Lombok

Prefeasibility studies on RE solutions

January 2019

EMBASSY OF DENMARK
Jakarta

Danish Energy Agency

KPMG

Background

Indonesia and Denmark are cooperating through a Strategic Sector Cooperation which facilitates government-to-government collaboration in areas where Denmark has decades of experience which is valuable to rapidly emerging economies. The Strategic Sector Cooperation programme is embedded in the Ministry of Foreign Affairs with technical support from different ministries and agencies in Denmark.

The Danish partner of the Strategic Sector Cooperation programme is the Danish Energy Agency and the main partners in Indonesia are the Ministry of Energy and Mineral Resources (MEMR) and the National Energy Council, who are both represented in the steering committee. At the same time, the Danish Energy Agency also cooperates with the state-owned electricity company (PLN).

During 2016 and 2017, the Danish Energy Agency has cooperated with the Indonesian counterparts in order to share Danish lessons learned from the transition into a renewable energy system and identify where and how these lessons learned could be useful in an Indonesian context.

Larger outputs from this cooperation are:

- Capacity building through various seminars and workshops where Danish lessons are learned.
- Integration of Balmorel Power sector model in the modelling team at NEC, and inputs to the "Indonesian Energy Outlook"- 2016 and 2017.
- Development of an Indonesian Technology Catalogue on power production anchored at NEC.
- RE-Integration study report. Transfer of Danish lessons learned on RE-integration into an Indonesian context.
- Cooperation with EBTKE and IEA, in order to define an energy efficiency baseline on current policies – to be used in the Indonesian EE Masterplan.
- Three study tours to Denmark on modelling, RE-Integration and EE. A total of 57 delegates and stakeholders visited Denmark in 2017.

As part of the Strategic Sector Cooperation programme, KPMG P/S ("KPMG" or "we") has been requested by the Embassy of Denmark to Indonesia to assist them with an analysis of:

- Prefeasibility study of four Generation Technologies in the island of Lombok – i.e. (i) a Biomass power plant, (ii) a Solar PV power plant, (iii) a Wind power plant, and (iv) a waste incineration power plant.

In addition, the prefeasibility study included:

- An analysis of three technologies that can support integration of fluctuating energy sources, such as wind and solar. These are (i) an interconnector to Bali from Lombok, (ii) a hydro-pumped storage, and (iii) a large-scale battery.
- An analysis of an off-grid PV/battery hybrid solution on the island of Medang.

The scope and execution of the work have been done in close cooperation with the Embassy of Denmark to Indonesia and the Danish Energy Agency.

Input and feedback from local stakeholders at PLN NTB, DESDM NTB, and DLHK NTB have been key for the quality of this study. The local departments have been cited throughout the report.

The work was initiated on 10 September 2018 and it was finalised on 30 November 2018.

KPMG visited and arranged meetings in Lombok and Jakarta in the period from 16 to 25 September (Kick-off meetings) and between 28 October and 5 November 2018 (Stakeholder consultation meetings). KPMG presented the findings listed in the Final draft on 13 December 2018 (Final presentation).

KPMG has together with the local partners been on site visits to Kebon Kongok landfill, Pengga hydro power plant, PV plant at Gili Air and two rice hellers for the gathering of information for the study.

KPMG has provided working drafts on 23 October, 19 November, 22 November, 25 November and 3 December 2018, and Final draft on 15 December. This report is the Final version.

Important notice

This report is prepared solely for the use of Embassy of Denmark to Indonesia, and should not be used, quoted, referred to or relied upon, in whole or in part, without KPMG's prior written permission, by any third party or for any other purposes.

The primary sources of information used in preparing this report have been information disclosed by the management at DESDM NTB, DLHK NTB and PLN NTB. KPMG does not accept responsibility for such information which remains the responsibility of the management of DESDM NTB, DLHK NTB and PLN NTB. Details of our principal information sources are set out in the report, and we are pleased that the information presented in our report is consistent with other information which was made available to us in the course of our work. We have not, however, widely sought to establish the reliability of the sources by reference to other evidence.

The purpose of our study was to assess high level feasibility, not detailed assessment of regulation, tax or capex. It is suggested that interested developers will need to carry out detailed review in conjunction with professional advisors (e.g. financial, legal and tax).

This engagement is not an assurance engagement conducted in accordance with any generally accepted assurance standards, and consequently no assurance opinion is expressed.

In the report, we assume that the sites located for commissioning the power plants can be used for just that. The sites have been located using satellite photos and comparing these with maps of land cover. It has not been examined if the land actually can be acquired, or if there exist unknown restrictions on the use of the land.

Our report makes reference to 'KPMG analysis'; this indicates only that we have (where specified) undertaken certain analytical activities on the underlying data to arrive at the information presented; we do not accept responsibility for the underlying data.

We have not considered events becoming known to us or occurring after the date of publication of this report (11 December 2018). Therefore, events which may significantly impact the findings after the date of the publication of this report are not considered.

We accept no responsibility or liability for the findings or reports of legal and other professional advisers even though we have referred to their findings and/or reports in our report.

Any findings or recommendations contained within the report are based upon our reasonable professional judgment based on the information that is available from the sources indicated in this report. Should the project elements, external factors and assumptions change, then the findings and recommendations contained in this report may no longer be appropriate. Accordingly, we do not confirm, underwrite or guarantee that the outcomes referred to in the report will be achieved.

We do not assume responsibility for loss and expressly disclaim any liability to any party whatsoever. We do not make any statement as to whether any forecasts or projections will be achieved, or whether the assumptions and data underlying any such prospective financial information are accurate, complete or reasonable.

We do not warrant or guarantee the achievement of any such forecasts or projections. There will usually be differences between forecast or projected and actual results, because events and circumstances frequently do not occur as expected or predicted, and those differences may be material.

Approach

KPMG has performed a prefeasibility study on the renewable projects decided together with the Embassy of Denmark to Indonesia and the Danish Energy Agency and presented some key observations for investing in renewable power generation in Lombok.

KPMG has together with the Embassy of Denmark to Indonesia and the Danish Energy Agency assessed the projects on the parameters Expected tariff, Resource potential, Capacity, CAPEX, and OPEX. These parameters serves as a basis for an assessment of the project's IRR.

KPMG has also performed an analysis of three technologies that could ease the integration of wind and solar power in the power system of Lombok. These technologies were chosen together with the Embassy of Denmark to Indonesia and the Danish Energy Agency. The technologies were evaluated based on investment, functionality, development, simplicity, social and environmental impact and whether they were fit-for-purpose or fit-for-future.

Finally, KPMG has performed an analysis of the off-grid system on the island of Medang. The system was chosen together with the Embassy of Denmark to Indonesia and the Danish Energy Agency. The analysis assesses the technical solution and possible benefit of a hybrid solar PV and battery to replace the existing diesel engine.

Glossary

AC	Alternating Current
ADB	Asian Development Bank
BPPT	Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi)
BPS	Statistics Indonesia (Badan Pusat Statistik)
BOOT	Build-Own-Operate-Transfer
CAPEX	Capital Expenses
CNG	Compressed Natural Gas
COD	Commercial Operations Date
DC	Direct Current
DESDM NTB	Local office on Energy & Mineral Resources at NTB (Dinas Energi Sumber Daya dan Mineral)
DLHK NTB	Local office on Environment and Forestry at NTB (Dinas Lingkungan Hidup dan Kehutanan)
EPC	Engineering, Procurement and Construction
FiT	Feed-in-tariff
GJ	Gigajoule
HVAC	High-Voltage Alternating Current
HVDC	High-Voltage Direct Current
IDR	Indonesian Rupiah
IEA	International Energy Agency
IPP	Independent Power Producer
IRR	Internal Rate of Return
JISDOR	Jakarta Interbank Spot Dollar Rate
KBLI	Indonesia Standard Industrial Classification (Klasifikasi Baku Lapangan Usaha Indonesia)
kW	Kilowatt
kWh	Kilowatt-hour
MEMR	Ministry of Energy & Mineral Resources
MW	Megawatt
MWh	Megawatt-hour
NEC	National Energy Council of Indonesia
NPV	World Wildlife Fund
NTB	Nusa Tenggara Barat
NTT	Nusa Tenggara Timur
OPEX	Operational Expenses
PLN	The state-owned electricity company (PT Perusahaan Listrik Negara)
PLN NTB	PLN at Nusa Tenggara Barat
PPA	Power Purchase Agreement
PUPR	Office of Public Work (Kementerian Pekerjaan Umum dan Perumahan Rakyat)
PV	Photovoltaics
RUPTL	PLN's Electricity Supply Business Plan (Rencana Usaha Penyediaan Tenaga Listrik)
SNI	Indonesian National Standard (Standar Nasional Indonesia)
US¢	US Cent
USD	US Dollar
WACC	Weighted Average Cost of Capital
WWF	World Wildlife Fund

Each Generation Technology is assessed by an estimate of the project IRR based on five parameters and evaluated by a project risk assessment

1 Expected tariff	The expected tariff level represents the revenue per unit of output for each Generation Technology, i.e. US¢/kWh. The expected tariff level is assessed based on the maximum levels from the Indonesian MEMR regulations.
2 Resource potential	The resource potential represents an assessment of the resource inputs of each Generation Technology based on two parameters (i) the amount of resource input being available, for example tons of Biomass in Lombok and (ii) the unit cost of the input resource, e.g. USD/ton for Biomass.
3 Capacity	The capacity of each Generation Technology is determined based on an assessment of available resources, grid connection, land acquisition, and logistics. Based on resource availability, the capacity is used to determine the amount of output – i.e. amount of MWh.
4 CAPEX	CAPEX represents the capital investment needed for the implementation of each Generation Technology up until commissioning of each plant. CAPEX is based on Indonesian sources and publicly available benchmarks from comparable South East Asia projects and studies.
5 OPEX	OPEX represents the yearly operation expense of each Generation Technology. OPEX is assessed from Indonesian sources and benchmarked with publicly available information from South East Asia projects and studies.

A Internal rate of return is used as the key parameter for the study

Internal Rate of Return (IRR) is the discount rate that makes the net present value (NPV) of a project zero. In other words, it is the expected rate of return that will be earned on the project.

$$0 = NPV = \sum_{n=0}^{N} \frac{CF_n}{(1 + IRR)^n}$$

CF_0 = Initial investment
$CF_{1,2,3,..}$ = Cash flows
n = Each period
N = Holding period
NPV = Net present value
IRR = Internal rate of return

The IRR refer in this study to the project IRR in USD.

B Project risk assessment

The project internal rate of return is evaluated using a project risk assessment of each Generation Technology.

The project risk is assessed on key risk parameters in terms of likelihood and capital loss. It is important to note that the risks are non-exhaustive in nature and do not reflect all of the risks faced in developing projects in the Indonesian power sector. Interested developers will need to undertake a wider risk assessment as part of a more detailed feasibility study

Based on the assessment of IRR and project risk, the Solar and Wind projects are currently evaluated to be the most economically viable projects

	Biomass power plant	Solar PV plant	Wind power plant	Waste incineration
1 Expected tariff	11.8 US¢/kWh	11.8 US¢/kWh	11.8 US¢/kWh	13.9 US¢/kWh
2 Resource potential	Rice husk: 300,000-400,000 ton 11 USD/ton	Solar resource: 1600-1800 full load hours No cost	Wind resource: 2700-3100 full load hours No cost	Municipal waste: 900,000 ton -3.3 to -33 USD/ton (gate-fee)
3 Capacity	20 MW	20 MW	50 MW	25 MW
4 CAPEX	USD 40-60m	USD 20-30m	USD 75-100m	USD 150-225m
5 OPEX	USD 1.6-2.4m p.a. (~4% of CAPEX)	USD 0.4-0.6m p.a. (~2% of CAPEX)	USD 3-4m p.a. (~4% of CAPEX)	USD 7.5-11.0m p.a. (~5% of CAPEX)
A IRR	**4-24%**	**7-14%**	**7-16%**	**2-15%**
B Risk	Assessed to be a higher risk	Assessed to be a lower risk	Assessed to be a lower risk	Assessed to be a medium risk

Project IRR in USD currency.
See next slide for further description on risk

Biomass and waste power plants could be economically viable if the risk of fuel supply can be handled

	Biomass power plant	Solar PV plant	Wind power plant	Waste incineration
A IRR	**4-24%**	**7-14%**	**7-16%**	**2-15%**
B Risk	Assessed to be a considerable high risk	Assessed to be a low risk	Assessed to be a low risk	Assessed to be a medium risk
Elaboration on largest project risks	▪ Overlapping activities with the agriculture sector reducing availability of feedstock – for example not enough biomass. ▪ Increasing prices of husk. ▪ Numerous agreements with low credit quality fuel suppliers is required. Fuel supply relies on 30-40 bilateral agreements. ▪ The lack of biomass supply might come after commissioning, hence risk of high capital loss.. ▪ High capital loss if the bilateral agreements are not fulfilled after commissioning.	▪ Challenges with integrating too much fluctuating power generation. ▪ However, if a PPA can not be agreed upon, it would happen before construction, so capital loss is limited.	▪ Challenges with integrating too much fluctuating power generation. ▪ However, if a PPA can not be agreed upon, it would happen before construction, so capital loss is limited. ▪ The wind turbines are 150 m high, and have a visual impact that might lead to local protest – for example from hotels. ▪ Since the tourist sector is important to Lombok's GDP, this could block the project.	▪ A sustainable gate-fee will need to be negotiated with the local government ▪ Failure to negotiate a gate fee before construction will result in low capital loss. ▪ However, if the government renegotiates the gate-fee after commissioning, then the capital loss can be substantial. ▪ Availability and strength of guarantees will be important

Considerations for future feasibility studies

Based on our observations in this report, we have assembled an overview of the most important considerations for future feasibility studies related to renewable energy solutions in Lombok:

- Further review and mature policies on renewable energy solutions in Lombok
- Carry out a feasibility study based on this prefeasibility study on all four Generation Technologies
- Carry out an investor interest analysis to understand investor's interest and concerns
- Review and mitigate current risks within each Generation Technology.

Project IRR in USD currency.

Contents

1 Introduction to the power system of Lombok

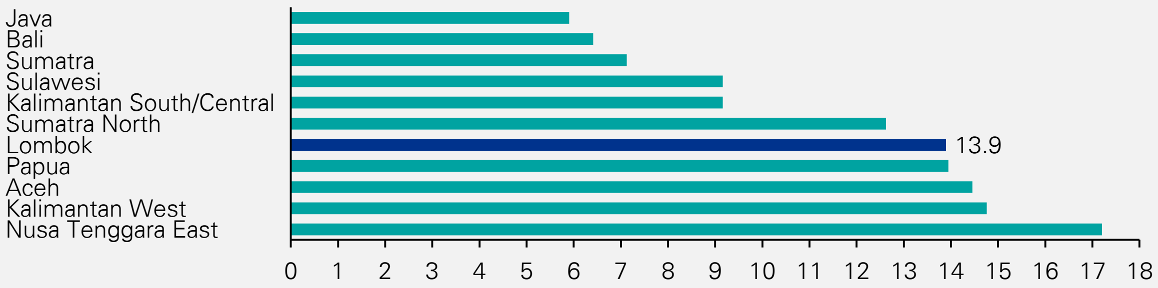
Lombok is an isolated island using diesel for power generation, which results in a power price above the Indonesian average

Lombok: Indonesia is an archipelago nation consisting of approximately 17,000 different islands. Lombok is a medium-sized island located east of the islands of Java and Bali in the province of West Nusa Tenggara of central southern Indonesia.

Population: Although Indonesia is the fourth most populous country in the world, the population of Lombok only makes up a small proportion of 3.35 million. The population is expected to grow to around 4 million by 2030. The majority of Lombok's population is located in the South, East and West of the main island and around the coastal areas. The centre of the northern part of the island is dominated by the volcano Rinjani.

Power prices: Lombok does not have significant fossil fuel resources and does not have a connection to any of the other major grids in Indonesia. The combination of lack of fossil fuel resources, dependency of diesel for power generation and low economies of scale results in power prices in Lombok at 13.9 US¢/kWh, which are considerably higher than the national average of 7.7 US¢/kWh.

Average power generation cost per Province* (US¢/kWh)



**Selected Province. Lombok is part of the NTB province. Some provinces are combined if they are part of the same system.*

Source: RUPTL 2018-2027; BPS; KPMG analysis.

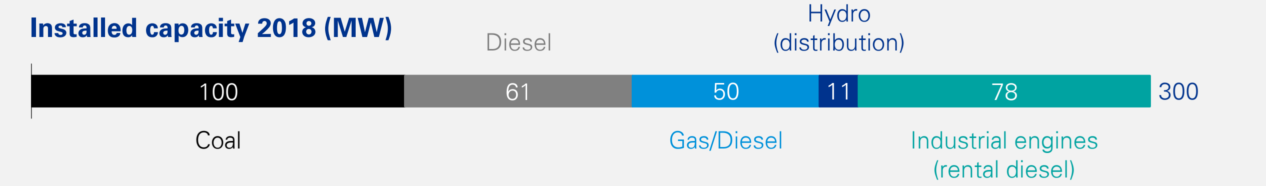
Expansion of the grid will strengthen the grid and improve integration of new and renewable power capacity

Current generation capacity: The majority of existing generators in Lombok are located around Mataram on the West coast where they connect to the main Lombok grid. These sources include a mixture of coal and diesel plants. There are diesel/gas hybrids in the southwest and one is being constructed at Mataram, but the supply of CNG has not yet been established to either of them – therefore they currently operate on diesel. The only other major generation asset currently in operation is a 50 MW coal plant located in the northeast of the island. However, new solar photovoltaic (PV) plants are being developed close to the transmission backbone that runs from the south to the northeast of the island.

