Scaling Up Solar in Indonesia

Reform and opportunity

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Foreword

Indonesia could fundamentally transform how it produces, delivers and consumes energy. But only if policymakers take swift, concrete actions to transition away from coal toward lower-carbon energy sources. Over the last few months, there have been public pledges to undertake change. Such verbal commitments must be followed with specific policies to trigger real change, however.

Indonesia's rich coal resources have long dictated the country's energy policies. Coal dominates the electricity supply and is an important export commodity that generates economic benefits to the government. Meanwhile, Indonesia's vast renewable energy resources – wind, solar and geothermal – remain largely under-utilized.

That could change almost immediately with policies that simply allow clean energy to compete against fossil fuels on even footing. Already, two-thirds of the world live in places where wind or solar are the cheapest options for new power generation – representing 77% of global GDP and 91% of global power generation. This supports the government's aspiration for a green and sustainable economy that creates economic benefits for all.

Solar in particular can make a significant contribution. The technology's quick development time and declining costs could enable Indonesia to meet its 23% renewable energy target by 2025 target, while keeping electricity affordable and reliable. Indonesia has sufficient solar resources to achieve this.

This report outlines how solar can contribute to Indonesia's clean energy goals and the opportunities it presents. It also highlights real-world examples of best practices that can help Indonesia develop its own solar industry. We hope this report informs policymakers, developers, investors, and utilities on the necessary reforms needed to unlock Indonesia's solar potential and to accelerate its power transition.

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Contents

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Table of tables

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Section 1. Executive summary

18GW

Minimum PV capacity needed to meet Indonesia's 2025 renewable generation target

$14.4 billion

Required to deploy 18GW of PV by 2025

2.7GWac

Planned PV projects identified by this report

2022

Year by which PV's levelized cost of electricity undercuts that of new coal plants in Indonesia

Indonesia is considering how to reduce its growing greenhouse gas emissions. A moratorium on new coal power plants bodes well for growth of solar power in Indonesia. Yet harnessing solar power requires government action such as improving transparency around power purchase agreements and revising long-term power plans. This report, jointly produced by BloombergNEF, Bloomberg Philanthropies and Indonesia's Institute for Essential Services Reform (IESR), explores the potential contribution from solar power in meeting Indonesia's renewable energy targets.

Solar holds the key to power sector decarbonization

- **Accelerating solar build to meet 2025 targets:** Indonesia wants renewable energy to account for 23% of primary energy by 2025. The power sector could achieve this level of renewable energy generation by installing 18GW of photovoltaic (PV) systems alone by 2025. While that would amount to a 100-fold increase in solar capacity from 154MW installed today, the target is achievable as PV can be deployed quickly. PV is the most economic clean energy technology that Indonesia can rapidly deploy.
- **Installing 18GW of PV would require $14.4 billion of investments**: This amounts to more than 50 times the $287 million invested in Indonesian PV deployments over 2005-20. The "pipeline" of PV projects in Indonesia under development today currently totals 2.7GWac. This translates to an estimated $3 billion investment if all projects are developed. Access to capital is not the primary challenge. Rather, Indonesia's current regulatory framework and power market have made it hard to develop projects that can secure financing. A better enabling environment is crucial to attracting capital and accelerating PV build.
- **Raising solar ambition beyond 2025**: The Indonesian government is considering a possible long-term net-zero emissions target. Whatever the timeframe, achieving that target will rely heavily on deploying solar to reduce reliance on fossil-fueled power generation. Concrete policy commitments – turning talk of new targets such as a coal moratorium, or carbon pricing into reality – can accelerate the pace of decarbonization and attract investors.

Regulatory reforms would help solar overcome obstacles impeding growth

- **Leveling the playing field for PV**: Existing regulations hinder uptake of renewable energy generation technologies such as PV. Current power purchase tariff regulations force clean energy to compete with subsidized coal power. Reforms needed include removing subsidies for coal-fired power, lifting caps on payments to renewables developers and removing constraints on behind-the-meter PV net-metering revenues. Moreover, plans to open access to PLN's networks for power wheeling could potentially boost corporate solar procurement.
- **Enhancing transparency through a clear PV procurement program:** Indonesia currently carries out tenders to procure power capacity, primarily through state-owned utility, Perusahaan Listrik Negara (PLN). The current power procurement process is opaque, limiting competition and price discovery. This increases costs to the public purse. Greater policy stability and transparency would help attract investment. A clearly defined long-term solar

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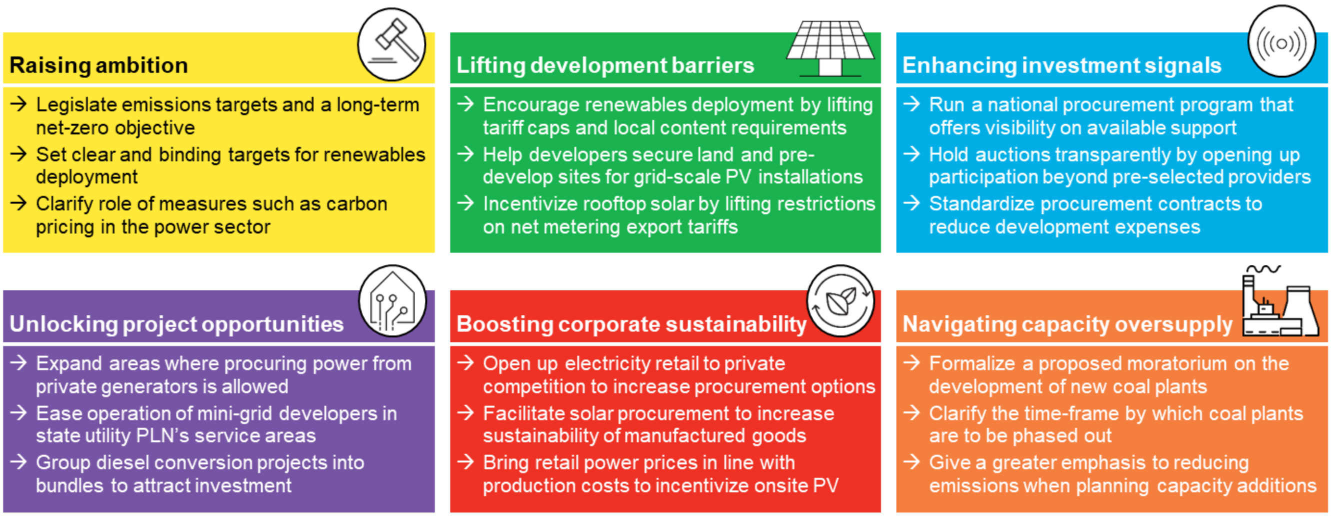
procurement program would encourage growth of a local solar manufacturing and deployment value chain. Standardized power purchase contracts would also help.

- **Addressing over capacity**: The country's main grids host a surplus of generation capacity, primarily due to an earlier over build of coal-fired power plants. Generation capacity on the country's largest grid exceeded net demand by 37% in 2019. While a moratorium on plans for new coal plants is under consideration, the country plans still to move ahead with the new coal capacity it previously approved. The country must reconsider adding more fossil-fueled power plants to reduce overcapacity. That would also rein in the state utility's ballooning payments to private fossil fuel plant operators. Any future growth in power demand can likely be met economically with clean energy sources such as PV.

Figure 1: Reforms required to accelerate Indonesian solar deployment



Source: Institute for Essential Services Reform, BloombergNEF.

Decentralized PV could provide affordable and reliable power to remote regions

- **Improving energy access through rural mini-grids**: Mini-grids using distributed solar can provide energy access to some 2.3 million Indonesian households that currently lack energy access. They could also improve grid reliability. Mini-grids currently face regulatory challenges such as restrictions around project ownership. Yet such projects could serve loads in less oversupplied grids, or where households lack reliable access to round the clock power. Solar and energy storage can also reduce fuel consumption hence emissions from Indonesia's diesel generators. PLN is already in the process of deploying solar and energy storage at its diesel generators. The first phase involving 225MW of diesel plants could translate to 600MW of solar coupled with 1.8GWh of energy storage.

- **PV systems can support corporate sustainability targets:** Industry accounts for a third of Indonesia's electricity demand, and many industrial consumers would benefit from PV deployment. Adding renewables would improve power reliability while helping meet sustainability goals. Nickel giant Tsingshan Holding Group, for instance, wants to add 2GW of renewables over the coming years. Solar deployment can support Indonesia's goal of utilizing its rich nickel resources to build a domestic battery manufacturing industry. The high emissions associated with Indonesia's current power mix means most international battery makers and their suppliers are hesitant to build manufacturing plants in Indonesia, as the emissions associated with those batteries would be too high.

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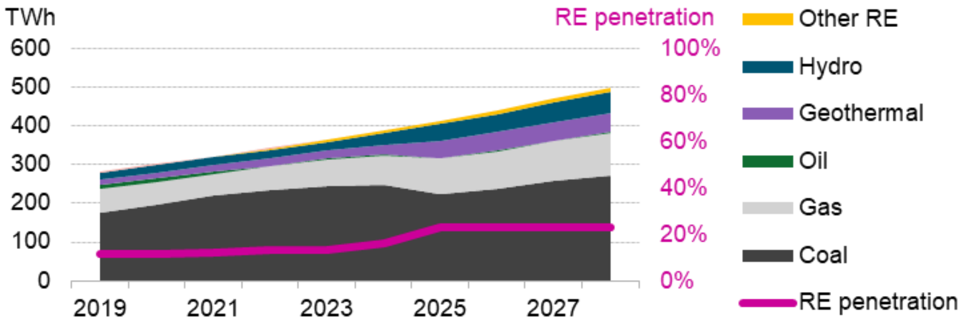
Section 2. Targets and solar pipeline

Indonesia's power supply has long been dominated by coal-fired power plants, thanks to plentiful domestic coal supplies. In 2019, thermal power plants accounted for 85% of power capacity and generation. The country's limited renewable power supply has been dominated by geothermal and hydro projects. Solar and wind currently account for less than 1% of power capacity. The country's moratorium on new coal power plants and long-term net-zero target creates an opportunity for rapid solar expansion.

In the short term, Indonesia aspires to boost "new" and renewable energy supply to 23% of its primary energy mix by 2025 and at least 31% by 2050[1]. The government includes a wide range of technologies such as nuclear, hydrogen, coal bed methane, gasified coal and liquefied coal, in its definition of new and renewable energy supply. If Indonesia prioritizes renewables for its 2025 target, this would be a significant step up from the 13% renewable energy penetration in Indonesia's 2019 primary energy mix.

While not formally legislated, the same targets are frequently applied to the power sector. The Ministry of Energy and Mineral Resources (MEMR) annually issues a power plan (locally known as Rencana Usaha Penyediaan Tenaga Listrik or RUPTL) that outlines the 10-year electricity development and procurement plan for state-owned utility Perusahaan Listrik Negara (PLN).

Figure 2: Projected generation mix and RE penetration under RUPTL 2019-28



Source: Ministry of Energy and Mineral Resources. Note: Renewable penetration include geothermal, hydro, solar, wind and biomass. Other RE refers to solar, wind and biomass based on projected installed capacity under the RUPTL 2019-28.

2.1. Gap to 2025 target

Coal power still holds center stage in the government's existing plan, with 27GW of new capacity expected in the 10 years from 2019-28. This represents the single largest pipeline of coal power additions in Southeast Asia. Gas power plants see the second-largest growth with 12.4GW of additions. While RUPTL 2021-30 is currently being finalized the new plan is expected to raise the target for renewables and reduce thermal power plant additions. Despite projecting large volumes of coal and gas power expansion, the current RUPTL still expects Indonesia to meet 23% of its electricity needs with renewables by 2025, up from 11% in 2019 (inclusive of large hydro).

