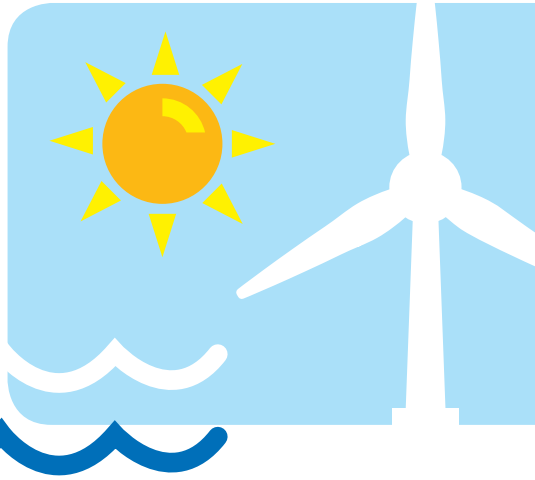
Indonesia Renewable Energy Business Opportunities



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Executive Summary

Indonesia matters: it is the 4th most-populous country and according PwC will be the 4th largest economy in the world by 2050. That growth will generate increased demand for energy, which will create new opportunities for renewable energy companies.

Indonesia is blessed with an abundance and wide variety of renewable energy resources. The government has therefore set ambitious targets for renewable energy as a means to meet its greenhouse gas emissions targets in the energy sector and to increase national energy security. The National Energy Policy (KEN) and Plan (RUEN) target that renewable energy resources provide 23% of all final energy consumption by 2025, and the draft National Electricity Plan (RUKN) targets 25% renewable electricity for the power sector by 2025.

The rest of the current policy environment, however, does not sufficiently incentivise private-sector investment, so significant amounts of international and domestic funding available to finance renewable energy infrastructure are not being accessed at scale. And while large hydropower and geothermal powerplants contribute sizeable portions of the current electricity supply, the Indonesian government and the national state-owned electric utility (PLN) have been less successful in increasing the contribution from other renewable sources such as small hydropower, biomass, biogas, waste-to-energy, solar PV, wind, and marine energy. Altogether, renewable energy resources supplied 12% of all electricity in 2018.

But things are starting to change. The country's second-largest coal producer, PT Adaro Energy, has recently established a renewable energy division as part of the company's long-term plan to enter the clean energy business. Foreign governments, international development finance institutions, private equity investors, foreign developers and equipment and service providers are all keen to help the Indonesian government and PLN to accelerate the market for all renewable energy project types. In this vein, the UK Government's Renewable Energy Prosperity Fund programme aims to help improve the policy

Estimated Market Value of Renewable Energy and Related Projects (USD millions)

Project Type	2020-2021	2022-2025	TOTAL	Foreign Share
Utility Scale PV	252.0	423.5	675.5	429.0
Rooftop PV	28.4	65.4	93.8	50.4
Small Hydro	1,795.0	1,565.0	3,360.0	598.1
Medium/Large Hydro	2,702.5	6,825.0	9,527.5	4,316.0
Geothermal	2,293.6	18,535.5	20,829.1	13,721.4
Wind Power	57.0	1,394.0	1,451.0	870.6
Biomass	271.5	378.0	649.5	227.3
Biogas	50.0	150.0	200.0	60.0
Waste-to-Energy	270.0	1,224.0	1,494.0	806.8
Biodiesel Generators	62.5	103.1	165.6	112.5
Smart Grid Controls	20.0	132.5	152.5	152.5
Battery Energy Storage	65.0	215.5	280.5	280.0
TOTAL	**7,867.5**	**31,011.5**	**38,879.0**	**21,624.6**

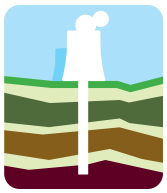
environment for investment, provide more access to reliable and affordable energy, and embed good practice and innovation across Indonesia's renewable energy industry.

Developing Indonesia's renewable energy sector will create medium- to long-term opportunities for international businesses in an area where the UK holds considerable expertise – UK businesses offer world-leading capability in the renewable energy sector and are well-placed to benefit from the downstream opportunities created by the programme's policy, technical and market assistance in Indonesia. To secure future high-value contracts, however, companies need to be on the ground developing their networks in the short term.

This report provides a high-level overview of energy market opportunities in Indonesia. A more-detailed free report – available to UK firms upon request – features live and pending commercial renewable energy projects as well as regulations, pricing, contract terms, procurement methods, key decision-makers, local-content requirements, and potential partners for each type of renewable energy. The full report aims to empower UK firms with the knowledge they need to enter Indonesia's energy market, develop relationships on the ground, and pursue projects before the market becomes mainstreamed. To request the full report, email DITJakarta.Enquiries@fco.gov.uk with your contact information, job title, company name, and renewable subsector(s) of interest.

Market Value for Grid Connected Renewable Energy Projects

In preparing this study, we estimated the total market for renewable energy to be USD 38.9 billion over the period 2020 to 2025, based on PLN's Electricity Supply Business Plan (RUPTL) and current market conditions. We further broke down the size of the market for each renewable energy type and segment, as well as determined the potential share for foreign businesses.

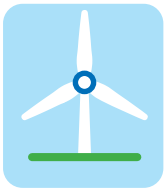


The **geothermal market** is estimated to be USD 21 billion. In 2018, Indonesia became the world's second largest geothermal power producer, with a number of projects coming online and new concession areas awarded. Geothermal exploration is characterized as highly risky and capital-intensive. New geothermal concessions have been primarily awarded to national state-owned companies, but many lack the capital and expertise to successfully develop the projects.

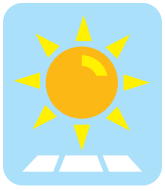
The **hydropower market** is estimated to be USD 12.9 billion, broken into two major segments: medium and large hydropower (> 10 MW) at USD 9.5 billion and small hydropower (< 10 MW) at USD 3.4 billion. With some exceptions, the government allocates most medium and large hydropower project development for PLN rather than IPPs. These projects have the advantage of attracting international development financing. Small hydropower projects, due to ownership restrictions, are principally developed and financed domestically. Imported hydropower turbine-generators are typically used, regardless of size. Foreign engineering and consulting services are used principally for medium and large-scale projects.

The **bioenergy market** is estimated to be USD 2.5 billion. This is comprised of biomass at USD 650 million, biogas at USD 200 million, waste-to-energy at USD 1.5 billion, and biodiesel generators at USD 166 million. Biomass and biogas projects are largely linked to operating forest and agro-processing facilities where the primary use is for internal, captive power. While there are no waste-to-energy projects currently operating in the country, the market is expected to accelerate with the issuance of a Presidential regulation covering 12 of the largest cities and a clearer procurement process.

Diesel generators using 100% biofuel (principally from palm oil) are now allowed to sell power to PLN under long-term contracts.

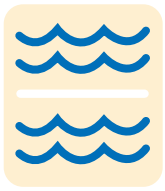


Indonesia's first commercial, utility-scale **wind farm** began operating in 2017, and other projects are currently under development. The wind power market is estimated to be USD 1.5 billion. As with solar PV, however, PLN is already experiencing difficulties in integrating higher percentages of wind power into its grid.



The **solar photovoltaics (PV)** market is estimated to reach USD 769.3 million, broken into two major segments: utility-scale at USD 675.5 million and rooftop at USD 93.8 million. Both segments are in the early stages of development as government policies and PLN procurement practices are just now taking effect. In addition to larger grid-connected solar PV projects, the government and PLN are promoting smaller systems (250 kW to 5 MW) on small island isolated grids currently served exclusively by diesel generators. Foreign developers are involved as developers of the larger utility-scale projects. Imports of solar PV panels and inverters account for the majority of the equipment opportunities in the market for both utility-scale and rooftop solar PV segments.

The market for **smart grid solutions** is expected to open during the 2020 to 2025 period. Currently, battery energy storage systems (BESS) and advanced micro-grids are currently in the pilot demonstration stage. Given MEMR's emphasis on improving grid operability and PLN's recognition of the value of smart transmission and distribution system control and BESS, we have estimated these markets to be USD 153 million and USD 280.5 million, respectively. We expect this market to be captured largely by foreign equipment suppliers and system integrators given the lack of domestic capability and the prevalence use of the technologies in more advance utility systems worldwide.



Marine energy was a focal point of attention in 2016 and 2017, when the Ministry of Energy and Mineral Resources (MEMR) appeared to encourage the international community to help harness the resource, principally tidal currents. Current government policy, however, is less favorable, and PLN now views marine energy as not yet commercially available for Indonesia.

Renewable Energy Business Opportunities

The principal business opportunities are associated with Independent Power Producers (IPPs) that are privately developed and financed, and sell power to PLN under a long-term (up to 30 years) Power Purchase Agreement (PPA) contract. There are opportunities at each stage in the IPP supply chain for both foreign and domestic companies; the value of those opportunities, however, differs both by type and size of project. The difference is a function of the Indonesian energy industry's capabilities, foreign investment and ownership restrictions, and local content requirements.

For foreign businesses, the greatest (by value) opportunities are found in consulting and engineering studies, major electro-mechanical equipment supply, and Engineering, Procurement and Construction (EPC) management, especially for projects with a capacity greater than 10 megawatts (MW). Because of the frequently changing regulatory treatment and permitting of renewable energy IPPs over the past five years, as well as the early implementation stages of current regulations, the renewable energy IPP business is considered risky particularly at the stages of project preparation up to signing a PPA contract. Most foreign companies have established offices in Indonesia in order to conduct market

intelligence, establish a relationship with PLN and assess potential Indonesian business partners.

With the exception of smart grid and BESS, emerging technologies or those that are new to Indonesia are not likely to be introduced in the 2020-2025 timeframe. Offshore wind and marine energy are not considered viable during the 2020-2025 timeframe, though there may be a market for feasibility studies for projects to be developed after 2025.

Conclusions

Indonesia's renewable energy market is in its infancy but is expected to grow quickly over the next decade. For UK renewable energy companies to be part of Indonesia's growth story, they will need to play by local rules.

Indonesia is not a transactional market where companies can setup meetings by email, fly in and fly out. The only way to succeed in Indonesia is to build strong personal relationships first, before securing deals; an on-the-ground local presence is essential. Patience, perseverance, and (a degree of) pushiness are required. But for those renewable energy companies willing to make the long-term investment and commitment, the opportunities in Indonesia over the coming decades are substantial.