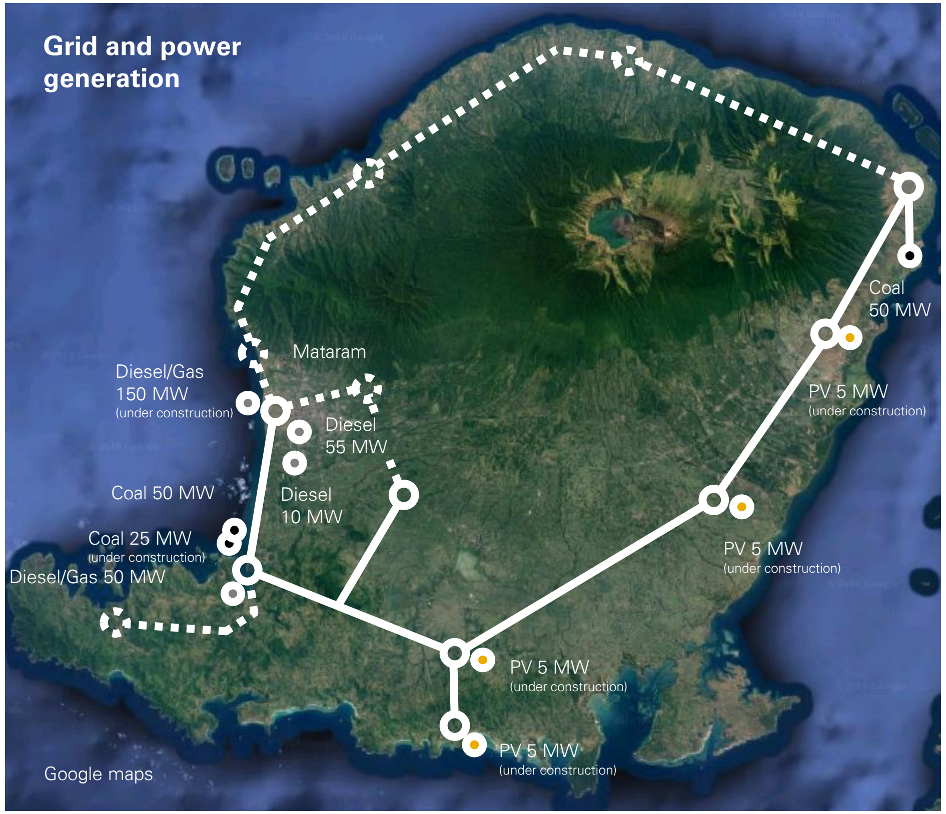
The installed capacity cannot cover the 260 MW peak, so the utility company PLN is renting peak load capacity from the local industry – total 78 MW diesel engines.

Power grid: The main (high voltage) Lombok grid follows the population pattern and runs from Mataram, the largest city on the island and largest load centre on the Western coast across the south of the island and up toward the East coast. Beyond the 150 kV transmission grid, there is also the distribution network which operates at 20 kV. It is estimated that the electrification of Lombok covers 85% of the population with the main unconnected population being located in the north. There are additional smaller populated islands not connected to the grid. The Gili islands off the West coast are connected to the grid with a 20 kV line.

PLN is currently developing the transmission and distribution grid around the north of the island (COD 2020). This expansion is expected to strengthen the grid significantly, increase the islands level of electrification and subsequently increase demand.



Source: RUPTL 2018-2027



Substation
150 kV transmission line
Under construction

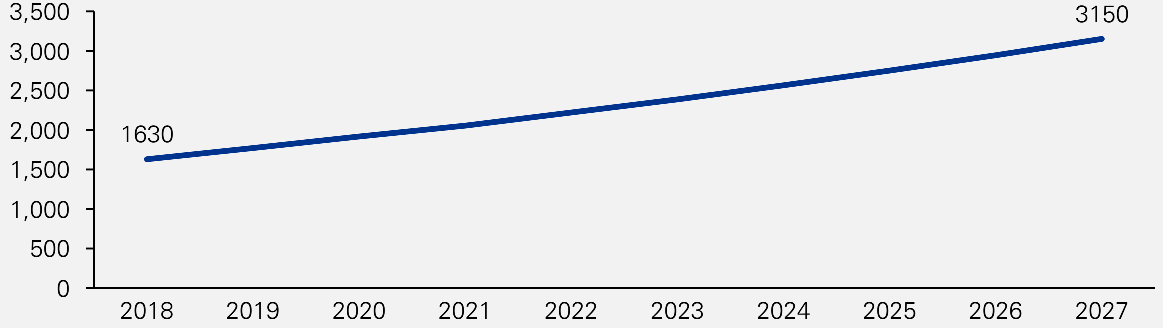
Rising demand may provide opportunities for new renewables if they can be shown to be financially and technically feasible

Peak Demand: From a current peak demand of approximately 260 MW, the 2018-2027 RUPTL (PLN's annual statement of planning for the Indonesian power sector) predicts that Lombok System's peak demand will grow at 7.6% per year, reaching above 500 MW by 2027.

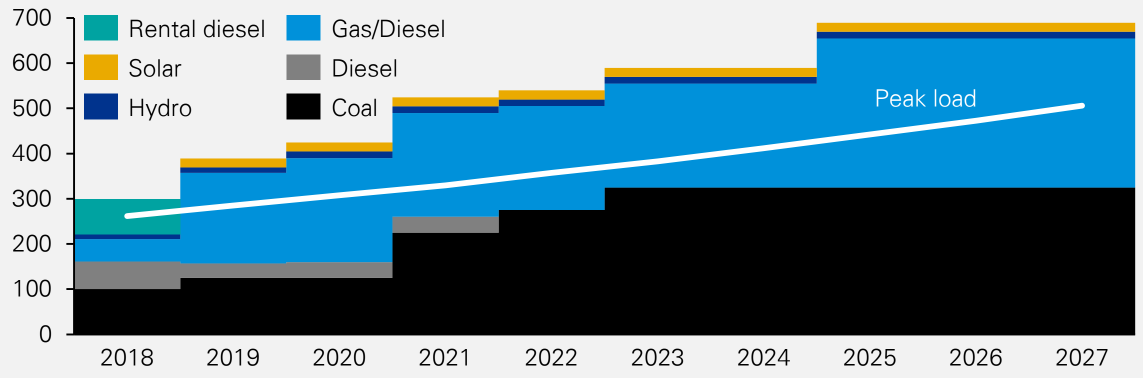
Expanding power generation capacity: The RUPTL also includes PLN's current plans for capacity expansion for each grid. Within Lombok, PLN is expecting that new gas-fired capacity will be developed by 2019, but the supply of gas is still uncertain, so these might run on diesel in the first years.

Although the RUPTL plans for expansions in coal-fired capacity, there may be space for new renewables to enter the system to meet demand growth if it can demonstrated that they are technically and financially feasible.

Projected electricity demand in Lombok (GWh)



Total planned installed capacity and peak load (MW)



Source: : RUPTL 2018-2027

Available renewables in Lombok include Biomass, Solar and Wind, and in addition, Lombok has a challenge with waste treatment

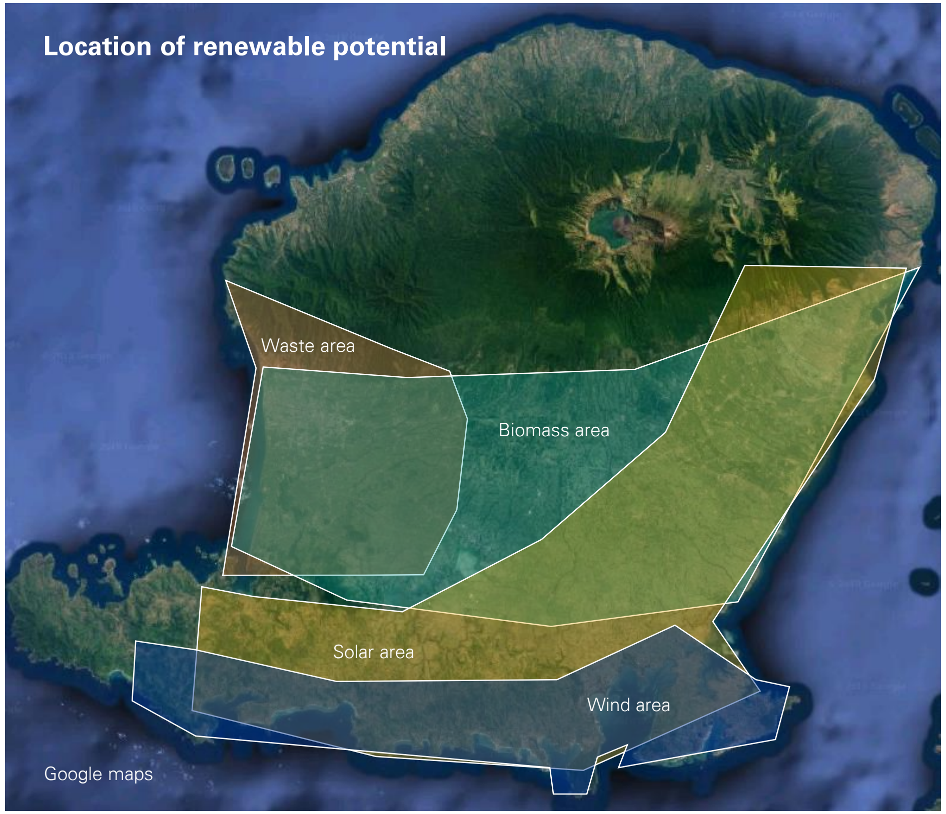
Resources in Lombok: Lombok has a number of available renewable energy sources, including the sources which have been chosen in this analysis; biomass, wind and solar. Additionally, Lombok faces an island-wide environmental challenge in terms of waste handling.

Biomass: Biomass potential in Lombok is high, although sources are relatively spread out. Biomass potential is typically found in the form of rice husk, a by-product from milling rice paddy into rice. The risk husk is estimated to yield sufficient energy to support a power capacity of 60-65 MW. Biomass potential is primarily located in East, Central and West Lombok.

Solar: There is high solar potential in Lombok. Hours of sunshine on Lombok is higher than on many other Indonesian islands. The average daily solar energy received on Lombok varies from 3.3 to 5.6 kWh/m2, and is being highest on the South and East coast.

Wind: Average wind speeds on Lombok are low. However, a limited number of sites in the Southern region have an average wind speed of 6 to 7 m/s.

Waste: Lombok faces a huge environmental challenge associated with the handling of waste. Each year, an estimated 900,000 tons of waste is generated by industry and households. Out of this, roughly 200,000 tons is collected and transported to one of the four landfills in Lombok. The remaining waste ends up in the ocean, on beaches, in forests or is being burned.



Source: PLN NTB; DESDM NTB; DLHK; NTB Local office of Agriculture; ESMAP SolarGIS; World Bank Group; Local rice hellers; WindProspect; KPMG analysis

KPMG EMBASSY OF DENMARK *Jakarta* Danish Energy Agency

Rice fields and agriculture land is assessed to be acquirable for development of the Generation Technologies

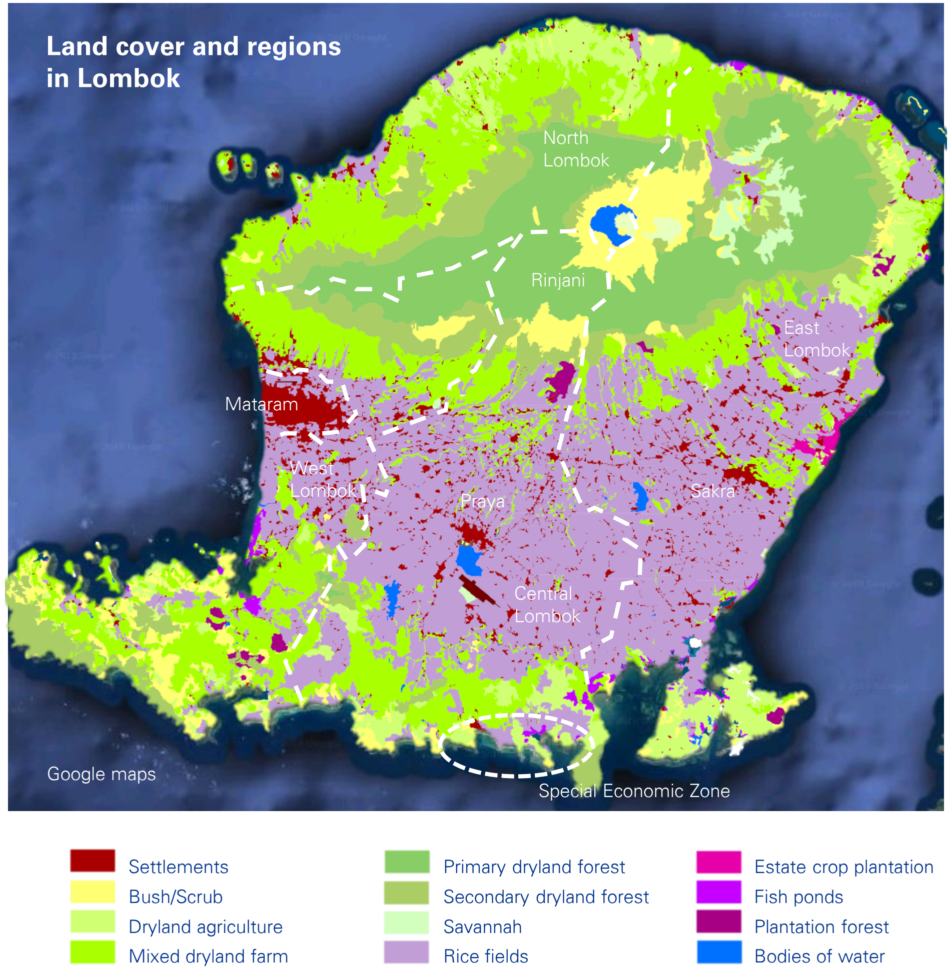
Settlements: The population in Lombok is concentrated in the western and central part of the island, especially in the provincial capital, Mataram, and two larger cities Praya and Sakra. Lombok is governed by the Governor of West Nusa Tenggara and has five districts Mataram, West Lombok, Central Lombok, East Lombok, and North Lombok. At the South coast, a special economic zone has been established to attract the tourist industry.

Agriculture: The majority of the land cover in Lombok is used for agriculture purposes (mostly rice fields). Agriculture is Lombok's main industry and main contributor to GDP. It is assumed that rice fields and other agriculture land can be acquired for power plant development.

Protected land: Lombok has areas of protected forest in the north on the volcano Rinjani, as well as at the southern coast, which require special permits from the Minister of Environment & Forestry (MOEF) to develop. Sites in non-protected areas are therefore considered to be preferable.

Land requirement

Biomass power plant	0.11-0.15 ha/MW	Wind power plant	1.0-1.5 ha/MW
Solar PV plant	0.7-1.5 ha/MW	Waste incineration	0.15-0.20 ha/MW



Source: DEA; NEC technology catalogue; DESDM; GlobalForestWatch; KPMG analysis.

The delivery of equipment for the projects is assessed to be technically feasible; however, the cost of logistics may be high

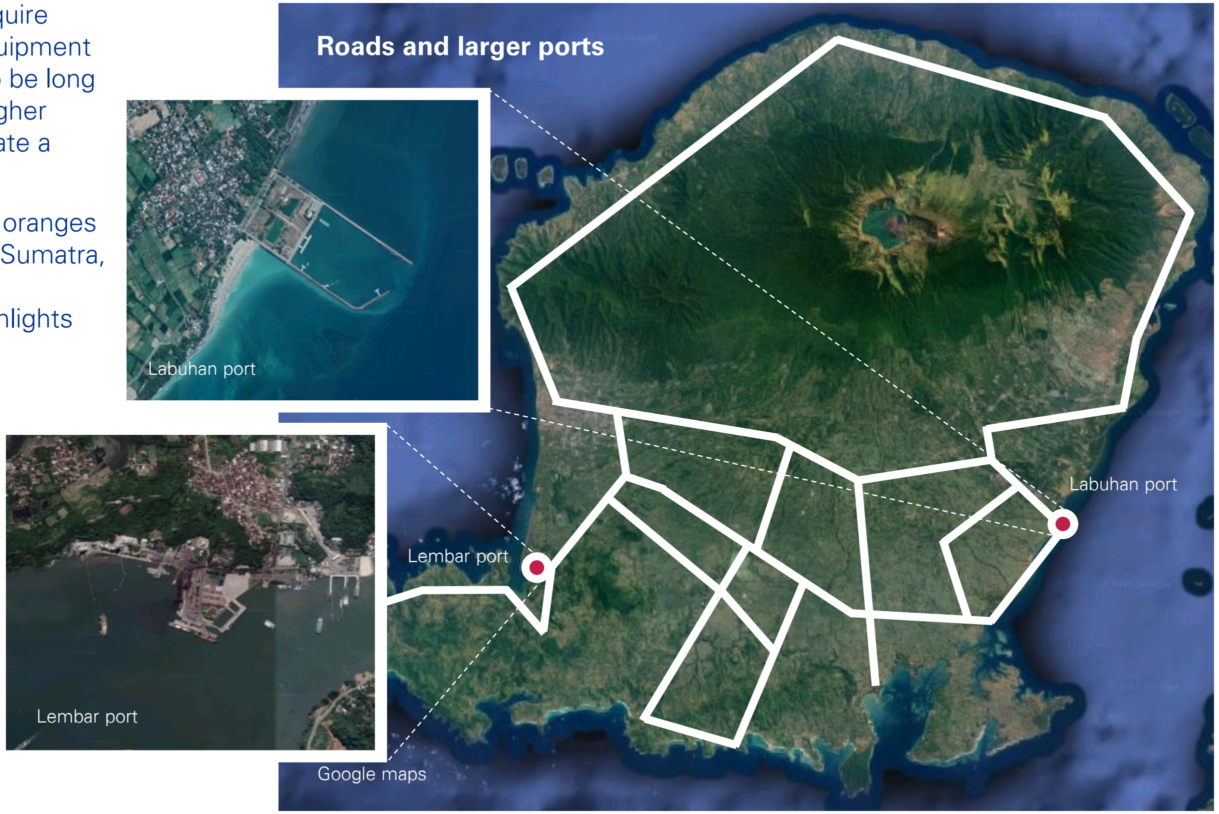
Logistical challenges: The logistics sector in Indonesia is generally considered to require further development, which implies risks associated with the import of necessary equipment for the projects. As an archipelago nation, logistical supply chains in Indonesia tend to be long and fragmented, and vessels are often relatively empty on return voyages creating higher costs of shipment. Additionally, poor dredging and a lack of deep water ports can create a challenge for entering ports with heavy cargo.