[1] KEN and RUEN (Presidential Regulation 22/2017)

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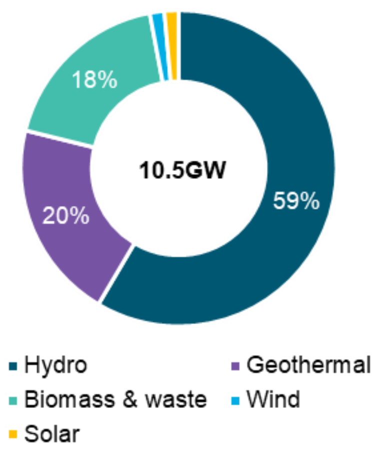
How much new solar capacity Indonesia will require to meet its renewable energy target depends on power demand growth. Under BloombergNEF's projection, Indonesia will require a total of 74.3TWh more generation in 2025. This implies 25TWh of additional renewable generation would be needed by 2025. Under its 2019 RUPTL, the government expects faster power demand growth than BloombergNEF. The roadmap expects Indonesia will require 95TWh of renewable generation in 2025. This would imply 46TWh of additional renewable generation by 2025 to meet the goal – 21TWh more than BloombergNEF's estimate (Figure 3-4).[2]

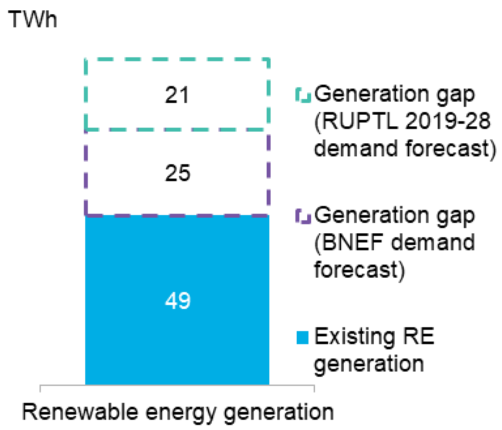
For its part, BloombergNEF's renewable energy generation 2025 projection could be met solely by 18GW of additional PV capacity, while the RUPTL2019 projection could be met solely by 33GW of additional PV capacity[3]. PV is the best option for Indonesia to meet its target due to economics, and the speed at which it can be deployed as demonstrated by neighboring Vietnam.

Figure 3: Indonesia installed renewable energy capacity, 2020



Source: Ministry of Energy and Mineral Resources, BloombergNEF.

Figure 4: Indonesia generation gap to 2025 renewable energy target



Source: BloombergNEF. Note: Existing RE generation based on 2020 installed renewable energy capacities and average historical capacity factors.

Spotlight: Vietnam's solar boom

Vietnam witnessed two consecutive solar booms in recent years. These resulted in 19GW of solar capacity built within just two years by the end of 2020, against just 180MW of capacity at the end of 2018 (Figure 5). A 2019 feed-in tariff (FiT) scheme primarily drove activities in the large-scale segment, while a second 2020 FiT program powered a rooftop PV boom (Figure 6) that propelled Vietnam to the rank of third-largest market for new solar capacity added in 2020.

Vietnam's experience demonstrates how quickly solar can scale when a clear procurement framework is in place. Its solar FiT schemes had clear commissioning deadlines, development processes and standardized contracts. Barriers to entry for foreign investors were low with full ownership of projects allowed (though many inked partnerships with local companies).

[2] See Appendix A for assumptions.

[3] Estimated based on a 16% capacity factor for solar PV.

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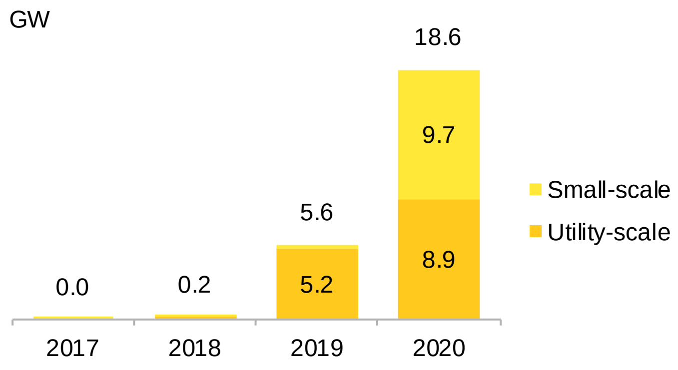
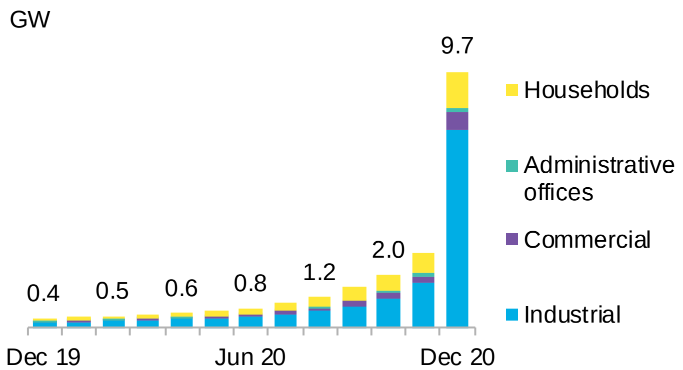
Indonesia faces distinctly different challenges in terms of power supply and geography, but Vietnam's success highlights how dramatically solar build can scale under the right circumstances. Indonesian policy-makers would be well served to keep the Vietnam example in mind as they develop new renewable energy regulations, and potentially a new FiT scheme for solar.

Figure 5: Vietnam cumulative PV capacity



Source: BloombergNEF.

Figure 6: Vietnam cumulative rooftop PV installation



Source: BloombergNEF, Vietnam Electricity Group.

2.2. Solar economics

Utility-scale PV

The economic case for utility-scale PV is getting stronger in Indonesia. Equipment cost declines are driving down the levelized cost of electricity (LCOE) for solar plants. An abundance of cheap domestic coal makes coal power plants the least-cost option for bulk electricity generation in Indonesia currently at $64/MWh, but solar is set to become cheaper than coal. The LCOE associated with newly-built coal plants is expected to rise as financing costs jump.

The LCOE for utility-scale solar in Indonesia currently ranges from $65-$137/MWh (real 2020 dollars) and by 2030 is expected to sink to $27-48/MWh (real 2020 dollars) on the back of cheaper equipment, lower development costs and more attractive financing terms. The wide LCOE range represents the differences in solar irradiance across the country, capital expenditure and financing costs.

Utility-scale PV achieves cost parity against new coal power plants within the next two years. PV also gets cheap enough to outcompete the existing coal fleet. Around 2040, the cost of PV generation undercuts the estimated $22-25/MWh marginal cost of running an existing coal plant based on coal calorific value from 4,200-6,000kcal/kg.

BNEF estimates the current LCOE of a PV-plus-energy storage (PVS) system in Indonesia is $113-251/MWh (real 2020) and already cost-competitive against diesel, which can be as pricey as $200/MWh in remote areas due to high fuel costs. PVS systems are likely to become cost-competitive against new coal and gas plant within the decade. The LCOE of a PVS system is expected to fall to $63-155/MWh (real 2020) by 2025 and to $49-119/MWh (real 2020) by 2030, thanks to declining lithium-ion battery prices.

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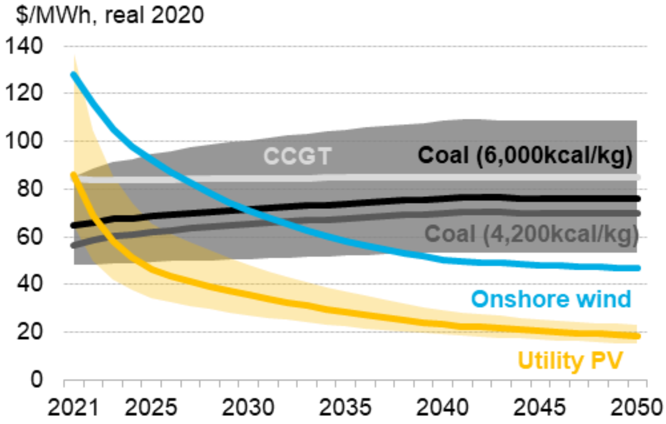
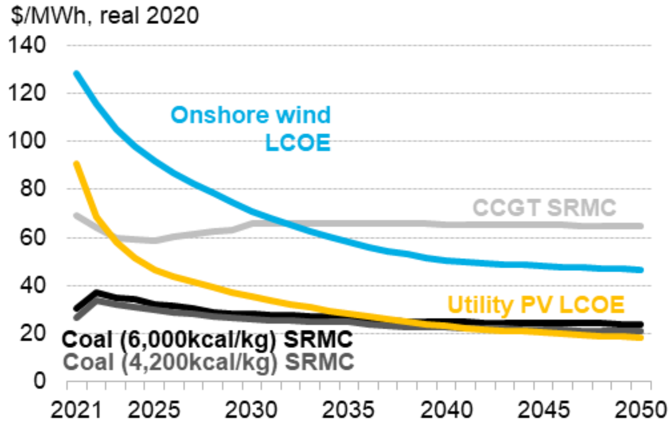
Figure 7: Indonesia levelized costs of electricity for new power plants



Source: BloombergNEF.

Figure 8: Indonesia LCOE of new PV and onshore wind vs. short-run marginal costs for coal and gas plants



Source: BloombergNEF. Note: LCOE stands for levelized cost of electricity. SRMC refers to short-run marginal cost.

By 2027, a PV system with energy storage sized at 25% capacity could undercut the generation cost of a new coal plant. This makes it an economic choice for rural electrification or in regions powered by diesel. A PV system with storage sized at 25% and 50% outcompetes the marginal cost of running an existing CCGT plant by 2029 and 2035 respectively. Current estimates suggest that the SRMC of existing coal plants will remain cost-competitive throughout the forecast period. However, carbon taxes currently under consideration by Indonesia as well as increasing aversion of financial institutions to fund coal power plants could diminish the economics of coal plants.

Figure 9: LCOE of PV-plus-storage against new coal and gas plant

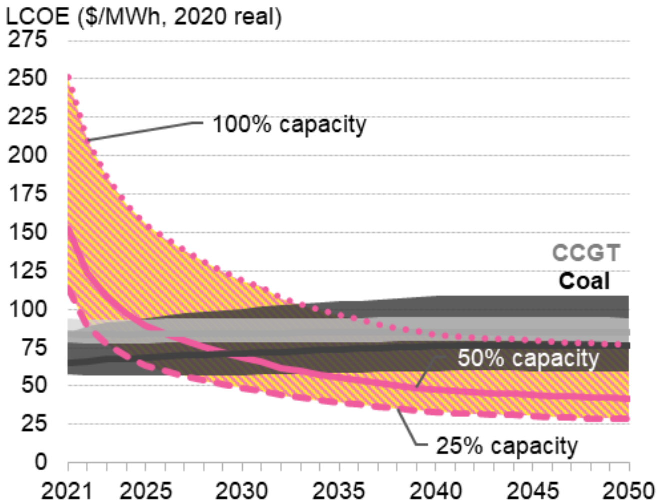
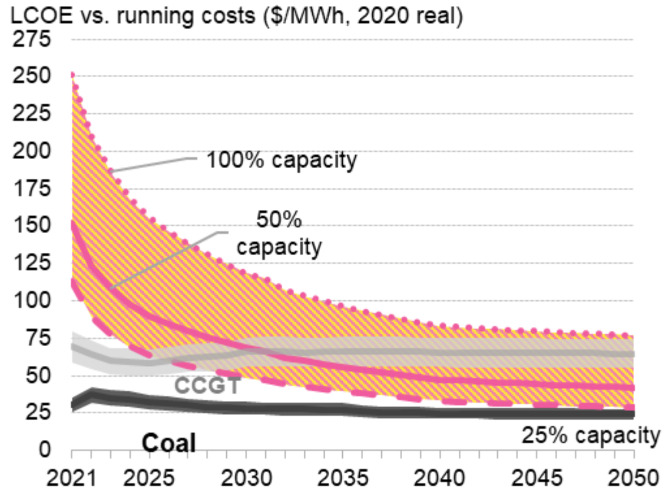


Figure 10: LCOE of PV-plus-storage vs. short-run marginal costs for coal and gas plants



Source: BloombergNEF. Note: LCOE range for PV-plus-storage system represents storage sized between 25% and 100% of PV capacity. Does not account for additional costs incurred through local cost provisions on battery storage.

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Spotlight: procuring battery-based energy storage in Israel

Israel shows how a country without wholesale or ancillary markets can procure PVS at scale. Like Indonesia, Israel lacks transmission interconnections with its neighbors, which makes integrating renewables with variable power output a challenge. Israel's power system regulator has called for 2GW/8GWh of energy storage to help balance the 30% of renewable generation the government hopes to achieve by 2030. The government then added batteries to the country's scheme to tender power-delivery contracts from PV projects. After two rounds of tenders in 2020, Israel's storage pipeline swelled to 3.3GWh.

