 2 GWac of green power to Singapore, adding up to 11 GW capacity by 2028. Additionally, mining companies and industrial parks are actively seeking to add renewable energy to lower their carbon footprint, with solar PV as the most cost effective option. Lastly, the government's ambitious plan to produce 9.9 MtPA of hydrogen by 2060 is driving the need for solar power, with both SOEs and private businesses confidently starting to produce green hydrogen using solar PV and wind power.

Still, it is difficult to obtain investments in renewable energy, especially solar, due to regulatory and non-regulatory hurdles, such as land acquisition. Making the potential demand for solar energy turn into real capacity requires a massive improvement in the enabling environment and reform: clear and transparent policy, predictable regulatory framework, transparent and frequent solar PV procurement of PLN, revision of the majority shareholder scheme of PLN's subsidiaries, managing local content regulation while building domestic solar PV industries, providing fiscal and non-fiscal incentives for consumers and industries to install solar PV, and taking away all forms of subsidies to fossil fuels, such as coal's DMO pricing.

If the reforms in these areas go well, the solar revolution will indeed happen in Indonesia.

Jakarta, October 2024

Fabby Tumiwa
Executive Director

List of Abbreviations

AESI	:	*Asosiasi Energi Surya Indonesia*
APBN	:	*Anggaran Pendapatan dan Belanja Negara*
APDAL	:	*Alat penyalur daya listrik*
ASEAN	:	Association of Southeast Asian Nations
BESS	:	Battery energy storage system
BNEF	:	Bloomberg New Energy Finance
BPP	:	*Biaya pokok produksi*
BPS	:	Best Policy Scenario
C&I	:	Commercial & industry
CA	:	Conditional approval
CBES	:	Cross-Border Electricity Sales
CAPEX	:	Capital Expenditures
CFPP	:	Coal-fired power plant
CHP	:	Combined heat and power
CL	:	Conditional license
COD	:	Commercial operation date
COP	:	Conference of Parties or United Nations Climate Change Conference
DG NREEC	:	Directorate General of New, Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources
DGE	:	Directorate General of Electricity, Ministry of Energy and Mineral Resources
EIRR	:	Equity internal rate of return
EMA	:	Singaporean Energy Market Authority
EMDE	:	Emerging markets and developing economies
EMITS	:	PT Empat Mitra Indika Tenaga Surya
ENEGEM	:	Energy Exchange Malaysia
ESDM	:	*Energi dan Sumber Daya Mineral*
ESG	:	Environmental, Social, and Governance
EU	:	European Union
EV	:	Electric vehicle
FPV	:	Floating photovoltaic
GoI	:	Government of Indonesia
GW	:	Gigawatt
IBC	:	Interdigitated Back Contact
IEA	:	International Energy Agency
IKN	:	*Ibu Kota Nusantara*
IPP	:	Independent power producers
IRENA	:	International Renewable Energy Agency
ISA	:	International Solar Alliance
ITRPV	:	International Technology Roadmap for Photovoltaic
IUPTLS	:	*Izin Usaha Penyediaan Tenaga Listrik Untuk Kepentingan Sendiri*
IUPTLU	:	*Izin Usaha Penyediaan Tenaga Listrik Untuk Kepentingan Umum*
KEN	:	*Kebijakan Energi Nasional*
LCOE	:	Levelized Costs of Electricity
LCR	:	Local content requirement
LOI	:	Letter of intent
LTSHE	:	*Lampu tenaga surya hemat energi*
MEMR	:	Ministry of Energy and Mineral Resources

List of Abbreviations

MNRE	:	Indian Ministry of New and Renewable Energy
MOEF	:	Ministry of Environment and Forestry
MoF	:	Ministry of Finance
MoI	:	Ministry of Industry
MPWH	:	Ministry of Public Works and Public Housing
MTF	:	Multi-Tier Framework for Energy Access
MW	:	Megawatt
NREL	:	National Renewable Energy Laboratory
NZE	:	Net-zero emission
PJUTS	:	*Penerangan jalan utama tenaga surya*
PLN	:	*Perusahaan Listrik Negara*
PMN	:	*Penyertaan modal negara*
PPA	:	Power purchase agreement
PPU	:	Private power utility
PSN	:	*Proyek Strategis Nasional*
PT	:	*Perseroan Terbatas*
PV	:	Photovoltaic
RE	:	Renewable energy
REW	:	Renewable Energy World
RIPIN	:	*Rencana Induk Pengembangan Industri Nasional*
RUEN	:	*Rencana Umum Energi Nasional*
RUKN	:	*Rencana Umum Ketenagalistrikan Nasional*
RUPTL	:	*Rencana Usaha Penyediaan Tenaga Listrik*
SAIDI	:	System average interruption duration index
SB	:	Malaysian Single Buyer
SHL	:	Shareholder loan
SLO	:	*Sertifikat Layak Operasi*
SPEL	:	*Stasiun pengisian energi listrik*
TOPCon	:	Tunnel Oxide Passivated Contact
UID	:	PLN's *Unit Induk Distribusi*
UP3	:	PLN's *Unit Pelaksana Pelayanan Pelanggan*
US	:	United States of America
VRE	:	Variable renewable energy

Table of Contents

Executive Summary

- In 2023, the global renewable energy sector saw a significant increase, adding 473 GW of new capacity, an 87% rise, according to IRENA (2024). Solar energy led this growth, contributing 73% (346 GW) of the new capacity. China dominated, installing 217 GW (63% of the global total), while India and Brazil also made notable gains with 9.7 GW and 11.9 GW, respectively, driven by auctions and favorable policies. Southeast Asia lagged, adding only 2.78 GW from 2021 to 2023, but countries like Malaysia, the Philippines, and Singapore showed positive momentum. Indonesia, with vast potential, achieved a record 260 MW in 2023. This solar growth is essential to meeting the global goal of tripling renewable energy capacity to 11 TW by 2030, set by COP28. Solar energy is on track to meet these targets, with annual capacity additions of at least 1 TW projected from 2024 to 2030, contributing 43.6% of renewable capacity by 2030.

- IESR consistently tracks the solar energy progress in Indonesia and has released the **Indonesia Solar Energy Outlook (ISEO) 2023** back in 2022. Since 2022, Indonesia has added 510 MW of new solar energy capacity. This capacity addition mainly comes from utility scale installations (208 MW), although rooftop solar has also shown remarkable growth in the same period with 196 MW capacity added. Off-grid installation has stagnated since 2022, with some progress on small-scaled pre-electrification projects such as mini-solar lamp and mini-home system. Unexpectedly, captive sites adoption in solar power has grown significantly, with over 100 MW of new capacity installed in this period.

- Since 2022, solar-related policy landscape in Indonesia has shifted quite significantly. The Ministry of Energy and Mineral Resources (MEMR) Regulation 2/2024 has finally stipulated in early 2024 after lengthy discussions over the years, with the quota system for rooftop PV has been effective since July 2024. The abolishment of net-metering system in the regulation has also shift the market balance into the big industrial and commercial consumers. Floating solar deployment is also gaining momentum with the Ministry of Public Works and Housing (MPWH) Regulation 7/2023 allowing larger water body usage, further supported by partnership with PLN's subsidiaries for bulk solar project procurement. Finally, the Indonesian government, specifically the MEMR and Ministry of Industry (MoI), has finally took an important action to reform the local content requirement (LCR) policy for solar energy, with the MoI Regulation 33/2024, MoI Regulation 34/2024 and MEMR Regulation 11/2024 are effective starting in August 2024. This will have an impact on several solar project development, including the Indonesia-Singapore Green Electricity Project, which already saw 3.4 GW of conditional export approvals and licences granted to 7 entities. Annual investment in solar energy has also constantly rising in the few recent years, from around USD 68 million in 2021 to USD 134 million in 2023. This positive investment trends in solar energy is also apparent in the solar module supply chain, as a total 19 GW of annual solar module production capacity has been announced, along with 200,000 million tonnes of solar-grade silicon annual production capacity, 11 GW of annual solar wafer production and 17 GW of annual solar cell production.

- Indonesia's solar energy future looks promising, with the latest energy plans (KEN, RUKN, and RUPTL) showing significant solar expansion. To meet climate targets, however, Indonesia needs to raise its renewable energy ambitions, with solar at the forefront. The preparation of the Second NDC offers an opportunity to integrate solar into climate commitments. Key projects like the Indonesia-Singapore green electricity export will drive growth, but strong leadership and regulatory clarity are crucial. Floating solar and strategic partnerships will support implementation. By 2025, regulatory effectiveness will be assessed, and infrastructure development will be key to handling high solar penetration.

Ringkasan Eksekutif

- *Pada tahun 2023, sektor energi terbarukan global mengalami peningkatan signifikan, dengan penambahan kapasitas baru sebesar 473 GW, atau kenaikan sebesar 87%, menurut IRENA (2024). Energi surya memimpin pertumbuhan ini, dengan kontribusi sebesar 73% (346 GW) dari kapasitas terpasang baru. China mendominasi, dengan memasang 217 GW (63% dari total global), sementara India dan Brazil juga membukukan catatan baik dengan memasang masing-masing 9,7 GW dan 11,9 GW. Penambahan kapasitas ini banyak disebabkan oleh lelang dan dukungan kebijakan. Asia Tenggara tertinggal, hanya menambah 2,78 GW dari 2021-2023, tetapi negara-negara seperti Malaysia, Filipina, dan Singapura menunjukkan kemajuan positif. Indonesia, dengan potensi yang besar, berhasil mencapai rekor 260 MW pada tahun 2023. Pertumbuhan energi surya ini penting untuk memenuhi tujuan global untuk meningkatkan tiga kali lipat kapasitas energi terbarukan menjadi 11 TW pada 2030, sesuai kesepakatan COP28. Energi surya berada di jalur yang tepat untuk memenuhi target ini, dengan penambahan kapasitas tahunan minimal 1 TW yang diproyeksikan dari 2024 hingga 2030, menyumbang 43,6% kapasitas terbarukan pada 2030.*

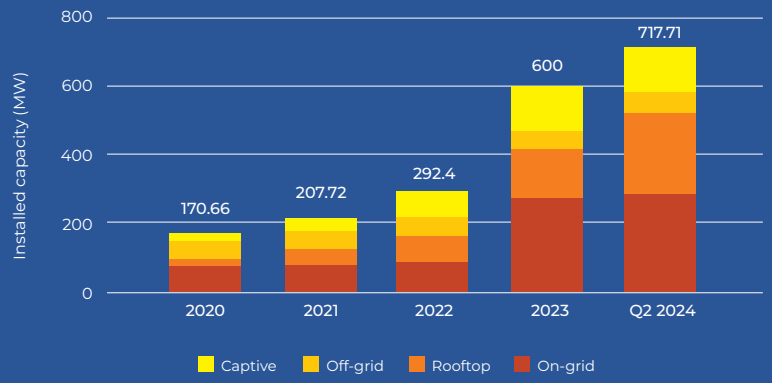
- *IESR memantau perkembangan energi surya di Indonesia secara konsisten dan meluncurkan* ***Indonesia Solar Energy Outlook (ISEO) 2023*** *pada tahun 2022. Sejak 2022, Indonesia telah menambahkan 457 MW kapasitas energi suryanya. Penambahan kapasitas ini didominasi oleh instalasi PLTS skala utilitas (208 MW), meski PLTS atap juga menunjukkan perkembangan yang luar biasa pada periode yang sama dengan penambahan kapasitas 143 MW. Instalasi* off-grid *berjalan stagnan sejak 2022, dengan sedikit kemajuan pada proyek pra-elektrifikasi skala kecil seperti lampu tenaga surya mini dan sistem rumah mini. Namun, secara tak terduga, adopsi energi surya pada lokasi* captive *justru tumbuh pesat, dengan lebih dari 100 MW kapasitas baru terpasang dalam periode ini.*

- *Sejak tahun 2022, lanskap kebijakan energi surya di Indonesia telah bergeser cukup signifikan. Peraturan Menteri Energi dan Sumber Daya Mineral (ESDM) 2/2024 akhirnya ditetapkan pada awal tahun 2024 setelah diskusi panjang selama bertahun-tahun, dengan sistem kuota untuk PLTS atap yang telah berlaku sejak Juli 2024. Penghapusan sistem net-metering dalam peraturan tersebut juga telah menggeser keseimbangan pasar ke konsumen besar dari sektor industri dan komersial. Pengembangan PLTS terapung juga mendapatkan momentum dengan Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat (PUPR) 7/2023 yang memungkinkan penggunaan badan air yang lebih luas, yang selanjutnya didukung oleh kemitraan dengan anak perusahaan PLN untuk pengadaan proyek energi surya massal. Selain itu, Pemerintah Indonesia, khususnya Kementerian ESDM dan Kementerian Perindustrian (Kemenperin) telah mengambil langkah penting untuk mereformasi kebijakan persyaratan Tingkat Kandungan Dalam Negeri (TKDN) untuk energi surya, dengan Peraturan Menteri Perindustrian 33/2024, Peraturan Menteri Perindustrian 34/2024, dan Peraturan Menteri ESDM 11/2024 yang berlaku mulai Agustus 2024. Kebijakan ini akan berdampak pada beberapa pengembangan proyek surya, termasuk Proyek Listrik Hijau Indonesia-Singapura, yang telah memperoleh persetujuan dan lisensi ekspor bersyarat sebesar 3,4 GW kepada 7 entitas. Investasi tahunan energi surya juga terus meningkat dalam beberapa tahun terakhir, dari sekitar USD 68 juta pada tahun 2021 menjadi USD 134 juta pada tahun 2023. Tren investasi positif terkait energi surya ini juga tampak dalam rantai pasokan modul surya, karena total kapasitas produksi modul surya tahunan sebesar 19 GW telah diumumkan, bersama dengan kapasitas produksi tahunan* solar-grade *silikon sebesar 200.000 juta ton, produksi wafer surya tahunan sebesar 11 GW, dan produksi sel surya tahunan sebesar 17 GW.*

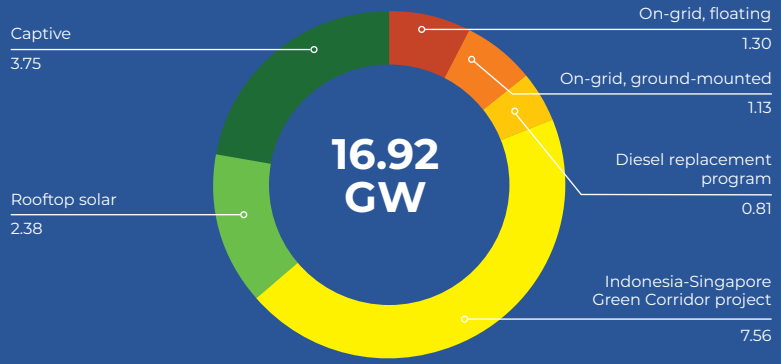
- *Masa depan energi surya Indonesia tampak menjanjikan, dengan rencana energi terbarukan (KEN, RUKN, dan RUPTL) menunjukkan pengembangan energi surya yang signifikan. Namun, untuk mencapai target iklim, Indonesia perlu meningkatkan ambisi energi terbarukannya, dengan energi surya sebagai andalan. Penyusunan NDC Kedua menawarkan kesempatan untuk mengintegrasikan energi surya ke dalam komitmen iklim. Proyek-proyek utama seperti ekspor listrik hijau Indonesia-Singapura akan mendorong pertumbuhan, tetapi kepemimpinan yang kuat dan kejelasan peraturan sangat penting. PLTS Terapung dan kemitraan strategis akan mendukung implementasi. Pada tahun 2025, efektivitas peraturan akan dievaluasi, dan pembangunan infrastruktur akan menjadi kunci untuk menangani penetrasi tenaga surya yang tinggi.*

Key Highlights

Indonesia's solar power capacity, 2020 - Q2 2024



Indonesia's announced solar power projects capacity

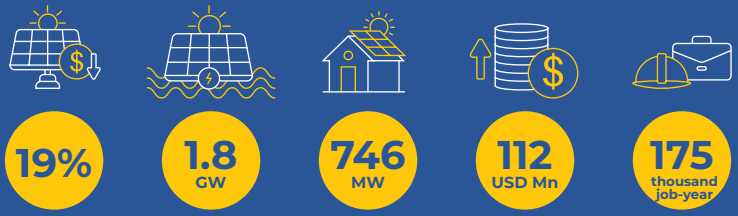


- Solar power has contributed to 346 GW capacity addition globally in 2023, or 73% of global renewable capacity addition. This global trend is also reflected in Indonesia's energy planning, with the latest National Energy Policy draft estimating around 31% of Indonesia's primary energy supply by 2060.
- However, Indonesia installed solar capacity has only reached 717.71 MW as per August 2024. The biggest contribution came from on-grid (PLN) installation, with 285 MW installed, including the newly enacted 145 MW Cirata floating solar that almost tripled on-grid solar capacity in 2023.
- Indonesia's current progress on solar development is inadequate to comply with global climate target, as several benchmarks show that Indonesia needs to add around 9-15 GW of solar energy annually between 2024-2030 to comply with the Paris Agreement 1.5 °C pathway.

- As per August 2024, there are a total of 16.92 GW of solar power project that has been announced. PLN is set to execute 3.24 GW of solar projects from the RUPTL PLN 2021-2030. These projects are dominated by floating solar (1.30 GW), while the diesel replacement program is also set to add significant solar power capacity (0.81 GW), with the first phase (0.16 GW) expected to commence in 2027.
- Indonesia-Singapore green electricity export serves as the biggest demand driver for solar projects, with a total 3.4 GW of export capacity, translated into approximately 7.56 GW of solar power plant capacity. Solar power demand from industrial captive sites is also unexpectedly high, with the announced capacity of 3.75 GW. IESR's analysis (2024) shows that the on-site solar capacity potential in captive coal sites only 2.88 GW, indicating that power wheeling could be a game-changing policy. PLN also has revealed the allocated quota for rooftop PV until 2033 (2.38 GW), with the 2024 quota having only 6-10% left.

Key Highlights

Enabling environment for solar power development in Indonesia



- Utility-scale solar power plant costs in Indonesia have dropped by 19% in the last 5 years, mostly driven by solar module and soft costs reduction. To increase the adoption of utility-scale solar, PLN has prepared bundled procurement with other power plant types, as well as put forward strategic partnerships with its subsidiaries. IESR has identified the need for an additional 746 MW of flexibility capacity to scale up rooftop solar adoption, provided by flexible power plant operation (notably coal), as a well as major rollout of the energy storage system.

- Solar energy-related investment in Indonesia almost doubled from USD 68 million in 2021 to around USD 135 million in 2023. In 2024, around USD 112 million of investment in solar energy has been announced. To support the ever growing solar energy sector, adequate and inclusive skill upgrades (both vocational and high-order skill) are needed to capitalize the expected 175,000 job years created.

Indonesia solar power supply chain production capacity

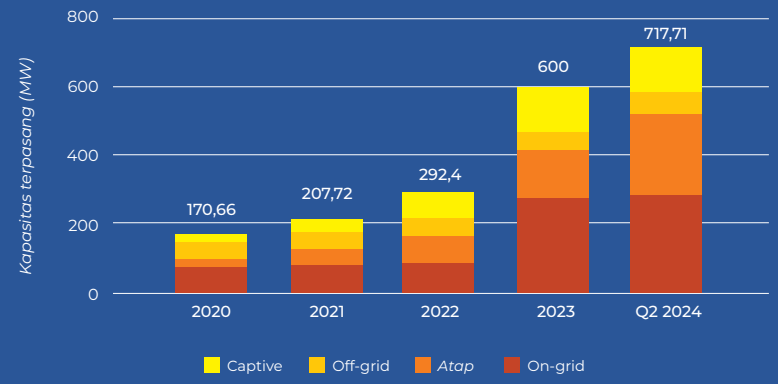
Solar-grade polysilicon	Silicon wafer	Solar cell	Solar module	Solar inverter
No available production capacity	No available production capacity	No available production capacity	**2.3 GW** annual production capacity	No available production capacity
200,000 million tonnes announced annual production capacity addition	**11 GW** announced annual production capacity addition	**17 GW** announced annual production capacity addition	**19 GW** announced annual production capacity addition	No announced project

- Indonesia's solar supply chain production capacity has remained stagnant in the past few years, with solar module production capacity stands at 2.3 GW per year and mostly running on a per-project basis. Lack of demand volume and unrealistic local content requirements (LCR) policy are several key factors hindering the development. However, the latest revision to relax solar LCR policy in the next 2 years could serve as a game-changing policy for scaling up domestic solar demand.

- Announced commitment to investing in Indonesia's solar module supply chain has grown in the last 1-2 years, with several already beginning construction phase. This is mainly due to strategic projects (Indonesia-Singapore green electricity export) and Indonesia's geopolitical advantage in several foreign markets. To sustain this growth, the Indonesian government should be keen on giving more fiscal/non-fiscal incentives to increase domestic products' competitiveness and create demand signaling through more solar projects in the pipeline.