The World Bank highlights that it costs more to ship a container of Chinese mandarin oranges from Shanghai to Jakarta than to send similar freight from Jakarta to Padang in West Sumatra, despite the distance between the former cities being six times further than the latter. Although this is not directly comparable to the development of a power project, it highlights the high costs of logistics in Indonesia.

Ports: For Lombok specifically, port facilities are limited to Lembar port and Labuhan port. The development of previous coal and diesel plant means that import of waste incinerators, biomass boilers and turbines should be feasible. Depth of port facilities for the import of wind turbines may need to be investigated.

Roads: Road networks around the island exist and should be sufficient to transport equipment to most locations. Although developments close to ports are more likely to encounter fewer issues.

Delivery of equipment: Given that previous power plants have been successfully constructed, delivery of equipment to Lombok should be feasible -although costs could be high. For each of the projects, an assessment of the additional cost of logistics will be needed as part of a detailed feasibility study.



Source: Martin Bencher Group; PwC; Business Monitor International; The World Bank; KPMG analysis

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Prefeasibility studies on Generation Technologies

The expected tariff level for the Generation Technologies is 11.8 US¢/kWh for Biomass, Solar and Wind, and 13.9 US¢/kWh for Waste

Regulation: The prices for electricity purchases from any renewables must be approved by the Ministry of Energy and Mineral Resources (MEMR). MEMR Reg. No. 50/2017 sets out the way that the maximum tariff for different technologies of renewable energy plants should be determined.

Maximum tariff: The applicable tariff ceilings are established at the time of PPA signing and are based on the published average electricity generation cost for the preceding year in the area where the project is to be located (known as the BPP). The logic behind the maximum tariff payable is:

- If the local BPP is below the national BPP, the tariff to be negotiated with PLN will be capped by local BPP.
- If the local BPP is above the national BPP, the tariff is capped at 85% of the local BPP for biomass, solar PV and wind power and at 100% for waste incineration.

Expected tariff: Note that for this study, we have used the tariff ceilings to assess feasibility, but final tariffs may be lower due to a competitive selection process. MEMR Decree No. 1320K/32/MEM/2018 sets the reference BPP from the period from 1 April 2018 to 31 March 2019. The BPP in West Nusa Tenggara, where Lombok is located, is 13.9 US¢/kWh, which is considerably higher than the National BPP of 7.7 US¢/kWh. Tariffs are therefore capped in relation to the local BPP. This yields a maximum tariff of 11.8 US¢/kWh for biomass, solar PV and wind and 13.9 US¢/kWh for waste incineration. For this study, this is applied as the expected tariff.

Regulation of waste: Although Presidential Reg. No. 35/2018 has been introduced to cover new and higher tariff for waste incineration projects in some parts of Indonesia, Lombok is currently not covered by this regulation. This means that the waste incineration plant within this study remains under the MEMR Regulation 50/2017 – i.e., 13.9 US¢/kWh.

Currency: We note that tariffs are required to be paid in IDR, but are expected to be kept indexed to a fixed USD amount. More explanation is provided in the Background material.

Maximum tariff regulation

	Maximum tariff off local BPP (%)	Maximum tariff in Lombok (US¢/kWh)
Biomass power plant	85%	11.8
Solar PV plant	85%	11.8
Wind power plant	85%	11.8
Waste incineration	100%	13.9

Source: MEMR Reg. No. 50/2017 and No. 10/2017, PR No. 35/2018; MEMR Decree No. 1320K/32/MEM/2018; Bank Indonesia

Prefeasibility studies on green power generation

Biomass power plant

EMBASSY OF DENMARK
Jakarta

Danish Energy Agency

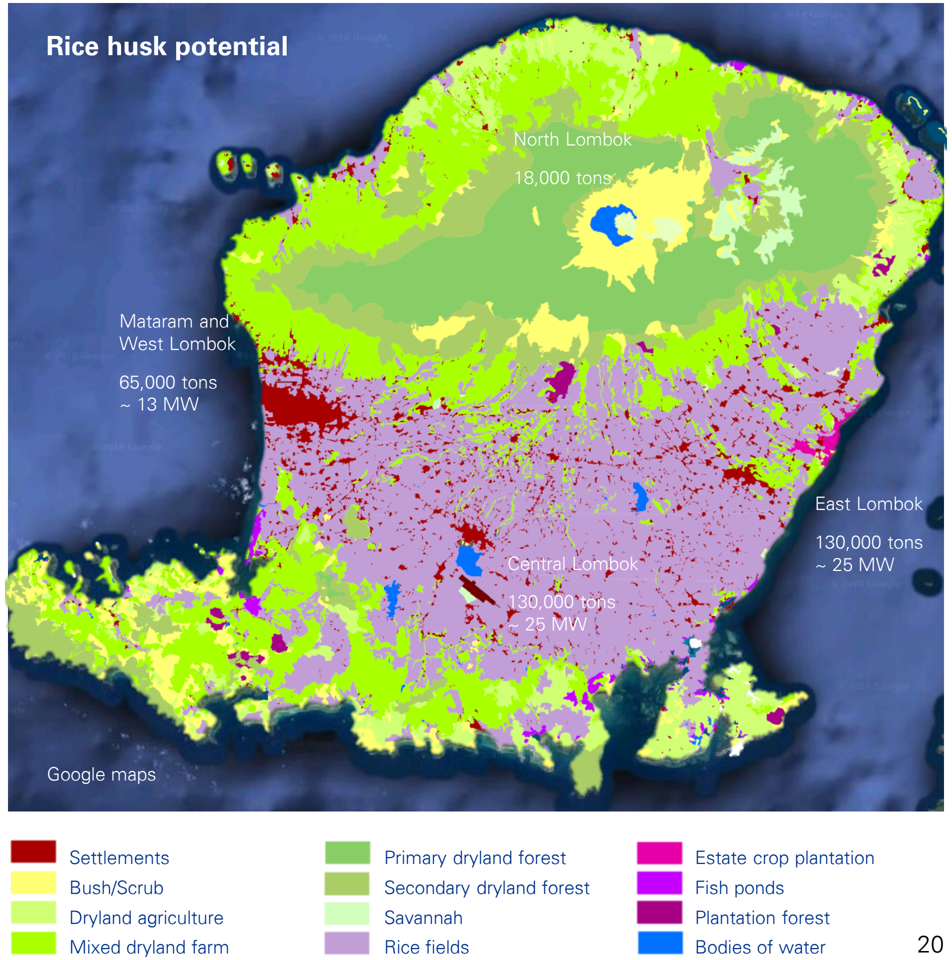
KPMG picture

Rice husk could provide fuel for power generation – potential of 340,000 tons result in a potential total capacity of 60-65 MW

Risk husk biomass: Rice husk is a by-product from the milling of rice paddy into rice. The husk is the shells surrounding the rice. For each ton of rice paddy, a treatment facility – known as a rice heller – receives, roughly 60% will become rice and 40% will end as husk.

Resource potential: According to the Regional Energy Plan (RUED) of West Nusa Tenggara, the largest biomass potential is from rice husks with a total annual resource of approximately 340,000 tons in Lombok – a number that the Provincial government expects to growth. The potential is primarily located in East, Central and West Lombok (incl. Mataram). The hellers' annual generation of husk vary from 200 tons to 5,000 tons. Throughout the year, paddy is being harvested, but the highest paddy production is in May, June and July.

The husk has a heating value of 13 GJ/ton, which yields a total estimated capacity of 60-65 MW in Lombok (assuming 6,000 full load hours and 30% efficiency).



Source: PLN NTB; DESDM NTB; Local office of Agriculture; Local rice hellers; KPMG analysis

The suitable biomass plant capacity is assessed to be 20 MW The cost of the husk is estimated to be 11 USD/ton

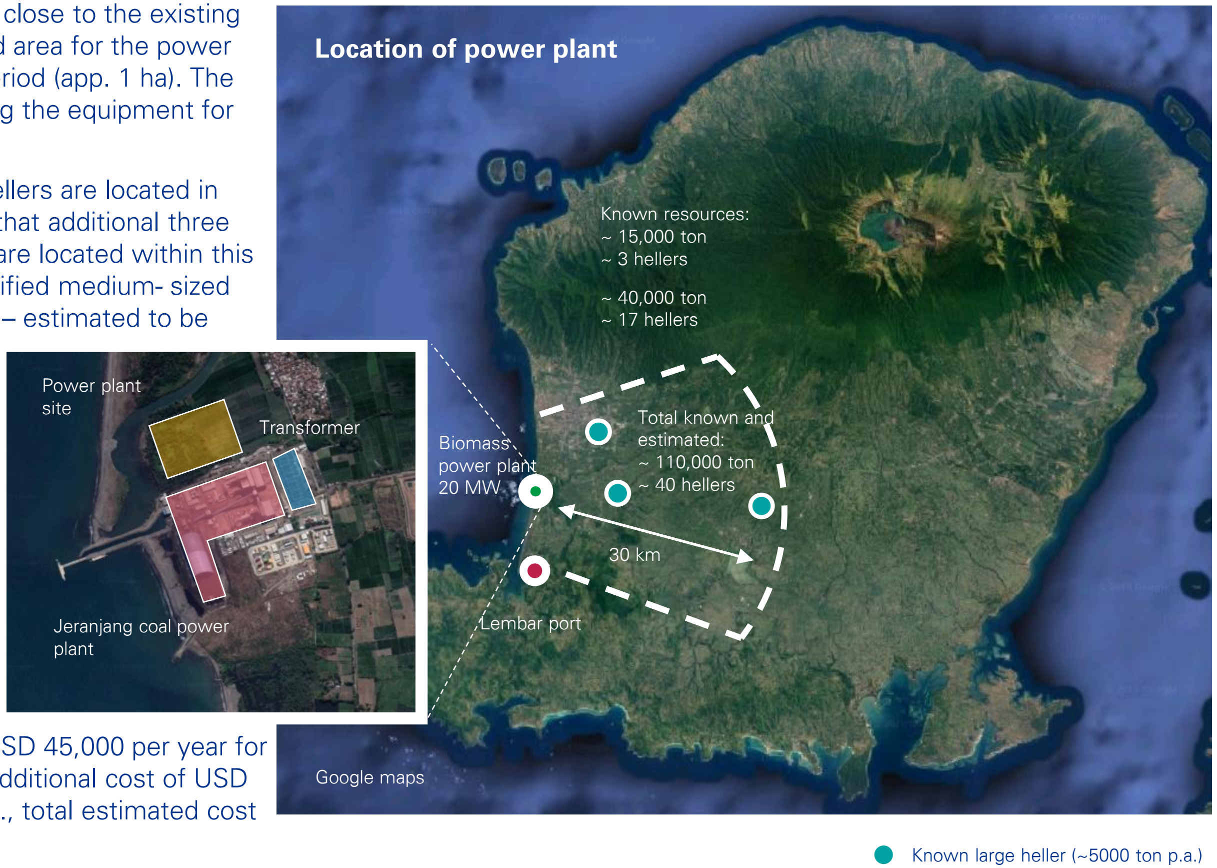
Location*: Based on the location of hellers, harbours and grid connection, a site very close to the existing coal-fired power plant on the West coast has been chosen for this study. The required area for the power plant and biomass storage is 2.5 ha, plus an additional area during the construction period (app. 1 ha). The Lembar port and existing road have been used for receiving, reloading and transporting the equipment for the existing Jeranjang power plant and so the logistics should be feasible.

Resource and supply: Within a beeline distance of 30 km, three known major rice hellers are located in West and Central Lombok, each generating 5,000 tons husk per year. It is estimated that additional three hellers exist in this area of the same size. Additional 17 known medium-sized hellers are located within this area – 1,500-3,000 tons husk each. We estimate that there is an additional 20 unidentified medium- sized hellers in this area. The biomass potential of these sites sums up to110,000 tons p.a. – estimated to be sufficient to operate a 20 MW power plant at an average 6,000 full load hours. .

Separate bilateral agreements might be needed to arrange for the sale of rice husk from each heller to the operator. However, some of these hellers are known to be held by the same owner which should enable a number of hellers to provide husk under a single bilateral agreement. It is currently estimated that the number of bilateral agreements necessary will be 30-40.

Fuel price: The rice hellers currently sell the husk to local farmers and flower shops as fertiliser and to manufacturers to be used for manufacturing of bricks. The husk is usually sold in 100 kg bags for 5,000 IDR – i.e. the current value of the husk is 50,000 IDR/ton (3.3 USD/ton). Due to increasing demand from the utilisation of husk in power plants we assume a 20% increase in price – i.e., 4 USD/ton.

Transport cost: The cost of collecting the rice husk is estimated to 3 USD/ton plus USD 45,000 per year for administration (3 skilled workers) on plant site. The collection thereby has an annual additional cost of USD 375,000 or 3.4 USD/ton. An overhead for a subcontractor is estimated to be 50% - i.e., total estimated cost being 11 USD/ton



Source: NuGen Engineering Ltd.; Ea Energy Analyses & IDEAS Consulting Services; NEC technology catalogue; DESDM NTB; Local office of Agriculture; Local rice hellers; KPMG analysis

*The sites have been located using satellite photos, and comparing these with maps of land cover. It has not been examined if the land actually can be acquired or if there exist unknown restrictions on the use of the land.

The total CAPEX of the power plant is estimated at USD 40-60m – OPEX is estimated at USD 1.6-2.4m p.a.

CAPEX: Biomass power plants are a mature and well-known technology – including in South East Asia. An ASEAN study on biomass projects found that CAPEX for steam boiler power generation (~10 MW) is 2-3m USD/MW. The same study includes Indonesian oil palm shell projects, but it is not specified if they use steam boilers or gasification.

According to the Indonesian Technology Catalogue from the National Energy Council, the capital cost of equipment and installation for a biomass power plant in Indonesia is 1.7m USD/MW.

A prefeasibility study on biomass husk for power generation in Myanmar lists a cost of 2.5m USD/MW.

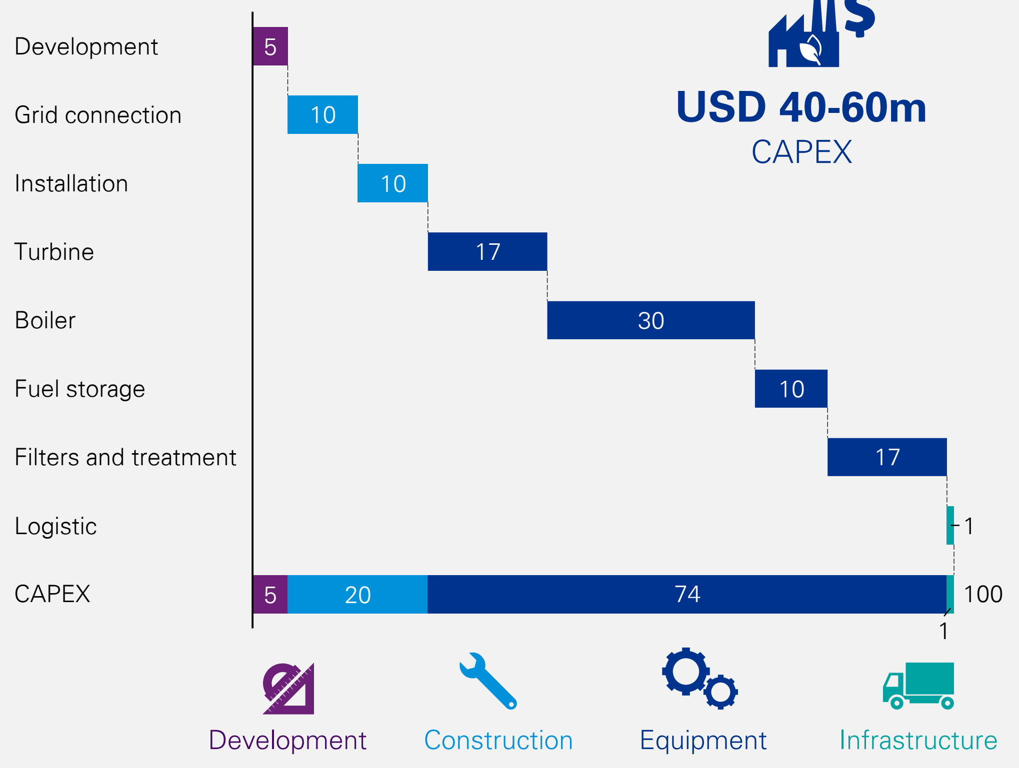
According to this, the Technology Catalogue seems to be in the low end. For the 20 MW biomass plant, total CAPEX is assessed to be 2-3m USD/MW or USD 40-60m.

The risk of irregular supply and low bulk density (100 kg/m^3 to 200 kg/m^3) calls for a large storage yard. Consequently, the storage area and cost of fuel handling are significantly higher for husk than, for example, coal. It is assumed that this extra cost is included in the total CAPEX of 2-3m USD/MW.

It is assumed that in Lombok there are some additional expenses relative to logistics and development. Our chosen site is located next to the existing power plant Jeranjang. The port of Lembar was used for receiving the equipment for the existing plant, and we assume that any additional enforcements of the roads have not been removed. We therefore believe that the additional logistics costs will be low and only reflect 1% of total CAPEX.

OPEX: From the ASEAN study and the Technology Catalogue, OPEX is assessed to be ~4% of the CAPEX – i.e. USD 1.6-2.4m p.a.