Developers got 23-year PPAs, with 609MW of PV and at least 2,435MWh of batteries tendered through the second auction. The latest auction cleared at $56/MWh. Clear regulations helped attract investors. Operators must provide four hours of storage availability for each megawatt of capacity, and the system operator can request one cycle per day. Indonesia could adopt a similarly simple approach to procuring solar-plus-storage.

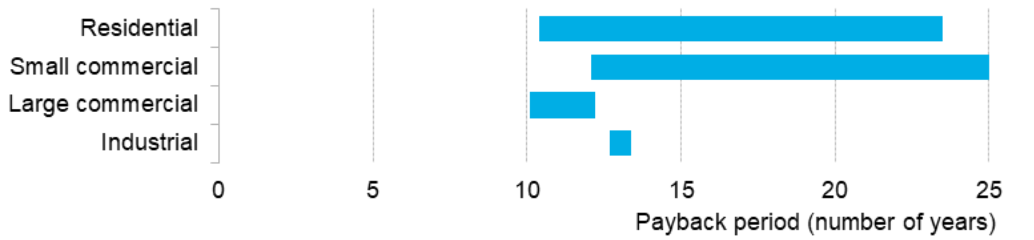
Rooftop solar

RUPTL 2019-28 estimates that Indonesia will need to install 3.2GW of rooftop PV to raise renewable penetration above 23% from 2025-28, although there is no specific deployment plan by PLN. Indonesia already has an export tariff scheme in place that compensates owners of rooftop systems for feeding electricity back to the grid. However, due to Indonesia's low regulated electricity tariffs, rooftop solar is not an economic option for most consumers. In 2020, the average PLN regulated tariff was just $0.07/kWh for households (including subsidized household groups), $0.08/kWh for industrial customers and $0.09/kWh for commercial customers.

Indonesia first introduced a net-metering scheme in 2013, then revised it to an export tariff scheme in 2018. As of June 2021, exports from rooftop PV systems are credited at 65% of the retail tariff, down from what was offered under the 2013 net-metering scheme. Grid-connected industrial customers in Indonesia who install a rooftop PV system are also subject to capacity charges (akin to a standby charge) by PLN.[4] The low regulated retail and export tariffs and the imposition of a minimum charge on customers erodes the economics of rooftop solar.

A study by the U.S. National Renewable Energy Laboratory estimates negative net present value and payback periods of more than 10 years for all rooftop customer groups in Indonesia (Figure 11). This is significantly longer than the 5-7 years in neighboring Vietnam and Malaysia. The government is reportedly working on revising the net metering scheme. Several probable reforms could increase attractiveness of rooftop PV: Indonesia may lift export tariff limits, increase the banking period of export credits and remove geographical restrictions (current rules restrict it to government-mandated business concessions).

Figure 11: Indonesia rooftop solar PV payback period by customer segment



[4] Capacity charge calculated based on 5 hours' inverter capacity (kW) applicable electricity retail tariff.

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Source: U.S. National Renewable Energy Laboratory.

2.3. Solar project pipeline

Given its size, Indonesia has attracted limited investment in new PV (Figure 12) and as of 2020 utility-scale capacity totaled just 154MW. The largest PV project owner in Indonesia to date is Vena Energy (formerly known as Equis Energy) with four utility-scale projects totaling 42MW.

Table 1: Indonesia announced solar PV projects

Project	Location	Project type	Capacity (MWac)	Developer	Status
Musi Green Hybrid	South Sumatra	Ground-mounted PV	10.5	PT Sumber Energi Sukses Makmur (SESM), PT Golden Blossom	Construction
Cirata Floating PV	West Java	Floating PV	145	PT PJB Investasi, Masdar	Financed
West Kalimantan	West Kalimantan	Ground-mounted PV	100	Acwa Power	Tender won
Lampung PV + storage	South Sumatra	Ground-mounted PV + battery energy storage	100	Acwa Power	Tender won
Singkarak	West Sumatra	Floating PV	90	Acwa Power	Tender won
Bangka	Bangka Island	Ground-mounted PV	10	PT Jasa Tirta Energi, PT Surya Energi Indotama	Tender won
Bali 2 x 25MW	Bali	Ground-mounted PV	50	PT Medco Power Indonesia, Solar Philippines	PPA negotiation
Saguling	West Java	Floating PV	60	Masdar	Tender held, pending award
Ombilin	West Sumatra	Ground-mounted PV	100	PT Bukit Asam Tbk	In development
Tanjung Enim	South Sumatra	Ground-mounted PV	100	PT Bukit Asam Tbk	In development
Batam 2.2GWp	Batam	Floating PV + battery energy storage	1,692[5]	Sunseap Group and BP Batam	Planned
Diesel conversion	Multiple locations	Ground-mounted + BESS	155	Unallocated	Planned
Labuan Bajo	East Nusa Tenggara	Ground-mounted PV	70	Scatec Solar (95%), PT Arya Watala Capital (5%), PT Flores Prosperindo (land developer)	Planned
West Java 50MW	West Java	Ground-mounted PV	50	IPP	Planned
Central Java 50MW	Central Java	Ground-mounted PV	50	IPP	Planned
East Java 50MW	East Java	Ground-mounted PV	50	IPP	Planned
Tambora, 2 x 5MW	West Nusa Tenggara	Ground-mounted PV	10	IPP	Planned
West Java 5MW	West Java	Ground-mounted PV	5	IPP	Planned

Source: Institute for Essential Services Reform, BloombergNEF.

[5] Assumes 1.3 inverter load ratio. Announced planned PV capacity at 2.2GWp.

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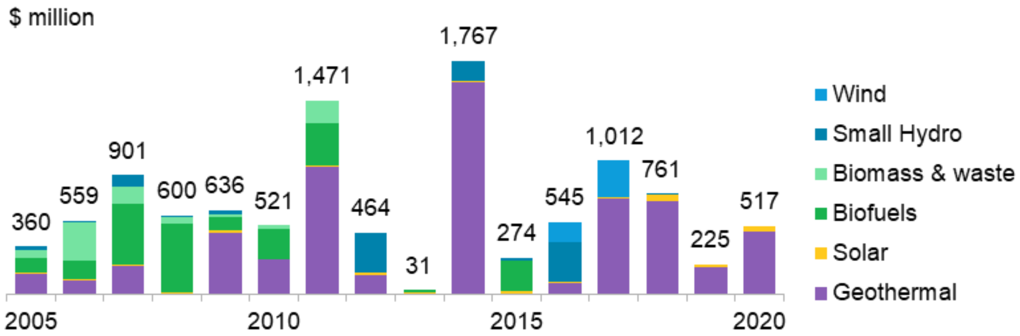
Interest has grown recently, however. Today, international developers and others plan over 2.7GWac of new PV projects **(**Table 1). Upon completion, these projects could generate up to 5TWh[6] annually. The pipeline of PV projects would require estimated $2.9 billion investment[7]. Such a sum would represent a 13-fold increase above all solar funding 2011-20.

Figure 12: Indonesia renewables investment



Source: BloombergNEF. Note: Includes utility-scale and small-scale solar.

Notable planned projects include: a 2.2GWp floating solar plant owned by Sunseap and BP Batam; the 145MW Cirata floating solar plant to be developed by Masdar and PLN; and another 50MW to be built in Bali by Medco Power and Solar Philippines that was awarded under a tender. The majority of the pipeline projects is still in the preliminary stage of planning or development. Few projects have yet to secure financing. Interest in the sector is evident but several structural and regulatory challenges need to be addressed for these projects to materialize (see next section).

2.4. Financing solar projects

There has been limited financing for solar in Indonesia to date, mainly due to the challenging regulatory regime hence limited bankable projects. Funding terms of many projects have also not been fully publicly disclosed. International development finance institutions have backed most large-scale solar and wind power projects developed to date.

In 2018, the Asian Development Bank signed a $161 million loan package with Vena Energy to finance Vena Energy's solar and wind project portfolio in Indonesia. The two-phased financing includes $121 million for a 72MW wind farm and $40.2 million for four PV projects totaling 42MW.

The availability of domestic loans varies widely among Southeast Asian markets. Projects in countries with relatively established banking sectors like Malaysia, Thailand and the Philippines can access non-recourse debt but local debt can also be quite costly. In Indonesia, Interest rates on local currency loans range from 8-13%, stakeholders told BloombergNEF in interviews. U.S. dollar-denominated loans are generally priced 250-300 basis points spread above financial institutions' funding costs (Figure 13).

[6] Generation estimated based on a 16% capacity factor for PV projects.

[7] Investment estimation based on $800,000/MWp capital expenditure assumption for PV projects and a 1.3 inverter loading ratio, excludes cost of battery storage.

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Local currency financing is likely to remain limited in Indonesia until domestic financiers become familiar with the sector. That requires significant deployment of solar in Indonesia.

Equity owners generally expect post-tax equity returns of 10-15% for projects in Indonesia (Figure 14), based on survey of developers and financiers by BloombergNEF. This is similar to what investors expect in Vietnam and the Philippines. Investors have expressed interest in developing projects in Indonesia even though the market has been difficult to enter (See Section 3).

Figure 13: Cost of debt for solar and wind projects in Indonesia

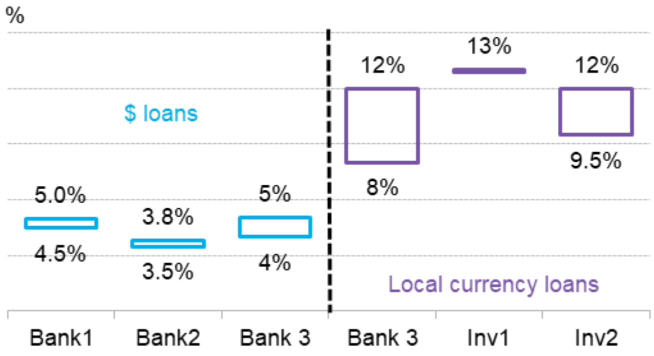
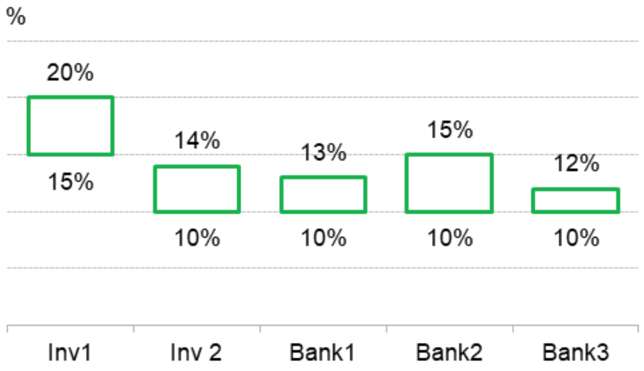


Figure 14: Equity internal rate of return (post-tax) expectations for solar and wind power projects in Indonesia



Source: BloombergNEF. Note: Floating U.S. dollar-denominated loans converted to all-in cost using LIBOR rate of 1.97%. "IPP" refers to independent power producer. "Inv" refers to equity investor. Based on a survey conducted by BloombergNEF in 2020. Inputs received from seven IPPs, one equity investor and four lenders active in Southeast Asia.

Availability of financing is not considered the primary barrier to clean energy development in Indonesia. Lack of transparency around securing permits, long development lead times, and high overall uncertainty have led to limited bankable projects.

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Section 3. Enabling environment

Some of Indonesia's main power grids, including the one that serves the country's main demand center, are plagued by over capacity. Consistently overly optimistic demand projections under previous RUPTLs resulted in a substantial over-build of new coal-fired power plants. The result has been high reserve margins and under-utilization of coal power plants, many with "take-or-pay" clauses in their long-term supply agreements with PLN. If the overcapacity situation is left unaddressed, renewables will face significant grid integration challenges (see Section 4.1).

The overcapacity challenge is exacerbated by the archipelagic nature of the country. Composed of thousands of islands, Indonesia's power grids are highly fragmented. Lack of interconnection between grids means oversupply in one area cannot be diverted to an underserved region.

3.1. Regulatory risks

Apart from the structural challenges, renewable project developers frequently cite myriad other risks and hurdles that hold back projects. In Indonesia's highly regulated power market, regulatory risks emerge as one of the top concerns among market participants (Table 2).