Sorotan Utama

Kapasitas energi surya Indonesia, 2020 - Q2 2024

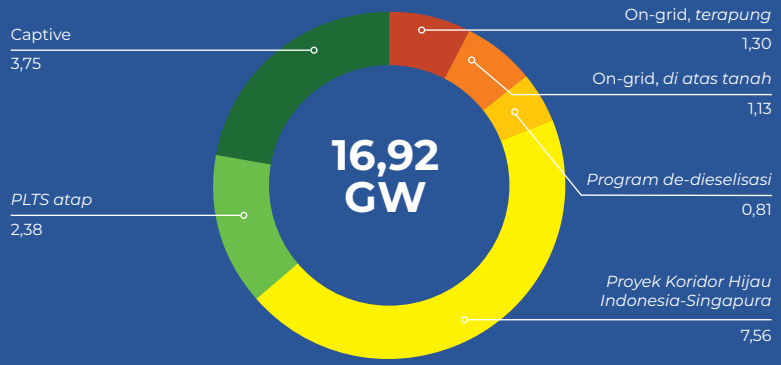


- *Energi surya telah berkontribusi terhadap penambahan kapasitas sebesar 346 GW secara global pada tahun 2023, atau 73% dari penambahan kapasitas energi terbarukan global. Tren global ini juga tercermin dalam perencanaan energi Indonesia, dengan rancangan Kebijakan Energi Nasional termutakhir memperkirakan sekitar 31% dari pasokan energi primer Indonesia pada tahun 2060 berasal dari energi surya.*

- *Namun, kapasitas terpasang tenaga surya di Indonesia baru mencapai 664,5 MW per Juni 2024. Kontribusi terbesar berasal dari pemasangan* on-grid *(PLN), dengan 285 MW terpasang, termasuk PLTS terapung Cirata 145 MW yang baru saja diresmikan, yang hampir melipatgandakan kapasitas tenaga surya on-grid pada tahun 2023.*

- *Kemajuan Indonesia saat ini dalam pengembangan energi surya belum memadai untuk memenuhi target iklim global, karena beberapa tolok ukur menunjukkan bahwa Indonesia perlu menambah sekitar 9-15 GW energi surya setiap tahunnya antara tahun 2024-2030 untuk sejalan dengan jalur 1,5°C Persetujuan Paris.*

Kapasitas proyek PLTS Indonesia yang diumumkan



- *Hingga Agustus 2024, total proyek PLTS yang telah dicanangkan mencapai 16,92 GW. PLN akan melaksanakan proyek PLTS sebanyak 3,24 GW dari RUPTL PLN 2021-2030. Proyek-proyek tersebut didominasi oleh PLTS terapung (1,30 GW), sementara program de-dieselisasi juga akan menambah kapasitas PLTS yang signifikan (0,81 GW), dengan tahap pertama (0,16 GW) diharapkan akan dimulai pada tahun 2027.*

- *Ekspor listrik hijau Indonesia-Singapura menjadi pendorong permintaan terbesar untuk proyek energi surya, dengan total kapasitas ekspor sebesar 3,4 GW, yang berarti sekitar 7,56 GW kapasitas pembangkit listrik tenaga surya. Permintaan energi surya dari lokasi industri juga sangat tinggi, dengan kapasitas yang diumumkan sebesar 3,75 GW. Analisis IESR (2024) menunjukkan bahwa potensi kapasitas energi surya di lokasi PLTU* captive *hanya 2,88 GW, yang menunjukkan bahwa mekanisme power wheeling dapat menjadi kebijakan yang transformatif (*game-changing*). PLN juga telah mengungkapkan kuota yang dialokasikan untuk PLTS atap hingga tahun 2033 (2,38 GW), dengan kuota tahun 2024 hanya tersisa 6-10%.*

Sorotan Utama

Lingkungan yang mendukung pengembangan energi surya di Indonesia

19%
Rata-rata penurunan biaya energi surya skala utilitas (USD/kW) di Indonesia, 2018-2022

1.8 GW
Potensi proyek PLTS utilitas yang dapat digabungkan dengan jenis pembangkit listrik lainnya

746 MW
Kapasitas pembangkit fleksibel diperlukan dalam sistem Jamali untuk meningkatkan adopsi PLTS atap

112 Jt USD
Investasi pada tahun 2024 untuk energi surya di Indonesia

175 rb pekerjaan /tahun
Lapangan kerja yang tercipta dari industri energi surya berdasarkan RUKN 2019-2030

- *Biaya PLTS skala utilitas di Indonesia telah turun sebesar 19% dalam 5 tahun terakhir, sebagian besar didorong oleh pengurangan biaya modul surya dan biaya lunak. Untuk meningkatkan adopsi tenaga surya skala utilitas, PLN telah menyiapkan pengadaan gabungan dengan jenis pembangkit listrik lainnya, serta mengajukan kemitraan strategis dengan anak perusahaannya. IESR telah mengidentifikasi kebutuhan tambahan kapasitas fleksibilitas sebesar 746 MW untuk meningkatkan adopsi PLTS atap, yang disediakan oleh operasi pembangkit listrik yang fleksibel (terutama batubara), serta implementasi secara luas sistem penyimpanan energi.*

- *Investasi terkait energi surya di Indonesia naik hampir dua kali lipat dari USD 68 juta pada tahun 2021 menjadi sekitar USD 135 juta pada tahun 2023. Pada 2024, sekitar USD 112 juta investasi dalam energi surya telah diumumkan. Untuk mendukung sektor energi surya yang terus berkembang, peningkatan keterampilan yang memadai dan inklusif (baik keterampilan vokasional maupun keterampilan tempat tinggi) diperlukan untuk memanfaatkan 175.000 tahun pekerjaan yang diperkirakan akan tercipta.*

Indonesia solar power supply chain production capacity

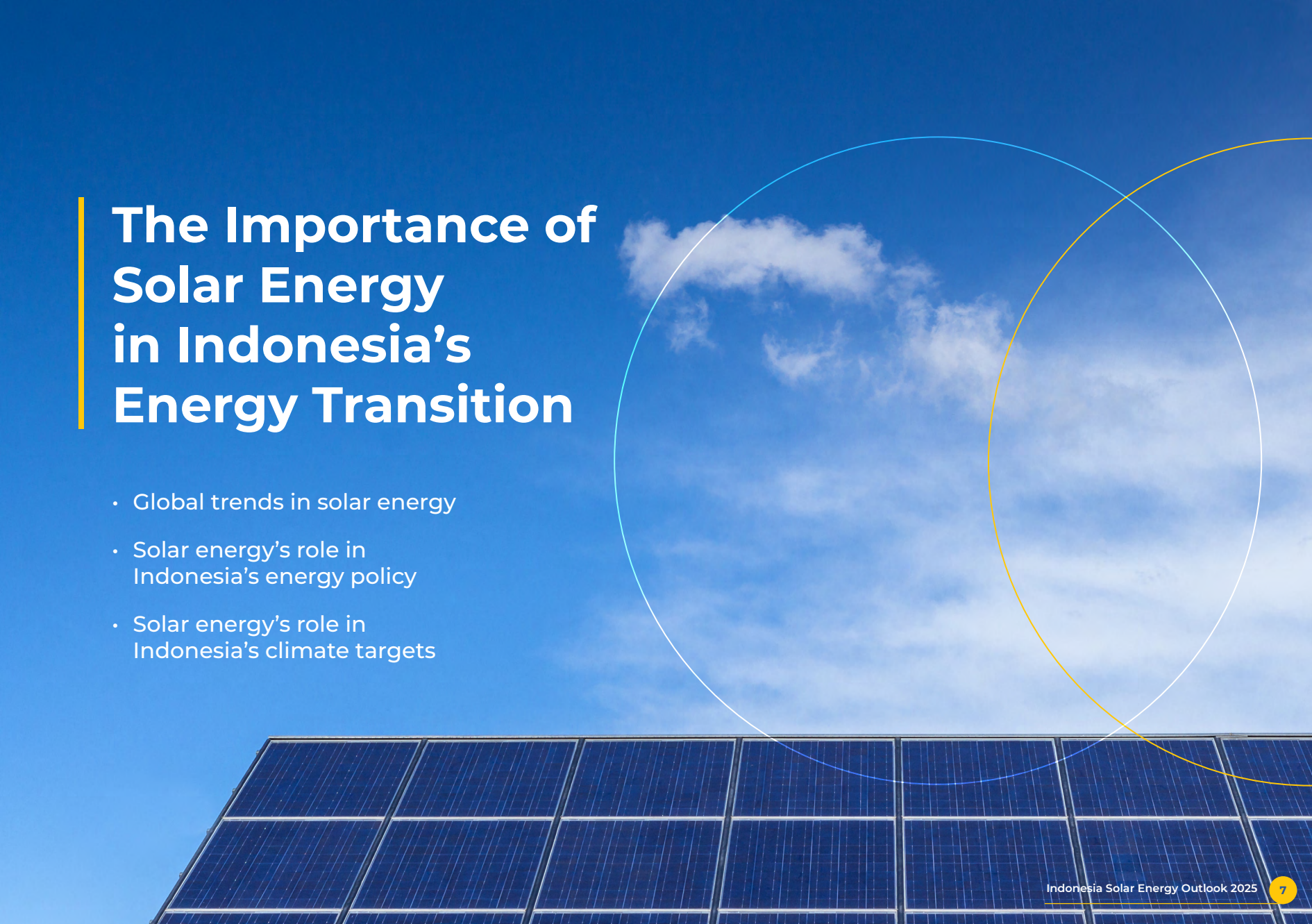
Solar-grade polysilicon	Silicon wafer	*Sel surya*	*Modul surya*	Solar inverter
Tidak ada kapasitas produksi yang tersedia	*Tidak ada kapasitas produksi yang tersedia*	*Tidak ada kapasitas produksi yang tersedia*	**2,3 GW** *kapasitas produksi tahunan*	*Tidak ada kapasitas produksi yang tersedia*
200.000 juta ton *komitmen penambahan kapasitas produksi tahunan*	**11 GW** *komitmen penambahan kapasitas produksi tahunan*	**17 GW** *komitmen penambahan kapasitas produksi tahunan*	**19 GW** *komitmen penambahan kapasitas produksi tahunan*	*Tidak ada proyek yang diumumkan*

- *Kapasitas produksi rantai pasokan surya Indonesia tetap stagnan dalam beberapa tahun terakhir, dengan kapasitas produksi modul solar mencapai 2,3 GW per tahun dan sebagian besar berjalan berdasarkan per proyek. Kurangnya volume permintaan dan kebijakan persyaratan Tingkat Komponen Dalam Negeri (TKDN) yang tidak realistis merupakan beberapa faktor utama yang menghambat pengembangan. Namun, revisi terbaru untuk melonggarkan kebijakan TKDN PLTS dalam 2 tahun ke depan dapat menjadi kebijakan yang inovatif untuk meningkatkan permintaan energi surya domestik.*

- *Komitmen untuk berinvestasi dalam rantai pasokan modul surya Indonesia telah tumbuh dalam 1-2 tahun terakhir, dengan beberapa yang sudah memulai fase konstruksi. Hal ini terutama disebabkan oleh proyek-proyek strategis (ekspor listrik hijau Indonesia-Singapura) dan keuntungan geopolitik Indonesia di beberapa pasar luar negeri. Untuk mempertahankan pertumbuhan ini, pemerintah Indonesia harus bersemangat memberikan lebih banyak insentif fiskal/non-fiskal untuk meningkatkan daya saing produk dalam negeri dan menciptakan sinyal permintaan melalui lebih banyak proyek energi surya yang sedang direncanakan.*

The Importance of Solar Energy in Indonesia's Energy Transition

- Global trends in solar energy
- Solar energy's role in Indonesia's energy policy
- Solar energy's role in Indonesia's climate targets



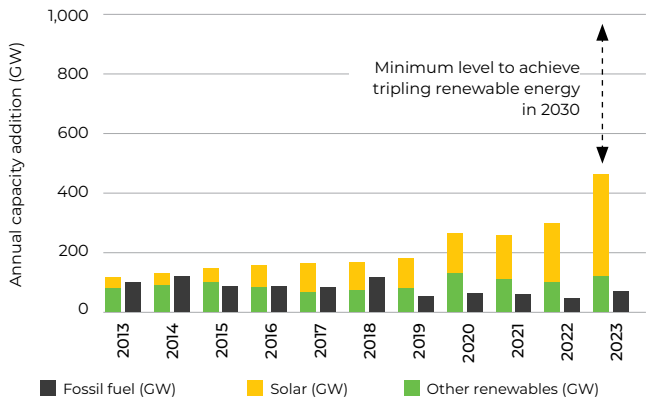
Solar energy leads global effort of tripling renewable energy by 2030, keeping the 1.5°C promise alive

- The world witnessed a remarkable increase of renewables in 2023 by up to 87%, with 473 GW of new installed capacity added. Seventy-three percent (346 GW) of this addition comes from solar energy (IRENA, 2024). China leads the solar energy adoption worldwide, with 217 GW of new capacity installed in 2023, contributing to 63% of global installation. However, several emerging markets and developing economies (EMDEs), namely India and Brazil, also have significant increases in solar installed capacity with 9.7 GW and 11.9 GW, respectively, making them among the top 5 solar markets in 2023. India saw a significant rise in solar auctions and tenders in 2023 in order to achieve the Indian MNRE bidding trajectory target of 50 GW during 2023-2024 (Mercom India, 2024), with the 5 lowest auctions consistently reaching USD 3/kWh of the awarded bid price (Mercom India, 2023). Interestingly, Brazil's solar adoption has been driven by distributed installations since its solar boom in 2019, mainly due to rising electricity tariffs along with net metering and self-consumption credit schemes (Rüther, 2024).

- Despite rapid growth in the 2010s, the Southeast Asia solar market has not really taken off since the pandemic, as only 2.78 GW of new solar capacity was installed in the 2021-2023 period. However, some countries have slowly gained positive momentum. Malaysia and the Philippines interestingly emerged as the region's top markets in 2021-2023 due to various attractive incentives such as large-scale solar tenders and net-metering schemes (Villegas, 2024; TNB, 2024). The Singapore Green Plan 2030 considers solar energy as an important piece of their Energy Reset (Ember, 2024b), resulting in consistent annual solar capacity addition above 140 MW since 2021 despite their limited land availability. Finally, Indonesia has started slowly realizing its potential as one of the biggest solar markets in the region, adding its all-time high 260 MW of new solar capacity in 2023.

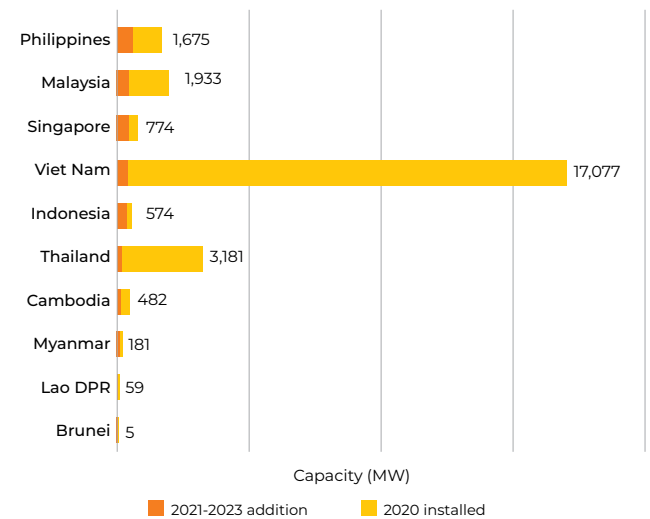
- This worldwide progress is vital to achieve the global target of tripling renewable energy capacity to 11 TW by 2030 as declared in the COP28 Dubai, aligned with the 1.5°C Paris Agreement compliant pathway. While other renewables are currently experiencing a relatively slow progress in achieving the aforementioned target, solar energy is the only one being on the right track to achieve at least 1 TW of annual capacity addition during the 2024-2030 timeframe (IRENA, 2024). This incredible solar growth will set the nuance for renewable energy target setting around the globe (reflected by the respective country's national energy policy/plan). Currently, the accumulated national targets show that solar energy is projected to contribute 43.6% of renewable energy installed capacity by 2030 (Ember, 2024a).

Global power plant annual capacity addition, 2011-2023



Source: IRENA (2024)

Southeast Asia installed solar power plant capacity



Source: IRENA (2024)

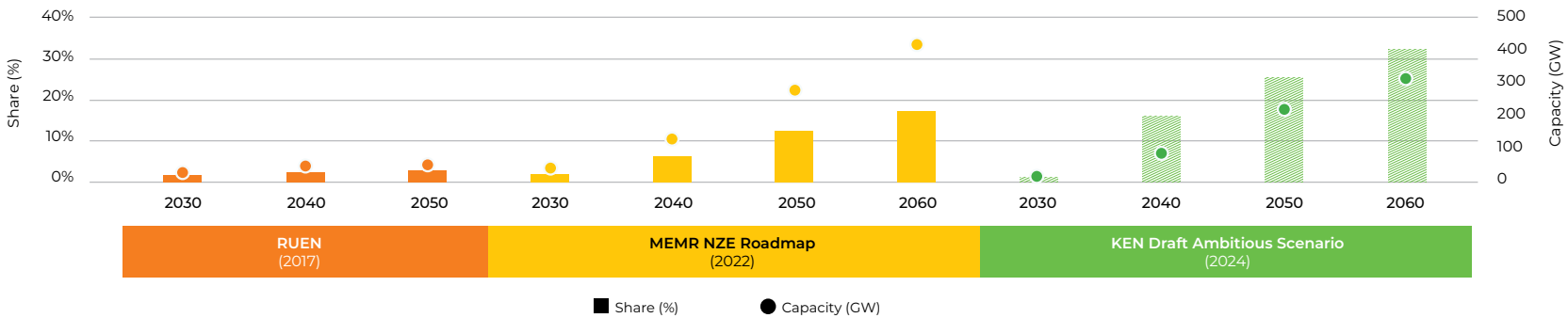
Solar energy slowly gains recognition as a crucial piece of Indonesia's energy transition

- The Government of Indonesia (GoI)'s view on solar energy role progressively evolves from time to time, reflected by its contribution to the national energy policy. Despite being in the middle of a global solar boom in mid-2010s, Indonesia's National General Energy Plan (*Rencana Umum Energi Nasional*/RUEN), which was enacted by Presidential Regulation 22/2017, observes minor solar energy role, with the projected primary energy share of only 3% in 2050, a minuscule contribution to the 31% renewable energy target by 2050 stated in the National Energy Policy (Government Regulation 79/2014). The 2019-2038 National General Electricity Plan (*Rencana Umum Kelistrikan Nasional*/RUKN) also projected only around 3 GW of solar energy capacity by 2030. However, the 2017 RUEN already recognizes the role of distributed rooftop PV to accelerate Indonesia's solar energy deployment. Thus, the first few ministerial regulations on rooftop solar were released in the subsequent years, namely the Ministry of Energy and Mineral Resources (MEMR) Regulation 49/2018 and 26/2021.

- Indonesia's energy policy then took a crucial turnaround after its announcement to go net-zero by 2060 or sooner at the COP-26 2021 in Glasgow. The Indonesian MEMR has recognized solar as one of Indonesia's energy transition frontliners, reflected in its net-zero emission (NZE) 2060 Roadmap, which saw a buildout of 32 GW of solar energy by 2030 and 421 GW by 2060 (MEMR, 2022). A joint report by IEA and MEMR proposed an alternative roadmap for Indonesia to accelerate its NZE target 10 years earlier with a major contribution from 500 GW of solar energy in 2050 (IEA & MEMR, 2022). The Directorate General of New, Renewable Energy and Energy Conservation (DG NREEC) also updated the solar energy potential from 207 GW to 3,294 GW in 2021, an important milestone for solar energy development in Indonesia.

- All these discourses and developments around solar energy's role in Indonesia's energy transition influence the latest development of the National Energy Policy (*Kebijakan Energi Nasional*/KEN) draft that should be enacted later this year. The latest draft in July 2024 stated at least 1.6% contribution from solar energy to primary energy supply by 2030 and around 32% by 2060 in its ambitious scenario, a significant improvement from the previous 2017 RUEN. This number could be translated to a minimum of 7 GW and 309 GW of solar installed in 2030 and 2060, respectively. However, the latest discussions on the RUKN draft in May 2024 only identified 14 GW of solar energy capacity in 2030 and 134 GW in 2060, a much less ambitious solar buildout compared to the MEMR NZE Roadmap and the latest KEN Draft.

Solar energy contribution stated in Indonesia's energy policies



Source: National General Energy Plan (PR 22/2017); MEMR (2022), latest National Energy Policy draft (July 2024). RUEN and KEN draft use total primary energy supply share, while MEMR NZE Roadmap uses share of final energy consumption

The Indonesian power sector is miles behind in the race toward meeting climate targets, while solar energy could be crucial in speeding up renewable deployment

- Electrification is an essential part of the global energy net-zero game plan. Electrifying more end-use sectors (such as transportation and industry) could improve overall energy efficiency and emission intensity. In the deep decarbonization pathway, IESR's Best Policy Scenario (BPS) shows an increase of 77.72% in electricity demand projection in 2030 compared to the expected load growth in the RUPTL PLN 2021-2030 (IESR, 2021a). This study shows that heat and electric vehicle (EV) demand should contribute to 38% of Indonesia's electricity demand in 2030, aligning with the Paris Agreement 1.5 °C pathway. This is in line with net-zero projections from IEA and IRENA, which also show significant annual electricity consumption of 547 and 756 TWh, respectively, by 2030.

- Reducing emissions from electricity generation will thus become more important moving forward. IESR estimates show direct emissions from electricity generation have contributed to 40% of Indonesian energy sector emissions, equivalent to around 297 MTCO2-eq (IESR, 2023), with a 2030 target of keeping it below 334 MTCO2-eq (IESR, 2022a). Several benchmarks have even shown the need to limit annual power sector emissions below the 200 MTCO2-eq mark by 2030 (IEA, 2022; IRENA, 2022b). However, renewable generation shares as per 2023 only account for around 19% (MEMR, 2024a), emphasizing a huge gap to a minimum of 30-57% renewable generation share by 2030, according to several 1.5°C compatible pathway benchmarks. With renewable energy generation only rising by 8% annually in the last 4 years, Indonesia needs to look beyond developing only baseload renewables such as hydropower, geothermal, and bioenergy.

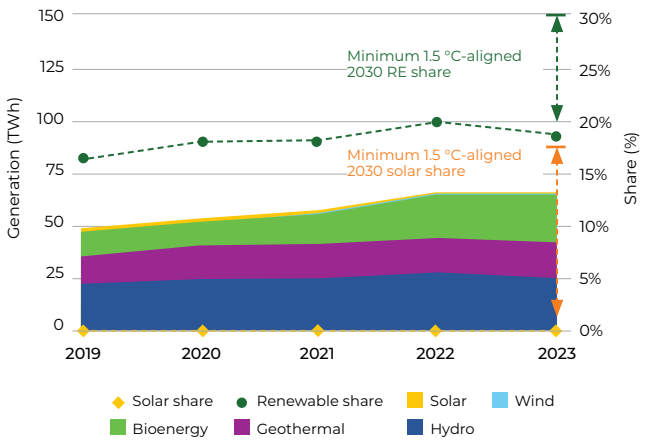
- Solar generation only accounts for 0.2% of Indonesia's electricity generation in 2023. However, several studies have emphasized the importance of solar energy for Indonesia in its race against 1.5 °C-aligned climate targets, mainly due to its cost competitiveness and short deployment time. The solar generation mix target of 17-23% in 2030 could be achieved if Indonesia can add 10-15 GW of solar power capacity annually in the 2024-2030 timeframe, on par with current leading countries' (e.g., Germany, India, Brazil) capacity addition rate. This could only be done by tackling issues related to solar energy development as well as nurturing an enabling environment for solar energy businesses to grow, which will be covered thoroughly in this report.