CAPEX breakdown (%)



Source: NEC technology catalogue; Mitsubishi Research Institute; ASEAN LCOE report; Singh et al.; KPMG analysis

Assumptions of the financial cash-flow model for the 20 MW biomass plant

Capacity	20 MW
Expected tariff	11.8 US¢/kWh (fixed USD-rate)
Payment currency	All payments are in IDR
WACC*	10%
Tax & depreciation*	25% (16 years depreciation period)
CAPEX	USD 40-60m
OPEX	USD 1.6-2.4m p.a. (~4% of CAPEX)

** See background appendix slides for further explanation of assumption.*

Fuel cost#	11 USD/ton
Heating value	13 GJ/ton
Efficiency	31%
Availability	80%
Load factor	90%
Technical lifetime	25 years
Abandonment+	USD 1.2m

 # The price consists of 3.3 USD/ton (plus 20% extra due to risk of price increase when we enter the market with additional demand), and a transport cost of USD 375,000 p.a. (3.4 USD/ton). 50% fee/overhead for a local subcontractor for handling bilateral agreements and collection.
+ After the lifetime of the power plant, it needs to be scrapped.

Source: NEC technology catalogue; DESDM NTB; ASEAN LCOE report; KPMG analysis.

Biomass power provides a project IRR of 4-24% -wide range driven by uncertainty of husk supply

Result: The cash-flow calculation shows a project IRR of 14-24%, where the higher IRR value is the lower CAPEX and OPEX, and vice-versa. For an estimated CAPEX of USD 50m and a WACC of 10%, the calculations result in a NPV of USD 20m.

The main reason for the highly positive result is the combination of a high power tariff (double of the tariff on Java), and a cheap fuel. The cost of rice husk including procurement, transport and administration is 0.85 USD/GJ – compared to coal from Kalimantan, which can be acquired for approximately 1.0-1.5 USD/GJ.

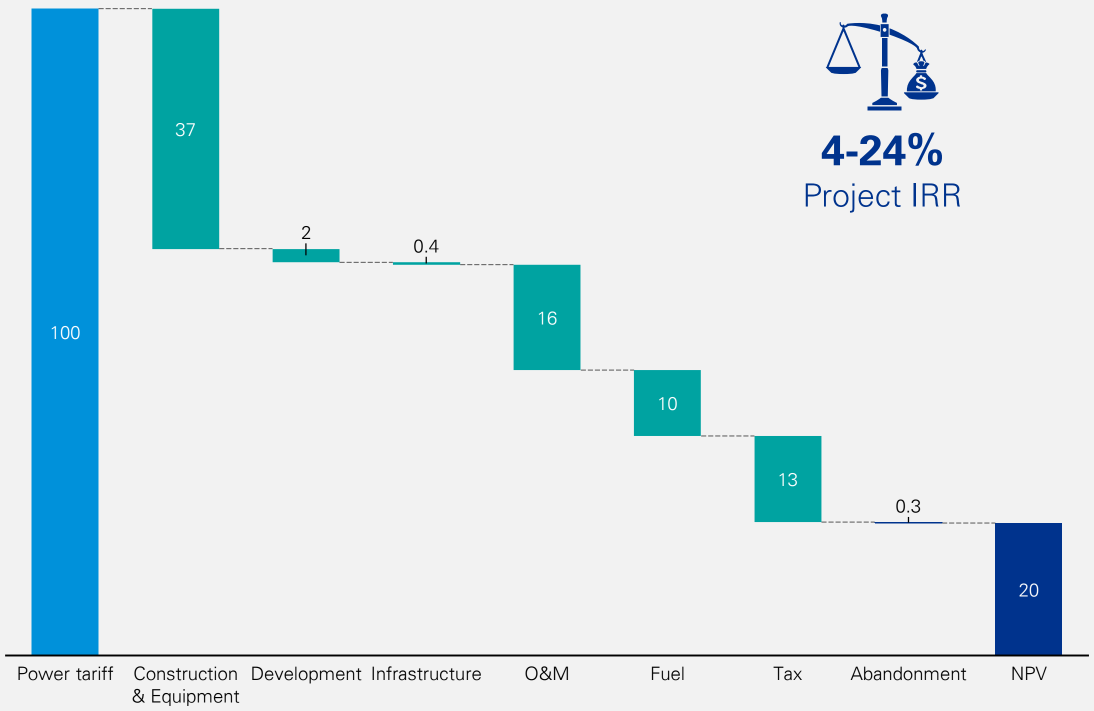
Sensitivity: Beside CAPEX and OPEX, the fuel supply is the most crucial parameter in the calculations. The sensitivity of lower supply of husk can result in a higher price than assumed due to higher demand, or even lack of supply due to quotas for use of husk for power generation vs use in the agriculture sector.

With a fuel price of twice the value assumed, the base case (i.e. 22 USD/ton) will result in a project IRR of 11-20%.

With a load factor of 60% instead of 80% due to lack of husk supply, the project IRR decreases to 4-11%.

Assessed project IRR: The overall IRR range is estimated to be 4-24%, which is a very large range of uncertainty. This risk of the IRR is evaluated on the next slide.

NPV breakdown of central guess (USDm)*



** Applied CAPEX of USD 50m and WACC of 10%.*

Source: NEC technology catalogue; ASEAN LCOE report; KPMG analysis

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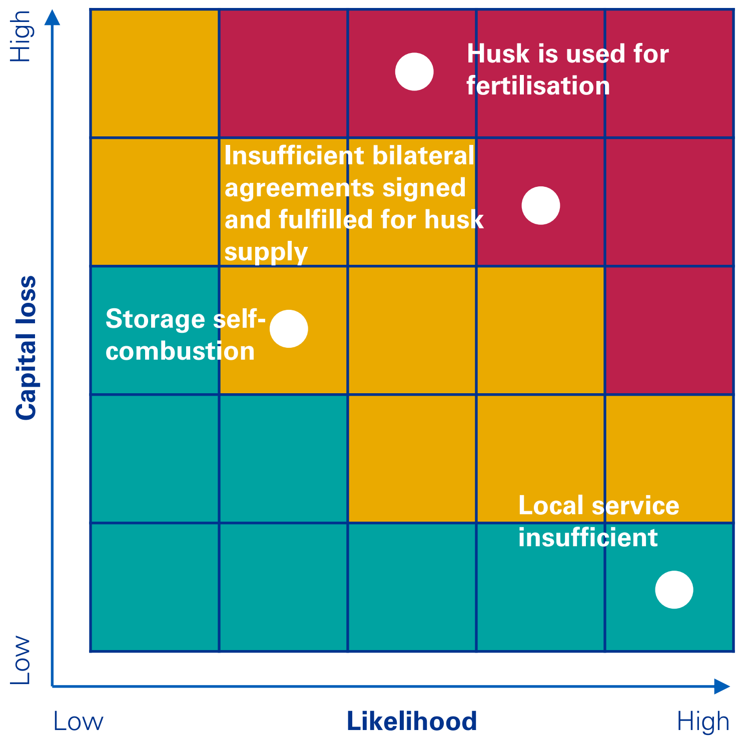
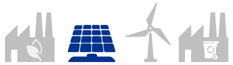
The supply of husk is a critical risk element and will need to be managed carefully

Risk	Risk description	Action
Husk is used for fertilisation	Risk of overlapping activities with the agriculture sector. The demand for husk as fuel will increase the price of husk, and there may not be enough husk for both fuel and fertilisation. Risk of political changes after commissioning which will decrease the supply of husk to power generation.	Work closely with politicians and farmers to evaluate the situation in the feasibility stage. If possible, try to ensure the supply of an alternative fertiliser in the same price range. Both to minimise the likelihood of risk.
Insufficient bilateral agreements signed and fulfilled for husk supply	There is a significant risk for the owner of not getting the fuel supply needed, since it relies on 30-40 bilateral agreements. There is a low risk of capital loss in the developing phase but high capital loss if the bilateral agreements are not fulfilled after commissioning.	To minimise the likelihood of risk, hire a local subcontractor for organising and collecting the husk. Prepare a screening in the feasibility stage to get insights on possible candidates to access creditworthiness.
Local service insufficient	A 20 MW biomass plant has local content requirement on services in the construction period of 56%.	To minimise both the consequence and the likelihood of risk, hire a local EPC company that can take some of the risk and provide understanding of the market. Manage the construction carefully and on site to decrease the likelihood of risk.
Storage self-combustion	Storing rice husk presents several risks. One being spontaneous self-combustion. If it happens, the stored husk is gone, the storage has to be refurbished for weeks and the power plant is out of operation in this period.	To minimise the likelihood keep husk dry under a roof, and monitor the storage temperature. To decrease the consequence, acquire the necessary equipment to extinguish fires.

Risk matrix



Source: DESDM NTB; Local rice hellers; KPMG analysis.



Prefeasibility studies on green power generation

Solar PV plant

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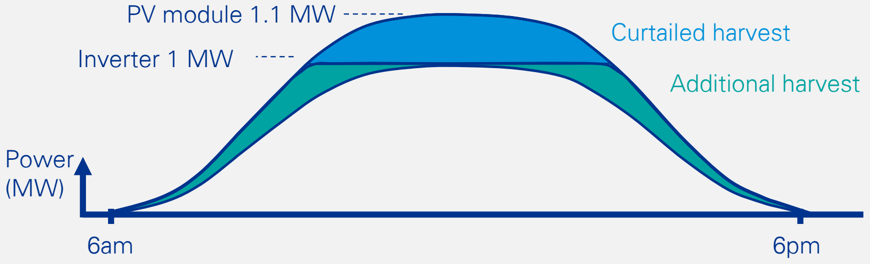
There is a huge solar potential in Lombok with 1800 full load hours achievable in the southern and eastern part of the island

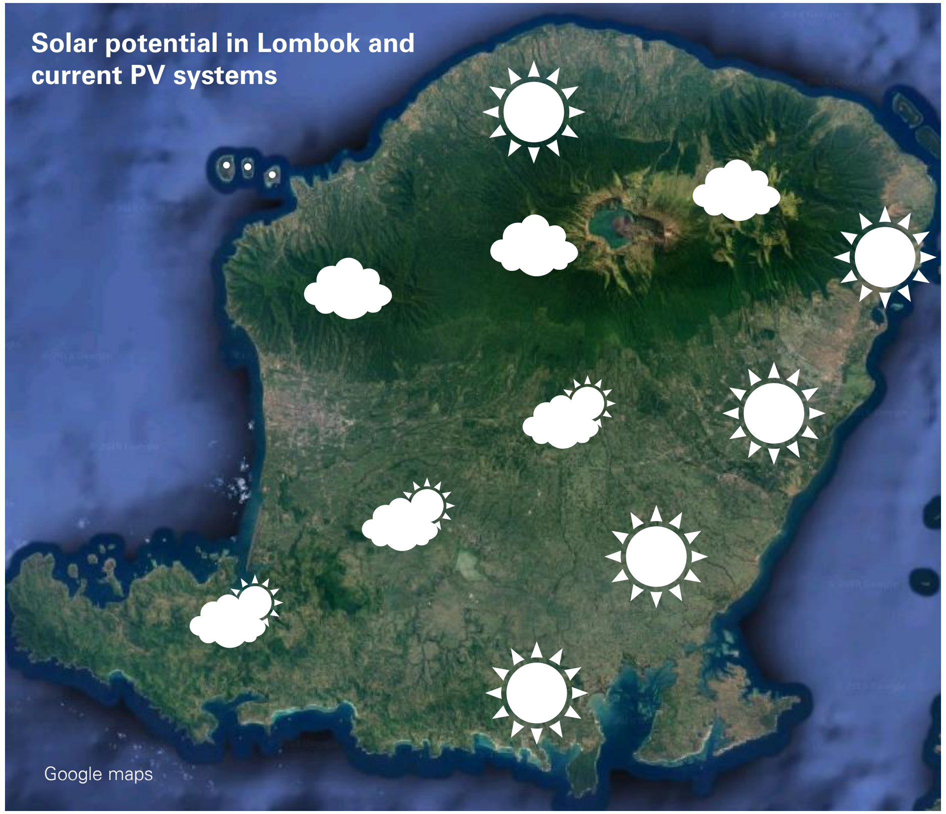
Resource: The hours of sunshine in Lombok is higher than on many of the other Indonesian islands. The average daily solar energy received on a horizontal surface (GHI) in Lombok vary from 3.3 to 5.6 kWh/m^2, the lowest being on the volcano Rinjani, and the highest being on the South and East coast and the most Northern coast of Lombok.

Utilisation: We assume that the modules of the solar PV plant will be installed with a fixed tilt of 10° and a DC/AC ratio of 1.1. A DC/AC ratio larger than one means that the PV array's DC rating is higher than the inverter's AC rating. This increases inverter utilisation, although it also results in some PV energy curtailment during the sunniest periods when PV output exceeds the inverter's capacity. The prices of PV modules have dropped more rapidly than the prices of the inverters, therefore many developers have found it economically advantageous to oversize their PV module surface. The additional harvest in the off-peak period more than offsets the losses from the curtailment. This design results in 1800 full load hours at the chosen site.

Solar PV daily power generation



Solar potential in Lombok and current PV systems



Source: DESDM NTB; ADB; ESMAP SolarGIS; World Bank Group (ESMAP); KPMG analysis.

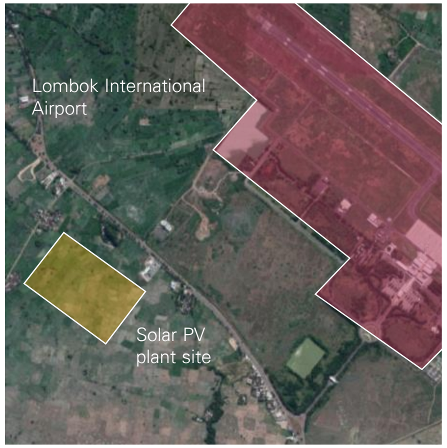
There can be challenges for integrating large-scale solar PV, which limit the size to 20 MW

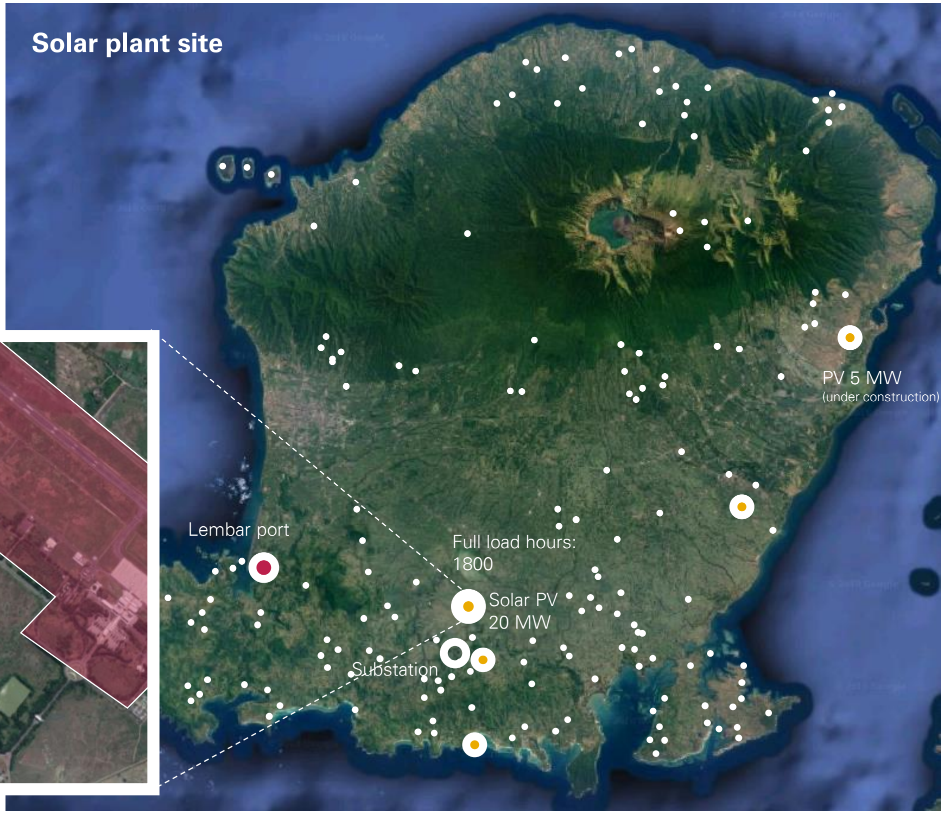
Current large scale PV plants: There are currently four 5 MW solar PV plants being constructed (COD 2019), from North to South, at Pringgabay, Selong, Sengkol, and Kuta. The three first-mentioned plants are developed by Vena Energy (formerly Equis Energy) and the last one is developed by German Ib Vogt.

Experience with smaller systems: In the period 2007 to 2015, ESDM and PLN established 38 off-grid PV systems in villages in Lombok. The sizes varied from 5 to 30 kW. Some of these villages have since been connected to the main grid. On the islands of Gili Trawangan, Gili Meno and Gili Air, larger PV systems have been installed, with sizes of 600 kW, 60 kW and 160 kW, respectively. These islands are also connected to the mainland with a 20 kV connection. Additionally, there exist more than 100 residential PV systems across Lombok. The use and integration of PV systems is therefore well known; however, large-scale PV plants are new.

Capacity: In the current system, fluctuating power generation can be a challenge for PLN. Based on conversations with PLN NTB, the capacity is limited to 20 MW. This is the same as the total large-scale PV capacity being commissioned in 2019 which should provide PLN with guidance on the ability of the grid to accept this size of variable resource.

Location*: The most suitable land to acquire for solar PV plants is rice fields, which are relatively flat, and also assessed to be possible to purchase to less on a long-term basis. A potential site is assessed to be suitable just south of Lombok International Airport. The site will cover an area of 20-30 ha. The site is chosen due to the substation location at Sengkol, just south of the airport - a substation which has just been extended in 2018. It is assessed to be technically feasible, since in the same area a 5 MW solar PV plant is being commissioned.