Table 2: Investor risk perception for solar/wind projects in Indonesia

Risk	Perception
Regulatory risk	High
Offtake risks	High
Grid availability and stability	Medium
Land acquisition	High
Execution risk	High
Forex risk	Low

Source: BloombergNEF, surveyed stakeholders.

Opaque permitting processes, lack of long-term policy visibility and consistency hinder renewables growth. In 2017, frequent changes to tariff guidelines for renewable projects and auctions cancelled with little explanation undermined investor confidence and hurt build. In 2017, the government also switched the award process for solar from an open tender to a "direct selection", defined as a limited tender run by PLN with a minimum of two bidders. Under this process, only pre-qualified bidders included in the 'list of selected providers' (locally known as the Daftar Penyedia Terseleksi, or DPT) are invited to participate. It is unclear if all pre-selected bidders are invited to participate.

In 2019, renewable energy developers participated in one prequalification process for multiple technologies. In 2020, PLN issued a pre-qualification invitation for solar projects. Developers who now wish to participate in tenders for different renewable energy technologies will have to participate in separate prequalification rounds, increasing administrative costs. The frequency of when PLN issues a pre-qualification round is also unclear, creating additional uncertainties.

There is also little transparency overall in the policy making process and implementation. Regulations are not always shared publicly and larger local companies tend to get access to these information through their networks. Schedules of planned tenders and outcomes of awarded projects are often not revealed, even to tender participants. This lack of transparency makes it very challenging for investors and developers to make long-term capital commitments.

While currency fluctuations could also be a potential risk, stakeholders interviewed by BloombergNEF said they view foreign-exchange risk as minimal. As power purchase agreements are negotiated directly for each project, developers could mitigate this risk by indexing tariffs to the U.S. dollar.

3.2. Solar tariffs

Dozens of nations around the world have held reverse auctions for clean power-delivery contracts. When well-executed, such tenders send clear signals to market participants about

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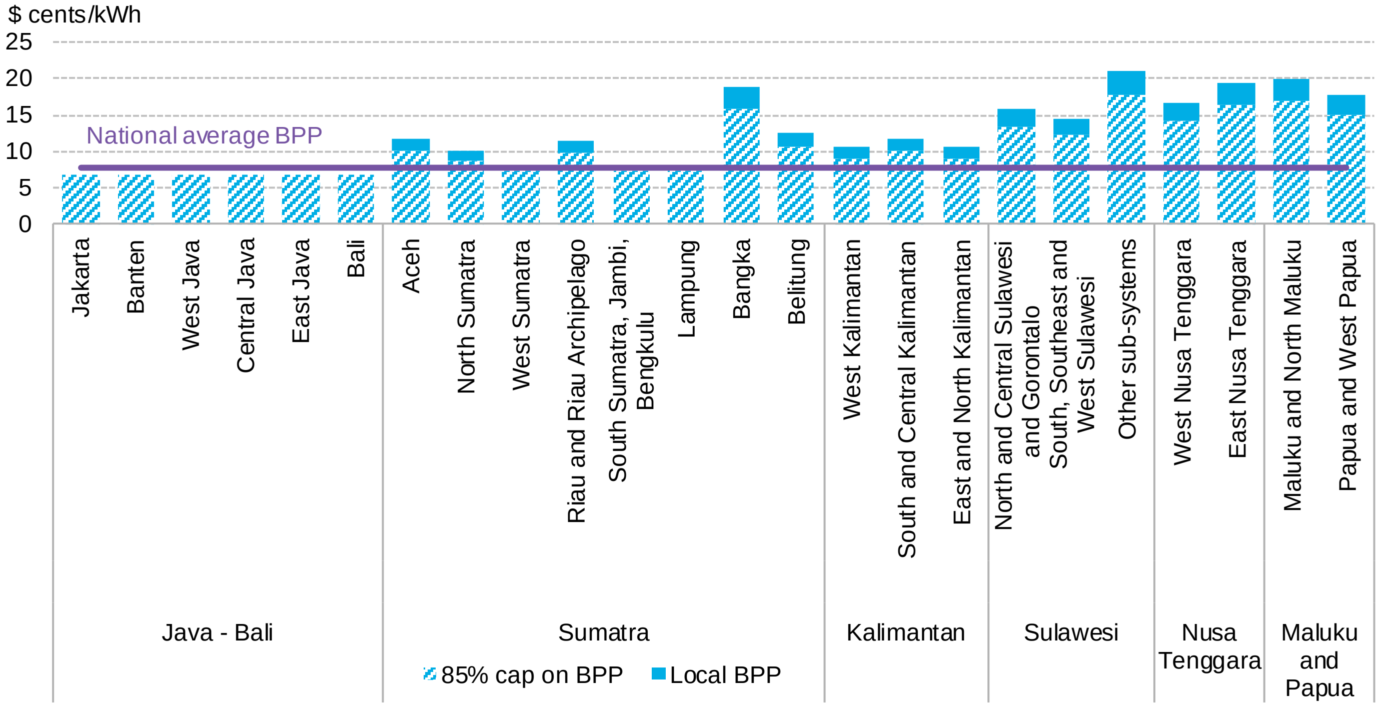
development opportunities and create price discovery. They can be a powerful tool for governments and utilities to procure large volumes of clean power at least cost. Bids offered by wind and solar developers in auctions globally have fallen sharply, reflecting lower technology costs and fierce competition.

Indonesia currently restricts how participants can bid in its auctions. Specifically, "tariff caps" were widely cited as problematic by stakeholders interviewed by BloombergNEF. Renewable energy tariff guidelines in Indonesia are outlined under MEMR Regulation 50/2017 as amended by Regulation 4/2020 and are pegged to local and national average cost of generation (Biaya pokok penyediaan or BPP).

If the local average generation cost of where a renewable project is being developed is below the national average, the PPA price for that clean power plant is capped at the local cost of generation (BPP). Otherwise, tariffs are subject to mutual negotiation between PLN and the developer but capped at 85% of the local BPP. Several regulations have been introduced in the past to aid the cost competitiveness of coal generation (see Section 4).

The price cap has been applicable for 2018-21 and is scaled for lower-grade coal, helping to reduce cost for coal generators which renewables projects compete directly against. Reviewing the existing coal support policies or the tariff mechanism for renewable energy projects is crucial to allow for true market reflection of costs and a level playing field for all technologies.

Figure 15: 2018 Indonesia average local and national generation cost by region



Source: Ministry of Energy and Mineral Resources, BloombergNEF.

Comparing procurement tariffs is complicated by a number of variables. Even in Indonesia, PPA prices announced over 2015-20 were based on very different procurement frameworks, project structures and regulations as the market evolved. Rapid technology cost declines have solar auction prices on a solid downward trend.

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“Record-low” PV auction tariffs

A recent PV-plus-energy storage auction in Portugal resulted in a record-low price of just over $0.01/kWh in August 2020. The tariff has been widely cited and appears to be informing solar procurement choices around the world. Yet the price was for just one 10MW lot awarded as part of a larger auction, and involved a number of extremely aggressive assumptions, notably concerning wholesale power prices. That limits its use it as a benchmark in markets like Indonesia, which lacks a wholesale electricity market. Portugal’s average solar irradiation is, moreover, higher than that of Indonesia.

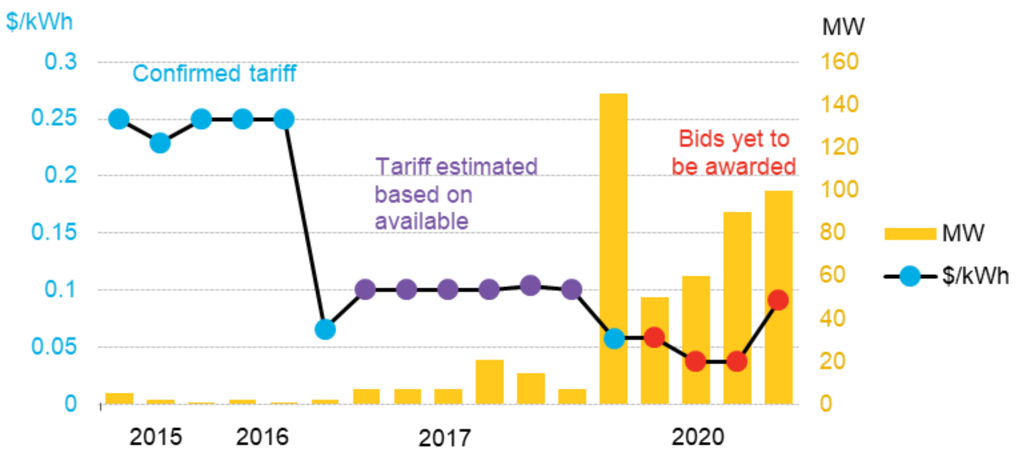
Similar issues can be identified with reports around record-low tariffs in Saudi Arabia and the U.A.E. In those cases, developers receive a host of other benefits, including pre-developed sites, free land and free connections to the grid. Saudi PV auctions have involved additional sweeteners, including accelerated depreciation and subsidized salaries of local nationals employed through the projects. These benefits drive down costs – land leases alone typically account for a large chunk of operating expenses.

Even in the absence of transparent, highly competitive auctions, recent announcements have indicated the significant drop in the cost of solar procurement. While the contracts recently put out to tender have yet to be awarded in Indonesia, the recent auctions suggest a tariff decline of some 85% since 2015, when the country’s first-ever solar PPA was concluded.

High land cost

Two floating solar projects registered bids under $0.04/kWh, a first for Indonesia. Little information has been released concerning the framework under which the auctions were held. The tendered projects will be developed by a PLN subsidiary together with IPPs, who can hold a maximum project equity share of 49%. Low costs were also facilitated by the fact that, contrary to other solar tenders held in Indonesia, the auction was site-specific. The auction reduced project development costs and risks by having PLN take on site selection and predevelopment tasks. Holding upcoming auctions under a similar format could attract more developers to Indonesia.

Figure 16: Indonesia’s solar PPA prices



Source: IESR, BloombergNEF. Note: ‘Tariff estimated based on available information’ and ‘bids yet to be awarded’ reflect IESR’s best estimates of undisclosed PPA prices based on relevant regions’ government-mandated tariff caps and available data points from the ministries.

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The cap on renewable energy tariffs is particularly a barrier to solar development on Indonesia's main grids. Demand centers such as Java-Bali and Sumatra have an oversupply of coal capacity which keeps average generation costs down. Where electricity demand and projected growth are highest, such as on the Java-Bali and Sumatra grid, project developers are met with high land costs and low renewable energy tariffs (Figure 15).

It is also difficult to acquire large parcels of land in these densely populated regions. Land costs in the Java-Bali region run $54,000-143,000 per hectare as compared to $35,000 per hectare on the eastern islands such as the Sulawesi region. This challenges the financial viability of large-scale projects in Java-Bali and Sumatra region. To circumvent land challenges, the government is turning to floating PV, which addresses scarcity of eligible sites near demand centers. Several such projects have been announced (Section 2.4).

Regulation 6/2020 issued by the Ministry of Public Works and Public Housing stipulates that 5% of the water surface at dams can be used for floating PV projects. PJB Investasi estimates that this translates to 4.3GWp of floating PV potential in Indonesia. IESR estimated that Central Java province has the potential to install up to 723MW of floating PV across 42 reservoirs, with the potential to generate up to 974.7GWh annually.

Spotlight: Cambodia's solar park auction

Cambodia's solar auction was launched in 2019. A total of 26 bidders, including international companies, vied for 60MW, the first phase of a 100MW solar park where land and the necessary grid infrastructure were prepared by the government. This removed two of the largest development risks for investors. Prime Road Alternative Company, a Thai-based firm, submitted the winning bid of $38.77/MWh, significantly below the ceiling of $76/MWh.

The auction was country's first solar procurement scheme and fostered high levels of competition. The result was the lowest solar power bid in Southeast Asia. This shows how, even in a nascent market, physical auctions can help mitigate risks and speed up cost declines. Indonesia is investigating a similar solar park model – providing developers with free land and grid connections – in Eastern Indonesia.

Spotlight: India's auction pipeline

It is possible for emerging markets to provide transparency on upcoming tenders and the opportunities they offer developers. India stands out as hosting one of the world's largest auction pipelines by capacity volume, having announced 20GW to be tendered in coming years (Figure 17). Policy stability and a clear commitment to increasing clean power capacity has attracted significant investment, making India a world leader in renewables. The auctions' success is down to a host of factors. A short-term capacity target of 175GW of installed renewables by 2022 has resulted in high volume of auctions in India. A transparent process that follows standardized guidelines has encouraged participation. High competition has pushed developers to optimize, cutting the 2019 average auction tariffs for solar to less than half of 2015 levels.