Acronyms

ADS	Automatic Dispatch System
AGC	Automatic Generation Control
AMI	Advanced Metering Infrastructure
Bappenas	National Development Planning Agency/Ministry of Planning (Badan Perencanaan Pembangunan Nasional)
BESS	Battery Energy Storage System
BOOT	Build, own, operate and transfer
BPP	Average Electricity Production Cost (Biaya Pokok Penyediaan)
DPT	PLN's Prequalification for Direct Selection Process (Daftar Penyedia Terseleksi)
DMO	Domestic Market Obligation
GHG	Greenhouse gas
GW	Gigawatt
IDR	Indonesian Rupiah (currency)
INDC	Intended Nationally Determined Contribution
IPP	Independent power producer/Penyedia Listrik Swasta (PLS)
KEN	National Energy Policy (Kebijakan Energi Nasional)
kV	Kilovolt
kWh	Kilowatt hour
LCOE	Levelized Cost of Electricity
LNG	Liquified Natural Gas
LTSHE	Low Energy Solar-Power Lamps/Solar Home System (Lampu tenaga surya hemat energy)
NEC	National Energy Council (Dewan Energi Nasional)
MEMR	Ministry of Energy and Mineral Resources/Kementerian Energi dan Sumber Daya Mineral(ESDM)
MW	Megawatt
NTB	West Nusa Tenggara (Nusa Tenggara Barat)
NTT	East Nusa Tenggara (Nusa Tenggara Timor)
PLN	Indonesia State Electricity Company (Perusahaan Listrik Negara)
PPA	Power purchase agreement
PV	Photovoltaic
RE 100	Renewable Energy 100 (companies committing to renewable energy use)
RPJMN	National Medium Term Development Plan (Rencana Pembangunan Jangka Menengah Nasional)
RUEN	National Energy Plan (Rencana Umum Energy Nasional)
RUKN	National Electricity Plan (Rencana Umum Kelistrikan Nasional)
RUKD	Regional Electricity Plan (Rencana Umum Kelistrikan Daerah)
RUPTL	PLN's Electricity Supply Business Plan (Rencana Umum Penyediaan Tenaga Listrik)
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goals
SOE	State Owned Enterprise
USD	U.S. Dollar
WKP	Geothermal Working Area (Wilayah Kerja Pertambangan)

Contents

Introduction

Energy Market Background

Indonesia is the most populous and largest economy in Southeast Asia, and could be the fourth-largest economy in the world by 2050.[1] At the same time, however, it has one of the lowest electricity consumptions per capita in the region. Built on an archipelago, the electricity system is non-uniform in terms of: 1) customer demand and expected load growth, 2) generation, transmission and distribution infrastructure, and 3) electricity supply quality and reliability. Though Indonesia has reportedly achieved 98% access to electricity services, in much of the country outside of the cities and other densely populated areas, electricity demand is suppressed by the limited availability of electricity supply. This leaves both unserved and underserved customers in many rural areas.

In order to provide for balanced and inclusive economic growth, Indonesia has a "uniform tariff" whereby all residential, commercial, institutional and industrial customer pay the same electricity retail tariff in each customer class regardless of their location and the local cost of electricity generation. This forced rate uniformity results in geographic cross-subsidies: the average electricity generation cost varies greatly across Indonesia, with the lowest production costs found in the Java-Bali system (less than USD 7 cents/kWh) and the highest costs in remote regions of East Indonesia and small islands (more than USD 21 cents/kWh) where diesel is the main fuel for electricity. The government's policy of maintaining affordable electricity prices is accompanied by its policy for controlling the cost of fossil fuel prices, specifically coal and natural gas. The national utility (PLN) primary objective in adding new generation sources to its grid is to lower its overall cost of production.

As has been the case in most countries, specific policies to incentivize the use of renewable energy resources are critical to both the creation of the market, as well as its growth and long-term outlook for investors and the renewable energy industry. These come in the form of policies related to pricing (e.g., power purchase prices, energy commodity prices), tax and other fiscal incentives, investment and ownership limitations,

Figure 1 – Map of Indonesia and its Provinces

[1] Power in Indonesia - Investment and Taxation Guide, 5th edition. Price Waterhouse Coopers, November 2017.

domestic content requirements, and business, land use, and environmental permits and license requirements. In the case of Indonesia, frequent changes in government regulations, coupled with poor implementation of tax and other incentives, have made Indonesia a relatively unattractive investment climate, especially in the context of the lack of a real market for energy and electricity where prices reflect real costs. It should be noted that higher-level policies such as greenhouse gas emission mitigation from the energy sector and targets for renewable energy share of total energy reflect government priorities, but in the case of Indonesia, they have yet to directly influence the market and business opportunities for renewable energy. PLN, the state-owned national utility, is not incentivized to reach these government goals.

Indonesia may become the world's fourth-largest economy by 2050.

Key Government Institutions

There are four main institutions that shape the renewable energy market in Indonesia. At the highest level is the National Energy Council that reports directly to the President. NEC is responsible for developing the National Energy Policy (KEN) which set a target for 23% of final energy consumption to come from new[2] and renewable energy resources. The Ministry of Energy and Mineral Resources (MEMR) prepares the national energy plan (RUEN) and National Electricity Plan (RUKN) to implement the KEN. MEMR also issues regulations for electricity planning, pricing, business licenses and contract terms, and renewable energy-generated electricity. The Ministry of Development Planning (BAPPENAS) is responsible for preparing the Medium-Term Development Plan (RPJMN) including energy/electricity infrastructure to support economic development. PLN is a vertically integrated monopoly electric utility serving all of Indonesia. PLN is directly responsible for generation, transmission and distribution, however PLN subsidiaries as well as private foreign and domestic companies are increasingly involved in generation as independent power producers (IPPs).

A domestic supply chain is a key component of lowering prices for renewable energy project development. The development of domestic inputs, however, should follow the growth in the market rather than the current government policy of imposing local-content requirements at the earlier stages of market development. Successful utility-scale projects developed by experienced international companies are needed to send strong market signals, create manufacturing demand, and improve the quality of local services. As the market grows, this creates opportunities for joint ventures with foreign companies, value-added manufacturing, and transfer of technology to the local industry. While there are some exceptions, the nascent status of the Indonesian renewable energy industry coupled with domestic-content requirements essentially adds cost for inefficient project development, higher manufacturing costs, and lower performance. Meanwhile, caps on foreign ownership restrict access to international equity sources and lower-cost capital from international lenders.

Other Key Stakeholders in the Power Sector

Private independent power producers (IPPs) are taking on an increasing role in developing, owning and operating powerplants with long-term

[2] "New" energy resources include nuclear, clean coal and coal bed methane, and other non-renewable energy resources.

power purchase agreements (PPAs) with PLN. Each project is set up as a Special Purpose Vehicle and can include shareholdings of foreign and domestic investment companies and equipment suppliers. IPPs play a critical role in the renewable energy sector, as they often take risks that PLN is not willing to take, for example, in developing and operating unfamiliar technology such as wind and solar PV plants. IPP projects range from 800 MW coal projects to bioenergy, mini hydro and solar PV projects with capacities of less than 10 MW. All IPP projects are now developed under a Build Own Operate and Transfer (BOOT) scheme whereby the generation assets are transferred to PLN at the end of the term of the PPA contract.

Equipment suppliers and service providers are a critical part of the supply chain whether for PLN, IPPs or captive power users. Indonesia relies on foreign suppliers for major powerplant components and for consulting and engineering services, particularly for larger-capacity powerplants.

Financing institutions that are active in the Indonesia power sector consist of multilateral development banks such as the Asian Development Bank and The World Bank/ International Finance Corporation, bilateral development finance institutions, private international and domestic banks, and specialized foreign and domestic private equity funds.

Note that Indonesia is a relationship-based market; to secure future high-value contracts, UK firms need to be on the ground developing their stakeholder networks in the medium term.

Market Size Estimation

We calculated the size of the Indonesian renewable energy market based on the planned and under-development generating capacity to be added in the near-term (2020-2021) and mid-term (2022-2025). Actual project cost data and expected price declines were used to calculate the value of the market during each term. Using real project experience from Indonesia where available, we determined the value of project costs at each step along the supply chain for each clean energy technology. We also estimated the share of foreign and Indonesian businesses in each segment.

The assessment of the market and identification of business opportunities is based on current laws, regulations, programs, procurement plans and industry capabilities. Indonesia held presidential elections in April 2019, and the new administration's proposed reforms in the energy sector and electricity subsector, as well as its priorities relative to climate change and renewable energy development, will be presented in the next RPJMN, which will cover the period 2020-2024.

Indonesian Power Market

As of 2018, PLN had 56.5 gigawatts (GW) of power generating capacity on its system. This was comprised of 40.5 GW owned and operated by PLN (71.9%), 13.3 GW owned and operated by IPPs (23.6%) and 2.7 GW of leased diesel and mobile powerplants (4.8%). PLN plans to double its current capacity over the next ten years, and will increase its reliance on IPPs. Of the 56.3 GW PLN expects to add, 16.2 GW will be owned and operated by PLN (29%) and 33.7 GW from IPPs (60%), while 6.2 GW are still unallocated.

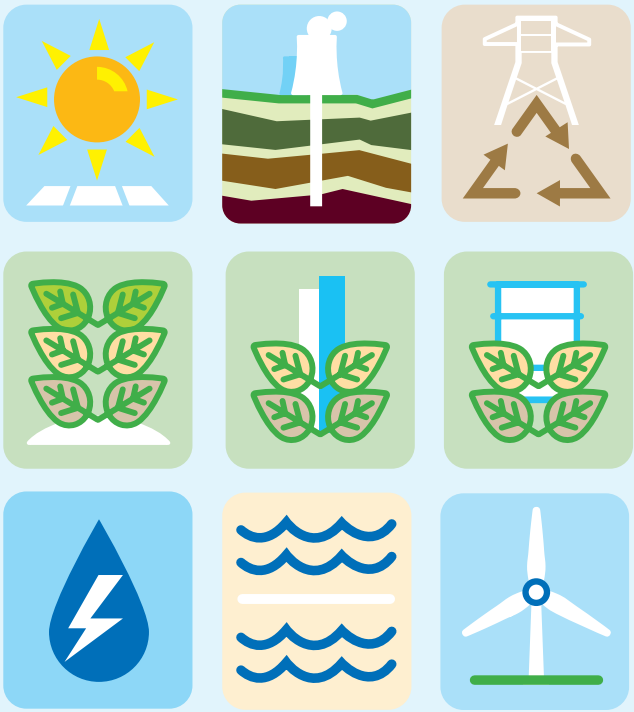
Each year, PLN prepares and MEMR approves a 10-year Electricity Supply Business Plan (RUPTL). In the 2019-2028 RUPTL, PLN provides a detailed plan including electricity demand growth, number of customers, village electrification, as well as the planned expansion of generation, transmission

and distribution system over the 10-year period. PLN has stated that in its long-term plan, coal-fueled electricity would continue to constitute more than 50% of its supply. A governmental Domestic Market Obligation (DMO) requires that a percentage of coal production be sold within Indonesia, while ceiling prices for different qualities of coal are designed to relieve PLN's financial burden and shield it from price fluctuations. It should be noted that under IPP contracts in Indonesia, PLN assumes the fuel supply responsibility and associated price risk.

Currently, gas-fired power stations account for approximately 22.5% of total generation and are expected to maintain a similar share over the next 10 years. Indonesia's has extensive gas reserves and there is a global and Asian (including Indonesian) glut of liquefied natural gas (LNG) production to ensure stable prices at least in the near term. Significant investment is still needed in gas infrastructure, including for pipelines and floating storage regasification units, in order to expand gas utilization, particularly in eastern Indonesia.