Indonesia's power system 1.5 °C compatible pathway benchmark

	IEA	IRENA	IESR
Electricity demand 2030 (TWh)	547	756	743
Power sector emission 2030 ($MTCO_2$-eq)	143	174	334
2030 renewable energy share	57%	30%	34%
2030 solar energy share	17.4%	17.65%	22.83%
Average annual solar capacity addition needs, 2024-2030 (GW)	10.06	9.54	15.46

Source: IEA (2022), IRENA (2022), IESR (2022a). IEA benchmark uses NZE 2050 scenario, while IRENA benchmark uses 1.5 RE100 scenario

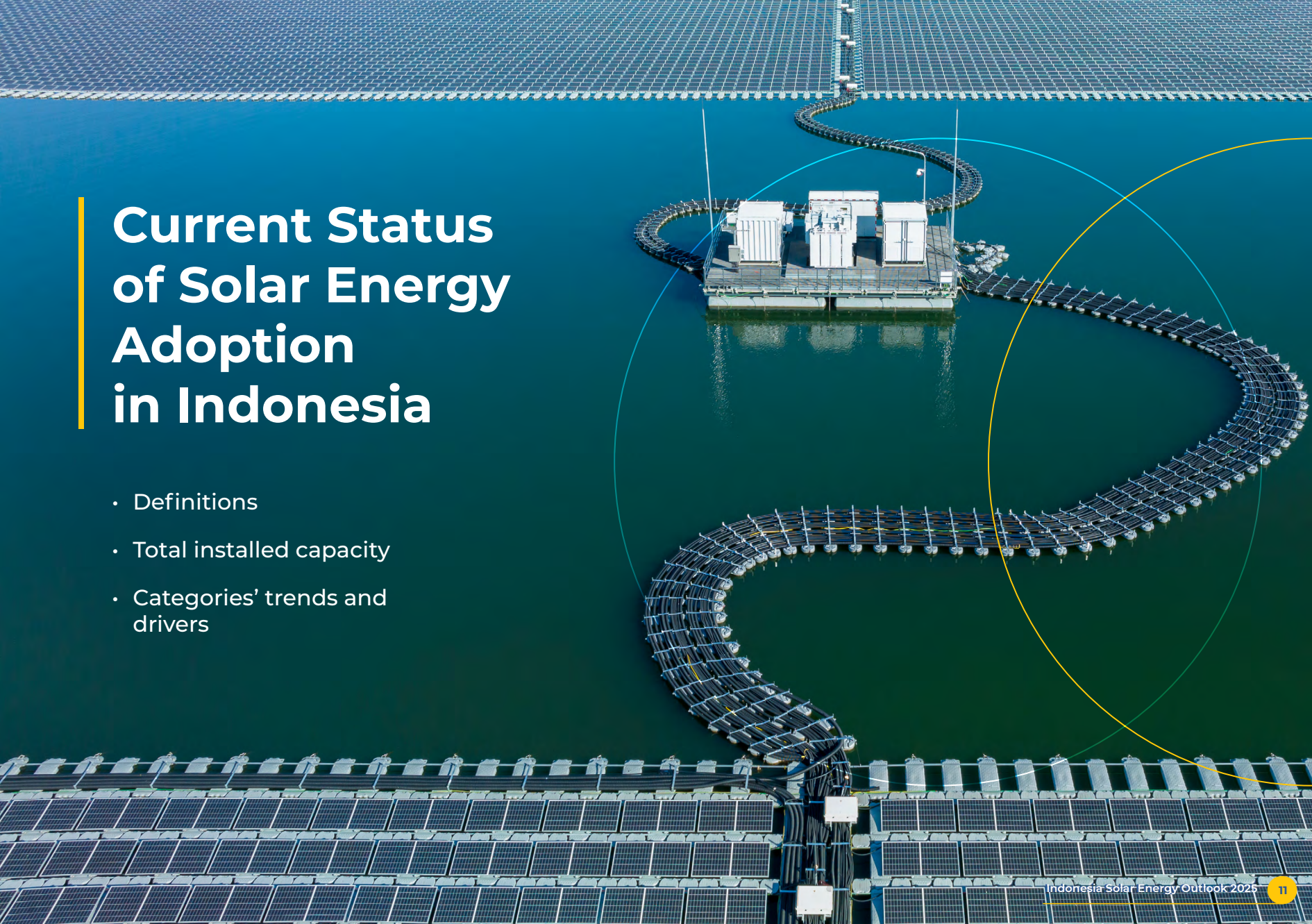
Indonesia's renewable energy generation, 2019-2023



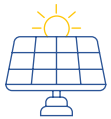
Source: MEMR (2023). Minimum 1.5°C-aligned 2030 shares are based on benchmarks from IEA (2022), IRENA (2022), and IESR (2022)

Current Status of Solar Energy Adoption in Indonesia

- Definitions
- Total installed capacity
- Categories' trends and drivers



# The current total installed solar capacity reached at least 717 MWp as of August 2024, with relatively equal contributions from each category



Utility-Scale

285 MWp

- Refers to ground-mounted or floating solar power plant that is either owned by PLN or an independent power producer (IPP) that sells and transmits electricity through a power purchase agreement (PPA) with PT PLN within its concession areas.
- As per August 2024, the total **utility-scale** solar installed capacity is **285 MWp** based on IESR collected solar plant data from MEMR's reports.
- Due to limited data on small-scale solar power plants, this category only includes plants with a minimum capacity of ≥1 MWp. While some small-scale installations for mini-grid applications are technically also within PLN's business area, such installations will be included in the **off-grid** category to avoid double counting.

Distributed

245 MWp

- Refers to solar PV power plants that generate power at the end-user's connection on the larger electricity grid (referring to definition in MEMR Regulation 2/2024). It can be analogously referred to as **rooftop solar**, since most distributed installations are done on the rooftop surface.
- The total **distributed solar** installed capacity of **245 MWp** is based on the latest data shared by MEMR in August 2024.
- While the legal definition also covers installation in non-PLN concessions, this number only includes installation for PLN customers. Installations for non-PLN consumers will be included in the **captive** category to avoid double counting.

Off-grid

56 MWp* (50 MWp)**

- Refers to centralized or decentralized solar projects in isolated, off-grid/ mini-grid systems with < 1 MW plant capacity. This includes mini-grid applications, either owned by PLN or local government.
- The total **off-grid solar** installed capacity is estimated at **56* MWp** based on MEMR data shared in March 2024.
- **) The pre-electrification and other programs, including:
  - Solar-powered public street lighting (also known as *penerangan jalan utama tenaga surya*/PJUTS).
  - Solar-powered energy-saving lamp for rural pre-electrification (also known as lampu tenaga surya hemat energi/LTSHE).
  - SPEL/APDAL (electric energy charging station/power distribution equipment) for rural pre-electrification.

With a total of approximately **50 MWp.** This number is excluded from the total installed capacity.

Captive

131 MWp*

- Refers to utility ground-mounted, floating, and distributed (rooftop/ non-rooftop) installations under non-PLN concessions. This includes installation by private power utilities (PPUs), IPP operating within a PPU's business area (often known as *wilayah usaha*/wilus), distributed installation for PPU consumers, or own-use standalone sites.
- The total captive solar installed capacity of **131 MWp** is based on the latest data shared by MEMR in March 2024.

*) Data from March 2024

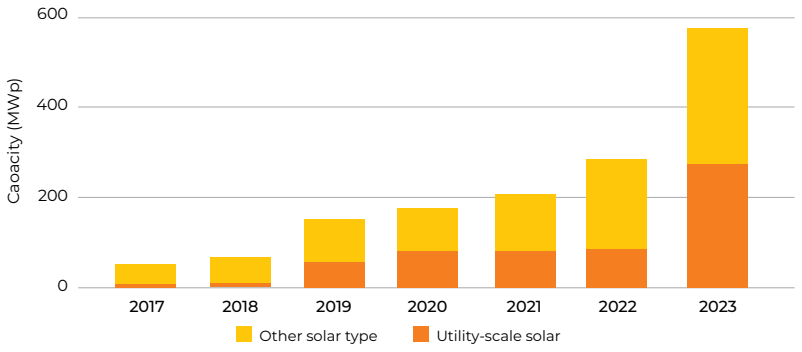
Utility-scale solar finally accounts for the largest scale of Indonesia's total solar capacity despite constantly missing RUPTL PLN trajectory

- In 2023, utility-scale solar emerges as the primary contributor to Indonesia's overall solar capacity, representing approximately 48% of the total installed solar capacity, marking an all-time high. This increase can largely be attributed to the commissioning of the 145 MWac Cirata FPV power plant in November 2023. While this achievement marks a new era for solar project development in Indonesia, there remains a disparity between actual realized capacity and power system planning. For instance, based on IESR analysis on PLN RUPTL documents, only 33.37% of utility-scale solar projects that should be operational by 2023 actually come into realization.

- Failure in reaching PLN RUPTL can be attributed to the lack of a firm regulatory framework and appropriate grid planning. While there were 621.75 MW of solar projects being auctioned before MEMR 50/2017 was stipulated, only 204.36 MW came into operation due to various reasons, such as grid immaturity (as seen in the 2017 Sumatra solar project auction) and regulation changes (as seen in 2016 feed-in-tariff solar auction) (IESR, 2021b). There are positive developments, however, notably seen in the expansion of the Indonesia Power's Hijaunesia project. After the successful equity partner auction for Cirata FPV in 2019, Hijaunesia replicated the same auction method in 2020 and 2023. There is a significant boost in auction volume with 500 MW of utility-scale solar installations started procurement process in 2023 (Rahayu, 2024), encompassing both floating and ground-mounted projects across various sites such as Jatigede, Gajahmungkur, Kedung Ombo, Pasuruan, and Banyuwangi.

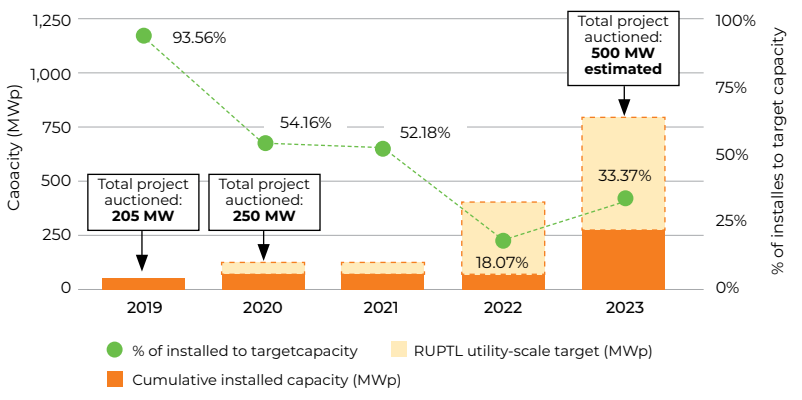
- However, PLN's procurement timing and volume in the past do not really show a firm ambition in fulfilling the operation target stated in the RUPTL. Despite releasing their "greenest" RUPTL in 2021, no large solar procurement was done until 2023. Aside from the global pandemic situation in those years, hesitation in procurement may stem from the need to address the oversupply issue (Hamdi & Adhiguna, 2021) and ensure a balanced energy portfolio (Zahira, 2023). PLN also highlights other challenges, such as the variability of solar power, which required PLN to improve its grid infrastructure before actually absorbing large amounts of solar energy.

Indonesia's installed solar capacity, 2017-2023



Source: IESR analysis based on compiled sources of PLN, MEMR, and company press releases (2024)

Indonesia's utility-scale solar installed and target capacity, 2019-2023



Source: IESR analysis based on compiled sources of PLN, MEMR, and company press releases (2024)

Weak planning-procurement nexus is hindering past utility-scale solar projects from timely delivery

- Looking more closely on a per-project basis, 66.7% of utility-scale solar projects included in the PLN RUPTL experiencing delays from the stated COD year, ranging from 1 to 3 years. However, this could be attributed to the unrealistic target stated in the early version of PLN RUPTL, emphasizing a weak connection between planning and procurement realization. The 2016-2017 solar auction is an excellent example. The 2016-2025 PLN RUPTL stated a total of 95 MW of substation quota for solar (site-agnostic projects, listed as "*kuota tersebar*") in West Nusa Tenggara (NTB) before the 2017 update of the PLN RUPTL revealed the project location after the tender was won in 2016. The PLN RUPTL update stated that this project was initially set to be completed in 2017, just one year after winning the tender. This should serve as a lesson learned for PLN to enhance its procurement scheduling, taking into account lead time for PPA negotiations and construction time. Historically, PPA negotiation could take 1-2 years, while construction timing could range from 1-3 years. Another challenge of such substation solar auction is land acquisition and suitability, as seen in the Sambelia project.

- Interestingly, the projects that were not delayed had specific events to meet, such as the 2018 Asian Games for Jakabaring, the 2022 G20 Summit for Nusa Penida hybrid PV system, and the completion of the new capital's phase I development in the case of IKN solar power plant. While these 'showcase' projects play an important role in promoting Indonesia's solar energy desire, pushing more systemic improvements in PLN planning and procurement harmony should be the main priority.

- Aside from delays, several reasons cited in 2021-2030 RUPTL include capacity adjustments to align with system requirements, as seen in the case of Likupang project. This indicates an overestimation compared to the projected system needs, underscoring the need for more accurate demand forecasting and grid planning to achieve optimal utilization of utility-scale solar.

Utility-scale solar power plant development timeline, Q1 2014 - Q2 2024

Project Name	Capacity (MWp)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Kupang (Oelpuah)	5	●	●●	●								
Sumalata	2	●	●●	●								
Hambapraing	1	●		●	●							
Jakabaring	2				●●	●	◆					
Maumere & Ende	2	●		●●			●					
Atambua	1	●		●●			●					
Pringgabaya	7			●	●●◆		●					
Selong	7			●	●●◆		●					
Sengkol	7			●	●●◆		●					
Likupang	21			●	●●		◆●					
Isimu	14.5			●	●		◆	●				
Kuta (Sambelia)	7.25			●	●●◆			●				
Selayar	1.3								●◆	●		
Hybrid Sangihe	1.3								◆	●●		
Hybrid Nusa Penida	4.2									◆●		
Cirata FPV	19.2						●	●	●	◆●	●	
IKN*	10										●●●	◆●

Tender won
PPA signed
Construction started
Target COD
Actual COD

Source: IESR analysis based on compiled sources of PLN, MEMR, and company press releases (2024)

*The target COD for IKN solar power plant is not listed in RUPTL, but rather the target stated by PLN Nusantara Power in accordance with the development of the new capital. Completion in February 2024 is for phase I only. COD for phase II is planned for May 2024, with a capacity of 40 MWp. As of June 2024, phase II is still in construction (EMedia DPR RI, 2024).

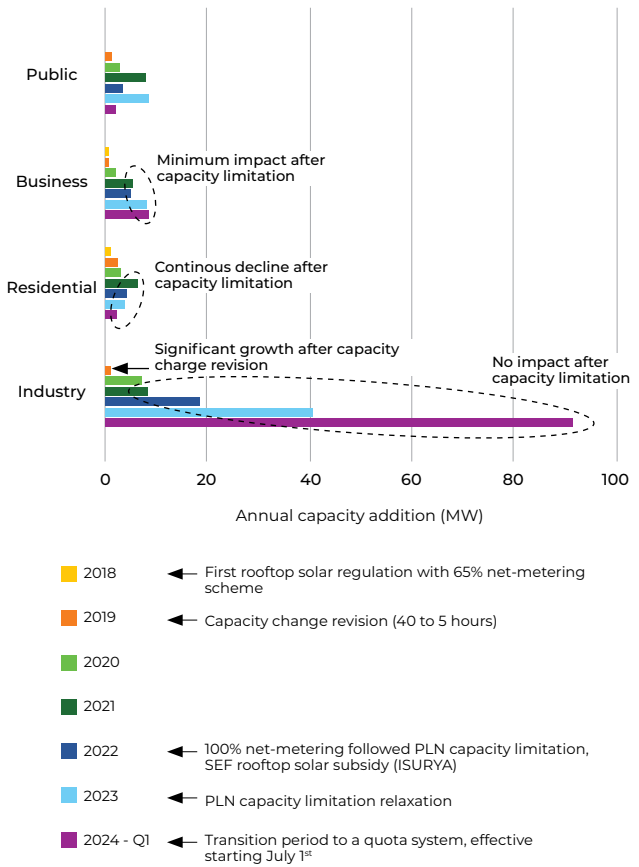
Promising distributed solar adoption rate despite turbulences in the regulatory framework

- Distributed solar (commonly referred to as rooftop solar) annual installation enjoyed a rapid growth of a cumulative 138% per annum in 2018-2021 period, after the enactment of MEMR Regulation 49/2018 as the legal cornerstone for rooftop solar deployment. Capacity charge revision in 2019 also helps this significant growth, especially in the industrial segment. Installed capacity in the public sector (government, social) is mainly driven by the government rooftop solar installations program, which mostly comes from the MEMR's budget. The DG NREEC planned a total of 14.727 MWp rooftop installations using the ministry's budget in 2018-2020 and 2022 on government offices and public buildings such as schools, hospitals, and mosques (MEMR, 2023). To further boost rooftop solar adoption, a direct subsidy program for rooftop installation was also launched in 2022 in partnership with the UNDP Sustainable Energy Fund (SEF), with a total of 8 million USD worth of installation cashback vouchers available to incentivize 5 MW non-state budget rooftop solar installation (UNDP, 2022).

- However, rooftop PV adoption experienced a significant slowdown after PLN applied the 10-15% capacity limitation in response to the MEMR Regulation 26/2021, reducing the rooftop capacity growth to only 41% annually in the 2021-2023 period. This is particularly apparent in the residential consumer, with annual capacity growth down to only 17% after the limitation, compared to 92% pre-2021. This capacity limitation by PLN was slightly relaxed in 2023, but the uncertainty remains high for rooftop solar developers. The 10-15% capacity limitation, however, only heavily hampers adoption in residential sectors, as rooftop PV demand in commercial/business buildings and industrial plants still soared highly in the past 1-2 years.

- To put an end to the capacity limitations conundrum, MEMR Regulation 2/2024 was issued in early 2024, eradicating electricity export* and imposing a quota system to incorporate PLN's concerns on system stability & grid congestion. The year 2024 saw the biggest capacity addition to the industrial sector, with around 104 MWp installed until end of July 2024. This positive trend is also driven by industrial decarbonization initiatives, either individual or collective effort. Installing rooftop PV ensures consumer retention for Indonesian manufacturers due to rising awareness of 'green products', as well as adding competitiveness due to operational cost saving advantage. This is mainly apparent from multinational or export-oriented manufacturers and businesses, as they push any amount of rooftop installation despite the permitting hurdles.

Rooftop PV capacity addition per year, 2018-2024 Q2



Source: Shared data from DG NREEC, MEMR (2024)

*Physical electricity export to the grid is not explicitly prohibited by the regulation, but no electricity bill saving will be applied

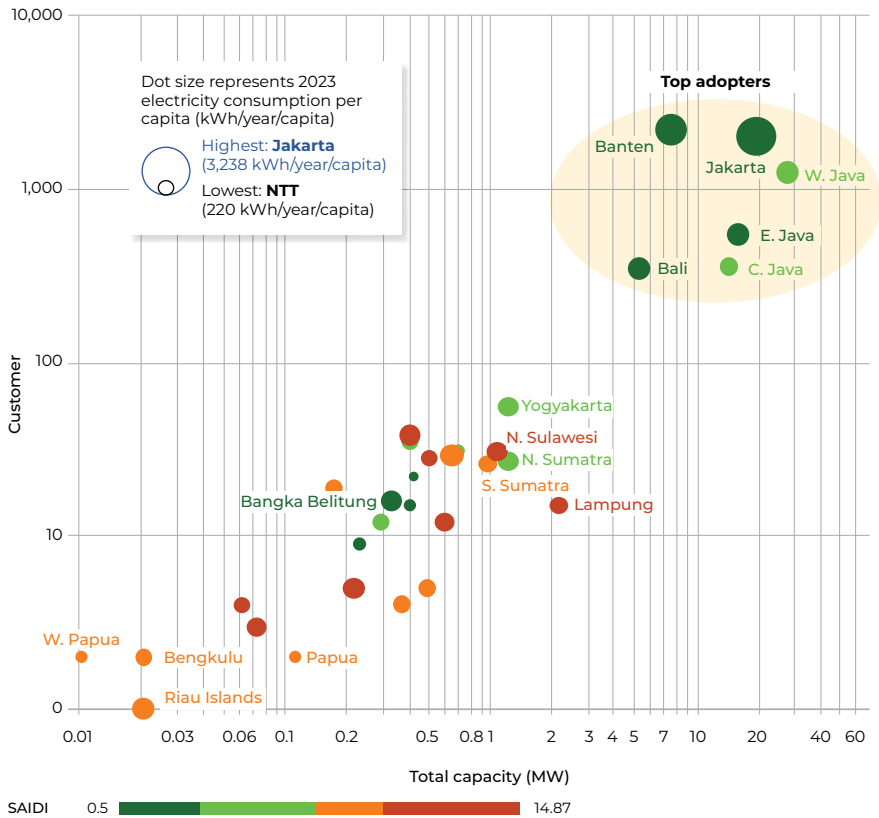
The largest rooftop PV adoption comes from high-consuming provinces, while untapped potential from outside of Java Island exists

- As expected, provinces with large electricity consumption dominate rooftop solar adoption, such as West Java, Banten, and DKI Jakarta, which are all located in the Jamali system. DI Yogyakarta is the only province in the Jamali system that is not in the 'top adopters' category (installed rooftop solar capacity above 5 MWp), with Lampung being the biggest installation number outside of the Java island. Better grid reliability (represented by low SAIDI*) also affects the adoption rate of rooftop solar, as grid operators in highly-reliable provinces tend to be more relaxed in granting permits. However, Lampung, North Sulawesi, and South Sumatra are curious cases of provinces with relatively good rooftop installation numbers (≥1 MWp) despite having a less reliable grid (represented by high SAIDI).

- Medium to large installations drive the growth in highly industrialized regions, such as West and East Java, as seen in 9.8 MWp Tjiwi Kimia rooftop PV in East Java (Sinarmas, 2023), and 7.2 MWp Coca Cola Amatil in Cikarang (Prasetyo, 2020). A different adoption driver is observed in the Banten and Jakarta regions, with more small-scaled (below 10 kW) units being more dominant. There are also flagship installations that boost installation numbers in certain regions, such as 1 MWp in Institut Teknologi Sumatera (ITERA) and 500 kWp in PT Visi Prima Artha (Hadiyatna, 2022), which accounts for about 80% of Lampung's total installed capacity.

- Several provinces can be viewed as an 'untapped potential' due to their relatively high electricity consumption (above 750 kWh/capita per year) and low SAIDI (below 7 hours/year) but with relatively low PV rooftop adoption (below 100 customers and 5 MW installed capacity), namely Bangka Belitung, Yogyakarta, and North Sumatra. A relatively low SAIDI number can be a good metric to assess the grid and distribution operator readiness to manage a higher number of distributed generations. However, managing permit issues with PLN's regional distribution units also serves as one of the key challenges in developing rooftop solar in these emerging markets, as some developers note challenges in acquiring permits in some regions, which leave some applications being delayed for months.

Rooftop PV capacity per province, 2023



Source: IESR analysis from compiled sources (2024)

*SAIDI: System average interruption duration index (hour/consumer/year).

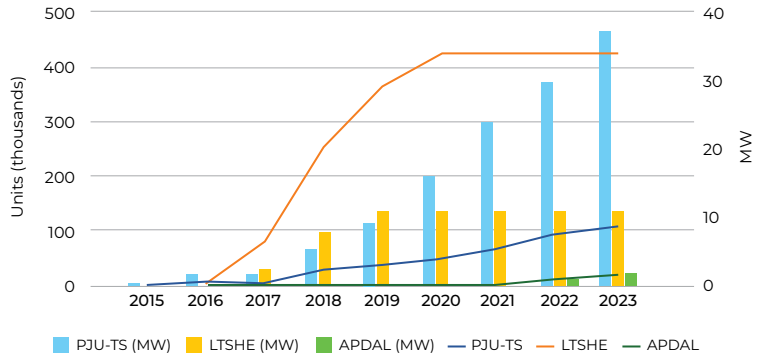
A steady rise in solar mini-grid programs boosts remote electrification, but significant costs remain to achieve 100% electrification

- Due to the declining costs of solar PV systems, their modular nature, and unstable diesel prices, off-grid solar initiatives are the most economical way to boost electrification in Indonesia. This is particularly apparent in remote areas with electrification programs. The government aims to electrify the remaining 0.22% of Indonesian households and 0.17% of villages, all located in Papua, by 2024 (DG NREEC, 2023).

- As per 2023, about 50 MWp of solar PV capacity in Indonesia came from the "pre-electrification and others" programs, including LTSHE (2017-2021), SPEL/APDAL (2022-present), and PJU-TS (2015-present). The LTSHE program, with a lifespan of three years, accounted for 3.4% of households classified as electrified by MEMR. The LTSHE program was discontinued and was succeeded by SPEL/APDAL, which offers greater continuity and lifespan. However, both LTSHE and SPEL/APDAL fall under Tier 1 of the Multi-Tier Framework (MTF) for measuring electric access due to their limited power capacity, which is sufficient only for lighting (ESMAP, 2015). Eventually, such stop-gap programs will need to be replaced by a more robust yet affordable source of energy, and solar energy generally fits the profile for mini-grid applications.