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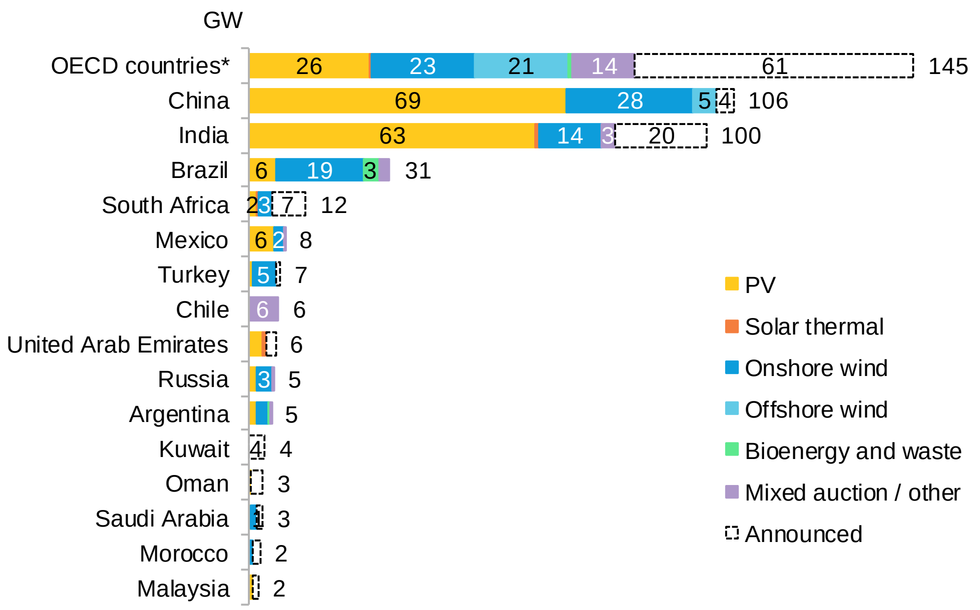
Figure 17: Clean energy capacity awarded and announced in select markets, 1Q 2021



Source: BloombergNEF.

Lack of transparency and visibility

Indonesia lacks standardized PPA templates that can be used for multiple projects. Each deal is negotiated separately under specialized terms, according to BloombergNEF interviews with stakeholders. Standardizing contracts would reduce lead times and development cost.

Local content and foreign ownership rules

Indonesia has onerous local-content requirements for solar projects divided by project type (on-grid vs. off-grid) and by components (see Appendix B for details). The local content rules' goal is to have 42.2% of a PV project rely on locally-made equipment but Indonesia's solar industry lacks the maturity and scale required to meet such a target. As of June 2021, the Solar Module Manufacturer's Association of Indonesia lists just 11 local manufacturers with a combined production capacity of 470MW/year. Stakeholder interviews indicated that local production can barely manage supplying equipment for 150-300MW of solar projects at once.

In 2018, MEMR reported that PV projects achieved an average of 35.2% local content. Developers face higher costs from locally produced equipment and growth is restrained by the limited current capacity of the domestic supply chain. International manufacturers are reluctant to set up production in Indonesia without clear visibility on how fast local demand will grow.

3.3. Policy reform

Both Indonesian government ministries and state-owned companies have started discussions around setting net-zero targets. The government has floated several potential net-zero target dates ranging from 2050 to 2070, while PLN recently presented a 2060 carbon neutrality goal. Coal's dominance in Indonesia's future power mix is under question for the first time. Recent

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announcements from a parliamentary session May 27, 2021 suggest the next RUPTL could see a much smaller fossil-fueled thermal power pipeline (Section 4).

A zero-emission pathway by 2050

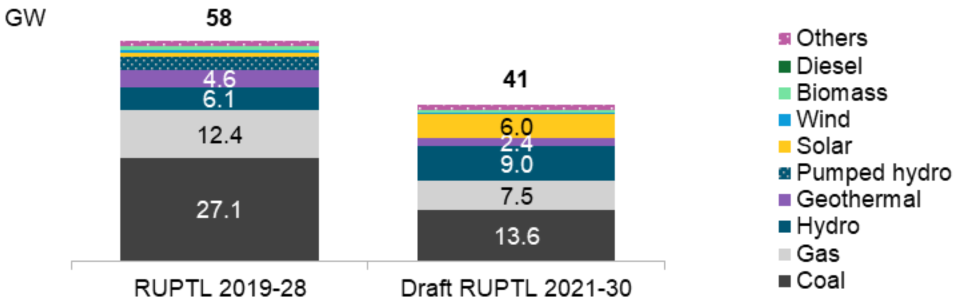
Achieving zero emissions would require short-term renewables build to accelerate significantly beyond Indonesia's current targets. IESR, in collaboration with Agora Energiewende and LUT University, has published a zero-emission scenario for Indonesia. Released in May 2021, the paper concludes that renewable energy could provide 100% of Indonesia's primary energy by 2050 at lower overall cost than continued reliance on fossil fuels. The paper modeled a Best Policy Scenario (BPS) calibrated to achieve a lower system cost than other pathways, including one based on current policies (which resulted in higher system costs from 2035). Achieving zero emissions by 2050 would, however, require large volumes of renewables to be installed in the short term – the BPS foresees 100GW of new solar build over 2021-30.

The report also highlights the importance of interconnecting the country's disparate grids (namely Java, Kalimantan and Nusa Tenggara) by 2030, which could help alleviate issues around land costs and oversupply (see Section 5).

A green RUPTL?

During Indonesia's parliamentary hearing May 27, 2021, the Ministry of Energy and Mineral Resources (MEMR) and PLN discussed a draft roadmap for 2021-30, referred to by officials as the country's first "green" RUPTL. The latest draft expects Indonesia will need 41GW of additional capacity 2021-30 (Figure 18).

Figure 18: Proposed capacity additions under RUPTL 2019-28 and draft RUPTL 2021-30



Source: Ministry of Energy and Mineral Resources, BloombergNEF. Note: Others include tidal, hybrid, EBT renewables and EBT peaker capacity. EBT refers to renewable energy. EBT baseload refers to solar-and-battery, wind-and-battery, geothermal or hydro projects.

This is 15.4GW or 27% lower than the previous RUPTL, which expected 56.4GW of additions over 2019-28. Excluding any potential capacity retirements, cumulative capacity in 2030 would reach 113.7GW, including 73% from fossil fuel generators and down from 86% in 2020. The lower expected capacity additions are driven by lower demand growth.

The draft RUPTL 2021 places greater emphasis on renewables. Under it, renewables account for 49% of capacity additions this decade, compared to just 30% under the previous RUPTL. The 2021 draft excludes 13.5GW of coal and 5GW of gas capacity proposed previously. Instead, the new document calls for 5.1GW more solar and 2.95GW more hydro capacity compared to RUPTL 2019. The government's move comes after a slew of international financial institutions declared they would no longer fund new coal plants. Dwindling funding and low power demand growth

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could speed the pivot away from coal. However, the government has yet to legislate its moratorium on new coal.

Recent and upcoming reforms

MEMR published Regulation 4/2020 to amend Regulation 50/2017, which governs the mechanism to award new renewable energy projects to private companies. Under the amended rules, all renewable energy projects are awarded “must-run” status, whereas previously only projects up to 10MW in size were eligible.

The new rules also removed the requirement of a build, own, operate and transfer (BOOT) model for renewable energy projects. Instead, solar developers can now follow a build, own and operate (BOO) model. This change removes the need for independent power producers to transfer asset ownership to PLN upon expiry of the PPA. Developers regarded the previous requirement as a deterrent and the change is expected to make local solar projects more attractive to investors.

The government is also reportedly drafting a presidential regulation on renewable energy to accelerate developments in the sector. The rule could re-introduce additional incentives such as feed-in tariffs (FiT) to spur build. The FiT would likely support project up to 5MW, with larger projects supported through auctions. Greater revenue certainty under the scheme would boost investor interest but the government must address other existing barriers to unlock the market’s full potential.

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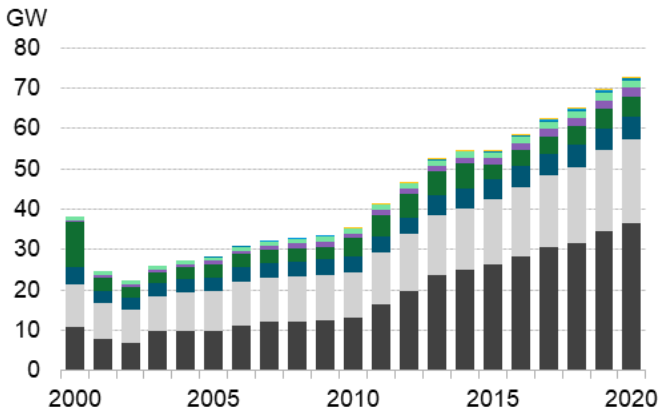
Section 4. Power sector planning

Coal today is the lifeblood of Indonesia's power sector. The fuel accounted for half of installed power capacity and provided 60% of electricity in 2019. Its use has risen since the mid-1990s, buoyed by local availability of coal, as well as the government's desire for greater energy independence. Government-issued power expansion plans have consistently prioritized coal over other technologies. Thanks to a steady rate of build, the country's fleet of coal plants is young; most are less than ten years old.

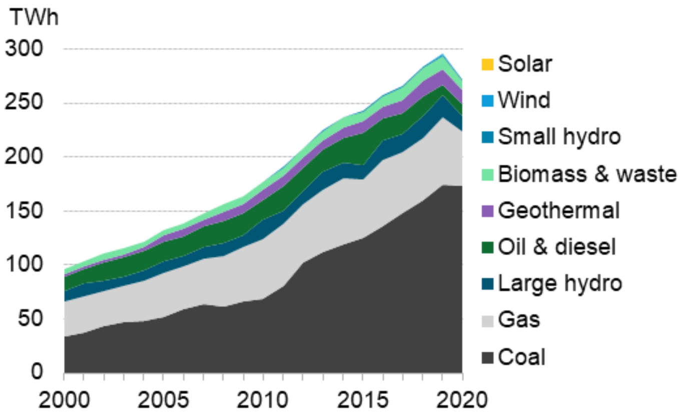
Use of coal power is incentivized in a number of ways. MEMR issues yearly supply obligations, mandating that coal mines supply a quarter of their output for domestic use. In 2018, the government also introduced a $70/ton price cap on 6,322kcal/kg coal sold to power plants. The cap has been applicable for 2018-21 and is scaled for lower-grade coal, helping to cut generators' fuel costs. As a result, renewables must compete with the indirectly subsidized coal power prices.

Figure 19: Indonesia installed power-generating capacity



Source: Ministry of Energy and Mineral Resources, BloombergNEF.

Figure 20: Indonesia electricity generation



Source: Ministry of Energy and Mineral Resources, BloombergNEF. Note: Includes off-grid generation. 2020 generation figures are estimated as official figures are not yet available.

4.1. Capacity oversupply

Indonesia's largest demand centers are oversupplied, hosting a surplus of fossil-fueled power capacity compared to demand. This removes the impetus for cleaner additions, and existing rigid PPAs leave policy makers little room to maneuver. Leaving the issue of oversupply unaddressed would confine clean power to a marginal role in Indonesia's power mix. Indonesia is broken into a myriad of grids, but the largest grids all suffer from overcapacity.

The surplus is highest in Java-Bali which, according to the Asian Development Bank, hosted some 62% of Indonesia's capacity for 60% of the population in 2019. According to PLN statistics, installed capacity in Java-Bali exceeded peak demand by 37% last year (Figure 21). This is largely the result of optimistic RUPTL demand growth projections. Downward demand growth revisions have been the norm in recent years (Figure 22).