• Village (5-30 kW) and residential (~1 kW) PV systems. The Gili islands have 60-600 kW.

Source: NEC technology catalogue; NREL PV benchmark; KPMG analysis

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**The sites have been located using satellite photos, and comparing these with maps of land cover. It has not been examined if the land actually can be acquired or if there exist unknown restrictions on the use of the land.*

Total CAPEX of the 20 MW solar PV plant is estimated at USD 20-30m – and OPEX to be USD 0.4-0.6m p.a.

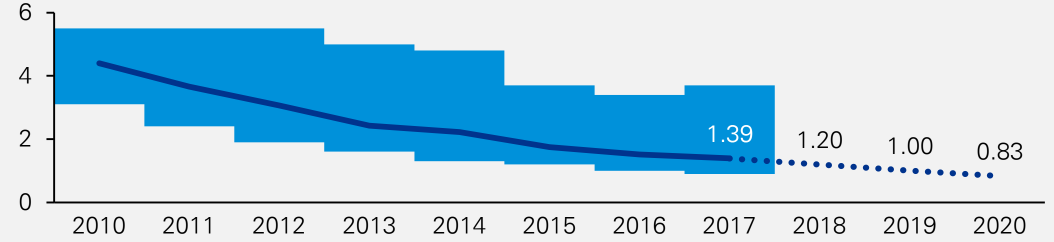
CAPEX: The cost of a large scale utility solar PV plant is around 2.0m USD/MW according to an ASEAN project study (2016) on PV plants (1-20 MW) in Indonesia, Malaysia, Vietnam and Thailand. This is significantly higher than the Indonesian Technology Catalogue, which projects the price to be 0.83 USD/MW by 2020. The main reason is that the cost of solar PV panels has decreased and continues to decrease rapidly. NREL states that the cost of solar PV plants in competitive markets is currently around 0.9-1.1m USD/MW and the global average is 1.39m USD/MW (2017).

For the 20 MW solar PV plant, total CAPEX is estimated at USD 20-30m – or 1.0-1.5m USD/MW.

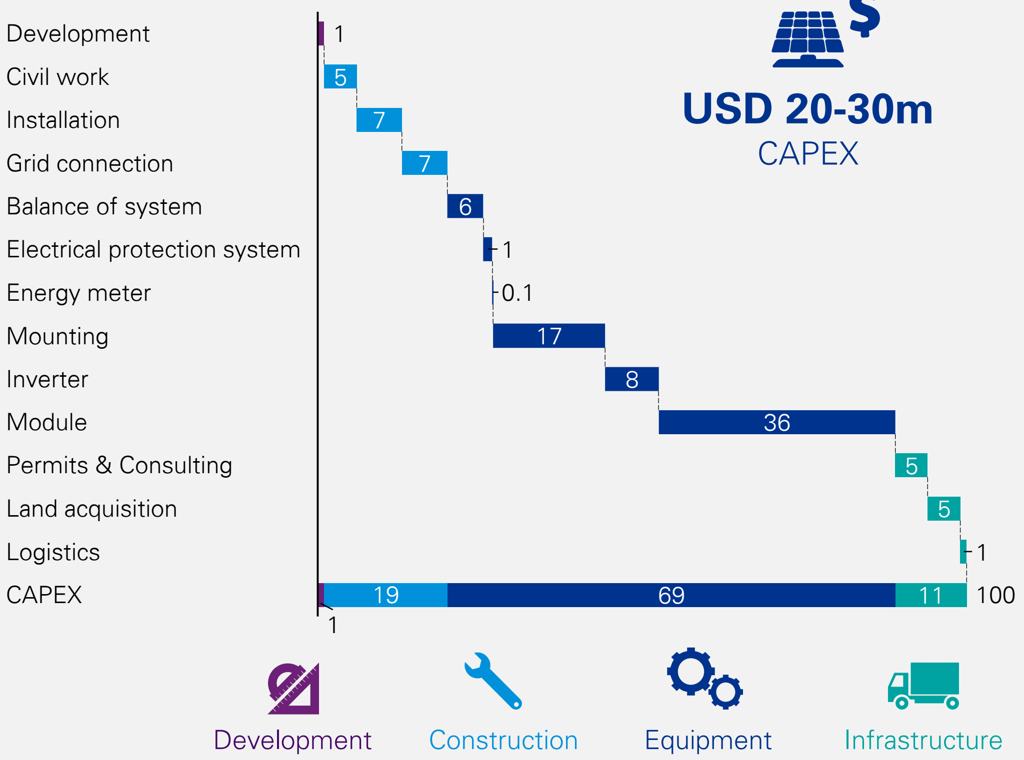
The element of economy of scale is also important. From NREL this is found to be 87%, i.e. that for each 100% increase in size (doubling) the total cost will increase by 87%.

OPEX: The OPEX is found by both NREL, ASEAN and listed in the Technology Catalogue to be around 2% of CAPEX – i.e. USD 0.4-0.6m p.a.

Development of total cost of PV and market spread (USDm/MW)



CAPEX breakdown (%)



Source: NREL PV benchmark; NEC technology catalogue; ASEAN LCOE analysis; KPMG analysis

Assumptions of the financial cash-flow model for the 20 MW solar PV power plant

Capacity	20 MW
Expected tariff	11.8 US¢/kWh (fixed USD-rate)
Payment currency	All payments are in IDR
WACC	10%
Tax & depreciation	25% (16 years depreciation period)
CAPEX	USD 20-30m
OPEX	USD 0.4-0.6m p.a. (2% of CAPEX)

Fuel cost#	-
Heating value	-
Efficiency	-
Availability	98%
Load factor	20% (1800 full load hours)
Technical lifetime	25 years
Abandonment+	USD 0m

 # No fuel cost on solar.
+ The net cost for abandonment is assumed to be zero. Equipment can be sold for reuse.

Source: NEC technology catalogue; DESDM NBT; NREAL PV benchmark; ASEAN LCOE report; ESMAP SolarGIS; KPMG analysis.

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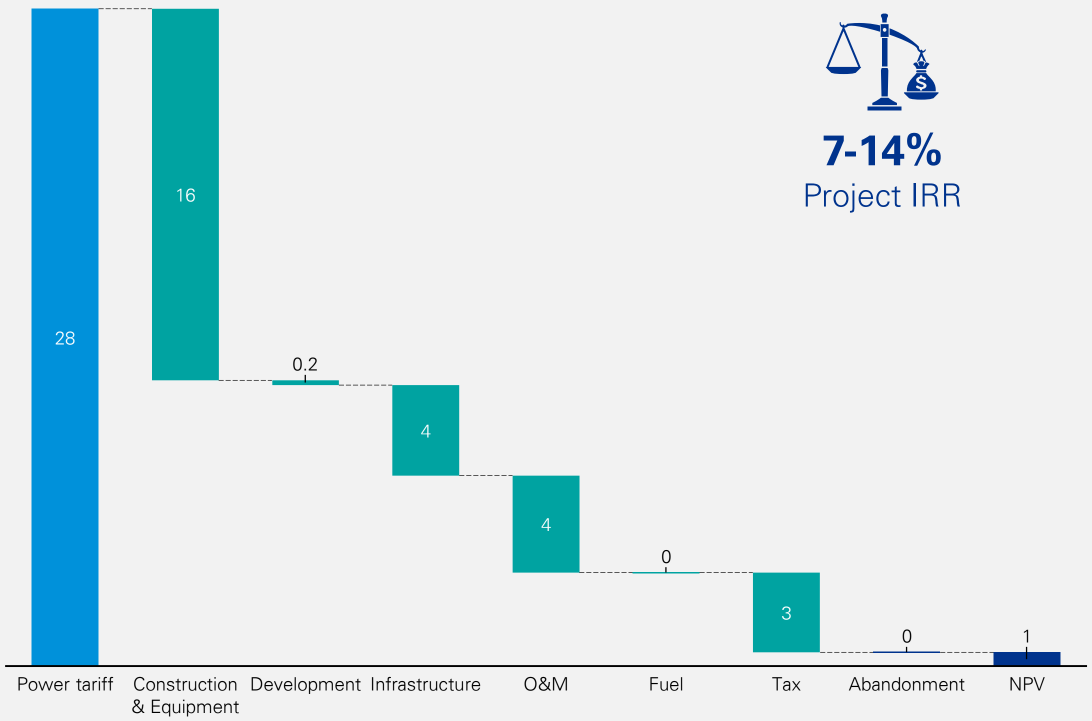
The solar PV plant provides a project IRR of 7-14%, with CAPEX being the major driver

Result: The cash-flow calculation of the solar PV case results in a project IRR of 8-14%, where the higher IRR value is the lower CAPEX and OPEX, and vice-versa. For an estimated CAPEX of USD 50m and a WACC of 10%, the calculations result in an NPV of USD 20m.

Sensitivity: Besides the CAPEX, one of the main elements in the cash flow is tariff revenue, which directly depends on the load factor of the solar PV plant. Lowering the full load hours to 1,600 will result in a project IRR of 7-12%.

Assessed project IRR: The overall project IRR range is estimated to be 7-14%, which indicate a possible positive investment, if the developer can optimise the CAPEX and utilisation of the PV plant. Key risks of the IRR are evaluated on the next slide.

NPV breakdown of central guess (USDm)*



** Applied CAPEX of USD 25m and WACC of 10%.*

Source: NEC technology catalogue; DESDM NTB; NREAL PV benchmark; ASEAN LCOE report; ESMAP SolarGIS; KPMG analysis.

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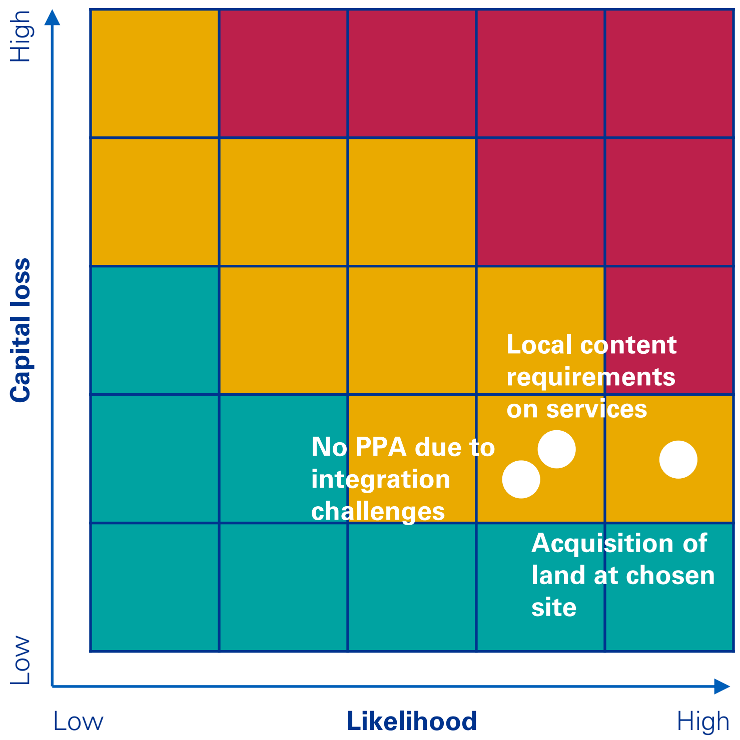
Overall project risk assessment indicate low risk for the solar PV plant - all risks can be covered in early stages

Risk	Risk description	Action
No PPA due to integration challenges	PLN has challenges with grid stability, and therefore has some hesitation with regard to integrating too much fluctuating power generation. If a PPA can not be agreed upon, it would happen before construction, so capital should be limited to development costs.	Go into dialogue with PLN in the early stage of the feasibility study to lower the likelihood of rejection of the project during due diligence. Consider the potential for integrating storage into the PV site.
Local content requirements on services	Solar PV has local content requirements in the construction period of 100% on cost of services. A developer is thereby required to use locals for consultancy and EPC. Indonesia has successfully commissioned other PV plants, so the capital loss of this is assessed to be low.	Hire a knowledgeable local EPC to diversify some of the risk. Manage the construction carefully and on-site to decrease the risk. Consider developing in combination with a strong local partner to help source local content.
Acquisition of land at chosen site	The chosen location covers approximately 100 rice fields owned by an unknown amount of farmers. Numerous purchase/lease agreements will need to be made with farmers. Farmers may try to raise land prices in knowledge of the development or may be unwilling to give up ancestral lands.	Land acquisition is a common problem in Indonesia and can take considerable time. In the feasibility stage, hire a local broker to screen the area and go into a dialogue with the farmers to lower the likelihood of the risk. Different sites can be sourced and issues will arise pre-construction limiting capital losses but this may create significant delays, increasing capital costs and time between development expenditure and revenue collection.

Risk matrix



Source: DESDM NTB; Local rice hellers; Presidential Reg. No. 44/ 2016, No. 35/ 2018, BKPM, Ministry of Industry Reg. No. 54 of 2012, and No. 5 of 2017, Baker McKenzie; KPMG analysis.

Prefeasibility studies on green power generation

Wind power plant

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Low wind speed turbines designed for the conditions result in 3000 full load hours - the capacity is selected to be 50 MW

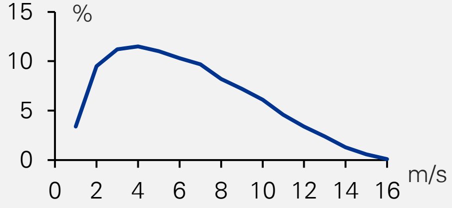
Wind resources: The average wind speeds in Lombok are low. In the South, the average wind speed barely reaches 6 m/s and moving North to Rinjani, the average wind speeds are only 2 m/s. These low wind speeds call for wind turbines designed for these conditions. The Vestas V150-4.2 MW is an example of this. Its long blades (74 m) and large sweep area of 17,670 m^2 make it possible to utilise energy in low wind conditions. Other manufactures have similar low speed turbines – such as the Siemens Gamesa SG 4.5-155.

Location*: The sub-district of Jerowaru is chosen for the site analysed as this location has some of the highest wind speeds in Lombok, and the land covers are mostly dry land agriculture, which are assumed to be acquirable. The land covered is around 100 ha (~1 km^2); however, most of the land can still be used for agriculture purposes.

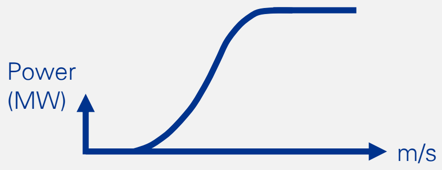
Utilisation: An analysis of the power curve from a V150-4.2 MW turbine and the distribution of wind speeds at a chosen site, results in 3000 full load hours.

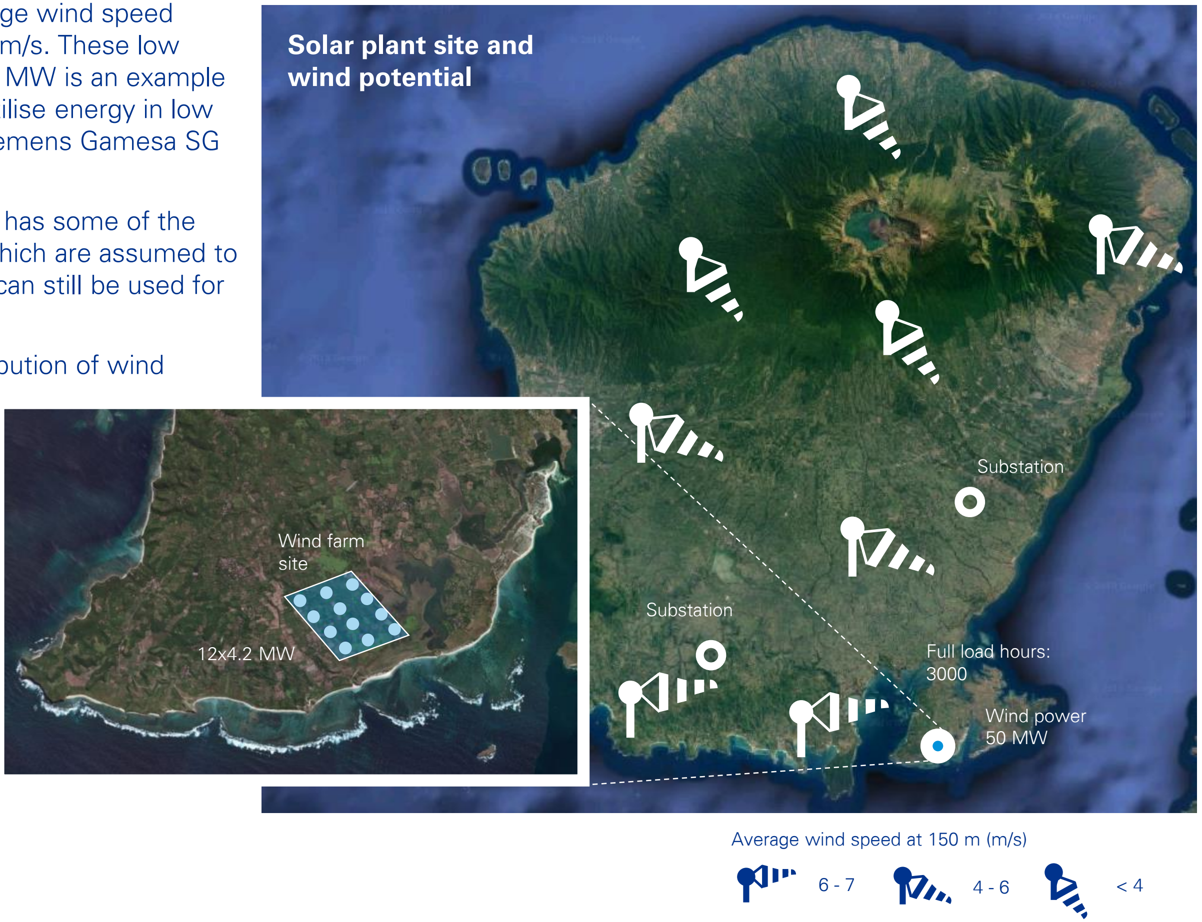
Capacity: Fluctuating power generation can in the current system be a challenge for PLN. However, economy of scale calls for higher capacity. A capacity of 50 MW is assessed to provide the best balance..