Oil, including high-speed diesel, marine fuel oil and industrial diesel oil, have been gradually phased out of PLN's fuel mix in favor of coal and natural gas. Power generation from refined oil products accounted for 6.9% of total generation in 2018. PLN plans to continue to phase oil down to 0.4% in 2028. The bulk of the oil use is for isolated grids across the country.

Renewable energy resources for electricity generation include: biomass, biogas, waste-to-energy, biofuel, geothermal, hydropower, wind, solar PV, and marine energy. Of these, medium and large hydropower and geothermal are well-developed and are core to PLN's current generation mix and future expansion plans. Together they supply 12% of all electricity generation in 2018 and 75% of all planned renewable energy capacity to be added between 2019 and 2028.



12%

of all electricity generation in 2018

Renewable Energy Market Characteristics

Major government policies and programs

Indonesia's Nationally Determined Contribution (NDC) outlines its transition to a low-carbon future; it has committed to an unconditional emissions reduction of 29% by 2030 compared to the business-as-usual scenario, and up to a 41% reduction with international assistance. Indonesia submitted its intended NDC in September 2015 and its first NDC in November 2016.

In March 2017, President Jokowi signed Presidential Regulation 22/2017 on the National Energy Plan (RUEN). The regulation states that RUEN is a central government plan for managing the national energy sector. It serves as an implementation framework for the National Energy Policy (KEN). The RUEN sets a target of 23% of Indonesia's final energy use to come from new and renewable energy resources by 2025.

Electricity planning is the purview of MEMR (through the RUKN), provincial energy offices (through the RUKD), and PLN (through the RUPTL, see Table 1). At this time, the draft RUKN (2015-2034), which has been submitted but not yet ratified, sets two targets: 1) new and renewable energy should constitute 25% of the electricity supply mix by 2025 and 2) the electrification ratio should reach 97.35% of all households by 2019. Although the RUKN has not been finalized and signed by the President, it serves as a reference for PLN in preparing its annual RUPTL.

Many of the smaller, distributed renewable energy resource-based projects are listed as "scattered" in the RUPTL meaning that PLN has not yet determined the size or location of the projects, requiring further analysis of the grid's capability to absorb the power. While the government has moved to a competitive procurement approach, many projects are still presented to PLN as unsolicited proposals and later offered for bidding by registered IPPs.

In 2017, MEMR issued new regulations that were intended to encourage renewable energy IPPs in regions where they can contribute to lowering PLN's average electricity production cost. The new rules focus on two main issues: 1) setting the tariff for PLN's purchase of electricity from renewable generators, and 2) tendering schemes for awarding renewable projects to IPPs.

The regulations set ceiling prices for the purchase of renewable energy by reference to the average

Table 1 - Planned Renewable Generating Capacity Additions, in Megawatts (2019 – 2028)

Project Type	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	TOTAL
Geothermal	190	151	147	455	245	415	2,759	45	145	55	4,607
Large Hydro	154	326	755	0	182	1,484	3,047	129	466	1,467	8,010
Small Hydro	140	238	479	200	168	232	27	20	20	10	1534
Solar PV	63	78	219	129	160	4	250	0	2	2	907
Wind	0	0	30	360	260	50	150	0	0	5	855
Biomass/Biogas	12	139	60	357	50	103	19	5	15	35	795
Marine	0	0	7	0	0	0	0	0	0	0	7
TOTAL	**559**	**932**	**1,697**	**1,501**	**1,065**	**2,288**	**6,252**	**199**	**648**	**1,574**	**16,715**

Source: PLN RUPTL 2019-2028

cost of generation or electricity production (biaya pokok penyediaan or BPP)[3]. BPP pricing is based on two principles: 1) renewable energy IPPs will not exceed the regional BPP in regions where the BPP is less than the national BPP, and 2) where the regional BPP is greater than the national BPP, renewable energy IPP's will contribute to PLN's efforts to reduce the regional BPP. Based on the 2018 BPP, power purchase prices range from the national average of US 7.86 cents/kWh in Java, Bali and parts of Sumatra where coal-fired powerplants are located to as high as US 21.34 cents/kWh in small islands and isolated grids power by diesel generators.

The regulations introduced two other conditions into the IPP program: direct selection and BOOT. Direct selection allows PLN to select among prequalified developers for the right to undertake the project. BOOT provides for PLN to assume ownership and control of the generation assets after the term of the PPA contract. Table 2 summarizes the regulatory treatment of various renewable energy type IPPs.

Cost and Technical Consideration

The levelized cost of electricity (LCOE) represents the average revenue per unit of electricity generated that would be required to recover the costs of building and operating a generating plant during an assumed financial life or term of a PPA. LCOE is often used to determine the overall competitiveness of different generating technologies. Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance costs, financing costs, energy production, and an assumed utilization rate for each plant type.

Biomass powerplants are similar to fossil fuel powerplants in that they have both capital costs and fuel costs. Biogas and waste-energy

Table 2 - Summary of Regulatory Treatment of Renewable Energy IPPs

Renewable Energy Resource	Appointment Method	Areas where Regional BPP < National BPP	Areas where Regional BPP > National BPP	Investment Basis
Solar	Direct selection based on capacity Quota	Negotiated between IPP and PLN	Maximum 85% of regional BPP	BOOT
Wind	Direct selection with capacity Quota	Negotiated between IPP and PLN	Maximum 85% of regional BPP	BOOT
Hydro	Direct selection	Negotiated between IPP and PLN	Maximum of 100% of regional BPP.	BOOT
Biomass	Direct selection	To be negotiated between IPP and PLN	Maximum 85% of regional BPP	BOOT
Biogas	Direct selection	To be negotiated between IPP and PLN	Maximum 85% of regional BPP	BOOT
Waste-to-Energy*	Direct appointment by municipality	To be negotiated between IPP and PLN	Maximum 100% of regional BPP	Not specified
Geothermal	Direct appointment where resources are proven	To be negotiated between IPP and PLN	Maximum 100% of regional BPP	BOOT
Ocean Energy	Direct selection	To be negotiated between IPP and PLN	Maximum 100% of regional BPP	BOOT
Biodiesel Powerplants	Direct selection	To be negotiated between IPP and PLN	To be negotiated between IPP and PLN	BOOT

* - Presidential Regulation 35 of 2018 set a higher price for 12 priority cities.

[3] BPP consists of the amortized capital costs, fuel and non-fuel operating costs. It excludes associated transmission and distribution costs including losses

projects also require fuel (or feedstock), which is often captured in the financing structure where revenues are shared with the feedstock supplier. The inputs to the levelized costs of electricity for hydropower, solar PV, wind and marine projects are concentrated in the project's capital costs.

Based on a Central Bank of Indonesia regulation, any transaction executed in Indonesia is to be denominated in local currency (Indonesia Rupiah, IDR). This is important for renewable energy (and other) projects that secure part of their financing in foreign currency in order to obtain lower interest rates. All PPAs signed by PLN dictate payments in IDR.

All power projects have an associated cost in connecting to the grid. These costs include transformers or substations to adjust the voltage level, transmission lines, and any additional modifications to the grid to accommodate the power. Of these, transmission line costs can vary considerably since they are a function of the distance between the powerplant and the grid interconnection point. PLN now requires that all renewable energy projects, regardless of their size, conduct an interconnection study as part of the feasibility study.

Each powerplant or generating facility has a "nameplate capacity" which indicates the maximum output that generator can produce under specific conditions. "Capacity factor" is the ratio between a generation unit's actual generation output over a period of time to what the unit is capable of generating at maximum output. These two numbers can be significantly different. The capacity of a powerplant may be de-rated over time, meaning that it will be considered to have a decreased maximum output due to inefficiencies that develop during operations.

Financing

Domestic financing supply is available for renewable energy projects. Channeling the funds and finding commercially feasible projects, however, are challenging in Indonesia. The two most prevailing challenges are legal aspects of Power Purchase Agreements (PPA) and tariffs for renewable power generation. International or off-shore financing is available for larger projects.

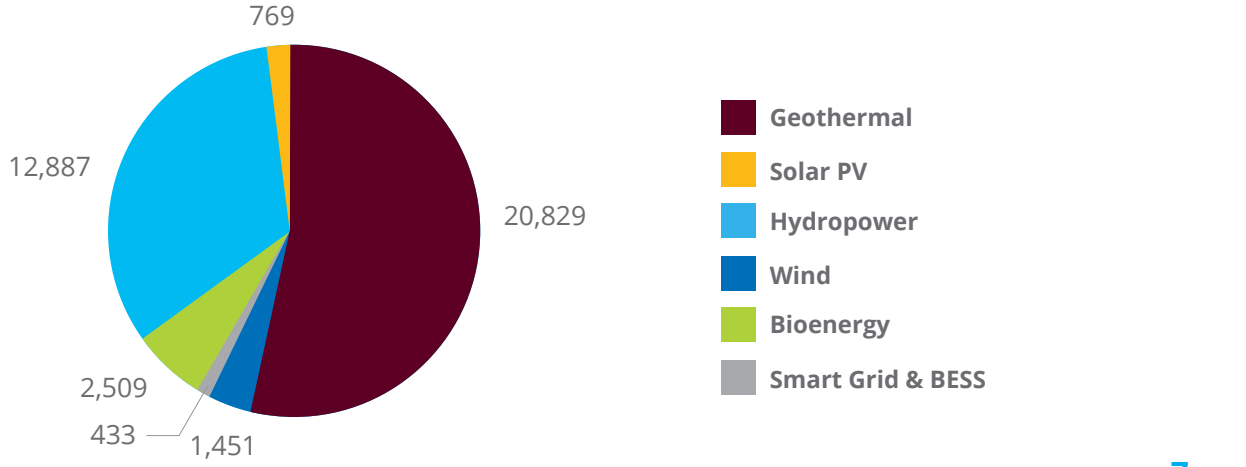
Ownership

Based on Indonesia's Negative List of Investment, power projects above 10 MW in generating capacity may have foreign ownership up to 95%. Smaller renewable energy IPPs restrict foreign ownership to 49%. Projects developed under the Public Private Partnership regulations allow up to 100% foreign ownership.

Renewable Energy Market Value

Based on PLN's planned capacity additions, the market value of renewable energy business in the period 2020-2025 is estimated to be USD 38.9 billion. Figure 2 shows the breakdown by technology.

Figure 2 - Indonesia Renewable Energy Market Value by Technology, 2020-2025 (in USD millions)



Market Condition for Solar Photovoltaic (PV) Power Development

Worldwide, solar PV systems are the fastest-growing segment of the energy market for a variety of applications ranging from small-scale direct use systems to large-scale powerplants injecting power into utility grids. While all such applications are present in Indonesia, the solar PV market has not kept pace with global trends. As of 2018, the total installed capacity from solar PV systems operating in Indonesia was 25 MW, with 45 MW under construction and 323 MW currently in the planning stages. According to PLN's RUPTL, 907 MW of solar PV generating capacity will be added over the period 2019-2018.