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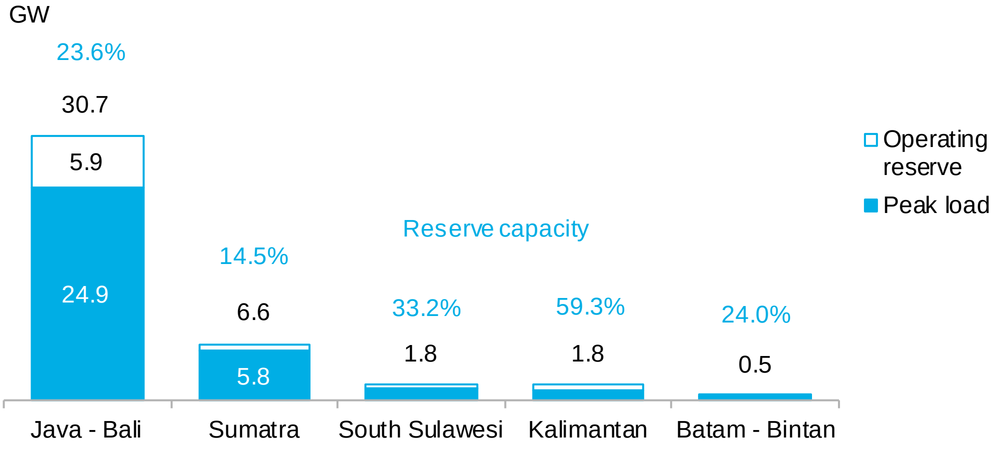
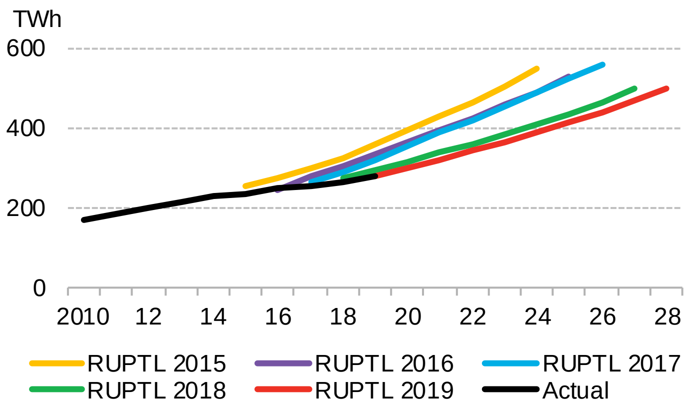
Figure 21: Reserve capacity by grid in Indonesia, 2020



Source: PLN 2020 Statistics (unaudited), BloombergNEF.

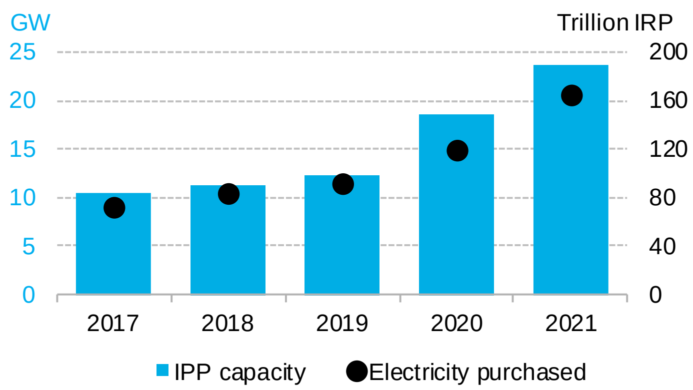
Policy makers have consistently expected that economic growth driven by increased industry, tourism activities would produce higher electricity demand, but actual demand continues to undershoot official forecasts. These earlier overestimates were the basis for high-risk bets the government made on independent power producers (IPPs). Specifically, under the rigid, long-term, "take-or-pay" PPAs PLN signed with IPPs, plant operators receive guaranteed capacity payments regardless of power plant utilization rates. The result has been a fleet of underutilized coal assets and ballooning IPP payments (Figure 23). With over supply chronic, PLN cancelled most of the 70 PPAs it originally planned to sign in 2017.

Figure 22: RUPTL Indonesia power demand growth forecasts



Source: Ministry of Energy and Mineral Resources, BloombergNEF. Note: Actual generation includes PLN's generation and purchases from independent power producers and excludes off-grid generation.

Figure 23: Power purchases from IPPs under RUPTL



Source: BloombergNEF, IEEFA, 2019-28 RUPTL. Note: Data points for 2019-21 represent government estimates.

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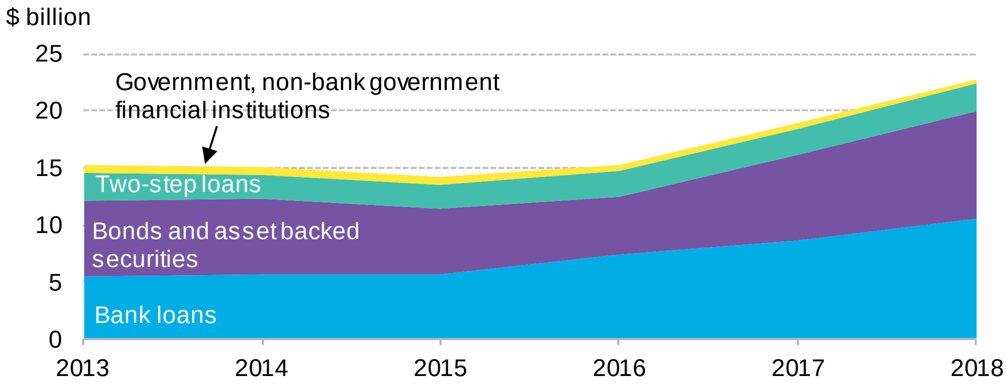
Locked into inflexible capacity payments potentially for decades to come and facing a host of new fossil-fuel contracts, PLN has limited financial headroom. The company's debt burden has swelled in recent years, in part due to concessional funding through 'two-step loans' and loans from publicly-owned financial institutions (Figure 24). PLN's available funding for solar is limited.

Low regulated retail electricity tariffs have compounded PLN's already difficult financial situation. A planned rate hike was frozen ahead of the 2019 election and prices are unlikely to rise while Indonesia suffers through a severe economic slump and the Covid-19 pandemic. Still, PLN is considering new coal PPAs. Indonesia's investment-grade status and government backing for contracts provides coal power plant developers with confidence that payments will be made in full.

Figure 24: Long-term debt for PT PLN, 2013-18



Source: BloombergNEF, PT PLN annual reports. Note: Foreign exchange conversion for Indonesian Rupiah to U.S. $ done as per the rate on December 31 of each year. Two-step loans are provided through financial intermediaries, passing through two or more financial institutions.

Spotlight: Oversupply in Ghana

Suboptimal power planning and procurement can have lasting repercussions. Indonesia is not alone in having made mistakes in past planning. In 2014-15, in response to a power crisis, the government of Ghana signed 43 new PPAs. By 2018, the national capacity margin stood at 51.7%, largely the result of 2.3GW contracted on a take-or-pay basis (against 4.33GW of total capacity). Finance Minister Ken Ofori-Atta has cautioned that the power sector's debt could reach $12.5 billion by 2023, nearly a fifth of the country's GDP.

The government began talks to restructure PPAs in August 2019. It initially sought to pay for generation only when needed, not through fixed capacity charges regardless of demand. Developers pushed back and negotiations – carried out on individual project basis – have dragged on. After more than two years, the renegotiation of a single contract was announced in September 2020. The Ghana example is a cautionary tale for Indonesia.

4.2. Managing the coal pipeline

The first and most obvious step Indonesia can do to lessen the current over-supply situation from deteriorating further is to stop adding more fossil-fueled power-generating assets. In that regard, 2021 may mark an historic shift. As discussed, the 2021-30 RUPTL is set to see markedly less capacity added over the coming decade than currently planned.

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During a recent parliamentary hearing, MEMR proposed a moratorium on supporting any new coal plant beyond those already under construction or with financing in place. Even if fully legislated, however, such a ban is unlikely to halt sizeable coal additions in Indonesia. As of December 2020, the government's previously announced "35,000MW" program had completed 28% of its goal with 9.9GW already built. Another 17.7GW is currently under constructions with 6.5GW having signed PPAs and presumably financed. Coal accounts for some 60%, or roughly 21GW, of the planned 35GW.

Figure 25: Capacity additions planned under 35GW program, by contractual status

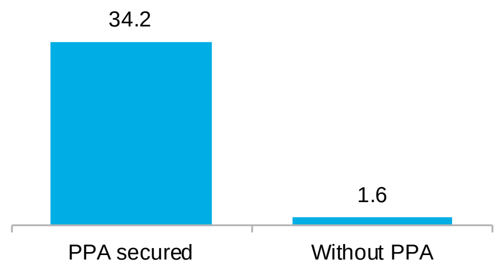
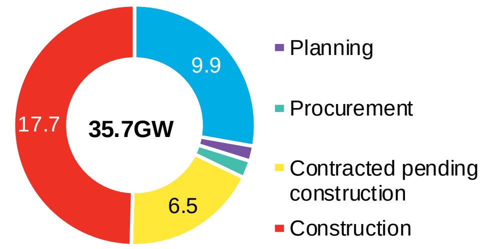


Figure 26: Capacity additions planned under 35GW program, by project development status



Source: ESDM, BloombergNEF. Note: Status as of December 2020.

The moratorium has yet to be legislated, but is aligned with the proposed 2060 carbon-neutrality goal that was also presented at the hearing. PLN is also seeking to have its own operations attain net-zero emissions by 2060. Even assuming coal plant lifetimes of 30 years, if the last planned coal plant comes online by 2026, a complete phase-out of coal would occur no earlier than 2056. PLN has presented a staged plan, first retiring its most polluting capacity, leaving its newest "ultra-supercritical" plants to be decommissioned last (Figure 27).

Coal projects that have yet to receive funding are unlikely to go ahead. Historically, Japanese, Chinese and South Korean companies have provided financing and construction services for coal-fired power plants in Indonesia. All three countries have now announced net-zero targets and are also starting to reduce overseas investment in fossil fuels. The Japan Bank for International Cooperation and Korea's National Pension Service have both already vowed to halt funding overseas coal projects beyond existing commitment.

The Indonesian government is also considering greater use of co-firing biomass in coal plants to reduce overall emissions. The proposed plan would impose domestic market obligations on biomass suppliers, similar to those applied to the country's miners. Trials have been conducted at 23 coal units, but the climate benefits depend on how the biomass supply is sourced. Indonesia's biomass sector has been mired in controversy and trading partners have voiced concerns over deforestation caused by biomass feedstock production.

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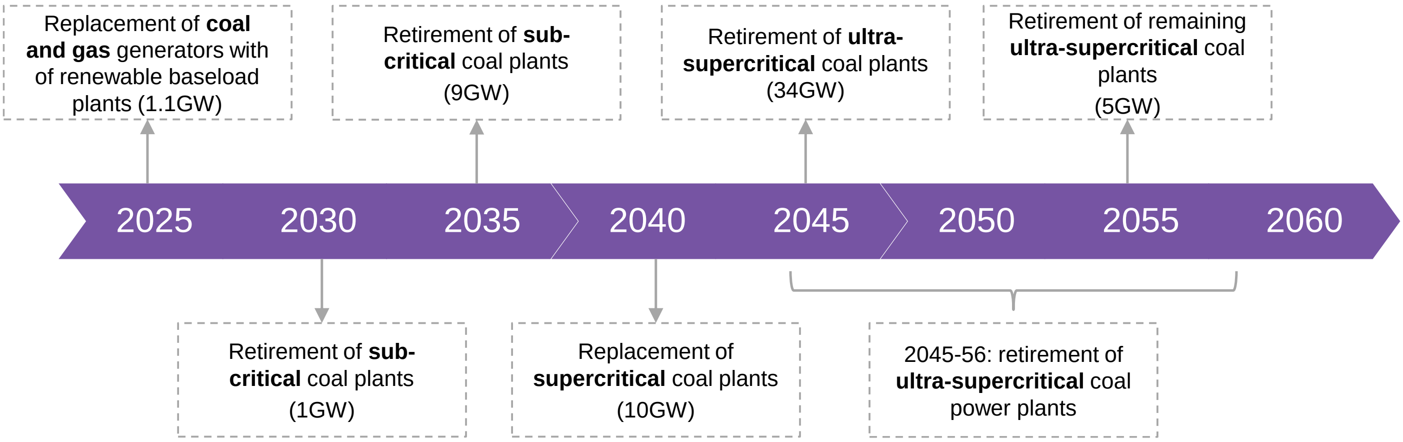
Figure 27: PLN's proposed coal phase-out timeline



Source: PLN as presented during Parliamentary hearing on May 27, 2021.