Distribution (%) of wind speeds (m/s)



Low wind speed turbine power curve





Source: Vestas; WindProspect; DEA; KPMG analysis.

*The sites have been located using satellite photos, and comparing these with maps of land cover. It has not been examined if the land actually can be acquired or if there exist unknown restrictions on the use of the land.

Total CAPEX of the 50 MW wind power plant is estimated at USD 75-100m – and OPEX to be USD 3-4m p.a.

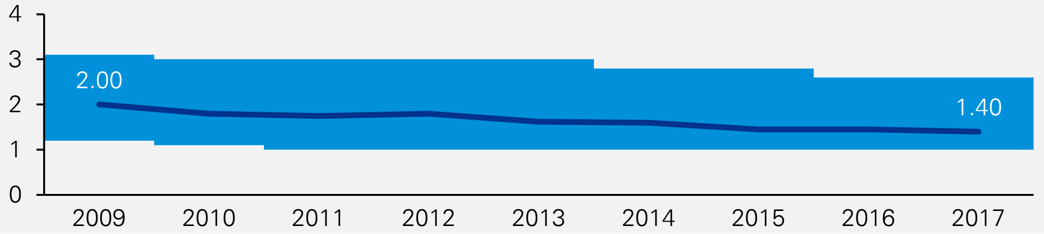
CAPEX: In Indonesia, the first large scale onshore wind farm is the 75 MW in Sidrap, South Sulawesi, which was inaugurated in July 2018. The Sidrap Wind Farm consists of 30 Gamesa 2.5 MW (G114/2500) turbines and had a total cost of USD 150m – or 2.0m USD/MW. This is significantly higher than the market average of 1.4m USD/MW – which is normal for the technology when entering a new market – and it is estimated that the cost will decrease for future projects. The Technology Catalogue lists a cost of 1.5m USD/MW by 2020.

The cost of large onshore wind turbines has decreased significantly over the years. Vestas average cost of a wind turbine has dropped from 1.75m USD/MW in 2010/2011 to around 1.0m USD/MW in 2017. One of the reasons is the economy of scale, hence wind farms are getting bigger.

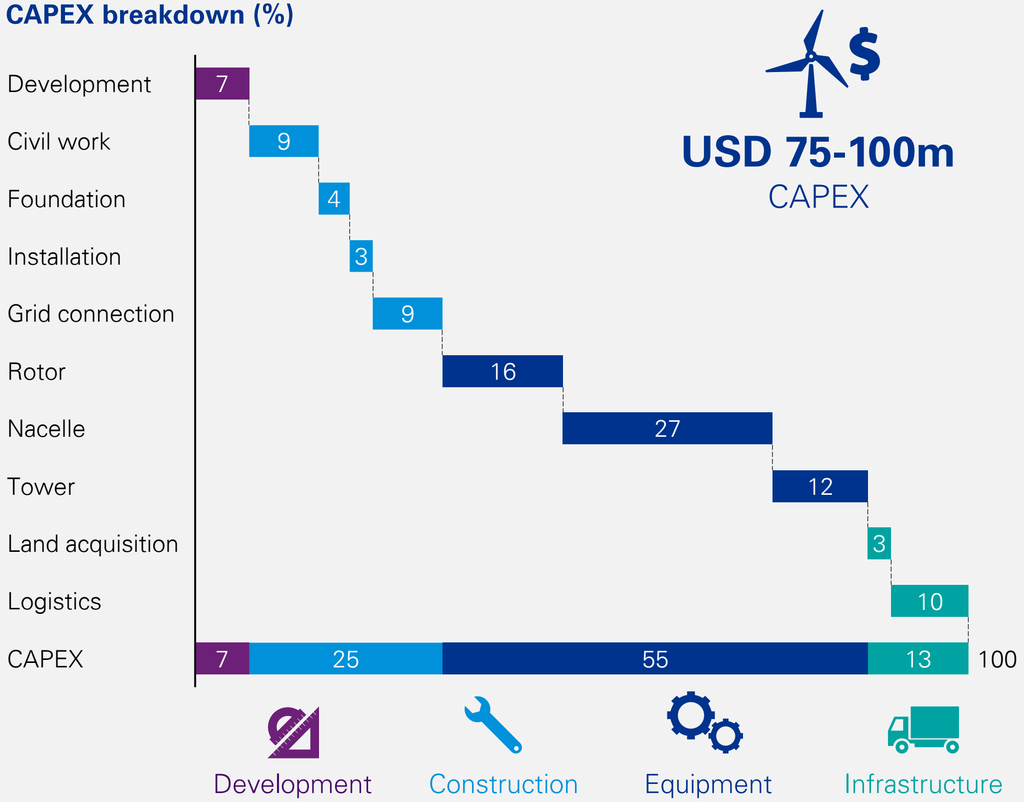
The wind turbine assessed is a low wind speed turbine which is expected to have a higher price than the average turbine, but instead has a higher utilisation. The cost for this study is estimated to be 1.5-2.0m USD/MW – i.e., USD 75-100m.

OPEX: The OPEX cost is from the Technology Catalogue and NREL cost of wind power found to be around 4% of CAPEX – i.e. USD 3-4m.

Global weighted average cost and market spread (USDm/MW)



CAPEX breakdown (%)



Source: Vestas; WindProspect; DEA; FCN & E.ON Research Center; IRENA power cost; NREL; NEC technology catalogue; Jakarta Post; KPMG analysis

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Assumptions of the financial cash-flow model for the 50 MW wind power plant

Capacity	50 MW
Expected tariff	11.8 US¢/kWh (fixed USD rate)
Payment currency	All payments are in IDR
WACC	10%
Tax & depreciation	25% (16-year depreciation period)
CAPEX	USD 75-100m
OPEX	USD 3-4m p.a. (4% of CAPEX)

Fuel cost#	-
Heating value	-
Efficiency	-
Availability	97%
Load factor	34% (3000 full load hours)
Technical lifetime	25 years
Abandonment+	USD 0m

 # No fuel cost on wind.
+ The net cost for abandonment is assumed to be zero. Equipment can be sold for reuse.

Source: FCN & E.ON Research Center; IRENA power cost; NREL; NEC technology catalogue; Jakarta Post; KPMG analysis

The wind power plant provides a project IRR of 7-16% - financial feasibility is most dependent on CAPEX

Result: The cash-flow calculation of the wind power plant results in a project IRR of 8-14%, where the higher IRR value is the lower CAPEX and OPEX, and vice-versa. For an estimated CAPEX of USD 75m and a WACC of 10%, the calculations result in a NPV of USD 5m.

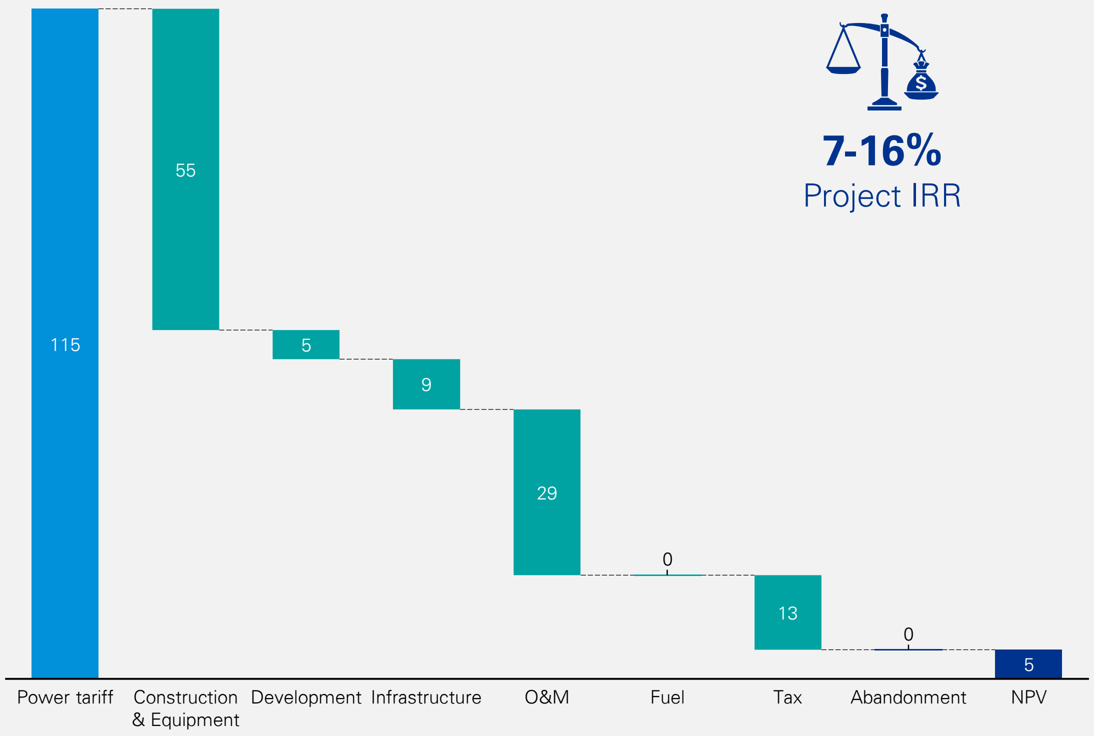
Sensitivity: Besides the CAPEX, the main elements in the cash flow is the O&M cost and of course the tariff revenue.

The OPEX is annually assumed to be 60,000-80,000 USD/MW. According to IRENA, it is in the high end of the price range for full service agreements in Europe (20,000-70,000 USD/MW). Assuming that the OPEX instead is 3% of CAPEX results in an IRR of 10-16%.

The revenue is directly related to full load hours. The relatively high number of full load hours is because the wind turbine designed for these low-speed conditions. Wind turbines that are not design for this, would have significantly lower amount of full load hours. Lowering the full load hours to 2,700 results in a project IRR of 7-12%.

Assessed project IRR: The overall project IRR range is estimated to be 7-16%, which indicate a possible positive investment, if the developer can build a low wind speed turbine with high utilisation at a competitive CAPEX and OPEX. Key risks to the project IRR are evaluated on the next slide.

NPV breakdown of central guess (USDm)*



** Applied CAPEX of USD 75m and WACC of 10%.*

Source: Vestas; WindProspect; DEA; FCN & E.ON Research Center; IRENA power cost; NREL; NEC technology catalogue; Jakarta Post; KPMG analysis

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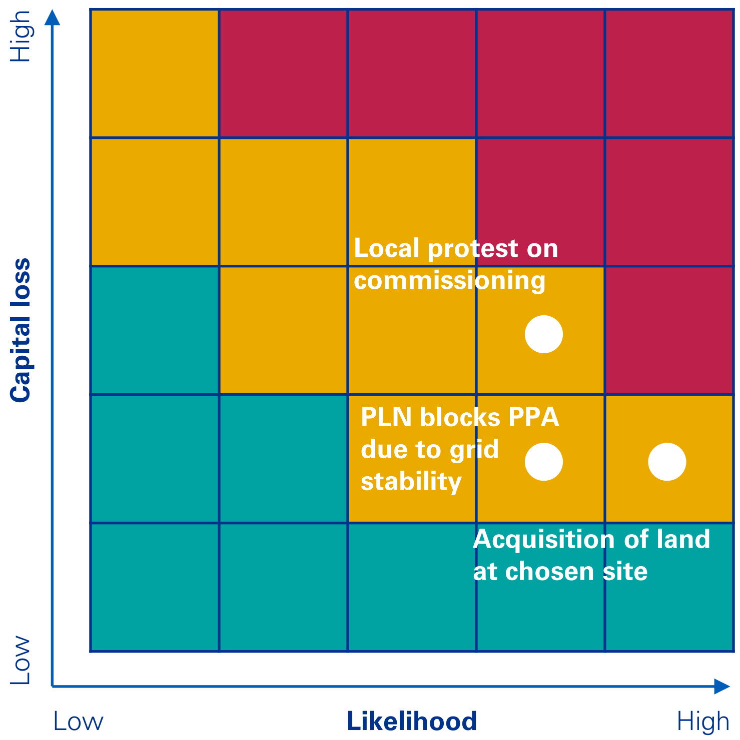
Managing the construction period to keep CAPEX low is essential for the project feasibility

Risk	Risk description	Action
No PPA due to integration challenges	PLN has challenges with grid stability, and therefore has some hesitation with regard to integrating too much fluctuating power generation. If a PPA can not be agreed upon, it would happen before construction, so capital loss is limited.	Go into dialogue with PLN in the early stage of the feasibility study to lower the likelihood. Solutions for integration is storage, flexible plants, and strengthened grid – including interconnectors.
Local protest on commissioning	The wind turbines are 150 m high, and have a visual impact that might lead to local protest – for example from hotels. Since the tourist sector is important to Lombok's GDP, this could block the project.	Go into dialogue with the neighbours and the tourist stakeholders in the area. Do this in the very early stage to minimise both the likelihood of the risk and its consequences.
Acquisition of land at chosen site	The wind farm covers an area of 100 ha. Most of the area can still be used for agricultural purposes. Numerous purchase/lease agreements will need to be made with farmers. Farmers may try to raise land prices in knowledge of the development or may be unwilling to give up ancestral lands.	As noted as part of the solar risk analysis, land acquisition is a common problem in Indonesia and can take considerable time. In the feasibility stage, hire a local broker to screen the area and go into a dialogue with the farmers to lower the likelihood of the risk. It may be easier for a wind plant to manage land acquisition at a specific site than for solar as land close to the turbines can still be farmed. However, there are fewer sites with the requisite wind speeds and so alternative sites may be harder to source.

Risk matrix



Source: DESDM NTB; Presidential Reg. No. 44/ 2016, No. 35/ 2018, BKPM, Ministry of Industry Reg. No. 54 of 2012, and No. 5 of 2017, Baker McKenzie

Prefeasibility studies on green power generation

Waste incineration

EMBASSY OF DENMARK
Jakarta

Danish Energy Agency

KPMG picture

Lombok has a huge and growing waste problem with a daily estimation of 1900 tons ending up in the ocean

Lombok's waste generation: Lombok is facing a huge environmental challenge with regard to waste handling. Each year, an estimated 900,000 tons of waste is generated by industry and households (0.7 kg waste/person/day). Of this, roughly 200,000 tons is collected and transported to one of the four landfills in Lombok. The other 700,000 tons ends up in the ocean, on beaches, in forests or are burned locally in the villages. The generated amount of waste is expected to grow with the population to 1,000,000 tons annually by 2030.

Waste ends up in the ocean: In November 2018, a dead sperm whale washed ashore in the National Park of Wakatobi close to South East Sulawesi. Researchers from WWF and the park's conservation academy found approximately 6 kg of plastic waste in the animal's stomach containing 115 plastic cups, four plastic bottles, 25 plastic bags, two flip-flops, a nylon sack and more than 1,000 other assorted pieces of plastic. Similarly, a group of scientists collected and analysed fish from the markets and local fishermen in South Sulawesi over four months in 2014. They found that 28% of all fish contained plastic debris.

Tourist industry: The uncollected waste is also a challenge for the tourist sector. The tourist sector contributes to the generation of waste, but is also highly impacted by it – for example waste floating up on the beaches at the hotels. The tourist sector is after the agriculture sector one of the most important sectors in Lombok by GDP.

"Villagers get angry if we dump our garbage on their land up from the beach. I have no place to bury it, so I dump it here – I have too much to burn. The government gave us a bin, but they don't empty it much and the hotel fills it."

Local Fisherman in Lombok
Inside Indonesia

"From a tourist's perspective, waste management is a local issue. Tourism has contributed to the mounting trash problem, but in the end, it is [poor] local waste management that has caused the trash to end up on the beach."

Rima Agustina
Coordinator, Trash Hero
The Jakarta Post

"The result is a little bit improved… but I am angry, I am sad, I am trying to think how best to solve this... the most difficult thing is the people's attitude and the political will."

Dr Anang Sudarna
West Java Environmental Protection Agency
BBC

"I think it's disgusting. We've just arrived last night, and we're absolutely appalled by the rubbish on the beach."

Australian tourist in Bali
ABC News


Mataram city


Kebon Kongok landfill


Senggigi beach
KPMG pictures

Source: DLHK NTB; The Guardian; Inside Indonesia; Jakarta Post; BBC; ABC News; KPMG analysis.

The urgent need for waste handling in Lombok is assessed to result in a willingness-to-pay for waste treatment

Landfills: There are four landfills in Lombok. The largest landfill Kebon Kongok is a Regional landfill managed by the Provincial government of West Nusa Tenggara, while the three others are managed by the local Regional governments.

Collection: The collection of waste is to a large extent handled locally by the villages or local industries. For example, in some villages, the Head of Village is arranging a collection of waste outside the households – a service for which they pay the local collector around IDR 40,000 per month (any restrictions on quantity are currently unknown).

Kebon Kongok landfill: The largest landfill in Lombok, Kebon Kongok, receives each day more than 300 tons of waste from Mataram and West Lombok. The landfill covers an area of more than 5 ha. It has been in operation since the end of the 90s and is now full. Consequently, the regions and the province urgently need to find a location for a new landfill site. A problem that is almost impossible to solve, since nobody wants a landfill in their backyard. By their assessment, they need to find a new place before the end of 2019.

Cost of landfill operation: The current operation cost of Kebon Kongok is 50,000 IDR/ton (3.3 USD/ton). It is assessed that the willingness-to-pay for the Provincial government is significantly higher than their current cost of 50,000 IDR/ton (3.3 USD/ton). From other waste treatment projects in Indonesia, KPMG has assessed a willingness-to-pay of 150,000-500,000 IDR/ton (10-33 USD/ton).