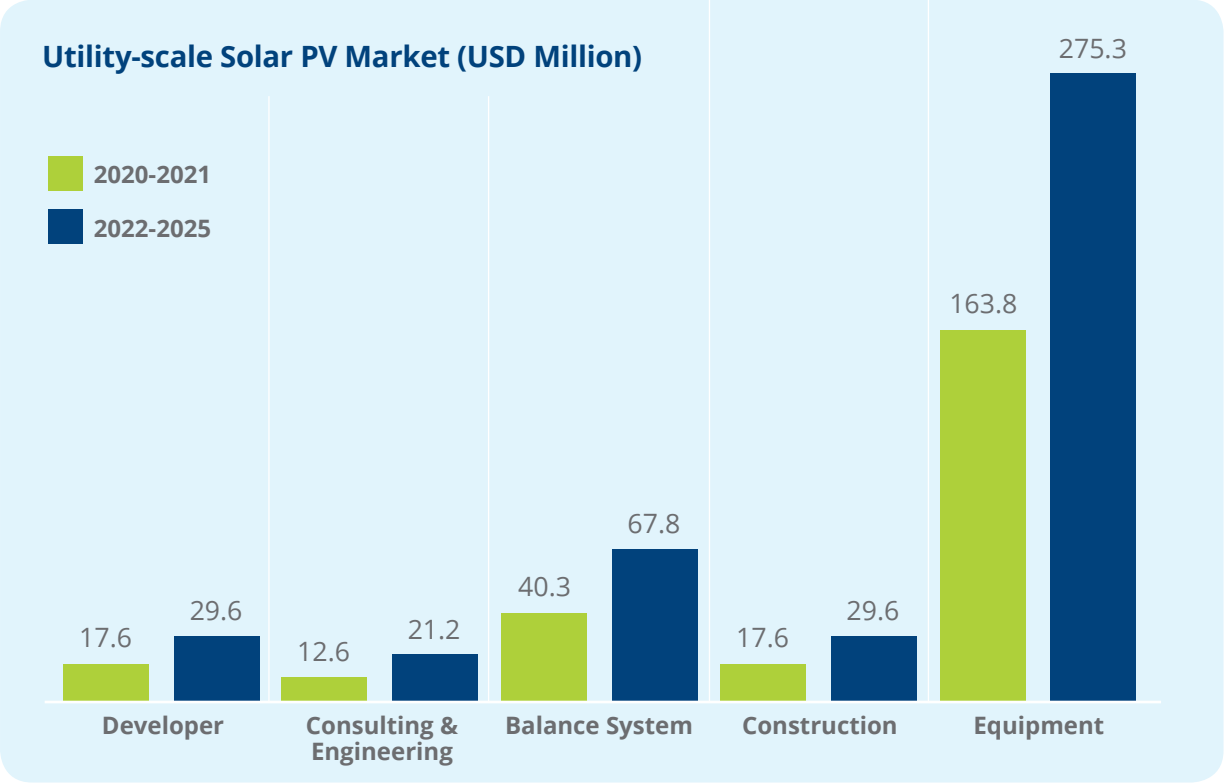
Indonesia straddles the equator, with the best solar radiation found in Eastern Indonesia, where cloud cover and monsoon season effects are minimal and electrification is most sought.

Utility-scale, ground-mounted systems

Utility interconnected systems are the largest segment of the relatively small solar PV market in Indonesia. The market outlook for utility-scale solar PV projects (> 10 MW capacity) connected to the transmission network is based on the ceiling power purchase price allowed under current regulations. There is large potential market for smaller solar PV systems (< 10 MW capacity) where those systems are connected to grids powered by diesel generators. Current regulations require PLN to determine a "capacity quota" for solar PV and to issue competitive tenders to pre-qualified project developers.

The PLN RUPTL, defines much of the solar PV capacity to be added in the next 10 years as "scattered", meaning that the individual project size and location have not yet been determined. All projects during the 2020-2025 period will

Figure 3 – Utility-scale Solar PV Market by Supply Chain Segment (2020-2025)



come through the "direct selection process" (Daftar Penyedia Terseleksi, DPT) which requires companies (or consortia of companies) to be pre-qualified in order to bid, as required for other renewable power projects.

We estimate the market for utility scale solar PV to be USD 675.5 million, comprised of USD 252 million during the 2020-2021 period, and USD 423.5 million during the 2022-2025 period. It should be noted that the government imposes a 40% local-content requirement for solar panels (which are assembled from imported components) that is a major impediment to achieving the low cost of solar PV experienced in other countries. As seen in Figure 3, the main business opportunities in utility-scale solar PV supply market chain are in the sale of equipment and the balance of system including interconnection to the grid.

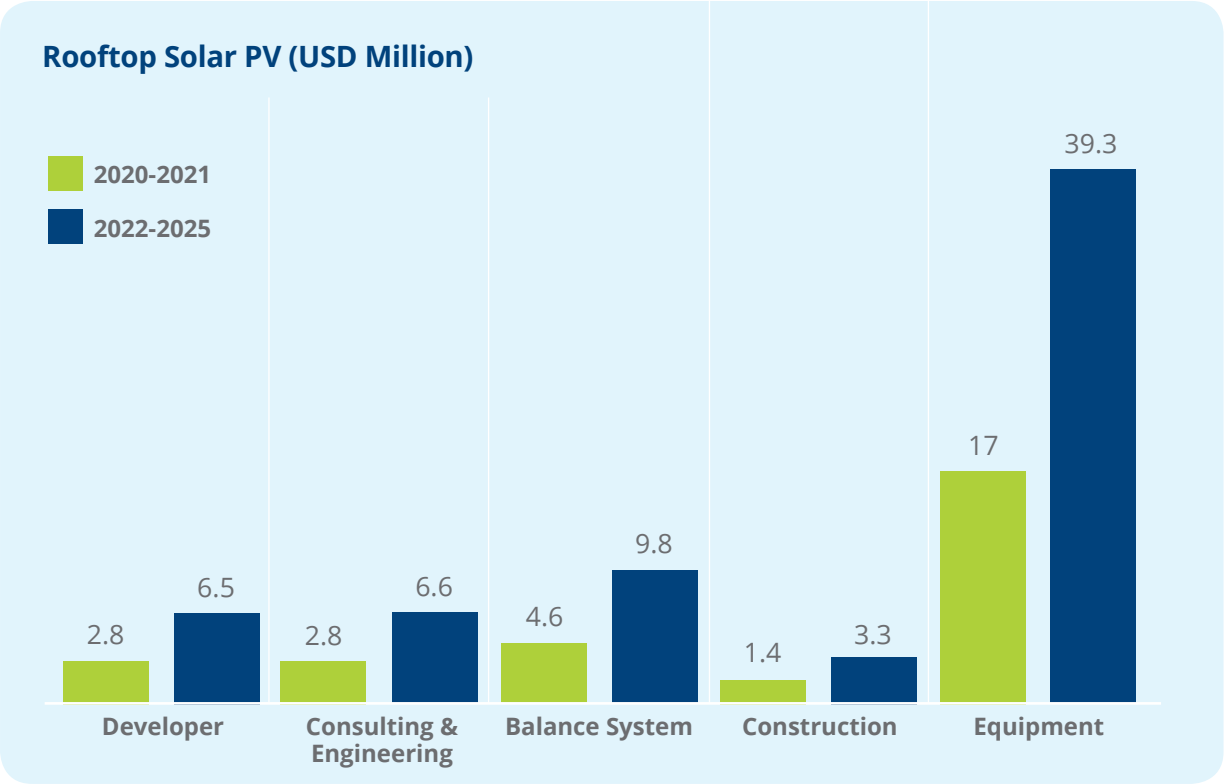
Rooftop Solar PV Projects

In 2018, MEMR issued Regulation No. 49 of 2018 on installation of rooftop solar PV systems by PLN customers, limiting the maximum capacity of rooftop solar PV projects – as calculated by the PV inverter's nameplate capacity – to 100% of the customer's building circuit capacity. Industrial customers installing a rooftop solar PV system will be assessed a capacity fee and an emergency energy fee based on the quantity of energy they use. Commercial and institutional customers are not required to pay a capacity fee or emergency fee.

The current market, which operates under a PLN net-metering program, is predominantly residential served by local companies that sell and install the systems. With the new regulation in place, all markets are expected to grow. Commercial and industrial customers who were previously not allowed can now consume the rooftop solar PV output during the day and should see more accelerated growth.

With larger systems now allowed, this creates business opportunities for both domestic and foreign companies to enter the market. For solar

Figure 4 –Rooftop Solar PV Market by Supply Chain Segment, 2020-2025



PV rooftop project opportunities, these are either business-to-consumers (i.e., selling directly to homeowners) or business-to-business (i.e., selling directly to commercial and industrial facility owners). The main rooftop business opportunities are in panels and inverters, construction (installation), and balance of system.

Off-Grid Solar PV Projects

An "off-grid" solar PV project is defined as the solar PV system and related components including battery storage and, in the case of hybrid, diesel generator. In Indonesia, there are essentially three different market segments characterized by programs under which PV systems are deployed: 1) solar PV-diesel hybrid program to reduce diesel fuel consumption; 2) government-funded off-grid renewable energy systems; and 3) MEMR's Solar-Powered Efficient Lamp program (LTSHE), which provides home solar systems to un-electrified villages. Of these, only the hybrid market is commercial; applications include mining operations where solar can be integrated with existing diesel generation. We did not calculate the market value for PV hybrid systems.