- Mini-grids account for approximately 65-75% of total off-grid solar installed capacity over the years, including contributions from company CSRs, grants, and nonprofits (IRENA, 2023). MEMR and PLN plan to expand mini-grid application through *lisdes* (*listrik desa*) program, which involves building electricity infrastructure, including power plants (including solar PV), networks, and substations. According to the 2021-2030 RUPTL plan, the program aims to install 168 MWp of power plants, mostly as mini-grids. Along with significant reduction in solar energy component costs, stakeholders in mini-grids have also overcome financial and logistical hurdles by adapting their business models accordingly. Currently, the program is managed by PT PLN and MEMR. It will be operated by the nearest PLN operator units or transferred to the *Pemdes* (*pemerintah desa*) to be operated by their BUMDes (village-owned enterprise). However, the cost of connecting each new customer in 3T (outermost, frontier, and less developed) regions is 20 times higher than in non-3T regions due to large logistic and transportation costs (PLN, 2023). It is estimated that PLN will require state capital participation (PMN) from the state budget (APBN) of around IDR 9 trillion (USD 560 million) to achieve 100% electrification by 2025 (Muslimawati, 2024), accounting for approximately 1.5% of the overall state budget.

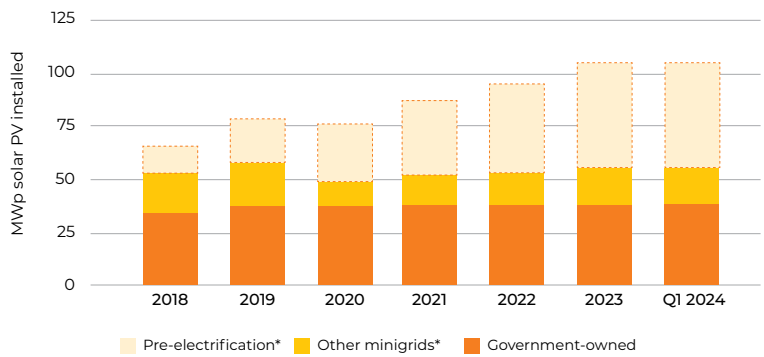
Solar-related pre-electrification and other programs, 2015-2023



Source: IESR analysis (2024).

Note: MWp of SPEL/APDAL is estimated from LKPP catalogue.

Solar off-grid capacity by type, Q4 2018 - Q1 2024

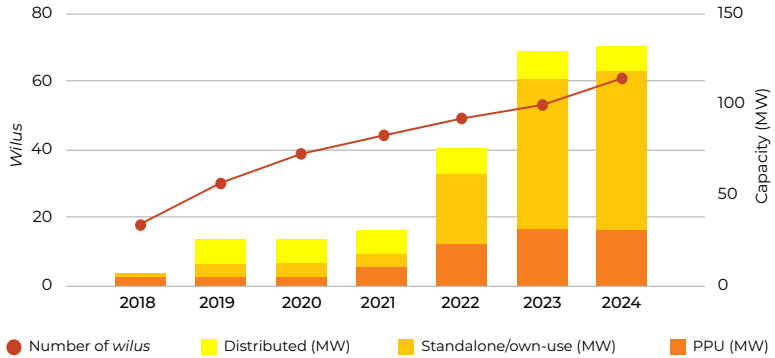


Source: Data shared by MEMR (March 2024)

*) IESR estimation based on the shared data

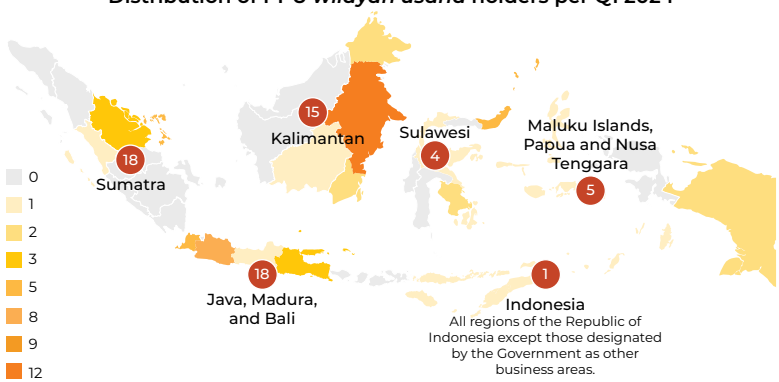
The number of *wilayah usaha* holders is on the rise, potentially attracting industries to generate their own low-carbon electricity and install their own captive solar PV

Number of *wilayah usaha* holders and captive solar PP capacity (MW)



Source: IESR analysis based on data shared by MEMR (March 2024)

Distribution of PPU *wilayah usaha* holders per Q1 2024



Source: 2024-2060 RUKN draft (May 2024)

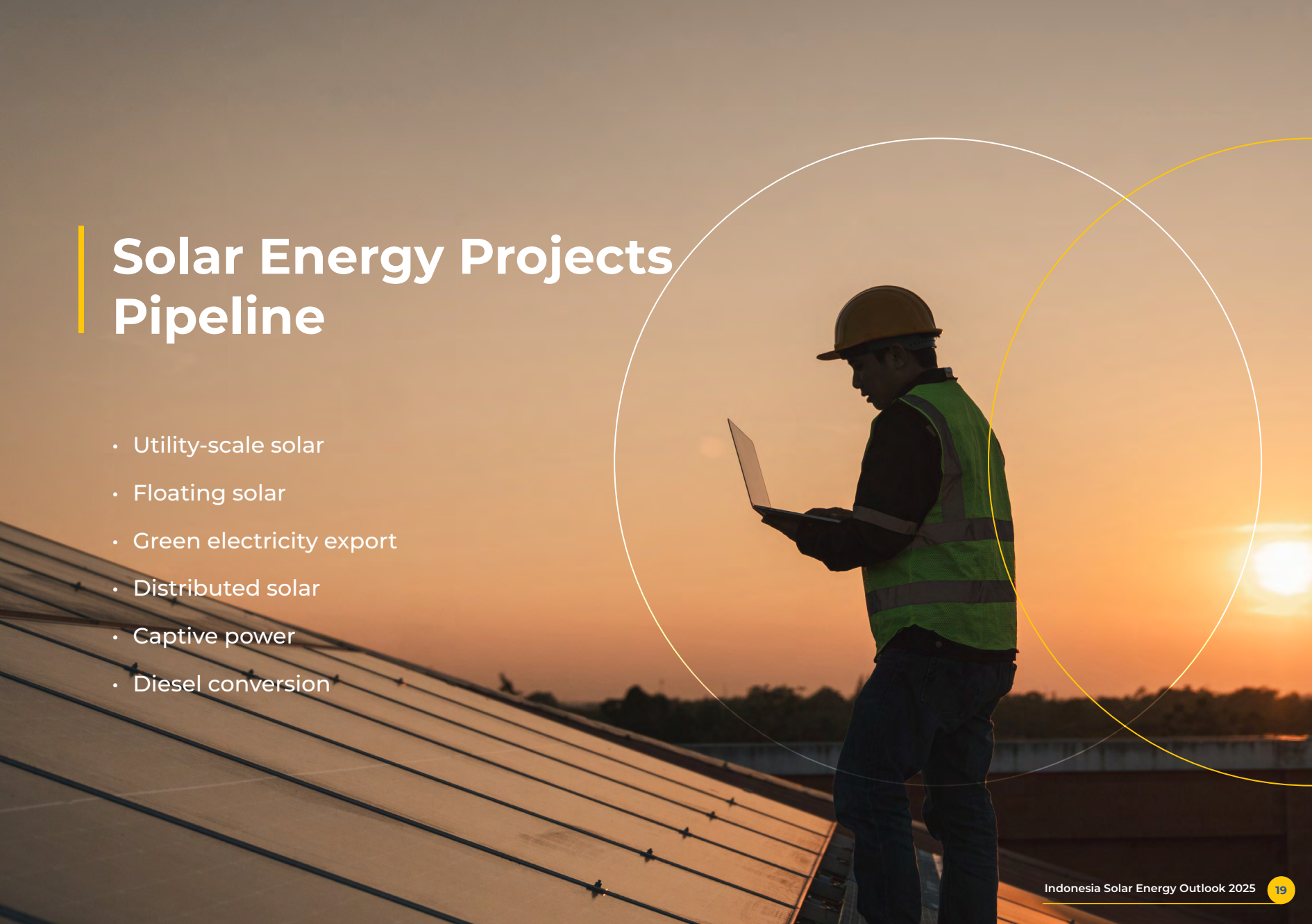
- Since 2017, the number of Indonesia's non-PLN electricity providers, known as *wilayah usaha* (*wilus*) holders, has tripled. This growth particularly stems from insufficient grid connections for reliable industrial electricity supply by PLN, particularly in remote eastern Indonesian industrial zones. Additionally, companies in *wilus* with their own electricity generation assets can manage power plants, allowing them to tailor power generation to their needs, such as the use of combined heat and power (CHP) systems in the pulp and paper industry. *Wilus* holders, equipped with their IUPTLU (*Izin Usaha Penyediaan Tenaga Listrik Untuk Kepentingan Umum*) permits, have significant potential to drive solar energy adoption. While they must align their own RUPTL (General Electricity Supply Business Plan) with the national RUKN document, the increasing awareness of environmental, social, and governance (ESG) factors may further promote the development of green industrial parks. These parks can attract companies seeking to achieve higher renewable energy targets than those provided by PLN's grid mix and national standards.

- Many PPUs have begun installing solar PV rooftops for their tenants. IESR analysis shows that by Q1 2024, at least 44.1 MW of solar capacity has been installed in the available 61 *wilus*. For example, the Jababeka Industrial Estate, managed by PPU PT Cikarang Listrindo, had 21.2 MWp of solar installed in 2023, a 70% increase from 2022 (Listrindo, 2023). The new solar PV rooftop MEMR Regulation No. 2/2024, issued in February 2024, also applies to PPUs. It mandates that PPUs in Indonesia submit their own quotas for solar PV rooftop installations based on technical availability. MEMR has recently introduced the Simantap application for potential customers in *wilus*, which aims to provide information on the available rooftop PV rooftop quotas in such areas.

- This trend in captive solar installations may appeal to industries with ambitious NZE targets and investors' demand for sustainable production, where PPUs can capitalize by offering streamlined permits and a ready grid infrastructure for solar PV rooftop installation. However, current PPU-related system planning and data lack transparency, hindering potential solar developers from tapping into the market. To address these challenges, the government should mandate greater transparency in captive site planning, data and permitting.

Solar Energy Projects Pipeline

- Utility-scale solar
- Floating solar
- Green electricity export
- Distributed solar
- Captive power
- Diesel conversion



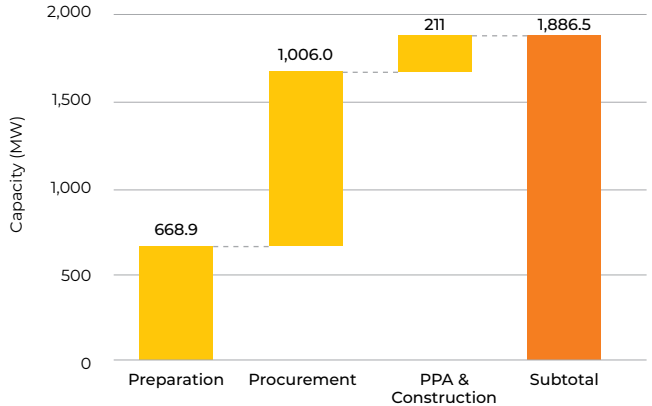
Big volume of solar power projects is on its way, with a partnership scheme with PLN's subsidiaries being the preferred method going forward

- Indonesia could see the biggest amount of solar power project procurement ever in the 2024-2027 period. As of September 2024, there are about 1.89 GW of solar energy projects waiting in the PLN's pipeline. About 669 MW of these solar power projects are in the procurement preparation phase (project feasibility study, bidding documents preparation) and are expected to move towards the procurement stage this year. Just above 1 GW of these projects have moved into the procurement process, with the other 211 MW having signed their PPA and are expected to enter the construction phase. However, even if all of these projects go into realization, the amount of solar energy procurement volume is still far from the latest RUPTL 2021-2030 target in 2027 of 4.19 GW.

- Direct assignment through its subsidiaries (Indonesia Power & Nusantara Power) is expected to increase procurement volume. The recent Indonesia Power's Hijaunesia renewable energy project auction claimed to comprise a total of 1 GW of solar power projects and 500 MW of them are set to be executed by 2024 (Rahayu, 2024). Similarly, the latest Nusantara Power's Project X Nusantara invitation revealed around 740 MW of ground-mounted solar projects (PLN Nusantara Power, 2023b). IESR's analysis of the collected data shows about 920 MW of solar projects in the pipeline will be executed in a direct partner selection scheme with PLN's subsidiary as the majority shareholder. PLN's seeming favor toward this partnership scheme is due to several benefits, mainly to enrich its renewable assets portfolio without compromising the financial balance sheet, as the required equity injection will be shared with the selected strategic partnership.

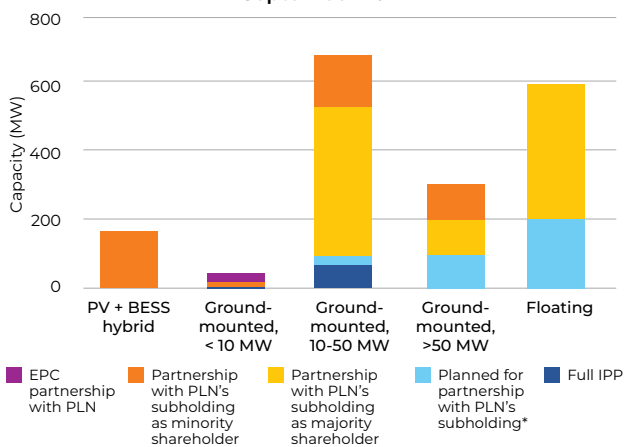
- However, this leaves only around 76 MW of solar power projects with a full IPP-owned scheme in the pipeline, with 61 MW of the projects having already signed their PPA and started their construction. Such project volume is extremely low compared to the 2.9 GW of IPP projects allocated initially in the PLN RUPTL. For the remaining 375.6 MW of solar power projects in the pipeline, PLN will still open IPP tenders but will include a mandatory partnership with one of PLN's subsidiaries as the minority shareholders, as seen in the recent diesel replacement program.

Solar power project pipeline progress, September 2024



Source: Interview with PLN's DIV MEB, Nusantara Power (2023b)

Solar power project pipeline breakdown, September 2024



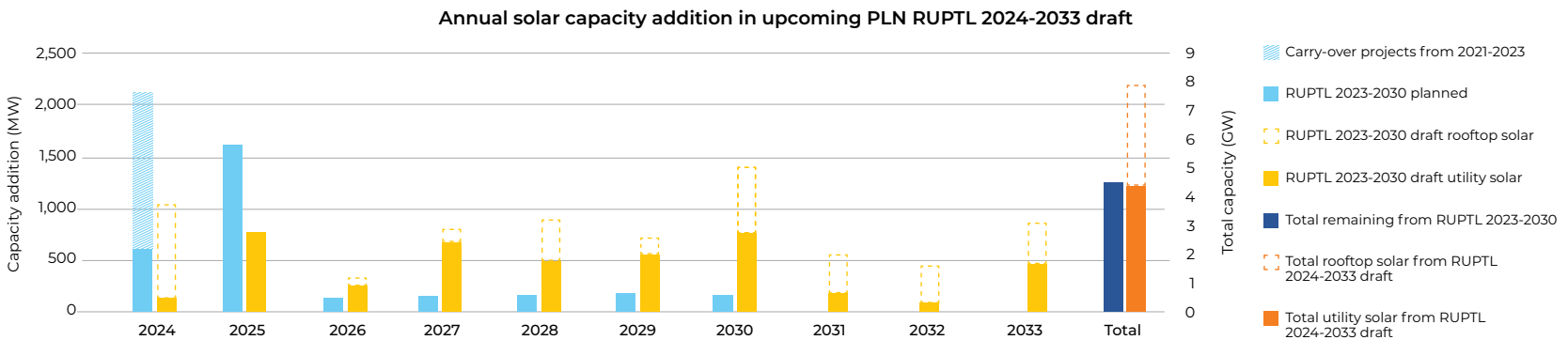
Source: Interview with PLN's DIV MEB, Nusantara Power (2023b)

*Partnership PLN's subholding, but no specific scheme (majority/minority) mentioned.

The latest reveal of 2024-2033 RUPTL PLN draft sparks disappointment due to unambitious solar energy deployment despite its potential and economics

- The long-awaited RUPTL PLN update is finally set to be released in 2024 after going through long discussions since 2022. This delay in the update is mainly due to harmonization with other energy-related policy documents, such as the RUKN and KEN, which are also set to be finalized this year. The latest presented draft RUPTL in July 2024 shows solar capacity addition in 2024-2033 is set to be around 7.9 GW, with total capacity addition until 2030 will be around 6 GW. Despite the final number is still on the final discussion, this project volume is highly insufficient compared to the 14 GW target in 2030 stated in the latest draft 2024-2060 RUKN (as per May 2024), putting the renewable energy mix target from the latest RPP KEN draft (as per Dec 2023) of a minimum 19% at risk as well as energy transition ambition. As these three documents are still in the finalization stage, further alignments need to be made to avoid unnecessary confusion in the future due to inconsistent numbers across the related bodies.

- On a high-level observation, the latest draft 2024-2033 RUPTL is set to increase solar power capacity by 3.22 GW compared to the previous 2021-2030 RUPTL PLN. However, looking more closely at the project type breakdown, the latest draft shows only 4.4 GW of solar power projects until 2033, with the remaining 3.5 GW will be allocated to rooftop solar quota. This solar project capacity is 0.28 GW lower than the remaining project list from the previous PLN RUPTL, and the deployment time is also expected to be pushed back (from 2023-2025 according to the current RUPTL PLN) to the 2027-2030 window. This pushback is mainly due to PLN prioritizing dispatchable renewable development in the upcoming 2-3 years, as solar energy's high modularity will enable them to catch up in the later years. Reduced project volume and constant pushback for project delivery time could spark negative sentiment in Indonesia's solar energy development, as the system planning and procurement ecosystem could be perceived as volatile. On top of the 1.59 GW rooftop solar quota for 2024-2028 released earlier this year, the latest draft RUPTL also revealed an additional 1.91 GW of rooftop solar during 2029-2033. While this overall number emphasizes the significant role of rooftop solar in Indonesia, this quota stipulation means the National Strategic Project target of installing 3.6 GW of rooftop solar may be delayed up to 2033, 8 years later than the initial target stated.



Source: 2024-2033 PLN RUPTL draft (presented in July 2024)

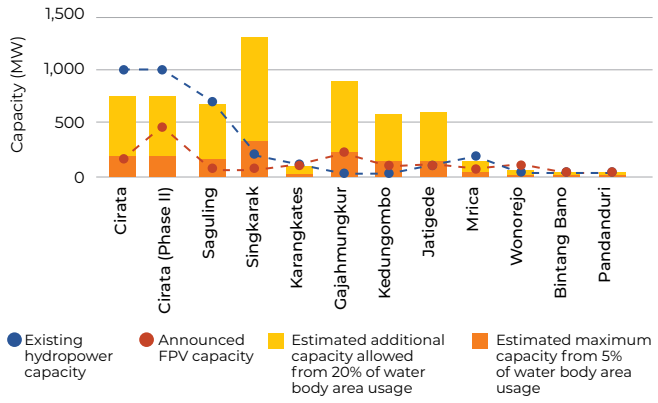
Floating solar projects on development would benefit from increased water body usage and pairing PV with hydropower

- The development of floating solar projects in Indonesia is projected to lead the way in utility-scale solar capacity additions. The preference for FPV stems from the benefit of avoiding land-use issues and high land-acquisition costs, which have historically hindered solar power plant installations. So far, PLN favors developing FPV on man-made reservoirs/dams, especially ones already used for hydro-powered plants, with 11 out of 13 projects in the pipeline situated in such locations. Using existing hydroelectric infrastructure simplifies implementation, and pairing FPV with hydropower offers benefits like reducing PV curtailment, conserving water by shifting hydropower generation, and decreasing dependence on gas-fired plants.

- Following the inauguration of Cirata FPV in 2023, there are plans to expand its capacity with an additional 500 MWp in the second phase (Masdar, 2023). This expansion is supported by the Ministry of Public Works and Housing (MPWH) Regulation no. 7/2023, which removed the previous regulation's 5% limitation on water body usage. To illustrate the implications of this change, if FPV projects in the pipeline were to expand their capacity to use 20% of water body areas, the total capacity could reach 5.9 GWp, a 340% increase from the total announced capacity. Notably, some projects, such as Karangkates and Wonorejo, have already been proposed to use more than 20% of the water body area. Exceeding 20% of the use of water body area is permitted with recommendations from the Dam Safety Commission, but it is crucial to consider the impact on the aquatic environment and dam structure. Therefore, the latest MPWH regulation mandates the General Directorate of Water Resources to develop a guide for assessing the technical and socio-environmental feasibility of such projects.

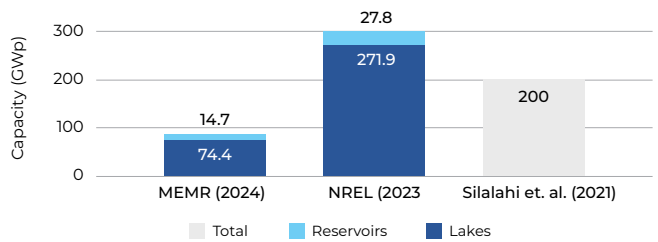
- The total announced capacity for FPV projects in Indonesia is around 1.3 GWp, which is only a fraction of the technical potential. Utilizing 20% of the available water body area yields an FPV potential of 89.4 GWp, with 74.7 GWp located at natural lakes (MEMR, 2024b). Nevertheless, this figure is lower than the estimates by NREL (2023) and Silalahi et al. (2021), which calculated potentials of 300 GWp and 200 GWp*, respectively. These figures indicate significant room for growth in FPV capacity, especially in natural water bodies, which currently remain unexplored. Another notable initiative to utilize natural water surface is the 2 GWp offshore FPV plant in Cilamaya, a partnership between PT Indo Energi Masa Depan (Inerman) and Shanghai Electric (Sari & Djumena, 2024). While initial mapping of the area shows relatively low risks based on historical weather data (Silalahi & Blakers., 2023), this project still faces challenges in managing offshore floating and anchoring structures, as existing projects of such size are limited all over the globe (ENGIE, 2024).

Floating solar projects in Indonesia, Q3 2024



Source: IESR analysis (2024)

Freshwater floating solar potential in Indonesia*



Source: MEMR (2024b), NREL (2023), Silalahi et al. (2021) with modifications

Note: MEMR's calculation uses 20% of the water body area. NREL's methodology limits the distance from shore as a parameter instead of area. The chart shows NREL's results for a median shore distance of 50 to 1,000 meters. Silalahi et al. (2021) estimated 50 GW potential for 5% water body area utilisation. Compared with MEMR's data, the data is extrapolated to 20% water body area use, resulting in four times the capacity.