Spotlight: Germany's coal phase-out

Phasing out coal could put Indonesia in good company as the country remains one of the largest coal burners yet to set an end date for its fleet. Germany, where coal provided 28% of generation in 2019, mandated the closure of a similar capacity volume to that online in Indonesia by 2038.[8]

Germany has emphasized addressing the phase-out's social impact. The German government has earmarked 40 billion euros ($48 billion) to support economic development in the country's mining regions by creating new jobs in sectors such as battery manufacturing. Germany's renunciation of coal shows that phase-outs backed by a broad societal consensus are possible. But the cost of managing the transition means that, when considering the future of coal-heavy Kalimantan and Sumatra, Indonesia needs to develop a just transition plan.

Moving gas plants and pricing carbon

Several other policy proposals have been floated recently in Indonesia for the power sector, but details have yet to be released.

- MEMR has alluded to plans to "move" gas-fired power plants from oversupplied regions to underserved regions. It is unclear how feasible this plan is. More importantly, even if implemented successfully it is unlikely to significantly reduce overcapacity as coal power plants are the primary culprits.
- The government has also mentioned plans to introduce a carbon tax. No details have been provided on which sectors and fossil fuels would be covered. Several emerging markets have introduced carbon prices in recent years, including Ukraine and South Africa. Generally, however, most have set relatively low carbon prices. No developing country has a carbon price in place today that materially affects power plant economics.

[8] The 2038 phase-out date may yet be brought forward in light of a new 2045 net-zero target due to be ratified by Germany's parliament over 2020.

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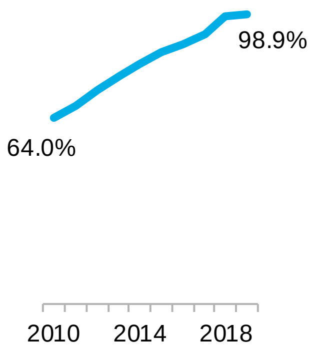
Section 5. Decentralized opportunities

While some of Indonesia's grids are plagued by overcapacity, others lack supply and offer limited reach to millions of consumers. Decentralized solar generation could address regions suffering from unreliable power supply. This can include hybrid mini-grids in rural communities, residential roof systems, or captive solar plants serving industrial facilities.

Factors beyond pure plant economics can drive growth of distributed solar. Moves to electrify industrial facilities or generally to move away from diesel are creating opportunities for distributed solar. Corporate sustainability goals are another driver.

5.1. Off-grid PV

Figure 28: Indonesia's national electrification rate

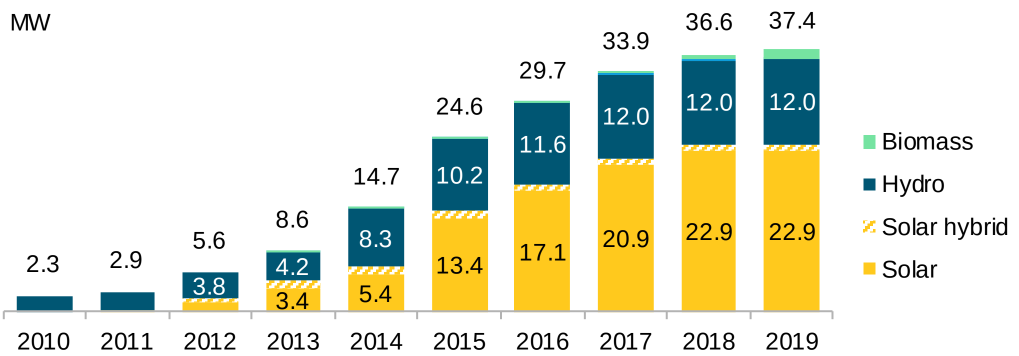


Source: BloombergNEF.

As a sprawling archipelago, Indonesia would benefit from greater reliance on decentralized energy resources. The country already hosts one of the world's largest fleets of mini-grids. Tens of thousands of diesel generators, many connected to small distribution networks, serve villages and hamlets. Indonesia imported over 23,000 diesel generators in 2018 alone. BloombergNEF has also identified 1,061 installed hybrid renewable mini-grids in the country totaling 37.4MW in 2019 (Figure 29). Indonesia's access to electricity rate has grown faster than almost any other country on Earth in recent years. In 2010, 64% of the country's population had power. By 2019, that figure had risen to 98.9%.

Despite near universal access, many regions do not receive power for 24 hours per day. The country's east in particular suffers from poor power reliability due to limited and aging infrastructure. According to the Asian Development Bank, some 2.3 million households were without access to power in 2018. Many are located in remote regions, where the cost of connecting them to a centralized grid powered by utility-scale power plants is prohibitive. That suggests a large potential market for distributed solar power.

Figure 29: Indonesia installed renewable energy mini-grid capacity



Source: BloombergNEF, GIZ, Carbon Trust, CLUB-ER, surveyed developers. Note: Operating projects without a specified commissioning year are not included.

Market overview

National and provincial governments have installed most of the country's mini-grids, at times with international donor support. IPPs can only directly sell power to customers outside of PLN's

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service areas for installations up to 50MW. In theory, mini-grid operators have slightly more freedom, as they are also allowed to install their assets and sell electricity directly to PLN in the state utility's service areas. However, this requires close negotiating and close cooperation with the utility. Interviews with stakeholders indicated that no private company has managed to obtain a license to sell electricity from a mini-grid to end-users in a PLN area. As a result, there are few private mini-grid operators in Indonesia – the fact that development is driven by the public sector is unique compared to most other large mini-grid markets.

Electrification projects are *de facto* limited to government-determined "business areas" consisting of multiple villages not served by PLN. The role of private companies has been restricted to providing engineering, procurement and construction services. Opening up mini-grid development to private players outside these areas would unlock private investment, thereby reducing the cost to the public purse. Corporate interest in the Indonesian mini-grid market appeared to be growing over 2015-17, with the announcements of partnerships involving the likes of General Electric, Caterpillar and Engie. However, these initiatives have yielded little recent updates.

Regulatory barriers

Developers operating in PLN areas are required to charge regulated tariffs. For subsidized developers, that meant PLN's regulated tariff in 2020. In return, they received subsidies, which took into account operational expenditures, losses, generation costs and expansion plans. Developers that do not receive a subsidy have their tariffs decided by the national or regional government. In theory, tariffs are unregulated where PLN is not present. Rural customers are unlikely to be able to afford to pay a fully cost-reflective tariff, but a lack of flexibility around tariff setting acts as a barrier to project developer.

Difficulties also plague provisions related to connecting mini-grids to the main grid in the future. Provisions are made for PLN to purchase power from IPPs upon arrival of the main grid at a mini-grid site, but regulated tariffs are often too low to warrant continued operation. BloombergNEF found that 140 mini-grids were abandoned upon grid arrival. The fact that PLN's tariffs were too low was often cited as the main reason for this. Only nine of 199 surveyed mini-grids were successfully connected to the main grid (Table 3).

Table 3: Outcomes of mini-grids in Indonesia upon arrival of the main grid

Outcome	Most common cited reason	Project count
Mini-grid abandoned	Tariff higher than that of PLN	140
Mini-grid operating in parallel to the main grid	Tariff cheaper than that of PLN	50
All electricity sold to PLN		5
Excess electricity sold to PLN		4

Source: BloombergNEF, World Bank, interviews with developers. Note: Green denotes favorable outcome, as mini-grids operating alongside the main grid suggests that investment in grid expansion may have been better directed elsewhere.

The number of mini-grids operating in parallel to the main grids in other markets underlines the opportunities available to developers. Often, power from a solar-hybrid mini-grid will be more reliable than that from the main grid, especially in regions where infrastructure spending has been lacking. This means that a mini-grid may remain competitive even where a community has access

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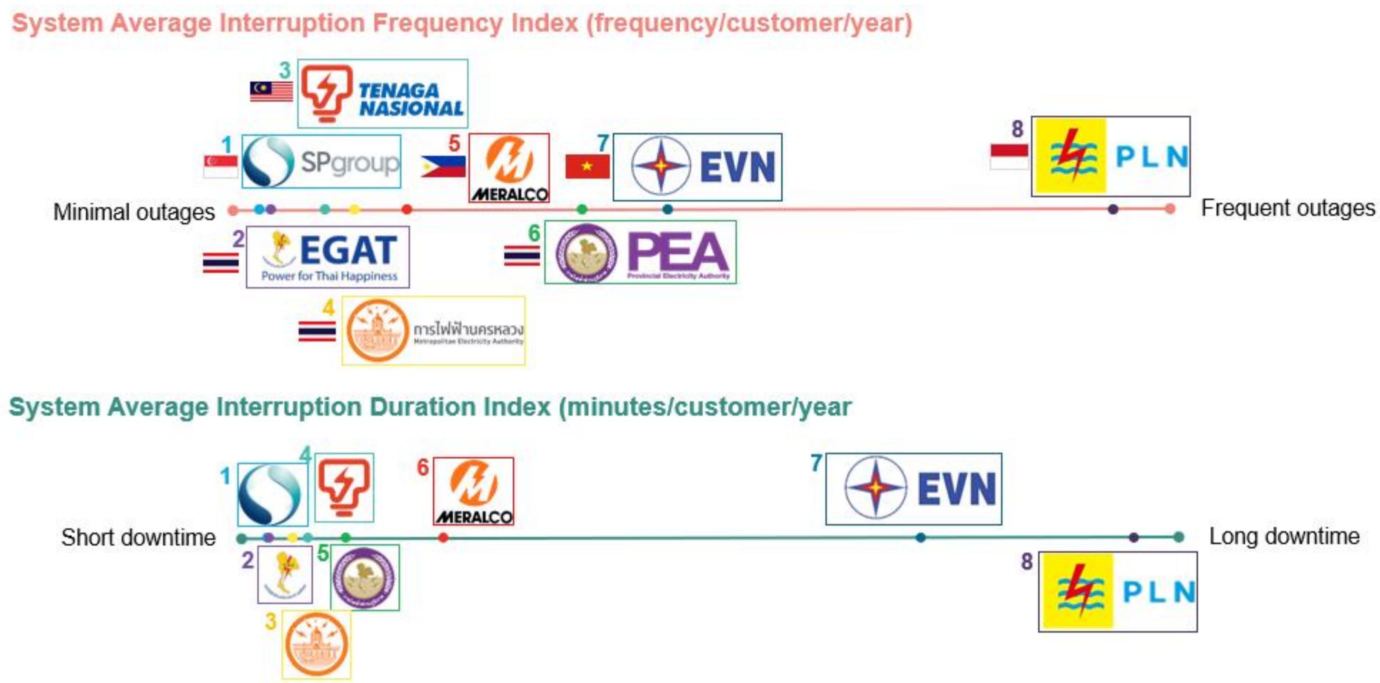
to a grid fed by utility-scale generation. Among Southeast Asia's national power utilities, PLN is bottom of the list on how frequent and how long downtime events occur on its grids (Figure 30).

Figure 30: Reliability and stability of electricity supply, select Southeast Asian utilities



Source: BloombergNEF, various utilities. Note: Based on reported 2018 SAIDI and SAIFI levels.

Spotlight: Grid arrival and mini-grids in India

Mini-grids can play a role even after a central grid reaches a far-flung community because they have the potential to deliver power more reliably around the clock. A relaxed regulatory approach adopted by several Indian states has seen the country become a leading solar mini-grid market.

In Bihar, mini-grid developers and the central grid operator have coordinated very little to date. Near the town of Pipra Kothi, a mini-grid employing PV, biomass and diesel has been online since 2017. The distribution grid then arrived within 2.5km of the 250 homes and businesses served by the mini-grid.

This opened the possibility of customers switching to the main grid for electricity – and paying lower tariffs. Yet most chose to stay with the mini-grid, largely because they value the more reliable power it provides. This raises the prospect that the addressable market for off-grid solar may be considerably larger than is suggested by Indonesia's electrification figures.

Diesel conversions

Diesel generators remain critically important sources of power to portions of rural Indonesia, but also produce disproportionately large volumes of CO2 emissions. The government aims to phase these out under a 15-year plan. Efforts will initially target the least efficient generators – diesel

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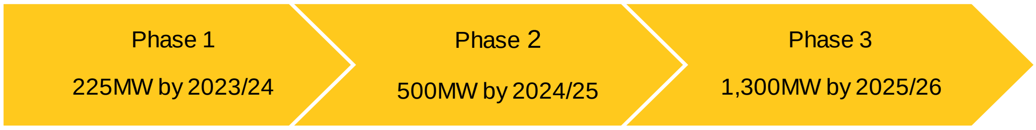
assets whose lifetimes exceed 15 years, and those whose fuel consumption lies above 0.28 liters/kWh.