*A more-detailed free report – available to UK firms upon request – features live and pending commercial **solar photovoltaic (PV)** power projects as well as regulations, pricing, PPA terms, procurement methods, key decision-makers, local content requirements, and potential partners for each type of renewable energy. The full report–aims to empower UK firms with the knowledge they need to enter the Indonesia energy market, develop relationships on the ground, and pursue projects before the market becomes mainstreamed.*

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Market Condition for Wind Power Development

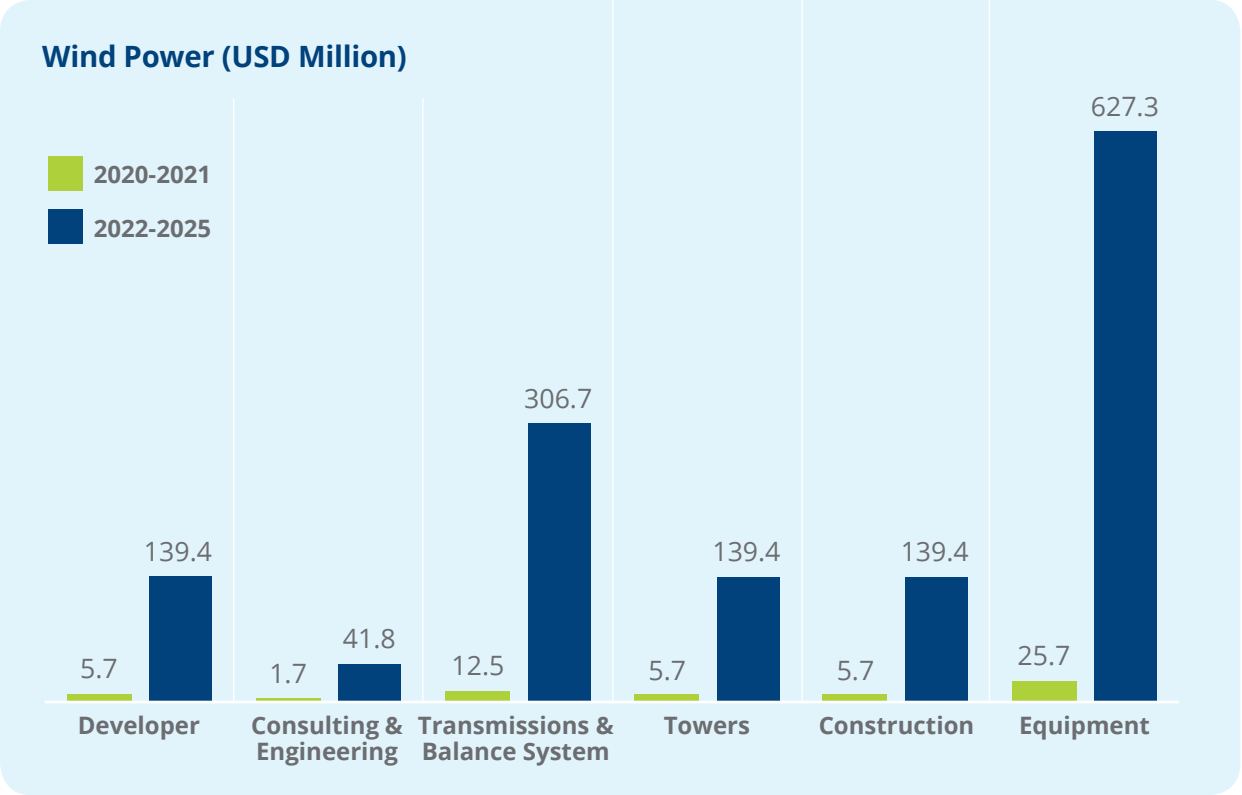
Utility-scale wind powerplants

In 2017, Indonesia's first utility-scale wind powerplant was commissioned on 100 hectares in South Sulawesi province. The 75 MW Sidrap wind power project in Sindereng Rappang regency has opened the door for other wind power projects in the province, as well as elsewhere in the country; a second 65 MW wind power project in Jeneponto, South Sulawesi, completed construction in December 2018 and is awaiting commissioning as of this writing.

According to PLN, there is currently 70 MW of wind power currently operating, 60 MW under construction and another 95 MW in the planning stages. Note that the wind power project developers are allowed to install up to 10% more capacity than what is stated in their PPA.
The PLN RUPTL 2019-2028 shows a planned addition of 855 MW of wind power capacity during the period. Given the economics of wind powerplants, where larger turbines sizes have lower costs per MW, and the considerable logistics and site preparation costs, all viable wind powerplants will be connected to PLN's high voltage transmission system. With the exception of Java's, all transmission lines are considered "backbone" lines connecting smaller grids. These transmission systems have difficulty integrating variable wind powerplants as currently operated by PLN.

The market value of utility-scale wind power projects is estimated to be USD 1,451 million, comprised of USD 57 million in 2020-2021 and USD 1,394 million in 2022-2025. The main business opportunities come in wind turbines, tower construction, substations and transmission lines, and construction.

Figure 5 – Breakdown of the Wind Power Market by Supply Chain Segment, 2020-2025



Offshore Wind

Offshore wind energy has not been included in Indonesia's renewable energy goals as its application is not considered feasible at present. The only realistic sites for offshore wind, where good wind resources align with large demand centers, are in West and East Java.

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Market Condition for Hydropower Development

The hydropower market is the most mature of all renewables in Indonesia; hydropower plants built during the Dutch colonial period are still operating today. The Master Plan Study for Hydropower Development in Indonesia identified and screened a total developable potential 26,321 MW of capacity, including operating projects and projects under development.

According to PLN, there are 427 MW of small hydropower capacity (<10 MW) currently operating, 375 MW under construction, 180 MW that have reached financial closure, 108 MW with signed PPA, and 871 MW in planning stages. PLN's RUPTL calls for 1,534 MW of small hydropower capacity to be added between 2019 and 2028. For medium and large hydropower (>10 MW), there are currently 4,048 MW operating, 2,439 MW under construction, 350 MW that have reached financial closures, and 5,221 MW in planning stages. The PLN RUPTL calls for a total of 8,010 MW of large hydropower to be added during the period 2019 to 2028.

Hydropower currently supplies 6.2% of all electricity in Indonesia, and 54% of all renewable energy sources. PLN is the principal decisionmaker for developing medium and large-scale hydropower plants; the government has given PLN the first right of refusal to develop the projects listed in the Master Plan Study. Since these projects typically take 5-7 years to develop, it is important to learn what stage of development a project is currently at to determine what business opportunities are available.

Medium and large hydropower plants (>10 MW) may have foreign ownership up to 95%. As a result, these projects can attract foreign (offshore) financing. Small hydropower plants (<10 MW) are typically developed by Indonesian sponsors. There is considerable work to be done during the preliminary stages (pre-PPA) of any hydropower project, but those costs are disproportionately higher for smaller projects (i.e., they have performed much of the same analysis in the feasibility study as a larger project).

Figure 6 – Breakdown of the Small Hydropower Market by Supply Chain Segment, 2020-2025

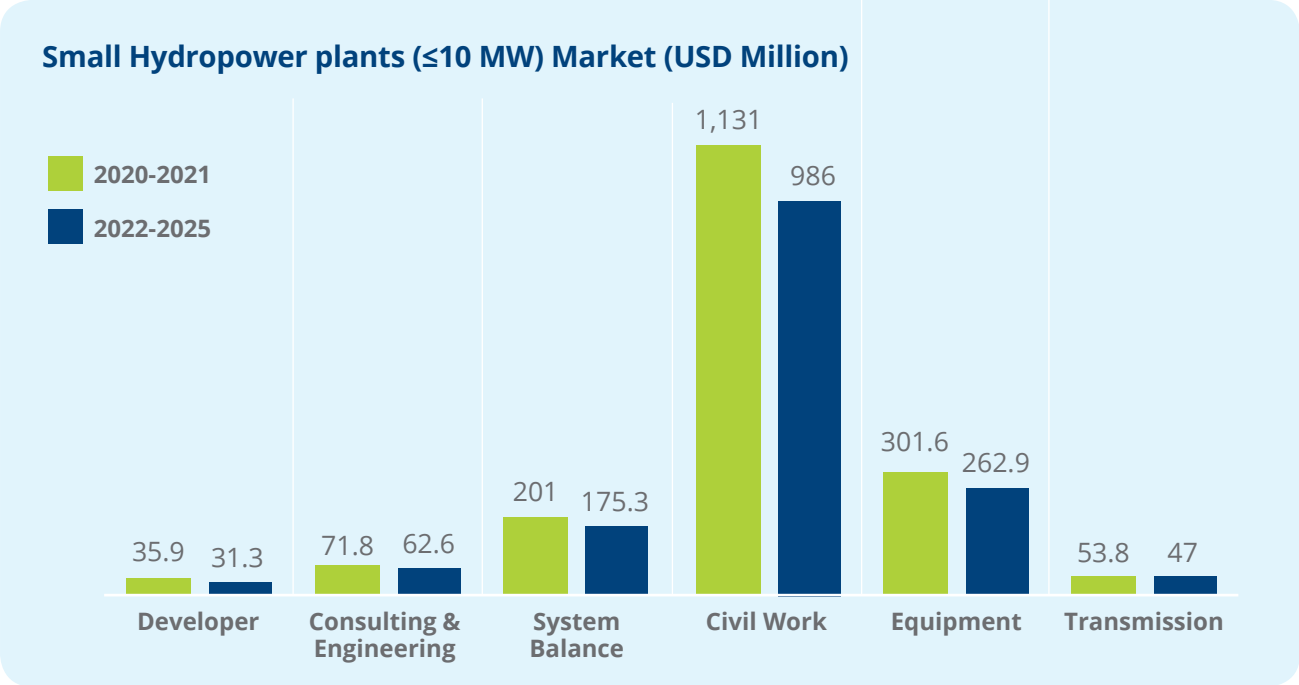
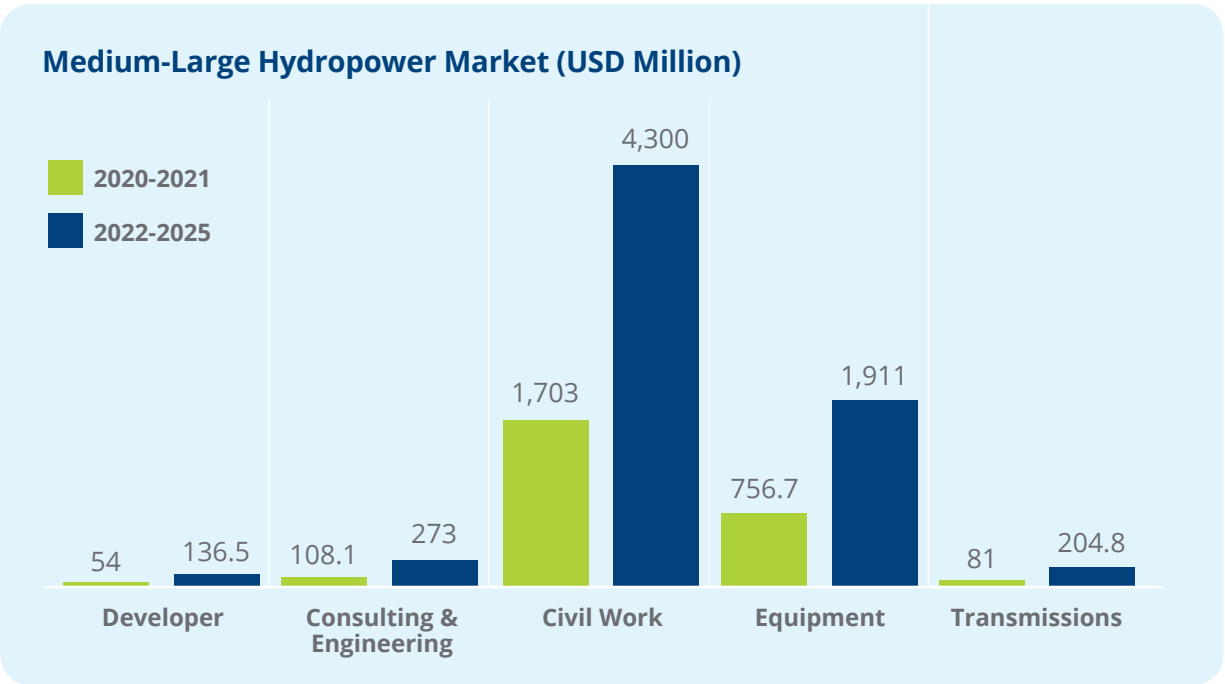