A firm legal basis for electricity export could reduce risks and uncertainty for cross-border Indonesia-Singapore electricity trade

- The latest official update in September 2024 stated that the Singaporean Energy Market Authority (EMA) had granted the first conditional licenses (CL) for 5 companies for the Indonesia-Singapore electricity export of 2 GW_{ac} in total. These projects are expected to be completed in 2027, as the Indonesian authorities are preparing for subsea cable interconnection and reviewing the required permits. Additionally, 2 other companies have also obtained conditional approvals (CA) for additional 1.4 GW export capacity, namely Singa Renewables, in cooperation with RGE and Total Energies (1 GW) and Shell Eastern Trading (0.4 GW) (Singapore EMA, 2024). With a total of 3.4 GW export capacity, this could translate into approximately 7.56 GW_{ac} worth of solar power project capacity.

- Another aspect of the partnership is strengthening the domestic solar module and the BESS supply chain. Article 18 of the latest MEMR Regulation 11/2024 stated that minimum local content requirement (LCR) level for cross-border renewable energy projects will be determined and announced separately by the Ministry of EMR, which is planned to be 60%. While the official stipulation is still under discussion, several CL grantees have started the process of partnering with global solar panel and battery manufacturers to supply this project and open production sites in Indonesia.

- Indonesian officials have firmly stated that this is a government-led project and PLN will play a crucial part in this project (Muliawati, 2023). However, a firm legal basis is urgently needed for such complex project implementation. Currently, the Government Regulation 42/2012 has stated the requirement for cross-border energy trade but does not explicitly specify the role of the related ministries nor the PLN as the single buyer in the Indonesian electricity market structure. Furthermore, MEMR Regulation 11/2021 stated that the permit for electricity export only applies for a 5-year period, giving more uncertainty for such a long-term project.

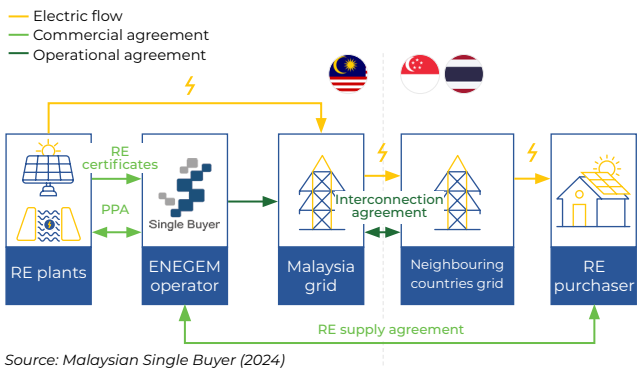
- Other countries are also preparing for this Singapore green electricity import. For example, the Malaysian government has already established Energy Exchange Malaysia (ENEGEM), acting as the facilitating platform under the late guide for Cross-Border Electricity Sales (CBES) issued by the Malaysian Energy Commission (Lim, 2024). In this case, the ENEGEM and Malaysian Single Buyer (SB) act as the aggregator, purchasing renewable energy using the renewable energy certificate (REC) mechanism while also securing deals with renewable energy purchasers in the neighboring countries (Single Buyer, 2024).

List of conditional license holders for Indonesia-Singapore electricity export

Export Capacity (GW)	Company	Plant capacity estimation	Local manufacturing progress
0.6	Pacific Medco Solar Pte Ltd, formed by PacificLight Renewables Pte Ltd, Medco Power Global Pte Ltd, and Gallant Venture Ltd	2 GW and 500 MWh in Bulan Island.	Letter of Intent signing with Jiangsu Seraphim Solar Energy, LONGi, IDN Solar, Huawei Tech Investment, and Sungrow Power Supply in September 2023 (Asmarini, 2023)
0.4	Adaro Solar International Pte Ltd., formed by PT Adaro Clean Energy Indonesia	No public details available yet	Letter of Intent signing with Jiangsu Seraphim Solar Energy, LONGi, IDN Solar, Huawei Tech Investment, and Sungrow Power Supply in September 2023 (Asmarini, 2023)
0.4	EDP Renewables APAC	No public details available	No public details available yet
0.3	Vanda RE Pte Ltd, formed by Gurin Energy Pte Ltd and Gentari International Renewables Pte Ltd	2 GW and 4,4 GWh	Framework Supply Agreement with Trina Solar to supply 1.2 GW n-type i-TOPCon modules (Gurin Energy, 2024)
0.3	Keppel Energy Pte Ltd	No public details available	No public details available yet

Source: IESR analysis from public sources (2024)

Malaysian ENEGEM scheme for cross-border electricity trade



Source: Malaysian Single Buyer (2024)

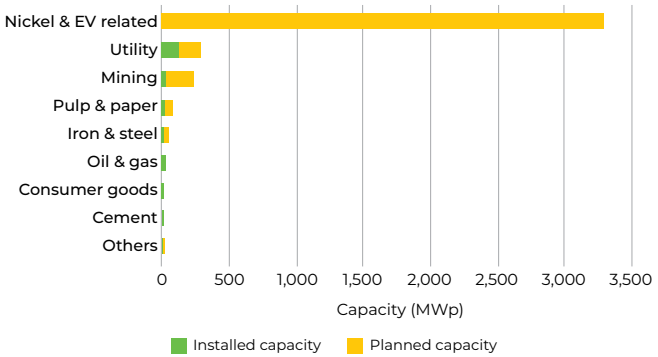
Energy-intensive industries are keen to capitalize solar energy in captive sites, while power wheeling could serve as a game-changing policy for captive green electricity

- The nickel and EV battery-related industry is set to lead the way forward in accelerating solar power capacity additions in captive sites, with up to 3.3 GWp planned at various locations despite having no prior installed capacity. The bulk of this planned capacity is held by PT IMIP (1 GWp) and PT IWIP (2 GWp). This initiative aligns with Indonesia's plan to expand its nickel industry to capitalize on the EV market while supplying increased energy demand with green sources. This creates a competitive edge in adopting sustainable practices, with on-site renewable energy generation seen as one of the most favorable options.

- Due to its relative accessibility and affordability compared to other renewable energy sources, solar energy for on-site generation in Indonesia's nickel and EV battery industries is perceived as a strategic move. Similarly, PPUs supplying various industrial parks in Indonesia are also planning to increase their solar capacity, increasing the amount of green energy supply for their tenants. Due to this rising trend of green industrial parks, the MoI also signals its support for developing more "smart-eco industrial park", including the 25 industrial parks stated as National Strategic Projects (MoI, 2023). While concrete action still needs to be taken, this trend should open the door for more renewable energy development in such areas, including solar energy.

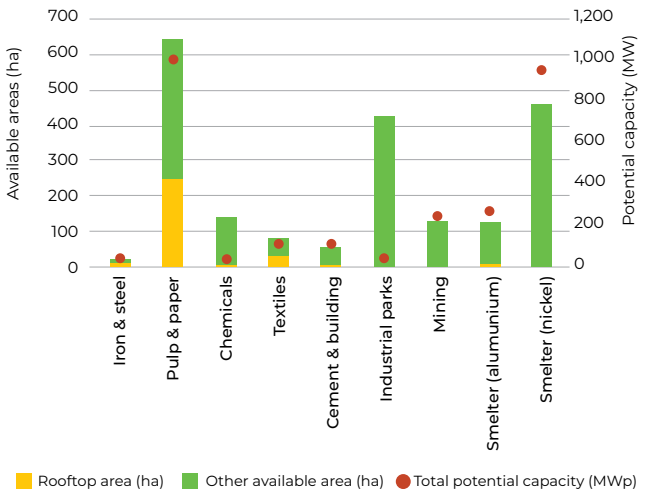
- Based on IESR's analysis of current captive coal-fired power plant sites, there are only 2.88 GW of solar capacity potential in 32 separate captive coal power plant sites, using available areas such as rooftop and unused land surfaces. IESR analysis shows an untapped solar power potential in pulp and paper industry facilities, boasting a massive potential of 1 GWp from roughly 645 ha of available. For example, APRIL group has supported their production facility in Riau with 11 MW of solar power and a target of 50 MW in 2030. (Adha, 2024). Mining and smelter sites also boast significant potential for captive solar power installations, with a total of 1.49 GWp of technical solar potential. While the actual potential could be much higher due to the currently limited detailed information on captive power sites, the technical solar potential on current captive sites are still inadequate to fulfill the green electricity demand. To really unlock the green electricity demand from such industries, power wheeling could provide option to tap into the enormous solar power potential.

Solar energy projects in captive power sites



Source: IESR analysis from company releases (2024)

Solar technical potential in captive coal power sites



Source: IESR analysis based on captive coal power plant data from Global Energy Monitor (2024)

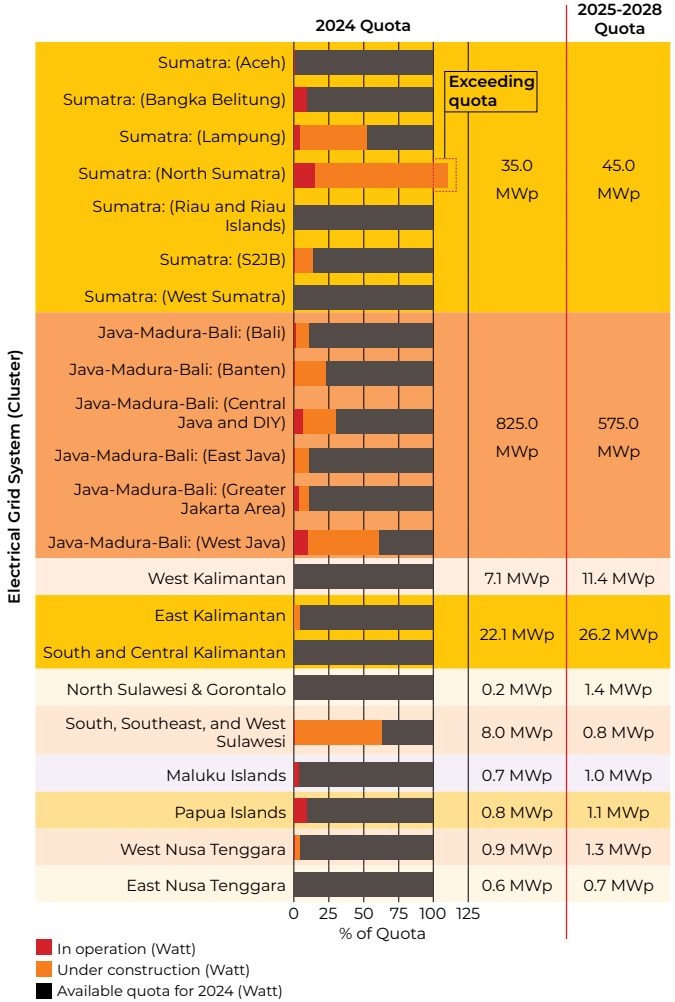
While positively welcomed by developers, the new rooftop PV quota system introduces a significant market shift toward industrial customers

- The limitations on rooftop PV installations imposed by PLN, driven by reliability concerns, eventually led to a compromise with MEMR, resulting in the replacement of MEMR Regulation 21/2021 with Regulation 02/2024. This new regulation eliminates the export-import pricing scheme, abolishes capacity limits, and introduces a quota system determined every four years by IUPTLU holders. On July 4, 2024, MEMR issued a Director's Decree detailing quota allocations for different locations, totaling 1.5931 GW, while the detailed sub-location quotas are available in the PLN Mobile or Simantaps application. However, PLN's published quotas also include capacity approved (in operation and under construction) before the new rooftop PV mechanism, which reduces remaining quotas per cluster, most notably in high-demand regions such as West Java and Southern Sulawesi. A notable case has been observed in North Sumatra, where the available quota has even turned negative (Ashurst, 2024), making quota reallocation for such cases is required.

- This revision is deemed acceptable by most solar developers, as it provides clarity and resolves some uncertainties. An internal survey by the Indonesian Solar Energy Association (AESI) reflects this sentiment among solar developers, with 250-300 MW of solar PV targeted to be registered in July 2024 and potentially 550-600 GW in 2025 (Wahyudi, 2024). Indeed, during the 2024 permitting month, around 60% of the quota has been filled, with many industrial zones maxing out their respective UP3 quotas while residential areas still have the remaining capacity (Wahyudi, 2024b; Agung, 2024).

- With the new policy, installations are less appealing for residential customers due to the removal of credits for exporting excess electricity. Existing customers will continue to receive credits for ten years from their SLO (*Sertifikasi Layak Operasi*) or IUPTLS (*Izin Usaha Penyediaan Tenaga Listrik Untuk Kepentingan Sendiri*) permit approval, but future residential customers face a longer payback period than under the previous MEMR Regulation. However, commercial and industrial (C&I) customers with greater financial and technical capacity benefit from the policy, as it opens up capacity available, potentially increasing their cost-effective sustainability measures. Our analysis has shown that the payback period for the residential sector will increase by 40%, while for C&I, it will only increase by approximately 5% and 0.015% times, respectively, further signaling the shift in market in the near future (IESR, 2023).

Rooftop PV remaining quota status, July 3rd 2024



Source: IESR analysis based on MEMR Director's Decree on rooftop PV quota and Ashurst (2024)

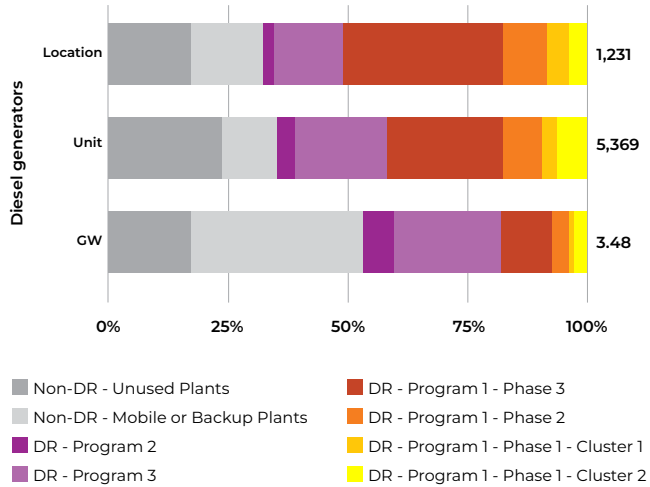
Diesel conversion to renewables program has been overhauled, delaying the original implementation timeline

- PT PLN's diesel replacement program aims to reduce reliance on costly imported diesel and increase the RE mix by 0.05%. The first phase, managed by PLN's Renewable Energy team, focuses on converting diesel plants to renewables, primarily PV+BESS. Future phases may include wind, hydro, biomass, and ocean power. The subsequent phases, overseen by PLN's Generation Management team, aim to convert diesel plants to gas engine power plants (Program 2) or grid interconnections (Program 3). This will serve as a big opportunity for solar developers to participate in mini/small scale PV+BESS projects in the upcoming years. The first phase tender, accounting for 485 diesel units across 94 locations, has already found its winners. Cluster 1 (West Indonesia) will convert 0.040 GW of diesel plants (*Pembangkit Listrik Tenaga Diesel*), awarded to IB VOGT, GmBh, in partnership with PLN Nusantara Power. Cluster 2 (East Indonesia) will convert 0.076 GW of diesel plants, awarded to PT EMITS, a consortium of Indika and Infraco, in partnership with PLN Indonesia Power. Both clusters are expected to commence COD in 2027.

- After the 2022 tender was canceled due to a lack of participation, the 2023 re-tender process improved the project's economics by consolidating eight clusters into two, attracting over 48 developers worldwide. These changes, including a 15% contribution from PLN's subholdings for land clearance and initial permits, have made the project more viable. Future phases aim to add a total of 847 MWp of solar PV power plants and 1,693 MWh of BESS, with COD expected in Q4 2028 and Q4 2030, respectively. Currently, the second and third phases are under feasibility study and will likely be tendered in Q3 2024-Q1 2025 and Q3 2025 - Q1 2026, respectively.

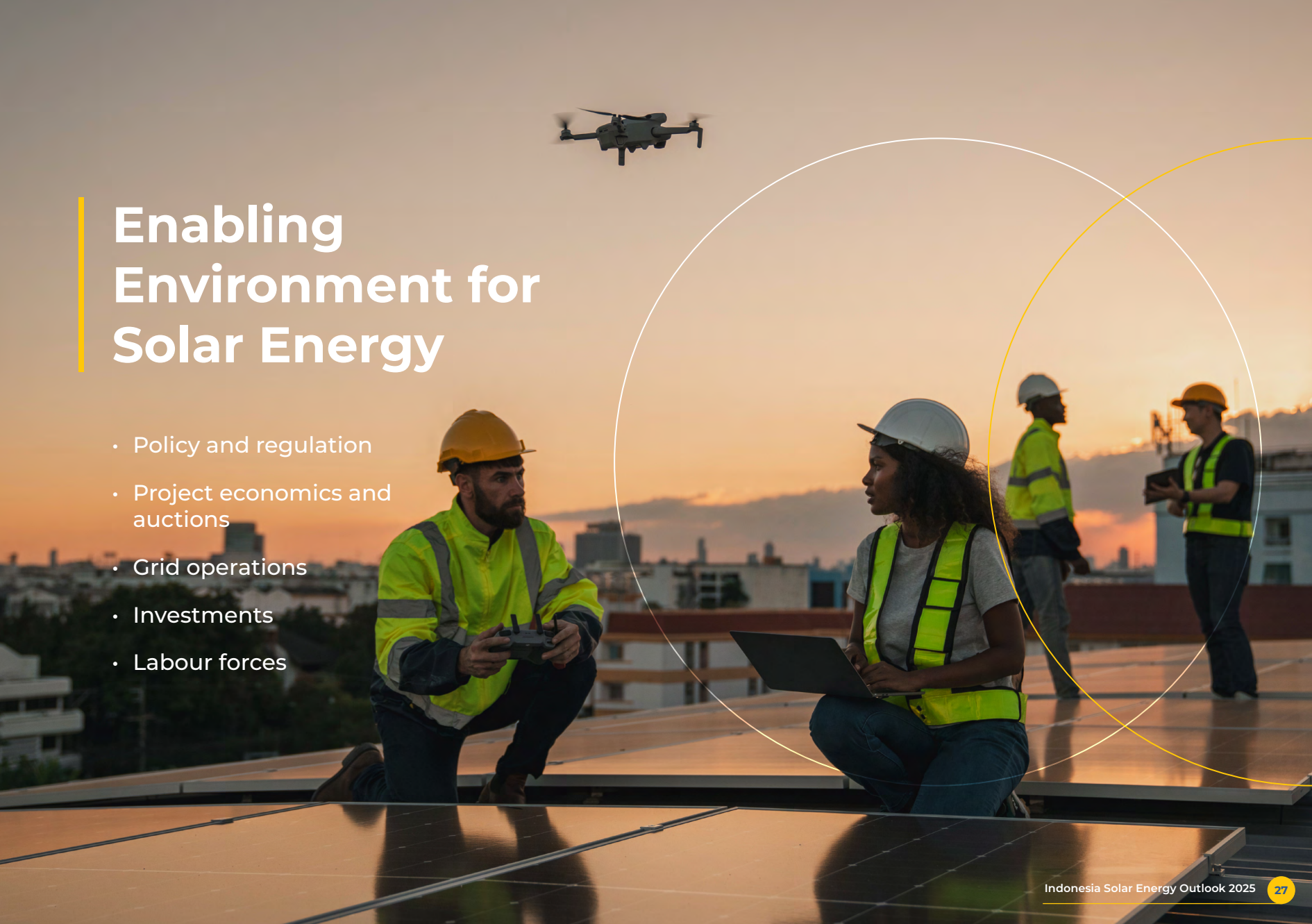
- Stakeholders in the next phases must take note of the current challenges. The final PPA price for the first phase is currently still under review from the MEMR and has been delayed; it was supposed to be finalized and signed by Q2 2024. The MEMR saw the need to balance the generation cost and the renewable energy fraction for each location to determine the final PPA price. PLN's internal joint study with *Universitas Indonesia* shows that a higher fraction increases CAPEX due to the BESS requirement for load shifting. However, given price volatility and forecasted diesel price increases, this study suggests that investing in a higher renewable energy mix might be more advantageous in the long run. IESR analysis also shares the same concern, with a standalone diesel plant could be 18% more expensive compared to a hybrid PV-BESS-diesel plant with a high (98%) renewable fraction in a high diesel price scenario (IESR, 2022b).

PLN's diesel capacity, units, and locations and inclusion in the diesel replacement (DR) program



Converted to:	Phase 3	Phase 2	Phase 1
PV	648 MWp	199 MWp	165 MWp
BESS	1,295 MWh	398 MWh	322 MWh

Source: Interview with PLN's DIV MEB, June 2024



Enabling Environment for Solar Energy

- Policy and regulation
- Project economics and auctions
- Grid operations
- Investments
- Labour forces

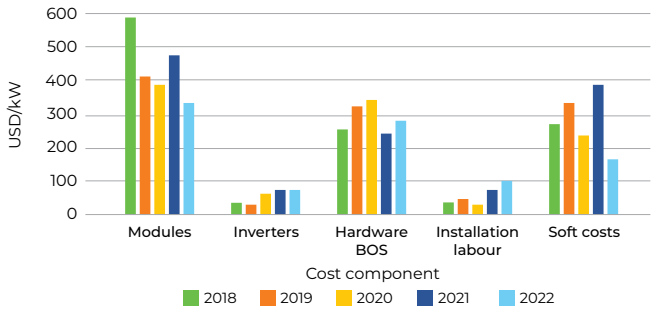
Steady decline in costs and lead time could be further improved by reducing solar project development risks and streamlining permitting process

- IRENA renewable energy cost breakdown data based on the utility-scale solar projects in Indonesia shows a 19% decline in total US$/kW price during the 2018-2022 period. As expected, the biggest cost decline driver is the module price, which comprises around 35-45% of the total project cost due to the global market being flooded with highly competitive products. This also affects the Indonesian market, as module cost components show a 44% cost decline in 2018-2022.

- Positively, the soft cost component for Indonesian solar projects has also experienced some improvement, declining by 38% in the 2018-2022 period. This is mainly due to reduced permitting and financing costs, which have declined by 34% and 42%, respectively, in the same period. However, the perceived risks for renewable energy investment (including solar) are still high, especially for procurement processes and tariffs (Yustika, 2024), affecting the financing costs imposed by banks or other financial institutions. A significant portion of the cost component (20% to 32%) comprises hardware balance-of-systems costs, including grid connection costs. This has fluctuated over the years, as some projects need to invest more in grid connections due to unavailable existing infrastructure. Interestingly, installation labor saw a significant 63% increase in 2018-2022, indicating the trend of rising skilled workforce demand in the construction process.