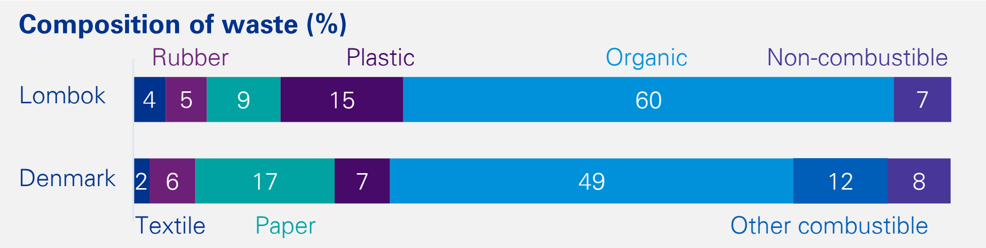
Source: DLHK NTB; DESDM NTB; SNI; KPMG analysis.

Collecting and burning 150,000 tons of waste would fuel a 25 MW plant in West Lombok

Waste for incineration: Establishing a waste incineration plant to generate power to the grid will solve two problems – removal of waste and power supply. The currently collected amount of waste in West Lombok and Mataram is 120,000 tons annually. It is estimated that a large amount of waste is not collected – and the total amount of generated waste is expected to increase. Therefore, an amount of 150,000 tons for power generation is assumed feasible.

Location*: The site is the same as analysed for a possible biomass power plant. They are thereby mutually exclusive on this location. The required area for the power plant is 4 ha, plus an additional area during the construction period (app. 1 ha). The Lembar port and existing roads have been used for receiving, reloading and transporting the equipment for the existing Jeranjang power plant. It is assumed feasible to build.

Capacity: The composition of waste is primarily organic, plastic and paper. The organic waste is both wet and dry. When comparing it to the Danish composition, owe assess the heating value to be is slightly lower. We therefore assume a heating value of 10 GJ/ton. An incineration plant of 25MW is assessed to provide the right capacity to burn the 150,000 tons of waste



Source: DLHK NTB; Danish Environmental Protection Agency; NEC technology catalogue; KPMG analysis.

*The sites have been located using satellite photos, and comparing these with maps of land cover. It has not been examined if the land actually can be acquired or if there exist unknown restrictions on the use of the land.

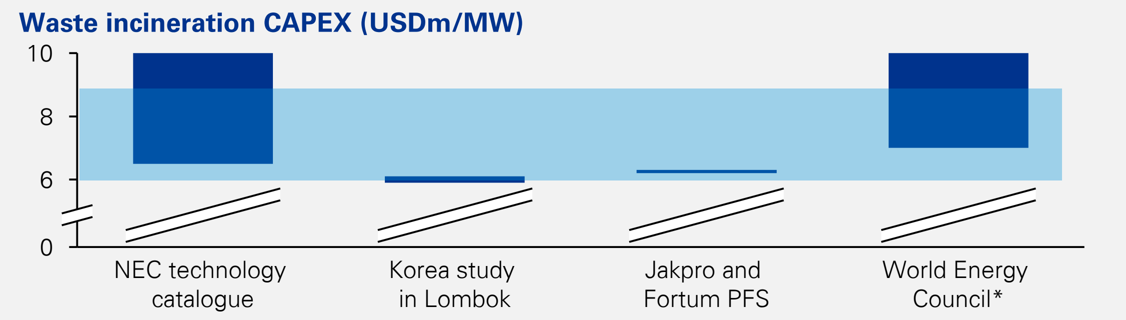
Total CAPEX of the waste incineration plant is estimated at USD 150-225m – and OPEX at USD 7.5-11m

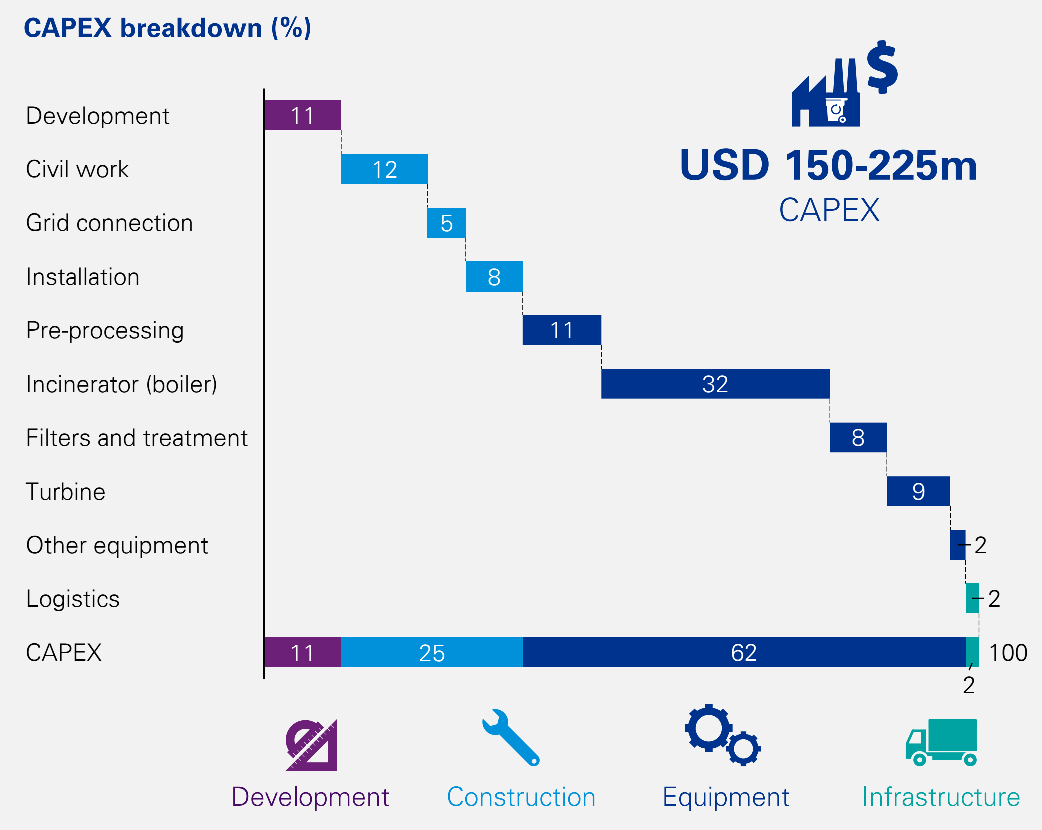
CAPEX: According to the Technology Catalogue, a waste incineration plant with power generation has a cost of 8.7m USD/MW. A South Korean prefeasibility study for Lombok estimated a 10 MW plant at a cost of USD 60m – or 6m USD/MW. Indonesian Jakpro and Finish Fortum planned to build a 40 MW waste incineration plant outside Jakarta at the cost of USD 250m - i.e. 6.25m USD/MW. The World Energy Council lists cost of waste incineration plants in western countries in the range of USD 7-10m.

For the 25 MW waste incineration plant, total CAPEX is assessed to be 6-9m USD/MW or USD 150-225m.

As in the biomass case, we analyse a site located next to the existing power plant Jeranjang. The port of Lembar was used for receiving the equipment for the existing plant, and it is assumed that any additional enforcements of the roads have not been removed. The cost of logistics is therefore estimated to be low.

OPEX: The OPEX cost is from the Technology Catalogue and the South Korean prefeasibility study found to be around 5% of CAPEX – i.e., USD 7.5-11m.





Source: : PT. MGB Hi-Tech Indonesia; Korea Engineering Consultants Corp.; UK Department of Environment; PwC; NEC technology catalogue; KPMG analysis

Assumptions of the financial cash-flow model for the 25 MW waste incineration plant

Capacity	25 MW
Expected tariff	13.9 US¢/kWh (fixed USD rate)
Payment currency	All payments are in IDR
WACC	10%
Tax & depreciation	25% (16-year depreciation period)
CAPEX	USD 150-225m
OPEX	USD 7.5-11m p.a. (5% of CAPEX)

Fuel cost	- 10 USD/ton (gate-fee#)
Heating value	10 GJ/ton
Efficiency	29%
Availability	90%
Load factor	98%
Technical lifetime	25 years
Abandonment+	USD 1.4m

 # The gate-fee is assumed to be the lower value of the willingness-to-pay that KPMG has assessed for other waste treatment projects in Indonesia (150,000-500,000 IDR/ton).
+ After the lifetime of the power plant it need to be scrapped

Source: NEC technology catalogue; DLHK NTB; DESDM NTB; IREAN power cost; NREAL PV benchmark; ASEAN LCOE report; ESMAP SolarGIS; KPMG analysis.

Waste incineration could be feasible, but uncertainty of gate-fee results in a wide range of project IRR from 2-15%

Result: The cash-flow calculation of thewaste incineration plantresults in a project IRR of 3-10%, where the higher IRR value is from the case with lower CAPEX and OPEX, and vice-versa. For an estimated CAPEX of USD 150m (lower range) and a WACC of 10%, the calculations result in a break-even case with a project NPV of 0. For CAPEX higher than the lower range, the results show a negative NPV. The plot to the right shows a CAPEX of USD 210m, resulting in a NPV of -59m.

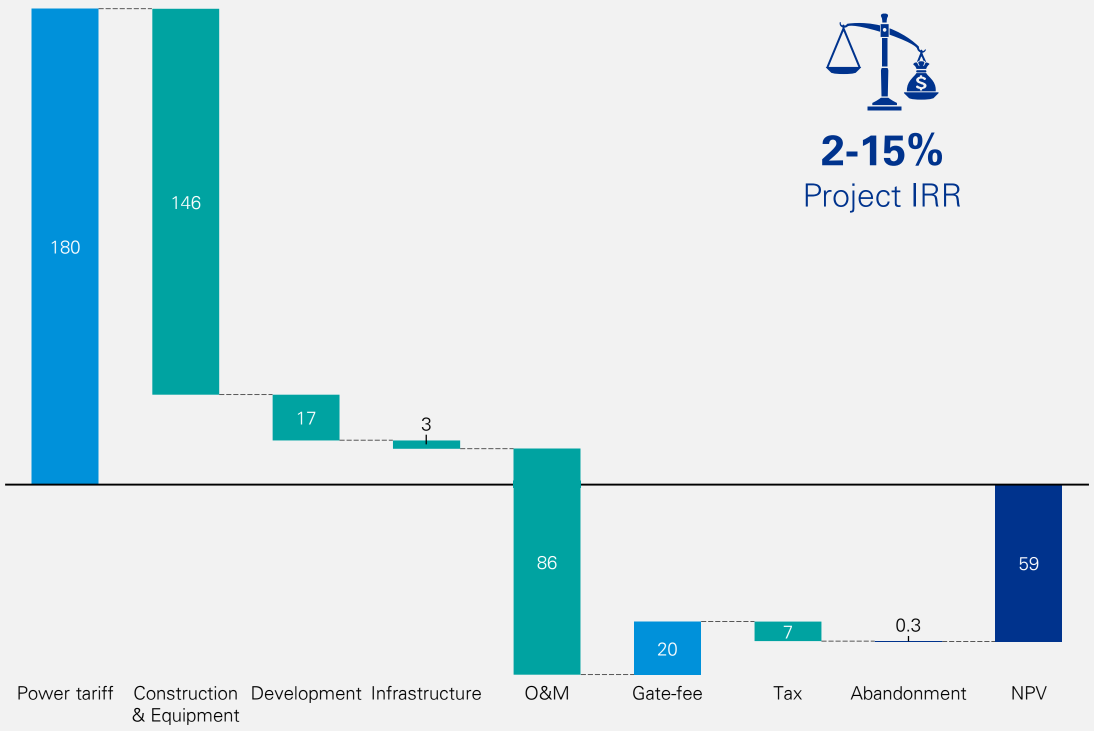
Sensitivity: Besides the CAPEX, the main elements in the cash flow are the O&M cost and the gate-fee.

The gate-fee applied is the lower value of the willingness-to-pay that KPMG has assessed for other waste treatment projects in Indonesia - i.e.150,000 IDR/ton (10 USD/ton). If a higher end of 500,000 IDR/ton was applied, this would result in a project IRR of 9-15%.

If the gate-fee was the same at the current operational cost for the Provincial government, i.e. 50,000 IDR, the project IRR would be 2-9%.

Assessed project IRR: The overall project IRR range is estimated to be 2-15%, with the size of the range driven by uncertainty around CAPEX and gate fee. Key risks to the project IRR are evaluated on the next slide.

NPV breakdown of central guess (USDm)*



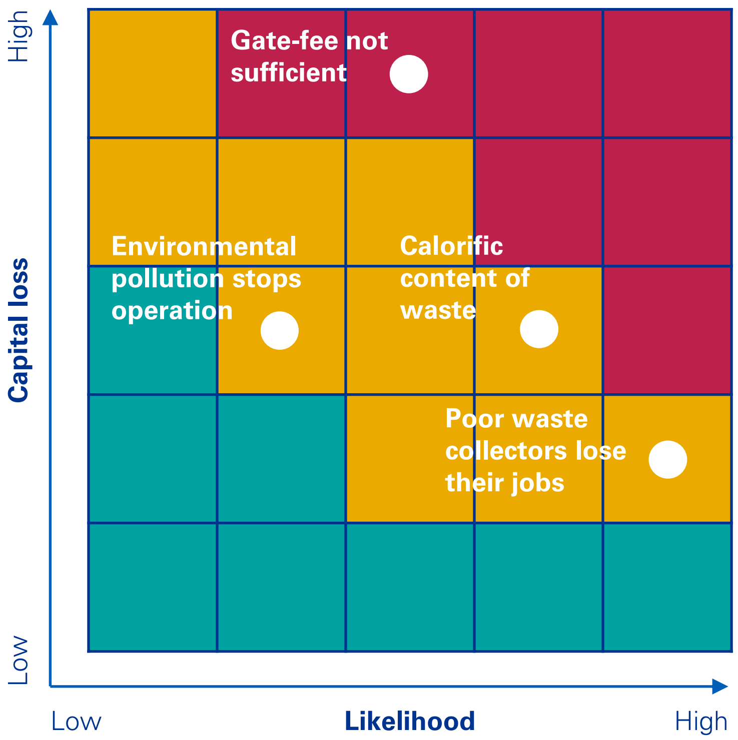
** Applied CAPEX of USD 210m and WACC of 10%.*

Source: DLHK NTB; NEC technology catalogue; PT. MGB Hi-Tech Indonesia; KPMG analysis

Uncertain revenue streams, plus social and environmental challenges, requires for careful planning

Risk	Risk description	Action
Gate-fee not sufficient	A sustainable gate-fee will need to be negotiated with the local government to ensure financial feasibility. Failure to negotiate a gate fee before construction will result in loss of development costs but little additional capital cost. However, if the government renegotiates the gate-fee after commissioning, then the capital loss can substantial.	In the early stages of the feasibility, go into dialogue with the regional and provincial government to agree on the environmental benefit and the level and timeframe of the gate-fee. Look to establish strong guarantees from government and investigate potential for guarantees from other bodies (e.g. multilaterals)
Calorific content of waste	Calorific content of waste may be less than estimated and/or vary over time due to uncertainty in waste composition and the moister content of waste.	Conduct detailed due diligence on the current waste being produced. Seek assurance and guarantee from government that gate fees will be adjusted if calorific value of waste changes significantly
Environmental pollution stops operation	Despite being an attractive option for waste management, in the absence of effective controls in the combustion, harmful pollutants are emitted in the air, land and water and they can influence the environment and human health.	Provide the needed control of the combustion and install filters and other cleaning equipment.
Poor waste collectors lose their jobs	On the landfill, There are around 300 collectors ("scavengers") that collect plastic and paper and sell it. The price is 3000 IDR/kg plastic and 1500 IDR/kg paper. There is a social risk is harming already vulnerable and poor scavengers and the risk that they may create protests that delay the project.	Go into dialogue with local authorities and the scavengers themselves to find out if they can be hired as collectors for the sorting and reuse of waste.

Risk matrix



Source: DLHK NTB; DESDM NTB; DEA; KPMG analysis.

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Integrating renewables - Interconnectors and storage solutions

Challenges with integration of fluctuating renewable generation could be solved with interconnectors or storage solutions

Renewables are non-dispatchable: Renewables are less flexible than traditional technologies – i.e. thermal power plants. Current generation technologies in Lombok are dispatchable. When in need of power, they can be switched on to meet demand and thus have a high degree of flexibility.

Renewable energy sources, however, such as wind and solar power, are inherently non-dispatchable – wind turbines are dependant on actual wind speeds and PV on the sun shining. As the weather has distinct patterns, so does renewable energy capacity – and the pattern does not always match the daily consumption demands.

Waste-to-energy and biomass can be operated as flexibly as traditional power plants.

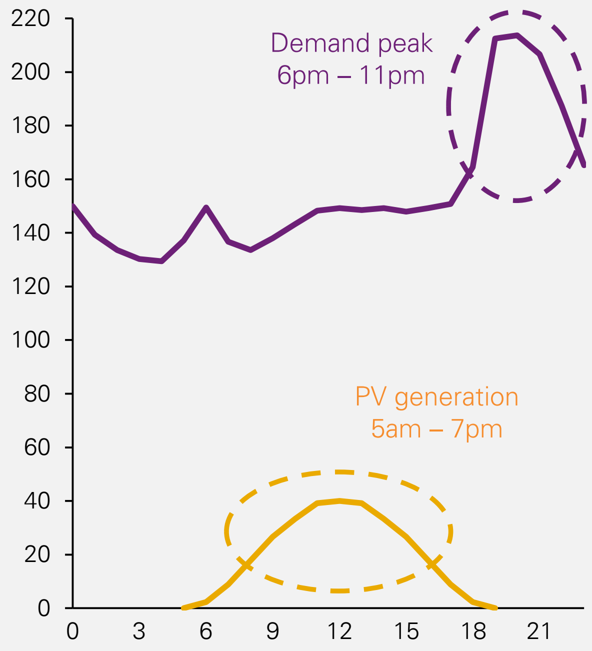
Mismatch in timing between energy supply and demand: Lombok energy demand curve peaks from 6 p.m. to midnight. As solar PV produces power between 5 a.m. and 7 p.m., the technology is largely mismatched to the Lombok consumption pattern. Wind power has a more suitable daily profile, as average capacity is more "flat" throughout the day. Wind power is fully dependent on wind speeds, so in periods without wind there is no production and therefore a risk in security of supply.