Figure 7 – Breakdown of the Medium and Large Hydropower Market by Supply Chain Segment, 2020-2025



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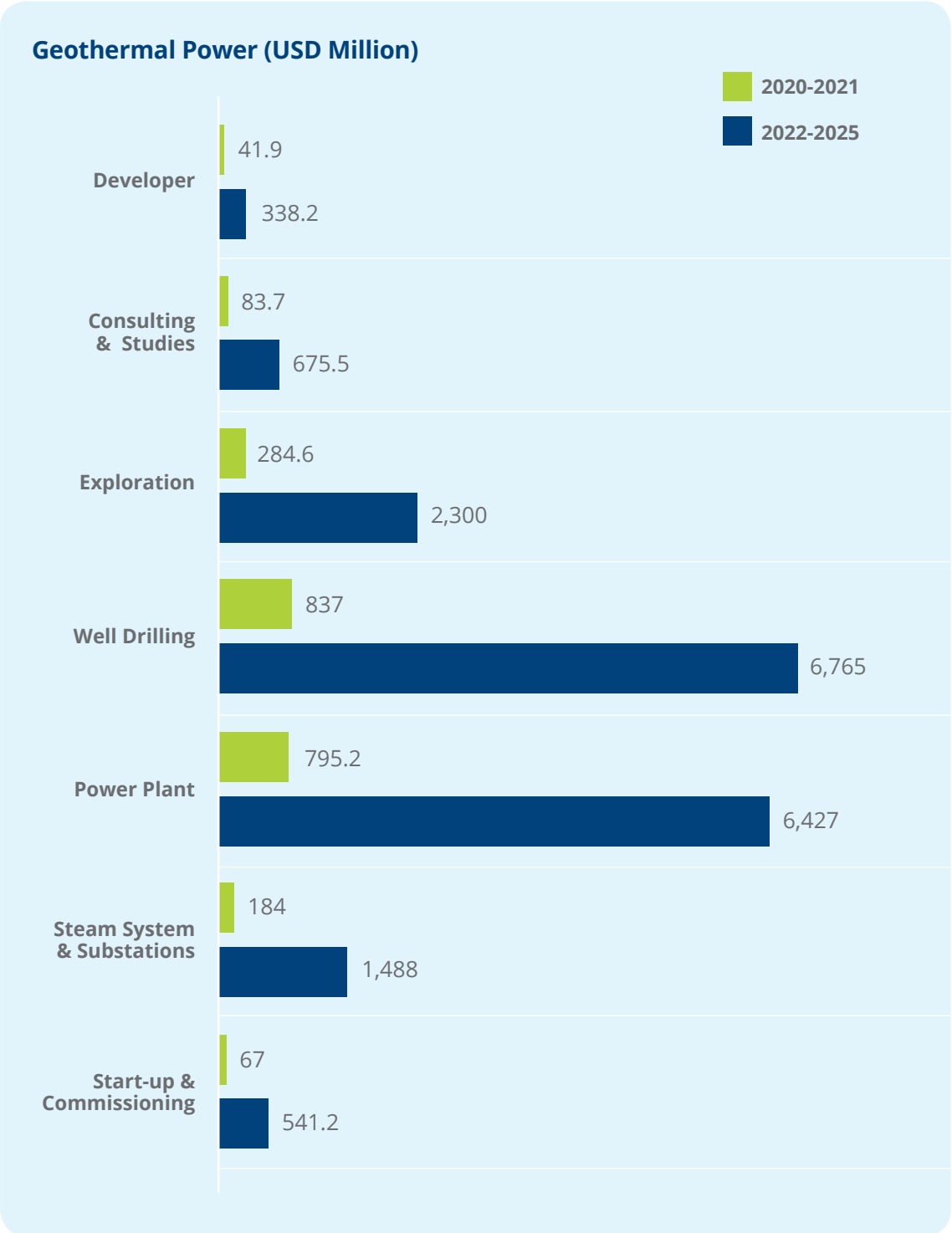
Market Condition for Geothermal Power Development

About 40% of the world's geothermal energy reserves are located underground in Indonesia, which is estimated to have the largest geothermal energy reserves of any nation. Most of this potential, however, has not been utilized. This abundant resource is scattered along volcanic belt paths of the Ring of Fire that pass through Sumatra, Java, Bali, Nusa Tenggara, North Sulawesi and Maluku.

Geothermal resources in Indonesia consist of volcanic and non-volcanic systems. Volcanic geothermal systems are spread along subduction pathways and have high temperatures (> 225°C). Many non-volcanic geothermal systems, which have low (<125°C) to moderate (125-225°C) temperatures, are spread on the islands of Kalimantan and Sulawesi.

It is estimated that there are over 330 potential geothermal locations spread across Indonesia that are strategic for investment and can contribute significantly to meet national energy needs. At present, Indonesia's geothermal potential reaches 28.5 GW, which consists of total reserves of 17.5 GW and resources of 11 GW. According to PLN, there are currently 2,115 MW of geothermal capacity operating at the end of 2018, 460 MW under construction, 1,720 MW having reached financial closure, and 2,227 MW in the planning stage. The PLN RUPTL calls for the addition of 4,607 MW of geothermal generating capacity during the period 2019 to 2028. Indonesia now ranks second behind the United States in in utilizing geothermal power. Based on the latest data from the Geothermal Directorate, the Directorate General of New Energy, Renewable and Energy Conservation counts 16 geothermal powerplants in 14 Geothermal Working Areas (WKP).

Figure 8 - Breakdown of the Geothermal Power Market by Supply Chain Segment (2020-2025)



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Market Condition for Bioenergy Power Development

Biomass Power

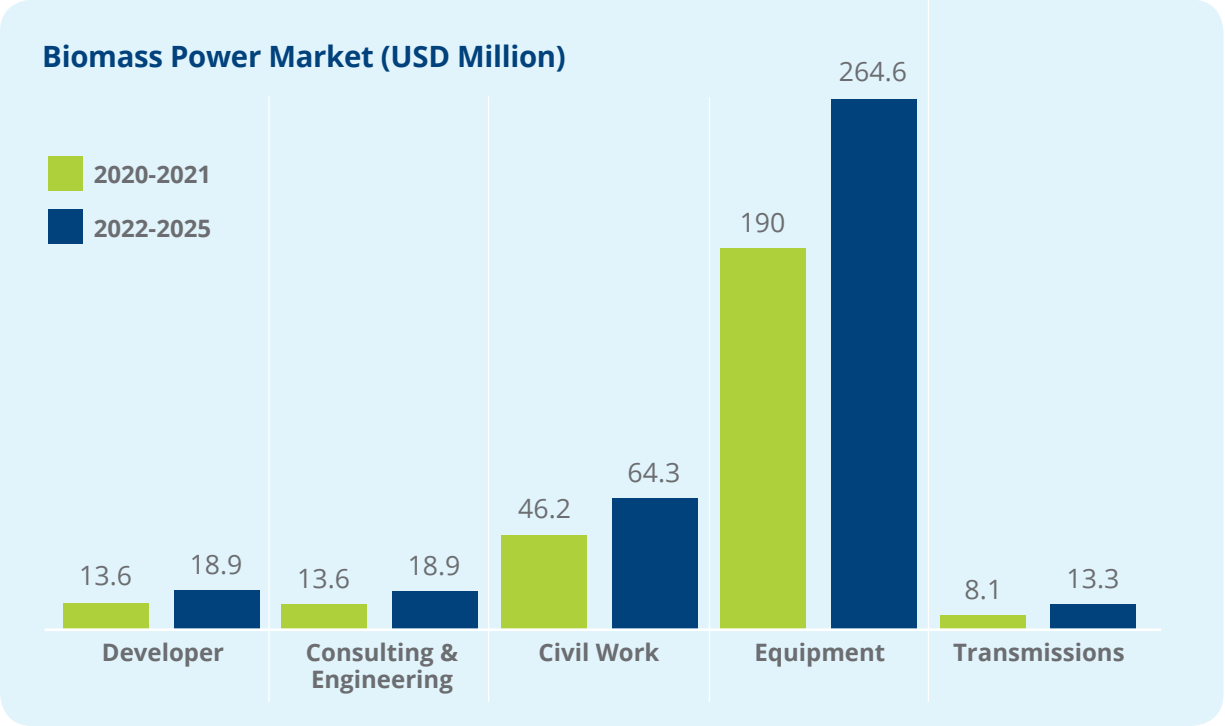
Biomass resources or feedstocks for power production come from palm oil mill processing, sugar processing, rice processing residues and wood waste from paper mills. The relatively high cost of transporting biomass results in these powerplants being located near the feedstock source. Agro-processing facilities have traditionally used their biomass waste as a fuel source for steam supply, captive power or cogeneration. A palm oil mill's main energy need is super-saturated steam, which is supplied by burning palm fiber mixed with shells. Shells are now a commodity in Asia so much of the waste is diverted to export markets. Empty fruit bunches are a waste product that are only now being considered as a biomass source for excess power production, or in some cases pelletized and exported. Due to the seasonal nature of sugar harvesting and processing, biomass-fired cogeneration systems do not operate throughout the year and are treated as "excess power" facilities by PLN.

In terms of commercial biomass technology, the principal is combustion for steam. Due to the size of biomass boilers, the most economic size for a biomass steam power plant is 10 MW or larger. Biomass gasification is possible at a much smaller scale, even less than 1 MW, but the capital costs per MW are much higher as are the operation and maintenance costs. Other technologies such as pyrolysis are not commercial in Indonesia.

According to PLN, there are 181 MW of operating biomass and biogas generating capacity connected to PLN's grid, 25 MW under construction, 10 MW having reached financial closure, 41 MW with signed PPA, and 460 MW in the planning stage. The PLN RUPTL calls for 795 MW of biomass, biogas and waste-to-energy powerplants to be added during the period 2019 to 2028.

Biomass power IPP projects must sell power under the BPP scheme as dictated by MEMR Regulation 50 of 2017, i.e., at 85% of the regional

Figure 9 - Breakdown of the Biomass Power Marked by Supply Chain Segment, 2020-2025



BPP wherever the regional BPP exceeds the national BPP. The power purchase price is negotiated wherever the regional BPP is equal to or lower than the national BPP.

Feedstock availability is a challenge in developing and financing biomass power projects. Banks look for a feedstock supply agreement equal to or longer than the tenor of the loan. In terms of powerplant operations, the project's viability is dependent on the availability and negotiated price of the biomass feedstock. For this reason, many projects are developed in which the feedstock supplier takes a shareholding position.