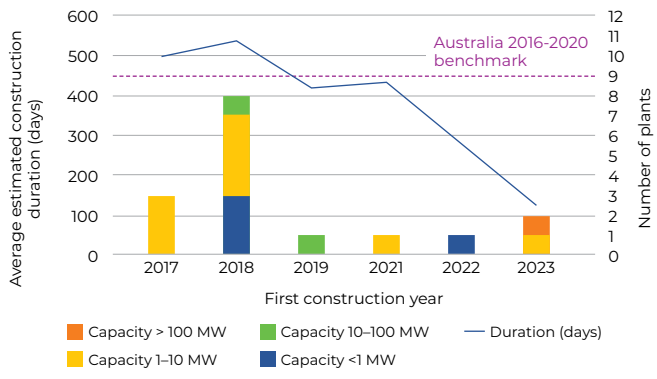
- IESR analysis using AI-powered satellite imageries dataset (TransitionZero, 2024) shows that the estimated construction time has drastically reduced in the last 5 years, from around 500 days in 2017 to almost 120 days per project in 2023. This is fairly comparable with practices in other countries. For comparison, construction data for Australian solar projects in 2016-2020 averaged around 447 days for construction time (Clapin & Longden, 2022). However, this dataset does not capture non-construction lead times in Indonesia, such as permitting, site preparation, and commissioning time. Solar developers also stated some challenges resulting in long pre-construction time, including tedious PPA negotiation time and a complicated permitting process for land acquisition. Data from several developers reveals that location and environmental-related permits could take as long as 9-12 months to process (EY, 2023). To avoid these long lead times, pushing for more site-specific projects rather than location-agnostic auctions (known as *kuota tersebar*) could assist the land acquisition process in the future, while providing a standardized PPA template should facilitate the process of PPA signing.

Indonesia's solar power project component cost breakdown, 2018-2022



Source: IRENA (2019-2023)

Indonesia's solar power project construction time estimation, 2017-2023



Source: IESR analysis, TransitionZero (2024)

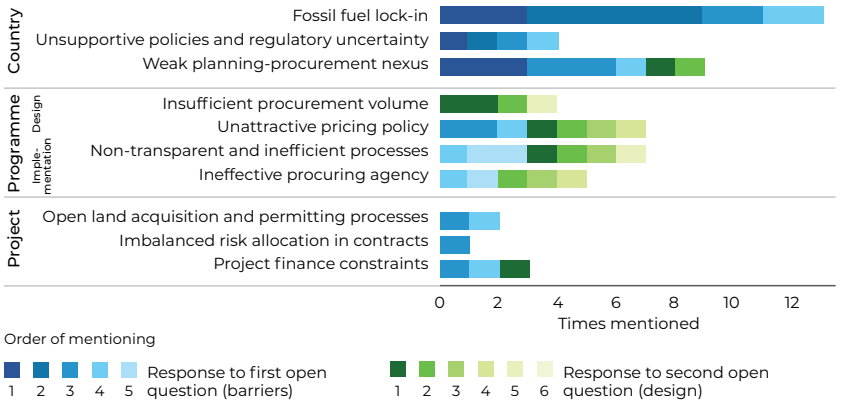
Procurement design will be crucial for utility-scale solar deployment, but bundling solar projects should prioritize renewable energy sources

- RUPTL PLN supposedly attracts renewable energy projects. However, renewable energy developers have constantly mentioned 'weak planning-procurement nexus' as one of the key barrier to renewable energy investment due to PLN procurement volume constantly missing the stated target year. The project-by-project approach in renewable energy procurement lacks the scale to make an economic viable for developers (Halimatussadiah et al., 2024). While the large renewable energy procurement volume seen in the Hijaunesia project seems like a big breakthrough by PLN to improve procurement volume, it still inherits the per-project nature process.

- As PLN already recognizes the push for procurement redesign, a location-based bundling tender scheme for upcoming renewable energy projects is being prepared, combining various sorts of power plant types in the same auction package. Similar bundling schemes have been done elsewhere, such as India's Jawaharlal Nehru National Solar Mission (Gulia et al., 2021), which resulted in a significant number of projects coming to realization. While combining several technology types will add complexity, such combinatorial bundling could provide substitutionality between individual projects, leading to overall economic competitiveness (Ehrhart et al., 2024). Technically, PLN has tried a similar 'cluster and bundle' method for the diesel replacement program, which has already seen its winner announced in late 2023. Thus, any lesson learned from the project could be implemented on a larger project scale.

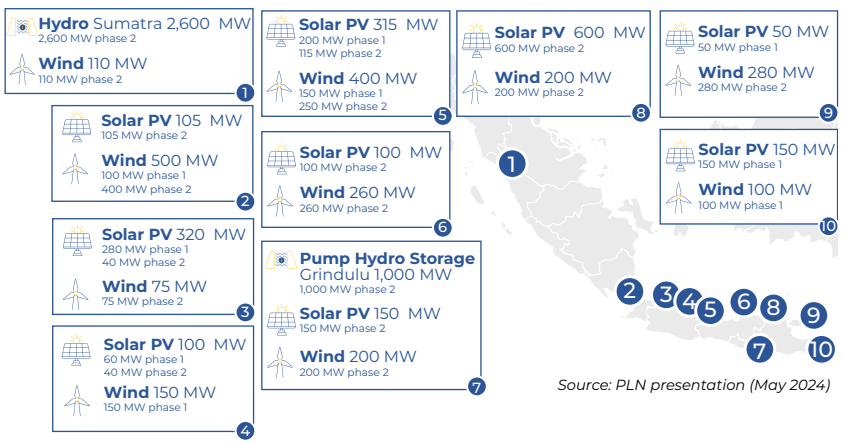
- Although the final project list and procurement mechanism are still in the process, PLN has identified a total of 1.8 GW of possible utility-scale solar power projects to be bundled in 9 different project packages, mostly in Jamali and Sumatra systems. While these tender schemes mostly combine solar with wind and hydro projects, PLN also planned some bundling options with gas and coal power plants. Instead, PLN should focus on such a bundling scheme for deploying renewable projects. On top of the bundling mechanism, improving market signal through consistent procurement scheduling is equally important to improve renewable uptake, as the current process still lacks transparency and regularity.

Barrier to investment and RE procurement design issues



Source: Halimatussadiah et al. (2024)

RE project with bundling tender scheme plan by PLN



Source: PLN presentation (May 2024)

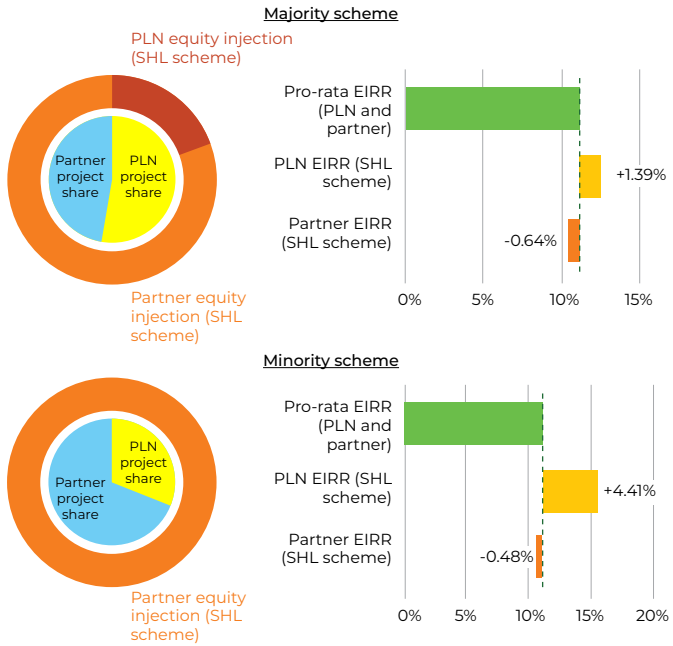
A transparent project ownership structure could avoid imbalanced risk sharing between PLN and solar developers

- Going forward, PLN, through its subsidiaries, prefers renewable project development under three development schemes, namely PLN fully owned generation and ownership sharing with private partners/IPPs under majority share and minority share schemes (PLN Nusantara Power, 2023a). PLN offers collaboration and co-investment with IPP partners where they can collaborate with PLN's subsidiaries as the mandatory partners in power plant development for the ownership sharing scheme. PLN would hold a minimum of 51% ownership under the majority scheme as stipulated under Presidential Regulation 4/2016 and possesses less ownership for the minority scheme. However, several developers have stated a couple of imbalanced risk-sharing in practice between PLN and IPP partners (Halimatussadiah et al., 2024; Yustika, 2024). This condition creates unfair competition in project development, specifically projects that incorporate an imbalanced shareholder loan (SHL) in its capital structure.

- Typically, PLN and IPP partners will individually inject the project equity based on their respective project ownership shares under the pro-rata model. However, the imbalanced shareholder loan scheme allows PLN to inject less equity while keeping the same project ownership share. The rest of the required equity is borne (or technically, loaned—thus the term "shareholder loan") by the partner and will be paid back by PLN at a certain agreed interest rate (known as the shareholder loan interest rate). This practice is commonly used for infrastructure project financing, as it provides more flexibility and could be designed to improve project cash flow. However, in a vertically integrated electricity market like Indonesia, this could be more challenging and complex, especially taking into account PLN's double role as the off-taker and the project developer partner (delegated to their subsidiaries).

- IESR financial model simulation attempts to illustrate the impact of such an SHL scheme for PLN's and partner's equity internal rate of return (EIRR). Under both the majority and minority shareholder scenarios, the SHL scheme could provide 1.39% and 4.42% higher EIRR, respectively (compared to the pro-rata equity injection scenario). Still, the partner's EIRR could be reduced to 0.64% and 0.48% under majority and minority scheme, respectively. While the exact numbers are largely dependent on the deal's structure (e.g., equity injection proportion, shareholder loan interest rate, debt payment terms, etc.), such partnership structure is typically only financially feasible for large developers with adequate capital and financial capability, mainly covering for PLN's equity share and taking the "calculated" opportunity cost due to potential revenue lost. If PLN is insisting the use of this scheme in future projects for the sake of its financial health, the procedure needs to be adequately transparent for the participating partners to improve practice standards, ensuring fair risk-sharing for both parties and avoiding lengthy process.

Simulation of EIRR sharing between PLN and partner under imbalanced shareholder loan (SHL) scheme



Source: IESR analysis (2024)

Note: Simulation done on a typical 50 MW solar project with a 80:20 debt-equity ratio, 10% equity subscription portion, and a shareholder loan interest rate of 8%.

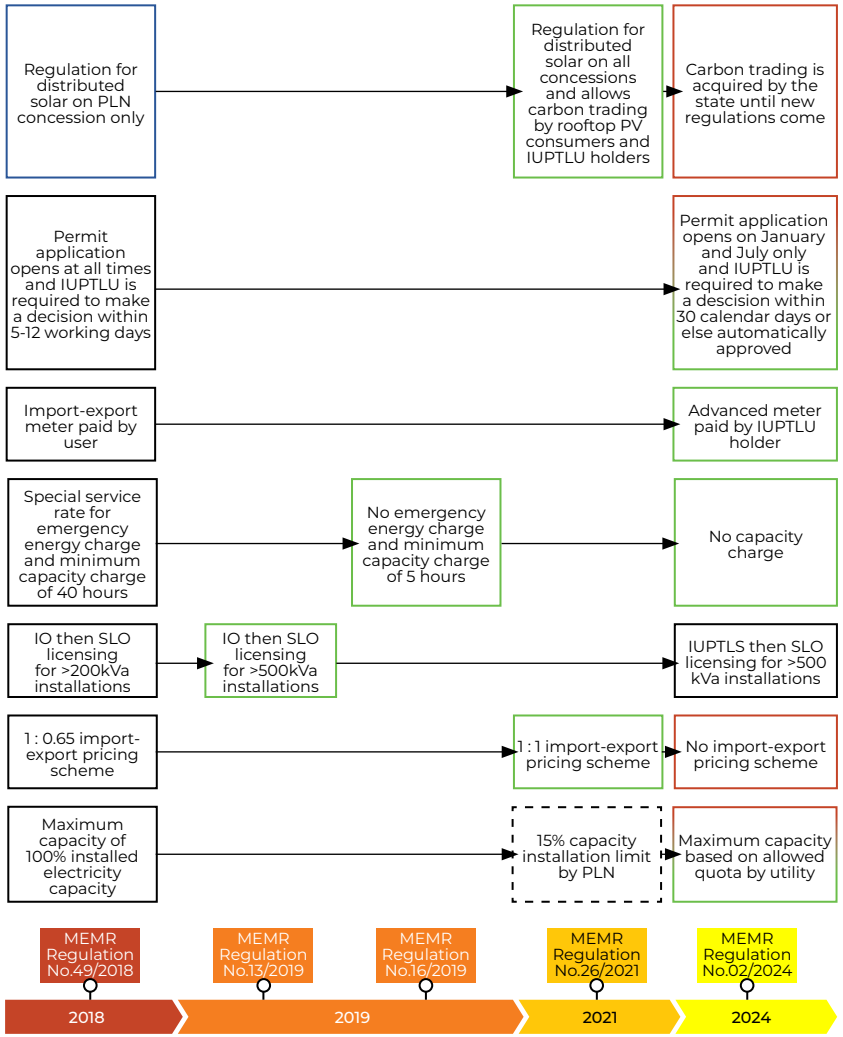
MEMR regulation on rooftop solar is a compromise, but can it accelerate deployment to meet 3.5 GW?

- The new MEMR's Ministerial Regulation 02/2024 introduces several positive aspects to boost rooftop solar development in Indonesia that intend to catch up to the 3.5 GW target in 2025. Developers and customers have welcomed the elimination of parallel operation costs and the transfer of the advance meter fee to IUPTLU holders to track household electricity system exports and imports. This adjustment likely compensates for the removal of export-import incentives. Additionally, the permitting process has been digitalized using software applications (PLN Mobile and Simantap), aimed at improving efficiency, monitoring, and evaluation purposes for both PLN and non-PLN *wilus*. This is a progressive step toward planning future policies and increasing the transparency of distributed solar PV in Indonesia.

- However, some elements of the regulation require greater transparency. For instance, during the quota determination process, the rationale and studies behind the IUPTLU holders' quotas were not made public. Historically, discrepancies have arisen between the implementation of regulations by PLN regional units, particularly related to allowed quotas and the time required to process required permits. During the permit submission process in July 2024, several developers noted that the quota "reallocation" mechanism between PLN customer service units (*Unit Pelaksana Pelayanan Pelanggan*/UP3) should improve its transparency. Some solar developers noticed abrupt quota re-adjustment in the last few days of the quota submission period, even "transferring" a significant amount of rooftop quota across different PLN distribution units (*Unit Induk Distribusi*/UID), interrupting their business processes.

- Moreover, there is currently no clear timeline for the carbon economic value guidelines for rooftop solar. In the absence of such guidelines, the carbon economic value will be claimed by the Indonesian government, hindering rooftop solar developers from participating in the carbon market. This is particularly discouraging for rooftop solar developers, as they are keen to participate in carbon trading or renewable energy certificates (REC) mechanism, adding an alternative source of revenue.

MEMR regulation on rooftop PV timeline, 2018-2024



Source: IESR analysis, 2024

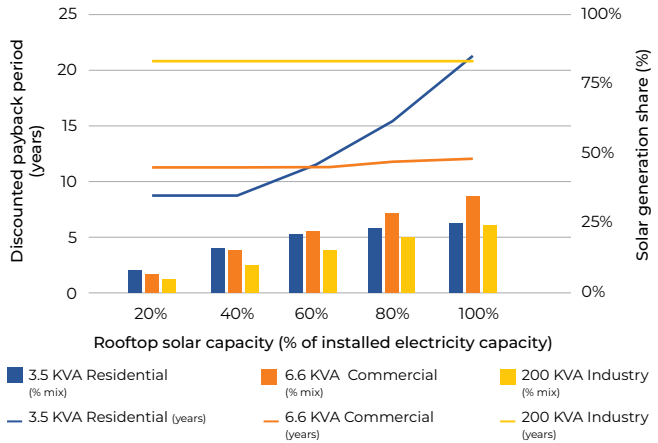
With no electricity bill savings from excess electricity, expect behavioral changes from behind-the-meter consumers to install BESS

- Since no electricity export will be rewarded with bill savings, consumers need to adapt to maximize the benefits of rooftop solar. Average plant sizing will be reduced to avoid excessive exports, more significantly in residential customers who consume less electricity in high irradiation times, resulting in a higher probability of unused solar generation. Our analysis shows that oversizing rooftop solar in residential would result in a longer payback period of up to 10 additional years, indicating that residential customers should keep their plant size about 20-40% of their installed electricity capacity. This plant sizing problem, however, would not affect commercial and industrial consumers, enabling them to reap most electricity cost and emission reduction benefits from on-site renewable generation.

- As energy conservation becomes crucial in all end-user segments, consumer behavioral changes should be anticipated to maximize cheap, low carbon electricity from rooftop solar. This could present an opportunity for companies providing energy monitoring and management services. Looking further forward, the deployment of small-scale, behind-the-meter BESS to complement rooftop solar installation could be imminent. Solar developers in Indonesia have seen a rise in PV+BESS demand in the high-end residential sector in recent years, and net-metering abolishment could speed up the adoption. Looking elsewhere around the globe, the rising adoption rates of behind-the-meters energy storage in the EU could be attributed to the system conditions and regulations, mainly on electricity tariffs (IEA, 2024). While such conditions might not be replicable in Indonesia due to different tariff structures, behind-the-meter BESS applications could also be beneficial for system operators, providing ancillary services should the right incentive arrive (Vafamehr et al., 2019).

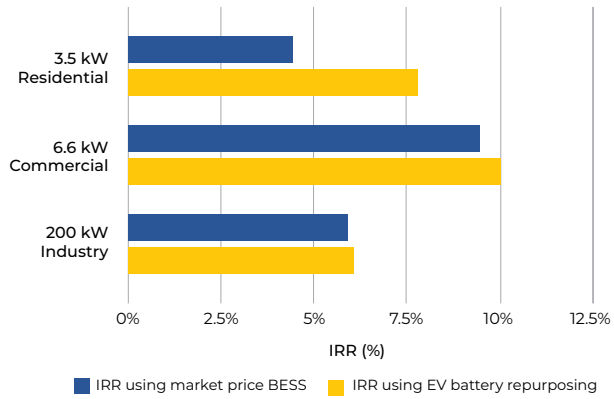
- Securing a long guaranteed contract (preferably above 7 years) with a battery technology provider is key to having an economically viable behind-the-meter BESS case in Indonesia. While the improvement of the domestic battery supply chain could help drive the cost down, EV battery repurposing could also provide a low-cost alternative for BESS applications, especially for residential customers. Although the actual economic case is still dubious for most developers, IESR's calculation shows almost twice the return for residential consumer investment using retrofitted EV batteries compared to the current market price BESS.

Payback period and solar generation share for several rooftop solar customer



Source: IESR analysis (2024)

IRR comparison of using EV battery repurposing for behind-the-meter BESS



Source: IESR analysis (2024)

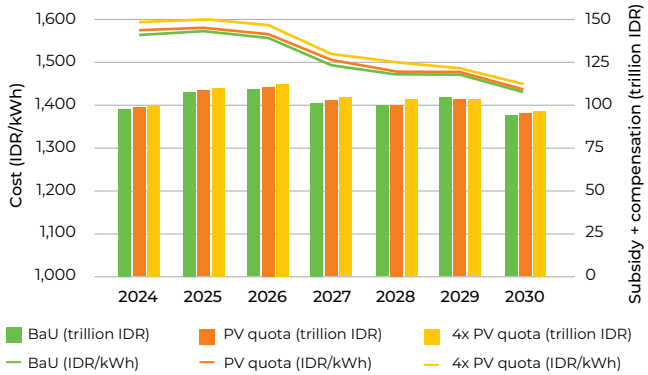
Utility and distribution operators should prepare flexible options to mitigate impacts of high rooftop solar adoption

- The latest MEMR Regulation 2/2024 on rooftop solar explicitly stated in Article 43 that any extra costs that are incurred as the result of higher rooftop solar adoption should be accounted for in PLN's calculation of principal electricity cost, which will affect the total electricity subsidy and compensation from the national state budget (APBN). IESR analysis using PLEXOS shows that with current electricity capacity expansion based on the 2021-2030 RUPTL PLN and latest RUKN draft, the current quota on rooftop solar based on Director General Decision 279.K/TL.03/DJL.2/2024 only resulted in an average of 0.49% increase in electricity subsidy and compensation needs. Going even further, sensitivity analysis with a rooftop solar quota 4 times larger (which ultimately would surpass the 3.6 GW strategic national project target in 2025) only resulted in an average 2.42% increase in electricity subsidy and compensation needs. This should put the paranoia of excessive electricity tariff increase due to rising rooftop solar adoption to an end.

- Instead, PLN should focus more on improving the technical capability aspect of the grid to absorb more distributed sources. Ultimately, it is inevitable that higher rooftop solar penetration (or any variable renewable sources) would eventually lead to rising demand for ramping capacity in the system, with our PLEXOS analysis showing the need to provide an average of 9.5% (around 764 MW) more ramping capacity compared to low adoption level (business-as-usual/BaU). Such sources of flexibility are currently being provided by existing gas power plants with higher fuel prices, thus explaining the slight rise in electricity cost.

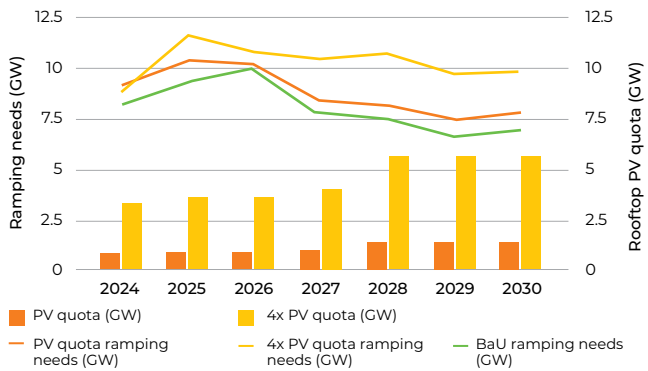
- Defining ancillary services in an updated grid code could be the first important step in paving the way toward a more systemic solution for grid flexibility provision. A larger roll-out of utility-scale energy storage, such as BESS and pumped hydro storage plants, could also help provide flexibility sources, while utility should also consider tapping into the underutilized flexible capability of coal-fired power plants. With utility-scale pumped hydro storage projects being deployed by PLN after 2028, this should be followed by a more ambitious rooftop solar quota determination. While currently being overlooked, distribution systems operators (DSOs) role in Indonesia's future power system should be modernized, starting by updating the 15-year-old distribution code to accommodate more PV rooftop adoption.

Estimated electricity cost and subsidy compensation needs for several rooftop solar quota scenarios in Java-Bali system



Source: IESR analysis using PLEXOS (2024). Technical assumptions can be found in Appendix B

Ramping needs for several rooftop PV quota scenario in Java-Bali system



Source: IESR analysis using PLEXOS (2024). Technical assumptions can be found in Appendix B

While the available fiscal facilities are useful for solar developers, providing incentives to household consumer could boost adoption of distributed solar and local PV manufacturing

- Presidential Regulation No. 112/2022 outlines the fiscal and non-fiscal incentives for renewable energy development in Indonesia, further regulated by derivative policies. Fiscal incentives are one of the instruments employed to increase the attractiveness of investment in the strategic sectors of a nation, including the energy sector. GoI has provided several fiscal incentives, including tax holidays, tax allowances, and duty exemptions for renewable energy. While these incentives have been proven to be useful for solar developers (especially the import duty facility due to most components being imported), in practice, these fiscal facilities primarily benefit developers or corporations with substantial capital (minimum level of investment value), excluding small and medium-scale businesses from accessing these benefits.