MEMR has identified 5,200 diesel-generator units spread over 2,130 locations totaling 2GW capacity. Diesel conversions are to be separated into three phases over 2023-26. The program is to kick off with phase one in 2021, once a ministerial decree is issued. The initial phase will tackle 225MW of diesel generation capacity spread over 200 locations. PLN estimates that, if all were converted using solar plus energy storage, 600MW of solar with 1.8GWh of batteries is required.

Figure 31: Indonesian government's diesel conversion plan, by capacity



Source: Institute for Essential Services Reform, PLN.

What renewable technology will ultimately be deployed is unclear, however. The program selects technologies for conversion carried out on off-grid sites based on several criteria (Table 4). Solar will likely be suitable for a wider array of sites and project sizes than small hydro, biomass or wind. All conversions are to be carried out on off-grid sites isolated from the main grid.

Government announcements have indicated that the initial target for diesel conversions to solar was relatively modest, at 307MW in 358 locations. Public efforts could be supported by private finance, but small projects sizes could complicate attracting investment. The government could approach diesel conversions by grouping projects into bundles. This would help achieve the scale required to "crowd in" private funds.

Table 4: Technologies supported under Indonesian government's diesel conversion plan

Technology	Criteria
PV	Average irradiation of at least 1,600 kWh/m2/year
Onshore wind	Average wind speed of at least 6m2
Biomass	Feedstock available within 25km radius
Small hydro	Resource located within 25km radius

Source: BloombergNEF, PLN.

5.2. Commercial and industrial solar

Indonesia's industrial sector accounts for about a third of electricity demand. The country hosts a range of industrial users, from mining companies to fertilizer and rubber producers. In the past, the government has cited rapid industrialization to justify its overly bullish electricity demand forecasts. However, the sector's size provides a large addressable market, and industrial demand grew 29% over 2012-19 (Figure 32).

As with all regulated electricity prices in Indonesia, industrial tariffs are heavily subsidized. That makes them lower than most countries in the region, and reduces the incentive to install renewables (Figure 33). They also rank low internationally – Indonesia's industrial tariffs were 73rd out of 105 surveyed emerging markets in 2019. Raising tariffs would burnish the case for adding solar. Increasing clean power procurement demand from companies with sustainability goals is

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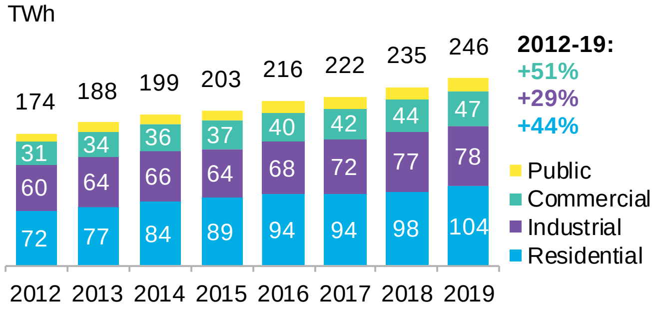
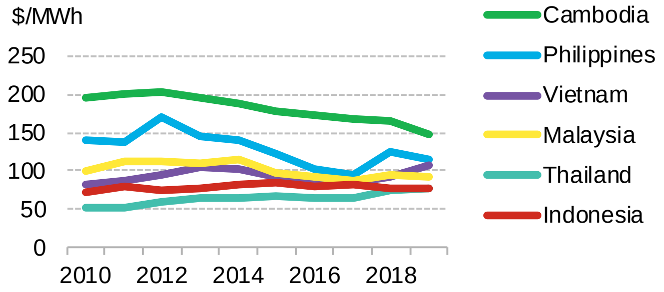
another driver. Other markets, including those in sub-Saharan Africa, have shown how commercial and industrial (C&I) solar can thrive even where utility-scale projects face challenges.

Figure 32: Indonesia power demand by sector



Source: BloombergNEF, Statistik Ketenagalistrikan 2019.

Figure 33: Industrial electricity tariffs by country, 2019

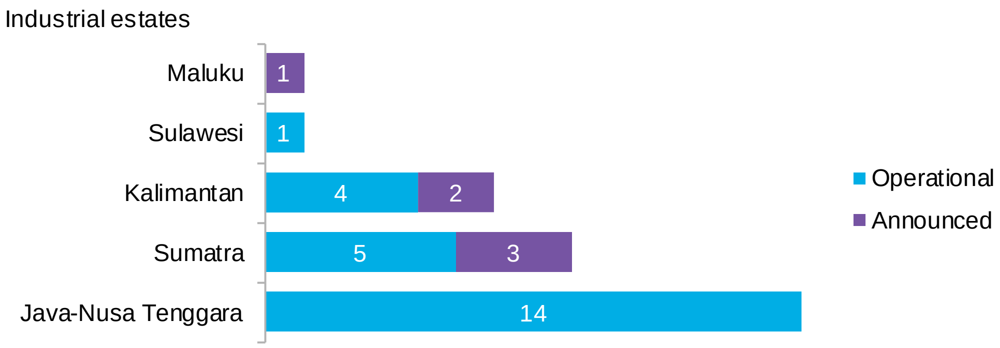


Source: BloombergNEF.

Solar for businesses

Opportunities for C&I solar are currently limited to regions outside PLN concession areas – locations where the state-utility has a monopoly on power procurement. Only in a select few regions beyond PLN concessions can developers or private power utility sell electricity directly to consumers, allowing solar to compete with other technologies on even footing. Opportunities may be more readily available in provinces like Kalimantan, which hosts several eligible industrial estates – plots of land hosting several facilities – and has less of a generation surplus (Figure 34).

Figure 34: Industrial estates outside PLN concession areas



Source: Institute for Essential Services Reform, BloombergNEF.

The case for captive power plants exists even in oversupplied provinces. Pairing solar with commercial facilities can act as a cost-effective alternative to the diesel that generators rely on during power interruptions, a particular issue for PLN customers (see previous section). Indonesia's frequent outages could favor more complex C&I configurations, such as on-site mini-grid systems able to coordinate and optimize the use of electricity from the grid, as well as onsite diesel, solar, and batteries.

Apart from on-site plants, opening access to PLN's transmission and distribution networks for power wheeling can also spur solar developments to meet growing C&I demand for clean energy. Regulation 1/2015 issued by the Ministry of Energy and Mineral Resources outlines several power wheeling schemes. The schemes look to allow electricity supply business license holders

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(locally termed Izin Usaha Penyediaan Tenaga Listrik, or IUPTL) that are permitted to sell electricity within a concession area or business entities with an operational license (Izin Operasi) for captive power plants to procure electricity from an off-site power plant through open access to electricity transmission and distribution networks within Indonesia.

The regulation has not been implemented fully however due to the lack of further detailed mechanisms including on wheeling contracts and charges. Liberalizing Indonesia's electricity retail sector to allow for off-grid power purchase agreements can tap into growing clean energy demand from the commercial and industrial sector to drive solar developments, although the impact could be limited by the fragmented grids in Indonesia.

Spotlight: C&I solar in Nigeria

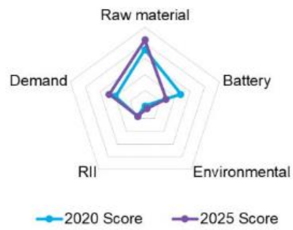
Nigeria's C&I solar sector is the 2nd biggest in sub-Saharan Africa by installed capacity after South Africa. Frequent and lengthy outages mean that C&I solar projects mainly compete with diesel generators, not the main electricity grid. The market is very distributed, with the majority of installations smaller than 30kW. Most projects are located in industrial areas where land is relatively abundant.

Most systems include uptime commitments and coordinate activities between solar, diesel and battery output, and the grid. Low power prices mean that it is common to size solar installations so that they do not exceed the facility's power consumption on days when it does not operate. That makes projects more economical when facilities operate seven days a week.

Clean power for battery manufacturing

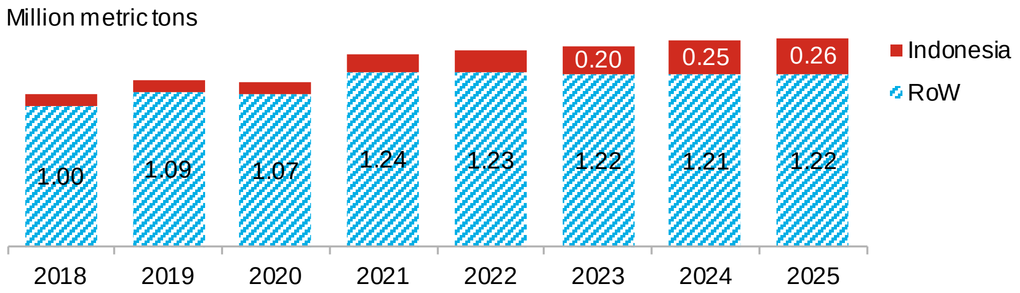
Indonesia's ambitions to become a battery manufacturing hub could be another opportunity. The government wants to leverage the country's vast nickel resources (Figure 36) – a key component for high energy density lithium-ion batteries – to build a globally competitive domestic battery manufacturing supply chain. Indonesia could become one of the cheapest locations to make lithium-ion batteries thanks to low-cost power, labor and material costs.

Figure 35: Indonesia score in the BNEF global battery supply chain rankings



Source: BloombergNEF. Note: RII refers to regulations, innovation and infrastructure.

Figure 36: Global class 1 nickel supply capacity forecast



Source: BloombergNEF, Ministry of Energy and Mineral Resources, company reports.

Indonesia has seen a flurry of announcements related to a potential build-out of the country's battery manufacturing supply chain in recent years (web | terminal). However, several challenges, including low domestic demand for batteries, stand in the way of various ambitious plans. The biggest of these is Indonesia's poor environmental record. Among 25 countries analyzed in BloombergNEF's Global Lithium-Ion Battery Supply Chain Ranking, Indonesia finished last on environmental metrics (Figure 35). Demand for batteries manufactured in a sustainable fashion is increasing as regulators starting in Europe are planning to introduce new standards. The primary

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culprit in Indonesia's poor environmental performance is the power sector's heavy reliance on coal.

Companies have taken notice: Chinese nickel giant Tsingshan Holding Group, announced that it would install 2GW of renewable capacity – prioritizing wind and solar – for its Indonesia operations over the next three to five years. Similar trends are afoot in other sectors: a major steelmaker is seeking to commission 40MW of floating PV to power its facilities.

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Section 6. Appendices

6.1. Appendix A

Table 5: Assumptions used in generation shortfall estimation

Category	Variable	Assumption
Target	2025 renewable energy target	23% of generation
2025 Indonesia generation forecast	RUPTL 2019-28	412,851GWh
	BloombergNEF	323,120GWh
Capacity factors	Coal	58%
	Gas	35%
	Large hydro	42%
	Oil & diesel	35%
	Geothermal	80%
	Biomass & waste	70%
	Small hydro	35%
	Wind	22%
	Solar	16%

Source: BloombergNEF

6.2. Appendix B

Table 6: Indonesia's local content requirements for solar projects

Categories	Distributed stand-alone PV	Centralized stand-alone PV	Centralized grid-connected PV
Materials (overall)	**39.87%**	**37.47%**	**34.09%**
Solar modules	40.0%	40.0%	40%
DC combiner box	-	20.0%	20%
Distribution panel	-	40.0%	40%
Transformer	-	-	40%
Battery	40.0%	40.0%	-
Battery control unit	10.0%	-	-
PV mounting systems	42.4%	42.4%	42.4%
Cable	90.0%	90.0%	90.0%
Protection system	-	20.0%	20.0%
Energy limiter	-	40.0%	-

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Services	**100%**	**100%**	**100%**
Combined (materials and services) local content requirement	**45.90%**	**43.72%**	**40.68%**

Source: Ministry of Industry Regulation 5/2017. Note: Ministry of Industry Regulation 4/2017 goes into further details on the local content requirement for each component. Ministry of Industry Regulation 5/2017 foresees local content for PV modules rising to 60% as of January 1, 2019, but it is unclear whether this is being implemented.

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