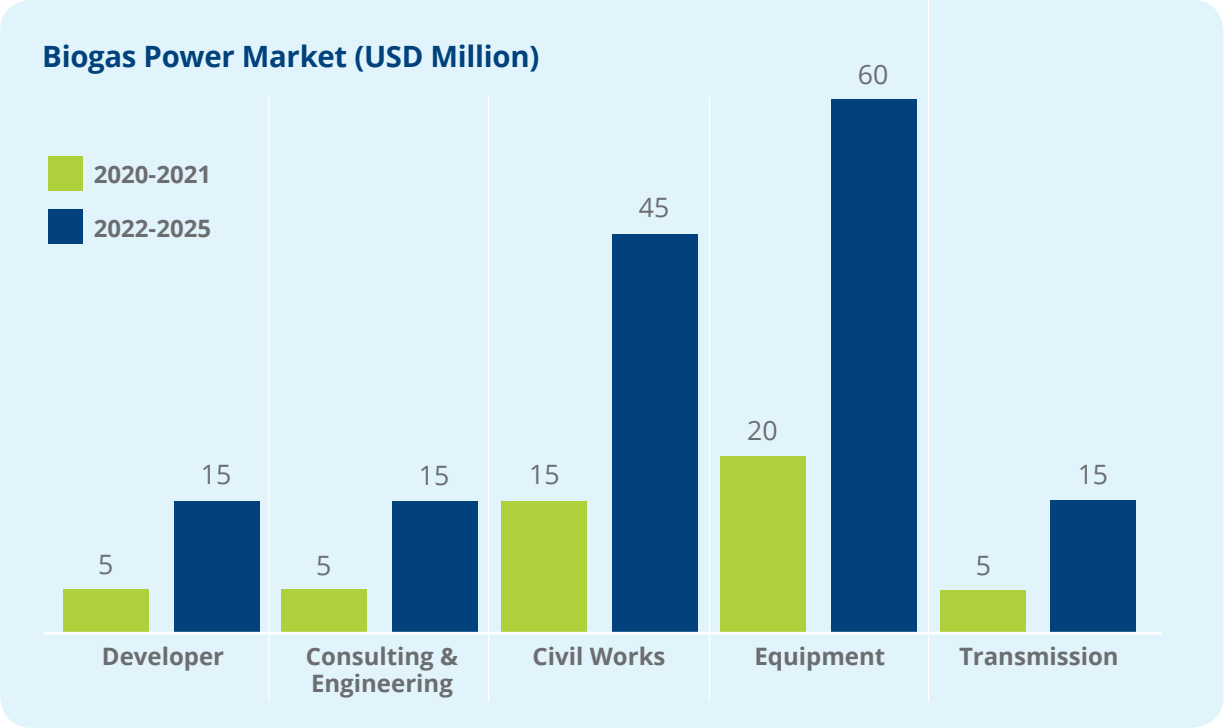
The feedstock agreement should have a cap on the annual escalation, since that cost cannot be passed through to PLN. Also of consideration, the BOOT requirement in current regulations means a powerplant is transferred to PLN at the end of the PPA term, though there may be no feedstock to fuel it.

Biogas Power

Biogas in Indonesia principally comes from the anaerobic digestion of palm oil mill effluent (POME) and cassava starch mill effluent. Of these, POME is seen as the main feedstock for commercial biogas production. An estimated 700 palm oil mills are located primarily in Sumatra and Kalimantan. The average palm oil mill can supply biogas to generate between 1 and 3 MW of power. While the electricity production potential is significant, POME biogas has not been developed for a variety of reasons. These include the location of mills typically being far from the nearest PLN grid, insignificant internal electricity needs, commercial energy production not being a core business for palm oil companies, and low power purchase prices for third-party biogas IPPs.

Biogas IPP projects must sell power under the BPP scheme as dictated by MEMR Regulation 50 of 2017, i.e., at 85% of the regional BPP wherever the regional BPP exceeds the national average BPP. The power purchase price is negotiated wherever the regional BPP is equal to or lower than the national BPP. Like for biomass power projects, biogas project viability depends upon the availability of the wastewater supply from the palm oil or cassava mill. Projects must have an agreement with the mill to supply the

Figure 10 - Breakdown of the Biogas Power Market by Supply Chain Segment, 2020-2025



wastewater at a given flow rate to make the biogas powerplant viable. For this reason, many projects are developed in which the mill owner takes a shareholding position or signs a revenue sharing agreement. Also like biomass IPPs, the BOOT condition in current regulations requires the powerplant be transferred to PLN at the end of the PPA term, though there may be no such similar guarantee for the wastewater supply.

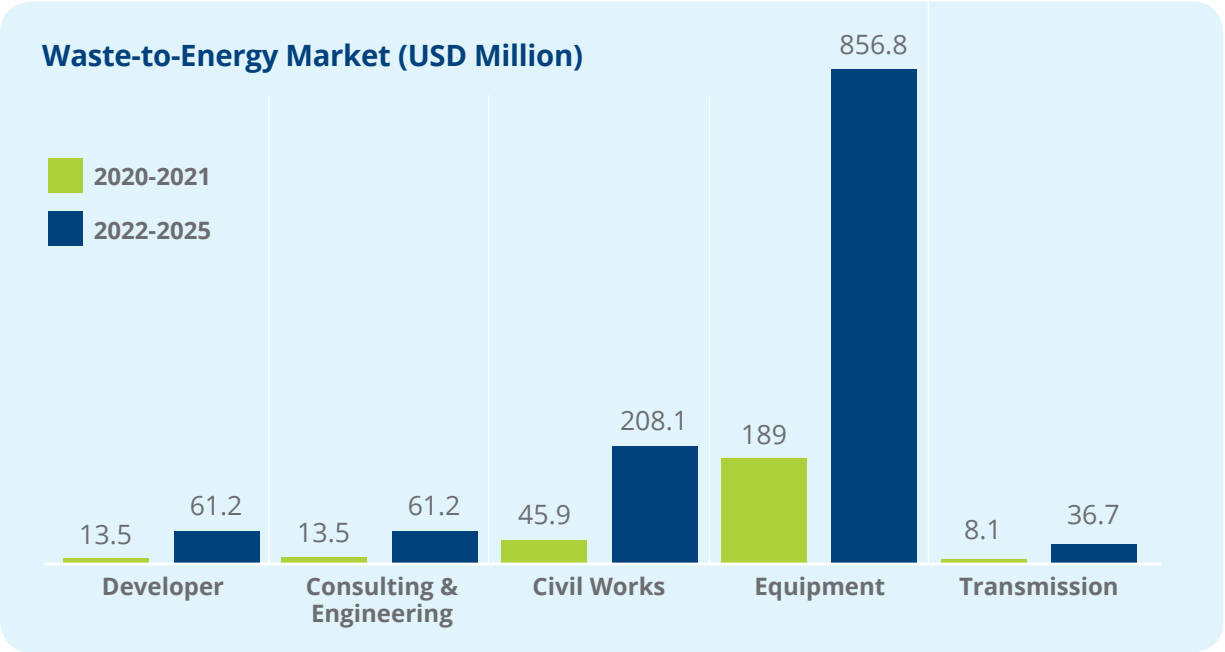
Waste-to-Energy

Another potential source of biomass energy is municipal solid waste. The quantity of city or municipal wastes in Indonesia is comparable with other big cities of the world. Most of these wastes originate in households in the form of organic wastes from the kitchen, but an increasing portion comes from plastics and other inorganic wastes. At present, municipal solid wastes are either burned at each household or collected by the municipalities to be dumped into a designated dumping ground or landfill. As of 2018, there were no commercially operating waste-to-energy projects in Indonesia and no sanitary landfills.

Presidential Regulation No. 35 of 2018 was issued to accelerate the construction of waste-based powerplants in 12 major cities, namely: DKI Jakarta, Tangerang, South Tangerang, Bandung, Bekasi, Semarang, Surakarta, Surabaya, Makassar, Manado, Palembang and Bali. PLN, under assignment from the government, is developing the project in Bali while the others are being developed by the local governments through tender or direct appointment to private-sector businesses. For all 12 cities, the local government must prepare a pre-feasibility study that determines the waste characteristics, the appropriate energy conversion technology, the project location and other factors that are used in the bidding and procurement process. Interested project developers would submit a full feasibility study to determine the capacity of their proposed plant and calculate the "tipping fee"[4] needed to make the project economically feasible. Presidential Regulation No. 35 of 2018 sets out a definitive single feed-in tariff for all waste to energy projects depending on their capacity, regardless of where the project is located or when the project achieves commercial operation.

[4] Tipping fee is the amount paid per ton of waste to the operator of the waste to energy facility.

Figure 11 - Breakdown of the Waste-to-Energy Market by Supply Chain Segment, 2020-2025



The selected developer will have dual roles as a waste manager (entering into a waste management agreement with the local government) and a power generator (entering into a PPA with PLN). For the waste management function, the developer will be entitled to receive a fee from the local government, calculated based on the weight of the waste (in ton) managed by the developer. Presidential Regulation No. 35 of 2018 also provides that the national budget can be allocated to provide additional funding for the payment of this waste management fee, capped at a maximum amount of 500,000 IDR (around USD 38.5) per ton of waste.

Biofuel for Powerplants

As an agricultural country, Indonesia is blessed with abundant biofuels materials. Feedstocks that can be used to produce biofuels include cassava, maize crops, sugarcane, sago, palm oil, Jatropha, waste cooking oil, etc. But since Indonesia is the world's largest Crude Palm Oil (CPO) producer – 43 million tons in 2018 – the national biofuel program is heavily focused on CPO and other palm oil derivatives. Although there is research into a variety of "green fuels", only biodiesel from palm oil and bioethanol from sugar cane (molasses) are commercially produced. Indonesia is among the 10 largest sugarcane producers in the world. There is, however, no fuel grade ethanol production in Indonesia, although there are ethanol plants producing non-fuel ethanol for the medical industry, cosmetics, other industrial uses and export. Despite ethanol-blending mandates of E5 and E10 by 2020 and E20 by 2025, there is no implementation due to an absence of financial incentives covering both price disparity and feedstock constraints.[5]

Biofuel production and use in Indonesia is a response to climate change, energy demand, and trade policy. Substitution of traditional petroleum fuels with biofuels is intended to reduce GHG emissions in the transportation and energy sectors, provide energy security, buffer the domestic economy against global oil price fluctuations, reduce foreign exchange expenditures on imported fuel, and stimulate domestic demand in the face of trade barriers in Europe and the U.S. to Indonesian biodiesel-based on palm oil. As of this writing, Indonesian biofuel production was up 57% over the average of the

[5] Indonesia Biofuels Annual 2018. U.S. Department of Agriculture, August 12, 2018.

previous two years, with much of the increase in response to the government's policy of mandatory biodiesel blending.

MEMR Regulation 12 of 2015 established biofuel-blending targets for transportation, industry and power generation sectors. The regulation set out the B20 Policy, commonly known as the mandatory government program, to require the mixed use of diesel fuel containing 20% of biodiesel and 80% of petroleum diesel. It should be noted that under current regulations, biofuels used as alternative fuels must use be sourced domestically. This means that when mixing the diesel fuel with biodiesel, the business entities must use domestically produced biofuel.