- When considering the consumer side, it is important to note that there are no incentives offered to customers for the purpose of beneficially installing distributed solar systems. This is especially true after the net-metering scheme was eliminated. Although this is a major setback, the government could offer alternative incentives, such as installation subsidies for household consumers with conditions such as only using a domestic-manufactured solar module, to encourage more adoption. For example, India has provided incentives under the Central Financial Assistance (CFA) scheme, which reduces up to 40% of the solar PV installation cost for residential and commercial use that massively drives rooftop PV adoption in the country (Indian MNRE, 2023).

- Historically, Indonesia has also provided similar incentives under SEF in 2022 that reduce the adoption cost of rooftop PV for SMEs and residential adoption (UNDP, 2023), but it ceased after the first round. The effectiveness of the program is also arguably hindered by the 15% capacity limitation imposed by PLN in the same year. With the new quota system being put in place, such a program could provide an effective demand-pull incentive that boosts rooftop solar adoption. A survey has shown that affordability serves as one of the dominant factors for rooftop solar adoption (IESR, 2021c), indicating that such a program should be continued for further growth, especially for residential and small-scale commercial installations that have been massively hampered by net-metering abolishment.

Fiscal incentives for renewable energy development in Indonesia


Tax holiday	Tax allowance	Import duty facility
• MoF regulation no. PMK 130/2020	• MoF Regulation no. PMK 153/2020 • Government Regulation 78/2019 • MoF Regulation no. PMK 128/ PMK.010/2019	• Government Regulation no. 48/2020 • Mof regulation no. PMK 176/2009 jo. PMK 188/2015 • Mof Regulation no. PMK 66/2015
• This tax facility is given to pioneer industries with a minimum IDR 100 million investment value • Corporate tax reduction of 50%-100% for 5-20 years	• This tax facility is for the national priority industry • Corporate net income deduction by 30%, accelerated depreciation and amortization, and loss compensation of more than 5 years • Super deduction facility through gross income deduction up to 300% for organizations that develop patents. • Gross income deduction of up to 200% for organizations that provide training and human capital development related to renewables technology.	• Import facility through VAT free for certain imported technology for strategic development. • Duty-free for imported goods and technologies for investment purposes for up to 4 years. • Duty-free for imported goods and technologies for electricity generation industry of up to 2 years.

Source: MoF (2022)

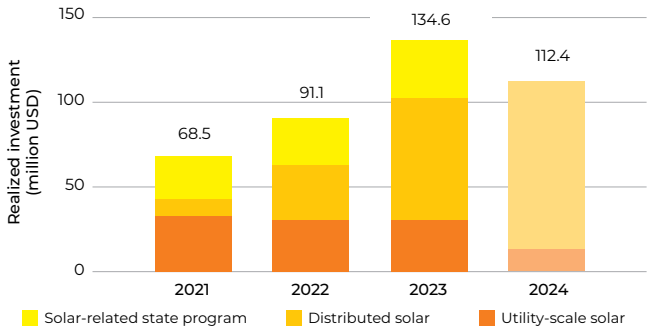
While significantly growing, providing market certainty for large-scale solar projects could propel investment volume to the required level

- Investment in renewable energy-related sectors has remained stagnant for the past few years. The MEMR annual reports show an average of around USD 1.4–1.7 billion realized investment in renewable energy and energy efficiency sectors, or around 5% of the total investment allocated for the whole energy and mining sectors. However, looking more closely, solar energy investment is almost double in 2 years, going from less than USD 70 million in 2021 to more than USD 130 million in 2023. The main driver of the growth is mainly distributed solar's investment, which grew 7 times within 2 years. This is a significant relief for Indonesia's distributed solar landscape, as investors are still willing to bet on the market despite turbulence in regulation for the last 1-2 years.

- Private investment in solar energy shows a promising sign this year (as per July 2024), with IESR analysis revealing at least USD 112 million in announced funding in solar energy-related sectors. Interestingly, contrary to popular belief of local bank's reluctance to invest in renewable energy, most of these are sourced from domestic banks/financial institutions, either from state-owned or private entities. The majority of these announcements came from the funding round for prominent distributed solar developers to scale up their businesses, but the total investment in the solar energy sector could be higher due to smaller funding to early-stage solar startups, which may have gone undetected. These big financing rounds on distributed solar developers may prove the effectiveness of MEMR Regulation 2/2024 to reduce uncertainty in the market, but with significantly less quota allocated in the subsequent years, the market might not experience the same growth rate as this year.

- However, this amount of investment in the solar energy sector is far from adequate to meaningfully propel Indonesia's solar energy sector. The 2023 JETP CIPP has identified the need to invest USD 2.5 billion in 2025-2030 to build around 29 GW of solar energy (mostly for utility-scale) to meet the JETP join statement target (JETP, 2023). Replicating the relatively success story in the distributed solar market and reducing uncertainty in utility-scale solar regulation could eventually boost the investment volume, particularly by establishing a robust solar project pipeline, permitting procedure, and procurement timeline (EY, 2023). Some utility-scale solar projects in the pipeline have also received funding, but the limited amount of such projects in the financing stage limits the investment volume that can be disbursed.

Solar energy-related investment in Indonesia, 2021-2024



Source: DG NREEC, MEMR annual reports

Several announced private financing related to solar energy in Indonesia, January-July 2024

Date	Funding source(s)	Amount	Details
February 2024	Permata Bank	Rp 500 billion (~USD 31 million)	Green financing scheme for an Indonesian distributed solar developer
March 2024	Bank Negara Indonesia (BNI)	USD 14 million	Utility-scale solar project in Kubu, East Bali
July 2024	Norwegian Climate Investment Fund, managed by Nordfund	USD 55 million	Oversubscribed financing round for Indonesian distributed solar developers
July 2024	Nanobank Sharia	Rp 200 billion (~USD 12.4 million)	Green financing scheme for Indonesian distributed solar developer

Source: IESR analysis, as per August 2024

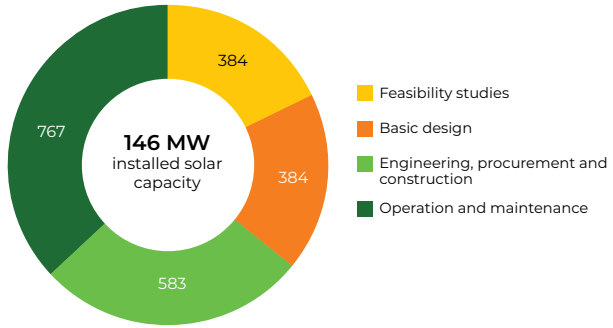
Turning knowledge into industrial know-how requires certainty in solar energy labour market and inclusive access to practical skill development

- The demand for green jobs in Indonesia's solar energy sector is estimated to increase significantly in the coming year due to the scaling up of the solar adoption plan within the country to meet the national target. Data from 2019 shows that from the 146 MW of solar capacity installed, the sector has created 2,118 direct jobs (Koaksi, 2022), ranging from the feasibility study phase, basic power plant design, up to the construction and maintenance phase. The operations and maintenance phase yields the biggest job creation, creating a total of 767 direct jobs.

- To capture the ever-growing demand and bridge the skill mismatch in the solar energy sector, the government has provided several basic training/courses for solar power plant installation and maintenance, namely through MEMR's Human Resource Development Center (PPSDM KEBTKE) and several training programs under Ministry of Manpower. However, such programs are only accessible in big cities and are unreachable in rural areas. Several local governments have also initiated training programs for solar power plants, but they were occasional rather than continuous. Acquiring competent, trained labor in several solar energy projects outside Java Island has been one of the challenges for developers, as transporting technicians from outside the region would increase accommodation costs. Enabling more inclusive access to vocational training in solar energy would require harmonization of both electricity planning by central authorities and training programs provided by the local government.

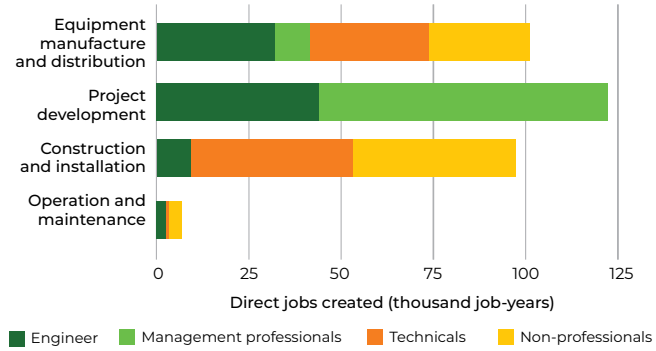
- The total direct job projection scenario based on 2019-2030 RUKN (GGGI, 2020) indicates that the solar energy sector would need more high-skill workers (e.g., engineers and management professionals) in the near future for various fields of work, totaling up to 175 thousand job-years worth of labor. Addressing such a problem would require a more systemic approach, focusing more on the connection between high-order thinking skill transfer in higher education institutions and industrial maturity. While several universities/higher education institutions have started to focus on renewable energy fields (including solar energy), uncertainty in the labor market due to the lack of sizeable projects leads to horizontal skill mismatch, encouraging both existing and new labor forces to pursue a career in a more relatively stable industry. This could lead to less industrial knowledge in the solar energy sector being transferred back to the academic community. Integration of applicable knowledge to education at the university level should begin with creating a strong industry fundamental, and ensuring a firm solar energy demand in the foreseeable future should be the starting point.

Number of solar direct jobs created in Indonesia, 2019



Source: Koaksi (2022)

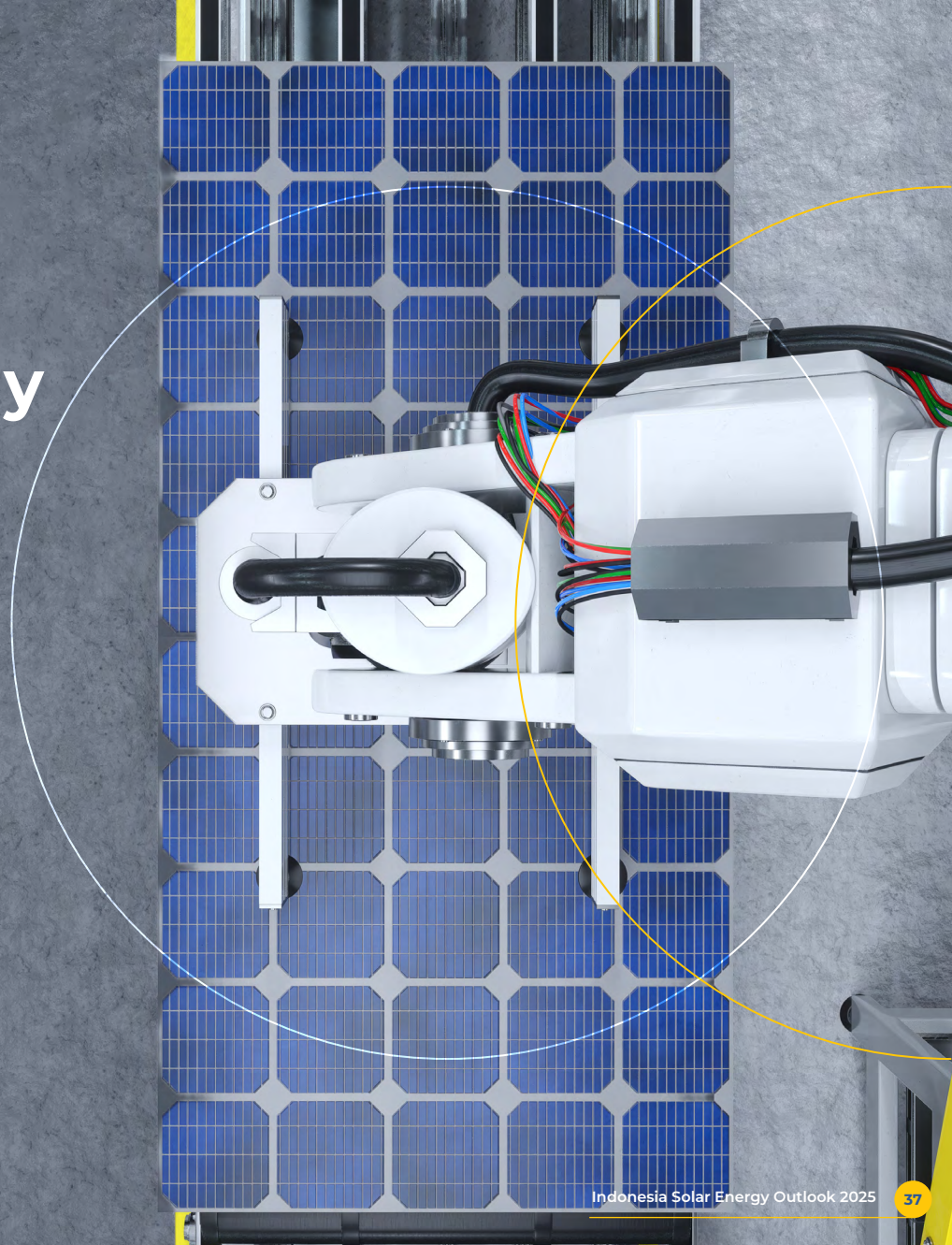
Total direct jobs created in solar energy-related industries under 2019-2030 RUKN scenario



Source: GGGI (2020)

Opportunities for Solar Energy Supply Chain

- Market share
- Domestic manufacturing
- Supporting components
- Local content requirement



The advancement in solar PV technology has made it cost-competitive, driving significant global adoption, although current low prices may be attributed to market oversupply

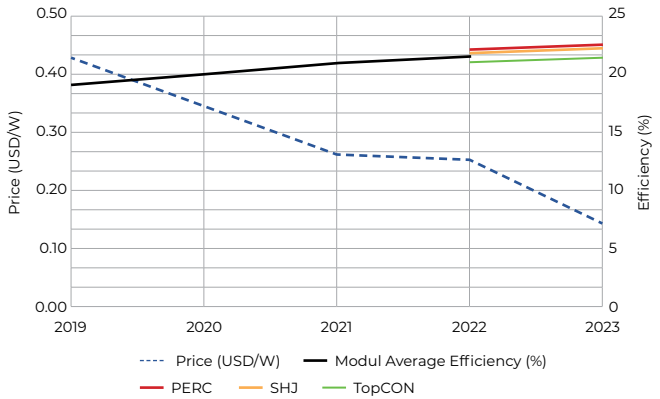
- For more than a decade, solar PV technology has undergone rapid maturity. As of 2023, crystalline silicon-based PV technologies still dominate and are increasingly dominating the market, accounting for nearly 98% of PV technologies. Their subset, monocrystalline technology, has shown substantial growth, increasing from less than 30% market share in 2010 - 2016 to over 80% of crystalline technologies in 2023 (ISA, 2023). This technology advancement has contributed to the global trend in solar PV modules that has experienced an 88.79% reduction in average prices and a 6.8% increase in average efficiencies from 2010 to 2022 (IRENA, 2022a).

- Both trends have been key drivers in the increasing global adoption of solar energy. In Q4 2023, module prices in India and China dropped to $0.22/W and $0.15/W (Wood Mackenzie, 2023a), respectively, with 2024 yearly price projected at an average of $0.11/W (Bloomberg NEF, 2024a). The current China module price is 42% below its price from 2022, primarily due to the country's significant PV module manufacturing overcapacity (23% utilization in early 2024) (Hayley, 2024). This overcapacity has led to market consolidation in China, benefiting leading manufacturers and raising concerns in the US and EU regarding their domestic industry's competitiveness.

- Moreover, commercial monocrystalline-based module technologies and new tandem technologies, projected to enter the market in 2025, are anticipated to reach efficiencies of up to 24.5% (n-IBC) and 27.3%, respectively by 2033 (ITRPV, 2024). Currently, research advancements like multi-junction cells and Perovskite/Si tandem cells have achieved efficiencies of 47.6% and 33.9%, respectively (ISA, 2023). However, commercial utilization within the next 5-10 years remains improbable due to existing challenges in lifetime and scalability (REW, 2023).

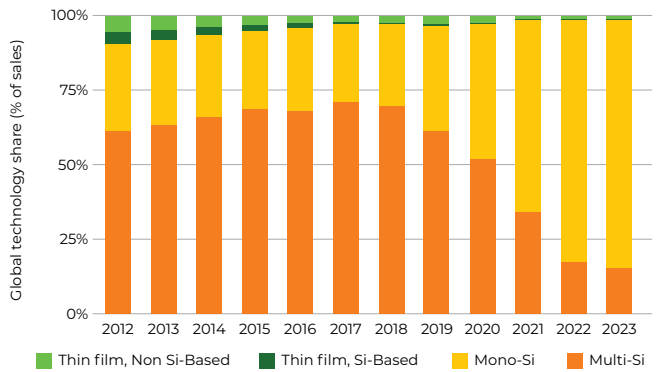
- Despite these factors, the global adoption of solar energy continues to grow, with solar Levelized Costs of Electricity (LCOEs) in most countries being highly competitive compared to fossil fuel generation (IRENA, 2022a). The overcapacity situation is expected to persist for a few years, potentially tampering with price reductions and efficiency improvements if the technology does not evolve. However, advancements are still anticipated. Combined with concerns over energy security and environmental impact, the adoption of solar energy is likely to continue to increase.

Global solar PV module average price and efficiency



Source: OurWorldinData, 2023; ITRPV, 2024

Global solar PV technology share



Source: ITRPV, 2024

Unpredictable market demand in Indonesia is a bane for local solar PV manufacturers, affirming the dominance of imported modules in the country

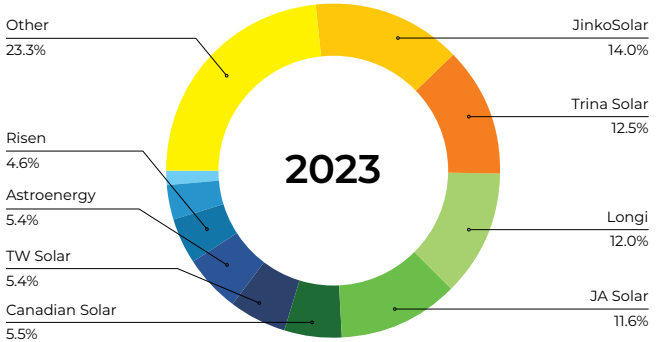
- In 2023, the top four companies dominated the global solar module market, with Jinko Solar leading with 78.5 GW of global shipments (Jinko Solar, 2024). Jinko Solar's success is driven by n-type cells, which offer higher efficiency than p-type cells. While other companies also produce n-type cells, Jinko Solar was the first to leverage this technology to boost sales and has surpassed most brands on the n-type TOPCon patent list. N-type cells are expected to overtake mono-PERC cells in global market share due to their higher efficiency and modest price premium (ITRPV, 2024).

- Similarly, in Indonesia, Jinko Solar holds a 60% market share, boosted by their TOPCon module supply for the Cirata FPV plant (Jinko Solar, 2023). Consequently, imported modules still dominate the market in Indonesia, and developers agree that this can be attributed to the better quality, higher efficiency, and more competitive pricing of imported, Tier-1 modules. In contrast, currently, only one local manufacturer produces 560 Wp modules, while most produce up to 450 Wp, with the other 21 relying on imports (Meilani, 2024). Domestic modules are 30-45% more expensive, have lower efficiency, and degrade faster but offer longer warranty periods (MENTARI, 2024).

- Considering the market landscape, local manufacturers need to step up their products to higher capacity and more efficient modules, preferably leveraging n-type solar cells. However, the appetite for expansion is understandably low, as manufacturers are reluctant to invest in new production lines due to unpredictable market demand and ever-changing regulations, leading to significant underutilized production capacity. Indonesia's domestic solar module production capacity is approximately 2.3 GWp per year, yet only 200 MW was produced in 2022, with 2023 production estimated at 300-400 MW (MENTARI, 2024).

- Another challenge local manufacturers note in competing with imported modules is the difficulty of achieving Tier 1 status. It is important to note, however, that Tier 1 status is a measure of bankability and not quality, as stated by Bloomberg New Energy Finance (BNEF) themselves, the firm that created this system. Furthermore, BNEF even advised manufacturers "against spending much energy pursuing it" because it is not recommended (Bloomberg NEF, 2024b). However, the fact remains that customers prefer a product that has an extra layer of credibility given by the Tier 1 status, especially to secure financing for large-scale projects.

Global solar module market share by shipment

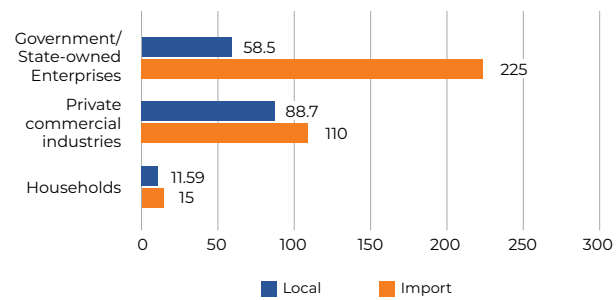


Source: Wang (2023)

Specification comparison of local vs. imported modules

Specification	Local	Import
Maximum module size (Wp)	560	750
Highest efficiency	21.50%	24.10%
Tier 1	No	Yes

Customer purchase capacity of solar modules in Indonesia, 2022



Source: MENTARI (2024), Huasun Solar (2023)

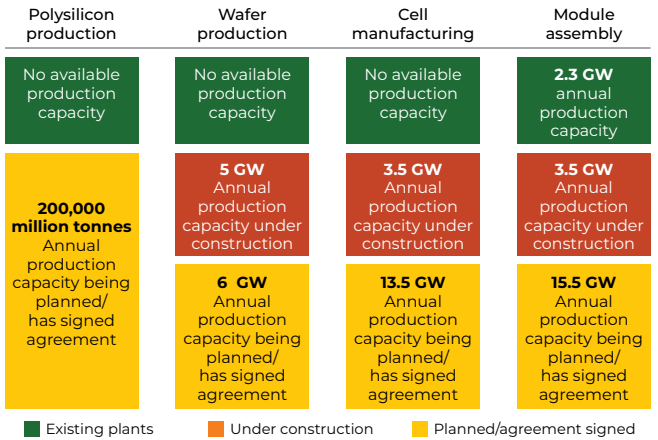
As minimum local content requirement for solar module is abolished, committed manufacturers should also explore export markets

- As of Q4 2023, Indonesia's solar PV module manufacturing capacity stands at approximately 2.3 GW. Around 90% of current domestic solar PV manufacturers have a production capacity of 100 MWp or less, and often operating on a project-by-project basis. However, foreign companies are significantly ramping up their investments in Indonesia, potentially adding 200 billion tons of polysilicon, 11 GW of wafer, 17 GW of cell, and 19 GW of module annual production capacity. These investments are spurred by strategic projects such as the Indonesia-Singapore Green Corridor project, which mandates the strengthening of domestic manufacturing capacity (Keppel, 2023). Access to export markets also serves as another key driver due to trade tension between China and Western countries (Chen, 2024).

- To create a push factor for accelerating domestic solar module production, the Indonesian government, through the Ministry of Industry (MoI), has established minimum local content requirement (LCR) specifically for solar module products, on top of the mandatory LCR for solar PV projects. The mandatory solar module LCR was initially stated to be 60% starting in 2019. However, the latest data from MoI shows that current domestic solar producers can only produce solar modules with around 40-55% of local content level. To resolve this issue, MoI Regulation 23/2023 was issued to postpone the 60% threshold in 2025. This regulation did not last long, as the latest MoI Regulation 33/2024 took it further and abolished the threshold altogether.

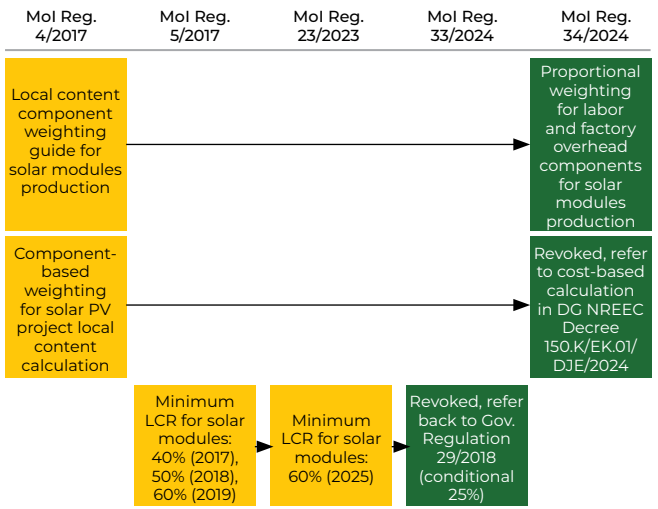
- While this module LCR revocation is beneficial for developing more solar PV projects due to cheaper imported modules, nullifying this push factor would reduce the rationale to invest in domestic manufacturing. Additionally, solar module production capacity under construction (3.5 GW/year) greatly exceeds the current domestic demand. To ensure such committed investment in domestic manufacturing does not become underutilized, MEMR and PLN should continuously build a strong solar project pipeline for demand signaling. In the meantime, MoI should facilitate exports for these companies so that they can utilize Indonesia's geopolitical advantage in some foreign markets. However, the recent case of US import tariff exemption revocation for several Southeast Asian countries (Ford, 2024; Herring, 2024) exhibits the need to meticulously manage partnerships with Chinese brands and shift the development focus on wafer and cell production.

Indonesia solar module supply chain manufacturing progress, June 2024



Source: IESR analysis (2024). Full detail available on Appendix C

Regulation updates on minimum LCR for solar module



Source: IESR analysis (2024)

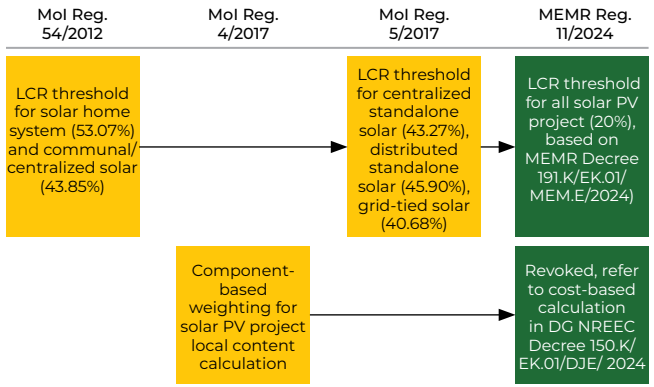
New LCR policy sets to unlock bottlenecks on solar PV projects, while solar module import relaxation could accelerate solar development in the next 1-2 years

- Local content requirement (LCR) policy for energy-related infrastructure serves as one of the bottlenecks of solar energy adoption in Indonesia (EY, 2023). Certain multinational/development banks are unable to accommodate such protectionist policy under their financing schemes (IESR, 2024), while local banks' perceptions towards such projects are still relatively high (IESR, 2023), resulting in high financing costs. Ironically, the implementation of LCR for solar PV has also not proven effective in boosting domestic manufacturing. Several large utility-scale solar projects in the past have had their request for LCR waiver granted, claiming that none of the current locally-produced solar modules met their requirements. This has resulted in local module producers being unable to scale up their production due to insufficient economics of scale, limiting them to only supply small-scale projects in an irregular manner.

- To resolve this bottleneck, the Indonesian government has transferred the project LCR authority to the MEMR, and has released Regulation 11/2024 that subsequently lowers the local content threshold to 20% based on historical data. The new DG NREEC Decree also changes the local content calculation mechanism from the previous component-based to cost-based calculation. Based on historical cost component data, IESR analysis shows that Indonesian utility-scale ground-mounted projects could achieve 16-23% of the local content level only by utilizing local manpower and minor supporting components (e.g., cabling and mountings). Additionally, Article 17 of the regulation has enabled more financing access to development banks/financial institutions, with the LCR threshold could be excluded if the foreign grant/loan portion of the project is a majority (>51%).

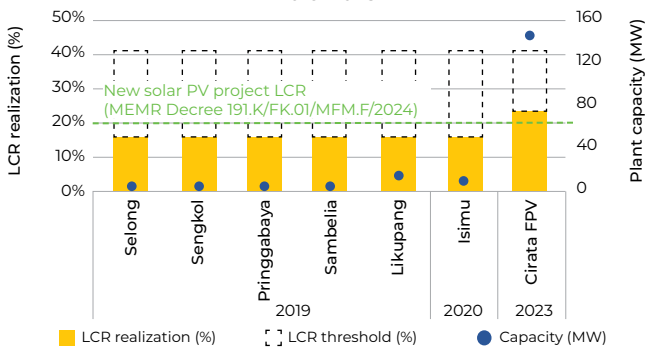
- Furthermore, solar module import waivers will be given to solar projects that commence before July 2026 or have signed their PPA before 2025. This could be a game-changing policy for utility-solar development in the next 1-2 years, doubling the current installed utility-scale solar capacity. Based on the collected solar project pipeline, there are 311 MW of solar projects set to fulfill these criteria, given that the ongoing PPA signing process falls through. However, as these import waivers will only be granted until June 2025, Indonesian authorities should also work on policies to ensure the domestic solar modules become competitive after the import exemption period, such as import duty facilities for production/complementary materials to reduce production costs. A follow-up guide on price preference for high local content modules needs to be established soon to incentivize domestic module adoptions.

Indonesia's solar PV project local content requirement policy timeline



Source: IESR analysis (2024)

Indonesia's utility-scale solar project local content level, 2019-2023



Source: IESR analysis (2024)

Note: LCR threshold uses the applicable regulation on COD year, which is MoI Regulation 5/2017

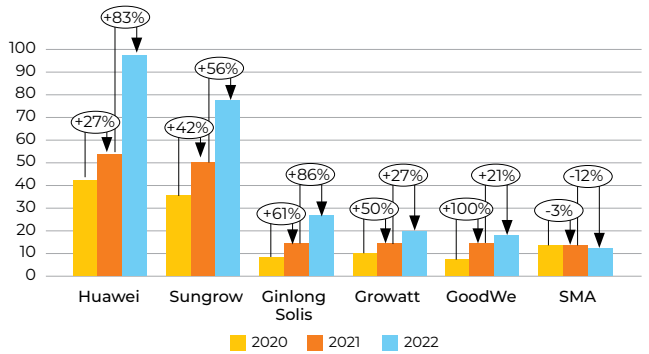
While constantly being overlooked, strengthening domestic solar inverter supply chain in Indonesia should start from demand firming and increasing industrial competitiveness

- Since Indonesian solar inverters are highly dependent on imported products, current market landscape mimics global market conditions. Collected data from inverter suppliers shows that Chinese brands such as Huawei and Sungrow dominate as the most sought-after on-grid PV inverter brands in Indonesia. Interestingly, compatibility with locally manufactured products can also improve sales for the Indonesian market due to minimum LCR. For example, while the off-grid/ hybrid inverter market is still dominated by Growatt and SMA, several brands, such as Deye, also gain popularity due to their ability to work in sync with local battery manufacturers.

- In contrast to domestic PV module manufacturing, which has gained much attention from the Indonesian government, domestic inverter manufacturing has constantly been overlooked and abandoned. This can be attributed to the need for mandatory local content level yet, specifically for inverter products, understandably due to lack of local capability as well. Based on LCR weighing stated in MoI Regulation 5/2017, inverters and solar charger controllers account for only 13.5% of plant-level LCR contribution. Furthermore, due to cost-based local content calculation based on the latest MEMR regulation on solar PV project LCR, IESR analysis shows that inverter component is expected to only contributes approximately 8% of the LCR calculation, which further discourages self-started inverter manufacturing in Indonesia. The latest industrial roadmap (RIPIN 2015-2025) does not specifically include inverter as one of the priority products (MoI, 2015), highlighting the lack of clear direction for such crucial technology.

- Inviting a global brand to invest in a manufacturing plant in Indonesia is a crucial stepping stone in strengthening the domestic solar inverter supply chain. However, global brands are reluctant to build manufacturing plants in Indonesia, limiting Indonesia's opportunity for technology and knowledge transfer. This is mainly due to a perceived lack of demand volume as well as a less developed electronic manufacturing sector in Indonesia, making the Indonesian market less attractive compared to other countries in the region. For example, Vietnam, as the Southeast Asia solar hub, has announced the operation of the first large-scale solar inverter manufacturing in Southeast Asia, a cooperation with global brand GoodWe. While there are no new manufacturing facilities announced specifically for solar inverters in Malaysia, the maturity of Malaysian semiconductor industries has put them at the door of the global solar inverter supply chain. Indonesia needs a more pragmatic game plan to improve its industrial competitiveness for inverter manufacturing in Southeast Asia, starting with low-value-added yet familiar industries such as product assembly factories, while taking solid steps toward mandatory technology transfer for committed global inverter manufacturers.

Top global solar inverter brand, 2020-2022



Source: Wood Mackenzie (2023b)

Solar inverter-related manufacturing sites in Southeast Asia

Company Name	Location	Description
GoodWe	Haiphong, Vietnam	Operating in March 2024. Producing both grid-tied and hybrid inverters, with an annual production target of 5 GW (Yuen, 2024)
Infineon	Kulim, Malaysia	Expansion of its 200 mm SiC (silica carbide) manufacturing, which serves as key component in power semiconductors and switches, including solar inverter applications (Infineon, 2023)
Texas Instruments	Kuala Lumpur and Melaka, Malaysia	Expansion of its assembly & test factory. Key products including microcontroller units, gate driver ICs and GaN (gallium nitride) power switches, essential for solar inverter applications (Texas Instruments, 2023)

Source: IESR analysis (2024)

Outlook & Recommendations

- Outlook
- Recommendations

The next three years will be decisive for solar energy development in Indonesia, with 2025 being the first reality checkpoint of the new solar energy promise

- The upcoming energy policy and planning landscape looks bright for Indonesia's solar energy, as the latest versions of KEN, RUKN, and PLN's RUPTL show a significant increase in solar buildout in the future. However, in terms of climate targets, several benchmarks show that Indonesia's renewable energy ambitions should be raised, with solar energy at the forefront. The current process of preparing Indonesia's Second NDC could serve as an opportunity to integrate solar energy growth into Indonesia's climate commitment. Moreover, harmonizing these planning documents should be prioritized to avoid incoherences in the implementation process.

- With the total available projects of almost 17 GW, implementation will be crucial in finally realizing the fairytale of Indonesia's solar energy potential. The Indonesia-Singapore green electricity export will be one of the biggest drivers, with 2 GW of conditional export licenses having been granted. Still, the high complexity of the project, both technical and non-technical aspects, will require strong leadership from the responsible authority, in this case, the Coordinating Ministry of Maritime and Investments Affairs and the Ministry of Energy and Mineral Resources (MEMR), to reduce risk and uncertainties related to the permit for electricity export and transmission development. Floating solar will spearhead the utility-scale solar implementation. Thus, related technical and legal guides for available water bodies should soon be established, especially for natural water bodies and non-PLN dams/reservoirs. Transparent "strategic partnership" terms will be crucial in streamlining the implementation process, as it would be the preferred method going forward. While still being discussed, the power wheeling mechanism would present an opportunity for captive sites to purchase green electricity (including solar energy) without hampering PLN's grid and financial stability, given the appropriate wheeling tariff setting.

- Investments in solar energy will be heavily influenced by Indonesia's regulatory and market stability. Despite the pros and cons, the introduction of MEMR Regulation 2/2024 and 11/2024 is an acceptable starting point to provide regulatory stability in rooftop solar and LCR policy, respectively. There are still some loose ends to be tied up, including the carbon offset ownership for rooftop solar and the price preference mechanism for domestic solar modules. The year 2025 will be the first checkpoint to evaluate the effectiveness of these regulations in resolving the long-standing bottlenecks on current solar projects (e.g., lengthy rooftop solar permit, unrealistic local content requirement), ultimately boosting its adoption to meet RUPTL's target and 3.5 GW solar rooftop.

- While solar energy's rising role in Indonesia's energy system serves as a least-cost pathway, operating a power system with high penetration of such variable energy will be highly challenging. Nourishing supporting infrastructure will be the key, including utility-scale flexibility options such as BESS, pumped hydro storage, and unlocking the flexibility of thermal power plants. PLN should focus on equipping its distribution units with the adequate resources to embrace high rooftop PV penetration and shifting the grid operation model to a hybrid between centralized and distributed dispatch.

- The year 2025 will also be crucial for strengthening the domestic solar module supply chain, as big manufacturers are currently in the process of setting up their factories. As the global landscape for solar module manufacturing is getting more competitive and fierce, establishing a strong domestic demand should be the long-term strategy for utilizing these committed manufacturers. In the meantime, tapping into advantageous foreign markets would only be possible if Indonesia is able to increase its industrial competitiveness, especially within Southeast Asian countries.

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Appendix A

List of Indonesia's solar project pipelines per September 2024 (1)

Projects	Location	Capacity (MW)	Installation type	Ownership type	Owner	Status
PLTS Bali (Barat & Timur)	Bali	50	Ground-mounted, 10-50 MW	Full IPP	PT Medco Power Indonesia - Solar Philippines consortium	PPA signed (2020), under construction
PLTS Belinyu	Bangka, Bangka Belitung	1	Ground-mounted, < 10 MW	Full IPP	PT Medco Power Indonesia - Solar Philippines consortium	PPA signed (July 2023)
PLTS IKN Phase II	Nusantara, Kalimantan Timur	40	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder	PT Nusantara Sembcorp Solar Energi (PLN Nusantara Renewables - SembCorp Utilities Pte. Ltd. consortium)	PPA signed
PLTS Bangka	Bangka, Bangka Belitung	10	Ground-mounted, 10-50 MW	Full IPP	PT Jasa Tirta Energi - PT Surya Energi Kobatama consortium	PPA signed (2023), under construction
PLTS Terapung Singkarak	Solok, West Sumatra	50	Floating	Partnership with PLN's subholding as majority shareholder	Indo ACWA Tenaga Singkarak (PLN Indonesia Power - ACWA Power consortium)	PPA Signed
PLTS Terapung Saguling	West Bandung, West Java	60	Floating	Partnership with PLN's subholding as majority shareholder	Indo ACWA Tenaga Saguling (PLN Indonesia Power - ACWA Power consortium)	PPA Signed
PLTS Bali	Bali	25	Ground-mounted, 10-50 MW	Planned for partnership with PLN's subholding		Bidding document preparation, target Aug 2024
PLTS Morotai 3	Morotai, North Maluku	10	Ground-mounted, 10-50 MW	Full IPP		Bidding document preparation, target June 2024
PLTS Namlea	Buru, Maluku	5	Ground-mounted, < 10 MW	Full IPP		Bidding document preparation, target June 2024
PLTS Bawean (Tersebar)	Gresik, East Java	5	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation
PLTS Kedung Ombo	Sragen, Central Java	100	Floating	Planned for partnership with PLN's subholding		Bidding document preparation, target Aug 2024

Appendix A

List of Indonesia's solar project pipelines per September 2024 (2)

Projects	Location	Capacity (MW)	Installation type	Ownership type	Owner	Status
PLTS Jawa Bali Jatim (Pasuruan)	Pasuruan, East Java	100	Ground-mounted, > 50 MW	Planned for partnership with PLN's subholding		Bidding document preparation, target Aug 2024
PLTS Jateng (Gajah Mungkur)	Wonogiri, Central Java	100	Floating	Planned for partnership with PLN's subholding		Bidding document preparation, target Aug 2024
PLTS Jawa Bali Bali (Buleleng)	Bali	25	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		Bidding document preparation, target June 2024
PLTS Jawa Bali Jatim (Banyuwangi)	Banyuwangi, East Java	100	Ground-mounted, > 50 MW	Partnership with PLN's subholding as majority shareholder		Bidding document preparation, target June 2024
PLTS Jawa Bali Jabar (Jatigede)	Sumedang, West Java	100	Floating	Partnership with PLN's subholding as majority shareholder		Bidding document preparation, target June 2024
PLTS Jawa Bali Jabar (Jatiluhur)	Purwakarta, West Java	80	Floating	Partnership with PLN's subholding as majority shareholder		Bidding document preparation, target June 2024
PLTS Alor	Alor, East Nusa Tenggara	1.2	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Lembata 1	Lembata, East Nusa Tenggara	3	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Flores	East Nusa Tenggara	10	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Rote 1	Rote Ndao, East Nusa Tenggara	1.2	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Rote 2	Rote Ndao, East Nusa Tenggara	2	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Sepanjang 1	Sumenep, East Java	1	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024

Appendix A

List of Indonesia's solar project pipelines per September 2024 (3)

Projects	Location	Capacity (MW)	Installation type	Ownership type	Owner	Status
PLTS Sepanjang 2	Sumenep, East Java	0.5	Ground-mounted, < 10 MW	EPC partnership with PLN		Bidding document preparation, target July 2024
PLTS Diesel Replacement Phase 1	Cluster I: western Indonesia. Cluster II: eastern Indonesia	166	PV + BESS hybrid	Partnership with PLN's subholding as minority shareholder	ib vogt - PLN Nusantara Power consortium (Cluster I), PT EMITS - PLN Indonesia Power (Cluster II)	PPA negotiation
PLTS Terapung Karangkates	Malang, East Java	100	Floating	Partnership with PLN's subholding as majority shareholder	PLN Nusantara Renewables - GD Power Hong Kong consortium	LOI Signing
PLTS Bojonegara	Serang, Banten	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Batang	Batang, Central Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Belitung	Belitung, Bangka Belitung	5	Ground-mounted, < 10 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Betun	Betun, East Nusa Tenggara	0.6	Ground-mounted, < 10 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Bojonegoro	Bojonegoro, East Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Cirebon	Cirebon, West Java	40	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Indramayu	Indramayu, West Java	100	Ground-mounted, > 50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)

Appendix A

List of Indonesia's solar project pipelines per September 2024 (4)

Projects	Location	Capacity (MW)	Installation type	Ownership type	Owner	Status
PLTS Jawa Bali Kuota Tersebar (Banten)	Banten	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Menes	Pandeglang, Banten	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Ngawi	Ngawi, East Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Paiton	Probolinggo, East Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Pemalang	Pemalang, Central Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Saketi	Pandeglang, Banten	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Sumba 1,1,2	East Sumba, East Nusa Tenggara	15	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Sumbawa Bima	Bima, West Nusa Tenggara	10	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Sumenep 1	Sumenep, East Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Sumenep 2	Sumenep, East Java	50	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as majority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Timor 1	West Kupang, East Nusa Tenggara	5	Ground-mounted, < 10 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Timor 2	West Kupang, East Nusa Tenggara	5	Ground-mounted, < 10 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)
PLTS Tobelo	North Tobelo, North Halmahera, North Maluku	10	Ground-mounted, 10-50 MW	Partnership with PLN's subholding as minority shareholder		EOI invitation from PT PLN Nusantara Power (September 2024)

Appendix B

Technical appendix of IESR's Jamali PLEXOS model

PLEXOS simulation topology

Note: *Jawa bagian barat* (*Jabagbar*) node represents West Java, Banten, and Jakarta Province. *Jawa bagian tengah* (*Jabagteng*) node represents Central Java and Yogyakarta Province. *Jawa bagian timur* (*Jabagtim*) node represents East Java and Bali Province. Each node is interconnected by a 500 kV backbone connection (red line).

PLEXOS simulation parameters

Simulation parameter	Value
Horizon	2024 - 2030
Optimization step	1 year
Load chronology	Sampled
Load details	Hourly (8760 data points)
Sampled days	365
VRE profile details	Hourly (8760 data points), sampled per node

Power plant technical parameters

Technology	Minimum Stable Level (%)	Efficiency (%)	Capacity Factor (%)	Variable O&M (USD/MWh)	Fixed O&M (USD/kW/Year)	Start Up Time (Hour)	Ramping Rate (%)
CFPP	40	35	N/A	1.5	51.6	1.5	4
Diesel	6	46		7.3	9.12	0.01	25
OCGT	40	38		3.6	26.5	0.1	20
CCGT	45	57		2.6	26.8	1	20
Geothermal	80	N/A	85	0.27	110	N/A	3
Hydro Large	0		50	0.74	43		50
Hydro Medium	0		50	0.57	47		50
Hydro Mini	0		60	0.57	60.4		50
PV	N/A		20	N/A	7.5		N/A
Wind			30		40		

Source: MEMR (2024).

Power plant fuel properties

Fuel	Price	Price (USD/GJ)
Coal	70 USD/ton	3.99
Gas Pipeline	12 USD/MMBtu	5.68
LNG	6 USD/MMBtu	11.37
Diesel	88 USD/Barrel	13.78

Source: 2024-2060 RUKN draft (2024).

Appendix C

Solar module manufacturing supply chain progress, June 2024

Location	Companies	Product Type	Status	Source(s)
Central Java, Batang	SEG Solar, ATW Investasi Selaras	Phase 1: + 5 GW cell and 3 GW module (start production in Q2 2024) Phase 2: + 5 GW wafer and 2 GW module (start production in Q2 2025)	Agreement signing with Kawasan Industri Terpadu Batang (Grand Batang City) for 40 hectares for the $500 million project	UMBRA (2024), Publicover (2024), MENTARI (2024)
Central Java, Demak	LESSO New Energy	Current capacity at 2 x 1.2 GW module, future plan to add 2 GW	Inaugurated in September 2023	Setda Demak (2024), Lesso Solar (2024)
Central Java, Kendal	Trina Mas Agra Indonesia (Trinasolar, PT DSS, PLN IP)	1 GWp cell + module in Q2/Q3 2024, 3 GWp cell + module in 2025/2026	Groundbreaking in August 2023, under construction	Kontan (2024), MENTARI (2024)
Riau Islands, Batam	INSPIRA (Medco, Adaro, TBS) and Utomo SolarUV	No specific information	MoU signing, possible partnership with Longi Solar and Sungrow	Bloomberg (2024), Handayani (2023)
Riau Islands, Batam	Vena Energy, Suntech, Powin, REPT Battero	No specific information	MoU signing	Wahyudi (2024a), Carroll (2024)
Riau Islands, Batam	IDN Solar Tech	Current capacity at 1 GW module, future plan to add integrated wafer + module production	No specific information	MENTARI (2024)
Riau islands, Batam	New East Solar	2.5 GW cell and module in 2023, + 5.5 GW cell and module by 2024	Under construction	NE Solar (2024)
Rempang Eco City (Batam) and North Kalimantan	Xinyi Glass Holdings	200,000 million tonnes polysilicon	Under discussion: integrated Industrial estate of glass, polysilicon, cell, and module plants	Rahman (2023) Wahyudi (2024a) FDD Global (2024)
Riau Islands, Batam (Wiraraja)	Mirah Green through PT Tynergy Technology Group	Silica processing for semiconductor and solar PV use	Declared a commitment to invest	Puspadini (2023)
Greenland International Industrial Center, West Java	GStar	3 GW silicon rod and 3 GW silicon wafer production by the end of 2024	No specific information	PV Magazine (2024), MENTARI (2024)

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