MEMR Regulation 66 of 2018 made the replacement of B20 for High Speed Diesel (HSD) mandatory for all kinds of powerplants. For this purpose, the government will ask PLN to soon convert its diesel-fueled powerplants into biodiesel-fueled powerplants. MEMR Regulation 53 of 2018 added private biodiesel-fueled power producers to the list of renewable energy IPPs that can sell power to PLN using the BPP scheme. The IPP developer must demonstrate that the powerplant has a sufficient supply of biofuel for the sustained operation of the PPA. The purchase shall be made through the mechanism of direct selection at a price that is set based on agreement between the parties and a BOOT cooperation mechanism.

Figure 12 - Total Biodiesel Production and Distribution 2016-2018 (in 1000 liters)

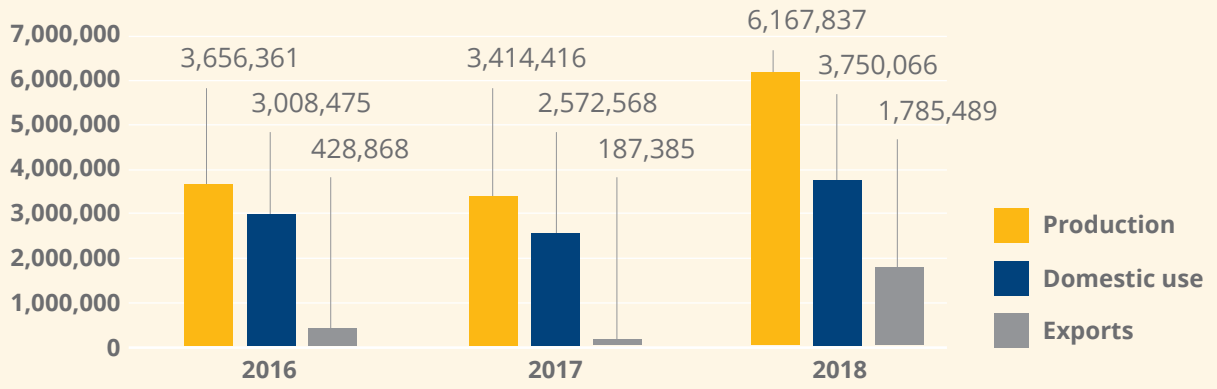
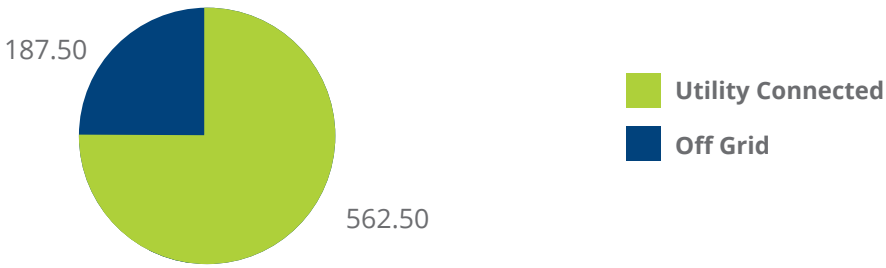


Figure 13 – Market for Biofuel Power 2020 - 2025 (USD millions)



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Market Condition for Marine Energy Power Development

Marine energy potential in Indonesia involves capturing the kinetic motion of the ocean through waves and tidal flows and converting it to electricity. Marine energy, and in particular tidal energy, has the greatest potential because the country's geography includes narrow channels and straights in between island archipelagos, amplifying currents and providing multiple locations of possibility to exploit the tides. Studies have been made to determine the energy potentials of these straights and channels in Indonesia. MEMR prepared a roadmap on Marine Energy Development in Indonesia for the period of 2018-2025, aimed at realizing the potential and promoting commercial development of the resource. MEMR has calculated the developable potential capacity from marine energy at 61 GW (61,000 MW) and has set a target for development of 1 GW (1,000 MW) of powerplants based on ocean currents by 2019, but until now there are no operating commercial projects.

Programs and development plans for marine energy are needed for companies to conduct offshore surveys, perform environmental impact studies, install electro-mechanical components, and provide system integration testing. In their absence, tidal and sea current potential has yet to be commercially harnessed in Indonesia, although some preliminary studies have been performed in some areas.

From PLN's perspective, marine energy systems remain in the stage of investigation. None of the technologies converting marine energy into electricity is proven commercially in Indonesia. In the RUPTL 2019-2028, PLN has identified several marine energy sites and associated generating capacities. Marine energy projects, if developed as IPPs, must conform to the BPP pricing scheme in MEMR Regulation No. 50 of 2017.

Given the current condition of the marine energy market, in which all efforts to develop pilots or demonstration projects have stalled, it is difficult to calculate the market size for the period of 2020-2025. As noted below, PLN has identified three 10 MW marine projects in Flores and NTB. It has also planned 7 MW of marine power in 2021 in the most recent RUPTL, though the location of that project is not mentioned. PLN considers marine current energy as most-promising, but it too is viewed as pre-commercial.

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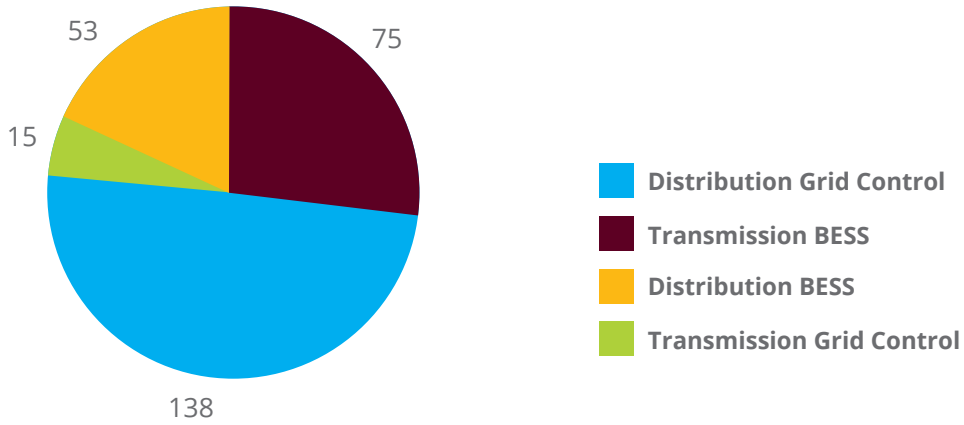
Market Condition for Smart Grids and Battery Storage Development

PLN operates transmission systems in Java-Bali, Sumatra, Sulawesi, Kalimantan, and small systems connecting isolated grids in NTB and NTT. During the period 2019 to 2028, PLN plans to add a remarkable 57,293 kilometers of high voltage transmission lines, 124,341 substations, 472,792 medium and low voltage lines, and 506,522 transformers.

PLN operates approximately 600 isolated grids across the Indonesian archipelago. The development of these grids follows a similar pattern. Initially, PLN installs diesel generators to serve load centers. As demand grows, PLN adds generation, extends its distribution lines and adds consumer transformers to serve new customers. On small island systems, isolated grids are eventually connected using 70 kV transmission lines. Over the past few years, PLN has begun to add larger generators using coal and multi-fuel land-based and barge-mounted generators.

As the cost of solar and other small-scale renewable energy powerplants and battery energy storage systems (BESS) for utility applications become more economical, PLN is reorienting its distribution system planning and investment to incorporate these options.

Figure 14 – Smart Grid and BESS Market 2020 - 2025 (USD millions)



Smart Grid Systems

In order to improve power quality and facilitate the integration of variable solar PV and wind power projects, PLN will need to invest in grid control systems that replace their current manual dispatch operations with Automatic Generation Control/Automatic Dispatch System (AGC/ADS) in both their transmission and distribution systems. The control systems are a basic element of smart grids, which use information and communication technology coupled with automation to enable efficient electricity regulation, offer higher reliability electricity supply, facilitate higher penetration of renewable energy, reduce non-technical losses and enable customers to become electricity producers as well as consumers. PLN has developed a "Smart Grid Roadmap" to guides its implementation of these new technologies.

PLN currently uses SCADA for communications and Energy Management Systems in the Java-Bali control center. PLN has also included AGC/ADS systems in its transmission grid codes, but until now has not implemented the systems. PLN is installing AGC/ADS in the Java-Bali control center to accommodate large-scale wind and solar PV projects, and possibly in South Sulawesi control center where new wind power projects have created challenges for PLN in dispatching its other generators.

PLN has received a number of unsolicited proposals, principally from technology vendors, promising to increase revenues and reduce service costs by more-accurately recording customer usage and communicating it to its data analytics and processing center. An Advanced Metering Infrastructure (AMI) pilot program has been initiated in the Surya Cipta Sarana Industrial Estate in Karawang, West Java, as a cooperation between MEMR and the Japanese New Energy and Industrial Technology Development Organization. PLN is also piloting AMI in Batam and Bali. Plans for AMI include the Jakarta region. The market for smart grid solutions and components is difficult to estimate at this time given that all projects implemented by PLN have served as demonstrations. Once the results of these demonstrations are known, and PLN includes smart grid systems in its procurement program, then the market size will become easier to estimate.

Battery Energy Storage Systems (BESS)

Batteries are just one of several energy storage options. There are solid state batteries, flow batteries, flywheels, compressed air storage and pumped hydro storage. Pumped hydro is being pursued by PLN for grid support and peaking purposes. There are no known applications of flywheels or compressed air energy storage for utility applications in Indonesia.

BESS are mainly used for shifting electricity availability to when its needed or highly valued, and for providing ancillary grid services to help regulate power quality, maintain system reliability, and prevent system faults.

In December 2018, PLN issued an invitation for prequalifying for supplying utility-scale, lithium-ion BESS. The compensation structure in Indonesia's rooftop solar PV policy (MEMR Regulation No. 49 of 2018) discourages exporting power to PLN but may result in storage investment so that the electricity produced during the day can be used in the evening when the solar PV system is not producing. Furthermore, PLN imposes a demand charge that requires a minimum payment based on 40 hours at the customer's building circuit capacity. As storage costs decline, customers will evaluate the costs and benefits of disconnecting from PLN and become fully self-generating.

PLN's principal means of increasing electricity access is to extend the medium voltage distribution network. The cost of line extension, when weighed against the low load coming from new connected villages, serves as a disincentive to

PLN to provide universal electricity access. Battery storage is part of MEMR's off-grid electrification program for both solar home systems as well as village electrification. Other off-grid systems include micro-hydropower, biomass and biogas.

*A more-detailed free report – available to UK firms upon request – features live and pending commercial **smart grids and battery storage** projects as well as regulations, pricing, PPA terms, procurement methods, key decision-makers, local content requirements, and potential partners for each type of renewable energy. The full report–aims to empower UK firms with the knowledge they need to enter the Indonesia energy market, develop relationships on the ground, and pursue projects before the market becomes mainstreamed.*

*To request the full report, email **DITJakarta.Enquiries@fco.gov.uk** with your contact information, job title, company name, and renewable subsector(s) of interest.*