Weather forecast can predict wind and solar activity fairly well on an intra-day level. Therefore, it is not necessarily a problem for the grid stability, as long as the thermal capacity can ramp-up very rapidly in the peak hours. However, in the future, if increasing numbers of non-dispatchable energy sources will be integrated into the system, it could challenge the grid stability in an isolated system. Besides the flexibility of power plants, other solutions can be implemented. (i) Strengthening the grid by connecting the system to Indonesia's largest power system, Java-Bali. (ii) Integrating power storage technologies in the system.

Interconnectors provide more flexibility. A stronger grid with interconnectors to the Java-Bali system will increase the dispatchable capacity, and this flexibility can be used for integration of the non-dispatchable generation.

Energy storage bridge differences in timing and increase the security of supply. Energy storage technologies, such as batteries or hydro pump storages, can mitigate timing differences by charging storages during non-peak hours and discharging during peak demand hours. Such technologies also mitigate challenges of periods with lower wind speeds – at least for shorter durations of time.

Daily power profile (MW)



Source: PLN NTB; Pusyantek BPPT; KPMG analysis.

Integrating renewables – Interconnectors and storage solutions

Interconnector to Bali from Lombok

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Interconnection with Bali can provide increased security of supply and reduce power price

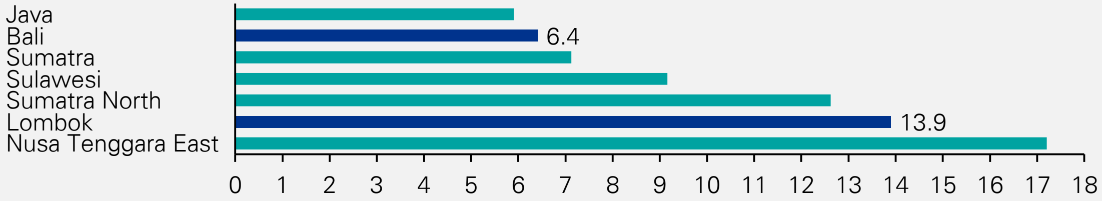
Lowering prices: Lombok has one of the highest power production costs in Indonesia, whereas Bali production cost is less than half of that of Lombok's. Connecting the two islands could lower the power prices in Lombok.

Strengthen the grid: Interconnection will strengthen the power transmission system and increase security of supply by connecting Lombok at the 150 kV level to the Java-Bali transmission grid with a 300 MW connection, allowing access to existing and planned efficient power plants in Java.

Security of supply: Interconnection will contribute to the long-term energy security in Lombok and NTB generally and ensure provision of an adequate and reliable power supply which is vital for economic development activities. The project will also supply reserve margin, so the reserve margin of Lombok would be much higher than 30% when the interconnector is included.

Increased flexibility: Interconnection also increases the system flexibility, which besides increasing the security of supply, also eases the integration of fluctuating renewables. In the future, the project can be extended to other adjacent islands in NTB and NTT (Nusa Tenggara Timur) provinces which have abundant renewable energy resources like wind and solar. Furthermore, Sumatera, Java, Bali and Nusa Tenggara will be interconnected into a single grid system.

Average power generation cost per province* (US¢/kWh)



**Selected Province. Lombok is part of the NTB province. Some provinces are combined if they are part of the same system.*

Source: MEMR; Pusyantek BPPT; KPMG analysis.

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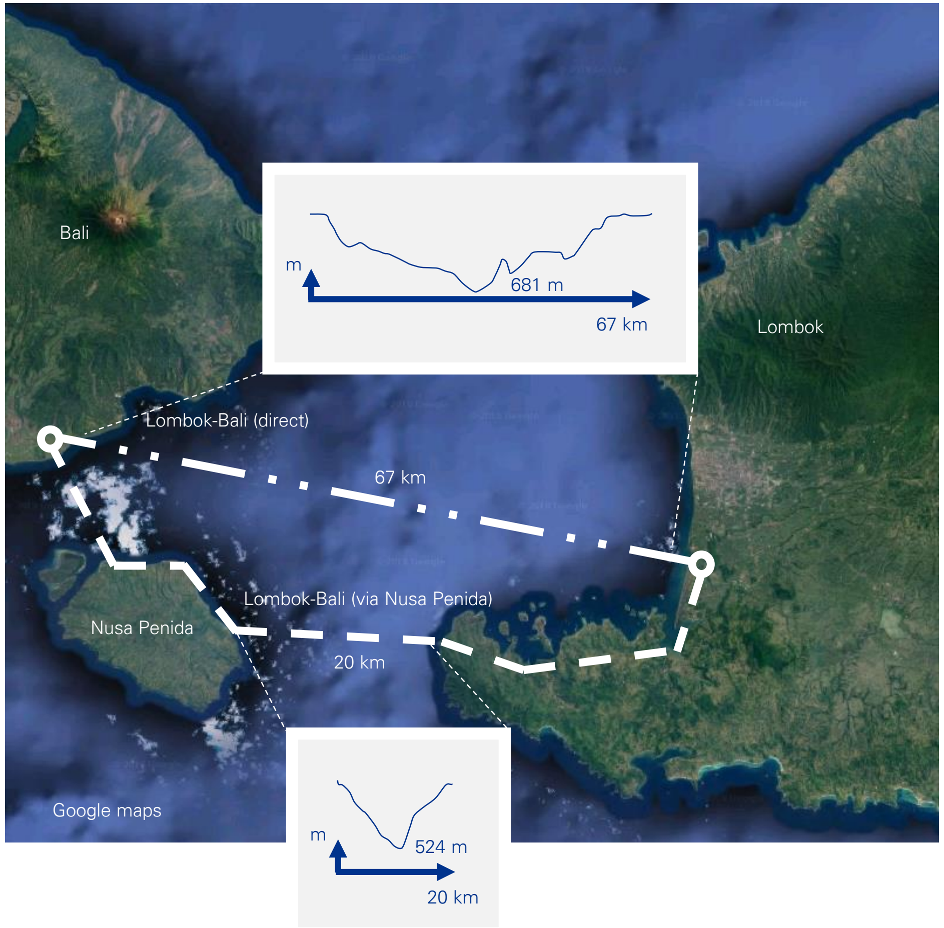
Assessment of the two solutions for the connection

Two solutions: The Lombok-Bali interconnection makes Lombok connected with the large grid of Java-Bali and hence provides a much more stable system. There are two technical solutions each with their pros and cons.

	Lombok-Bali (direct)	Lombok-Bali (via Nusa Penida)
Solution	The pathway of the transmission line will not be crossing Nusa Penida island in order to get the shortest possible total distance. The total line distance of this solution is about 113 km and comprises 46 km overhead line and 67 km submarine cable	The pathway of the transmission line will be crossing Nusa Penida island in order to shorten the distance in submarine cable. The total line distance of this option is about 127 km, consists of 92 km overhead lines and 35 km submarine cable
Pros	▪ Transmitting power over a direct line requires fewer conductors ▪ 30-40% more energy transmission is possible than with conventional overhead lines carrying alternating current	▪ Both HVDC and HVAC can be used ▪ HVDC transmission will make an energy loss of only 0.9% per 100 km of cable as well as a conversion loss of about 1.5%
Cons	▪ Subsea cable is 67 km, which suggests that the HVAC might have a significant loss and only HVDC is possible	▪ The overhead lines on Nusa Penida might impact the residents and environment, and thereby meet local protests



Source: Pusyantek BPPT; KPMG analysis.

The HVDC connection via Nusa Penida is the cheapest solution with a CAPEX of USD 150m-200m

Cost of equipment: The total project cost varies, depending on the route and transmission technology selected. The total cost includes physical and price contingencies, but no financing charges during implementation, and taxes and duties.

Cost of loss: If the cost of losses is taken into account, the total cost of HVDC transmission technology is less expensive than the total cost of HVAC technology for both alternative routes. The HVDC is15-30% cheaper than HVAC. The cost breakdown is shown for the HVDC solutions.

Total cost: The Lombok-Bali (via Nusa Penida) connection is the cheapest solution. The main reason is the savings in the shorter submarine cable, with subsea cabling being significantly (~7 times) more expensive than overhead cabling the additional distance is more than offset by the lower average cost per km. The total cost is 25% lower compared to the Lombok-Bali (direct) solution.

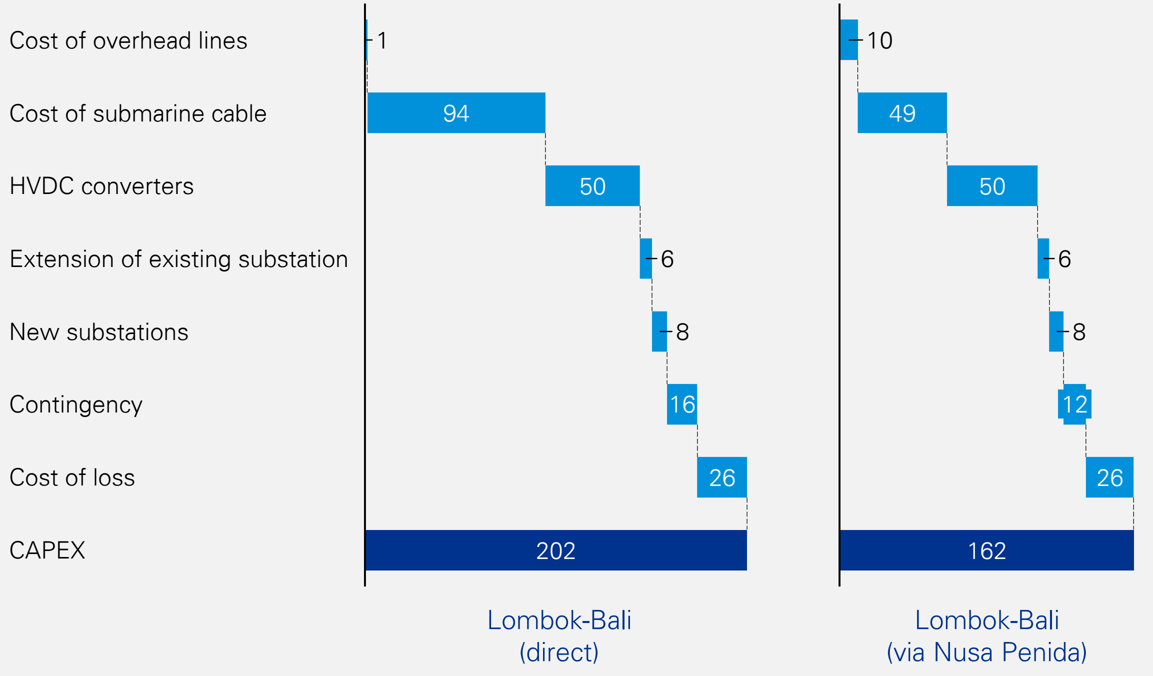
The cost of the interconnector is estimated to be USD 150m-200m.

Total estimated cost of the projects (USDm)*

	Lombok-Bali (direct)	Lombok-Bali (via Nusa Penida)
HVDC	202 (+25%)	162 (0%)
HVAC	257 (+58%)	186 (+15%)

** Numbers in parenthesis show the relative difference to the cheapest solution.*

CAPEX breakdown for HVDC (USDm)



Source: Pusyantek BPPT; KPMG analysis.

Integrating renewables – Interconnectors and storage solutions

Storage solutions – Pumped storage and batteries

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A pumped storage in connection with Pengga lake could generate 100 MW for 2-3 hours covering the peak demand

Pumped storage: Pumped hydro storage is a tried-and-tested technology for energy storage. The possibility of building a pumped storage is highly dependent on geography, the topography and the local environment. The key parameter here is altitude. The pumped storage pumps water up a hill and stores the water in a reservoir where the water has a higher potential energy, the water can then be released and utilised in a turbine in a similar fashion to a conventional hydro plant. Therefore the higher the differential in height between the reservoir and the point from where the water is pumped the greater the amount of energy that can be stored.

Lake Pengga: A possible site could be Lake Pengga. This is a 27 million m^3 dammed reservoir which is used for irrigation of the farmland in the surrounding areas – almost 4000 ha.

In the rainy seasons, the amount of water in Lake Pengga has a level where it also can be utilised in the 400 kW Pengga hydro power plant. In the period from June to October, the water level is too low to be utilised for power generation. The power plant is operated by PLN, but is governed and dispatched by local authorities on Public Work (PUPR) – since the main purpose is irrigation of agricultural land.

Hydro pumped storage: Through satellite photos and typographic data, a site southwest of the hydro plant has been assessed as a possible site for an upper reservoir. Building a dam of 200-300 m will provide a reservoir of roughly 1.5-2.0 million m^3. This upper reservoir will be 85-115 m above the level of Pengga lake.

Capacity: A capacity of 100 MW for the turbine is estimated to be a suitable size for the system, based on the increase in demand during the evening peak from 150 MW to 220 MW (70 MW) within an hour. The effective volume of the reservoir – i.e. the water that will be used as storage – is assumed to be 50% or 0.75-1.0 million m^3. The average elevation is 100 m, yielding a potential energy of a 200-300 MWh – 2-3 hours storage of 100 MW.

Source: Galvan-Lopez; PLN NTB; DLHK NTB; DEA; KPMG analysis.

The pumped storage is estimated to cost USD 100-120m There could be environmental and social considerations

Cost of pumped storage: Pumped hydro storage is a well-understood and proven technology with decades of operating experience. Due to this maturity, only slight improvements in cost structure or transformation efficiency can be expected during the coming years.

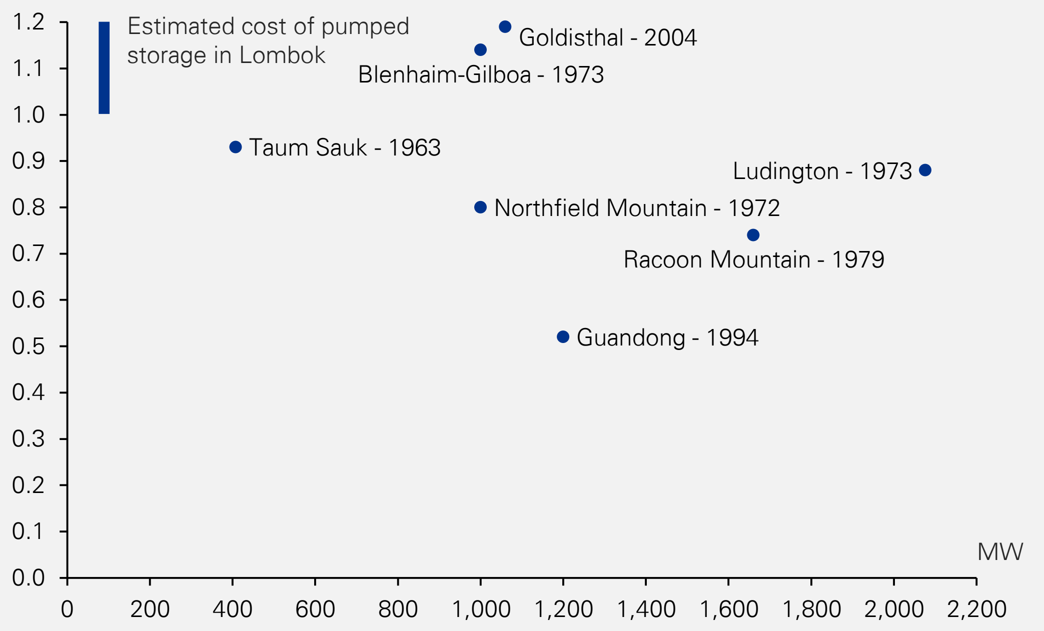
The cost of constructing a pumped storage highly depend on geography, the topography and the local environment. The cost of pumped storage projects vary from 0.5-1.2m USD/MW.

There is an economy of scale in these projects, so the 100 MW might be in the high end of this range (1-1.2m USD/MW), however the cost is very site-specific. This results in a total cost of USD 100-120m

Lifetime of a pumped storage: The technical lifetime of a pumped storage is 40-100 year, due to the very simple setup of a dam, pump, pipes and turbine. The pump, pipes and turbine need to be replaced during the lifetime.

Considerations: The upper reservoir covers 40 ha whose present use is unknown. There might be people living in this area, who will have to relocate. This will come at a high social cost. The typography has only been analysed as a desktop study, and all aspects have not been considered. The environment might also be sensitive in these areas for major changes. It is therefore impossible to clarify if this solution is technical, environmental and socially feasible without significant further study that is outside of the scope of this report.

Reference Projects (USD/MW)*



** Adjusted to USD 2018 values.*

Source: Alvan-Lopez; Lazard LCOS study; NEC technology catalogue; PLN NTB; KPMG analysis.

Large-scale battery storage solutions have been successfully implemented in Australia

Large-scale battery park: In Australia, Neoen and Tesla were awarded the contract to build the world's largest lithium-ion battery at the Hornsdale wind farm. This 100 MW and 129 MWh battery, known as the 'Hornsdale Power Reserve', was commissioned on 1 December 2017.

The main aim of the project is to stabilise the South Australian electricity grid, facilitate integration of renewable energy in the State and assist in preventing load-shedding events.

To a limited extent, Neoen also strategically sells electricity stored in the battery when demand is high (e.g. at midday or during the evening) after having purchased electricity at times of low demand (e.g. at night). This provides an avenue to productively deploy available battery capacity when the battery is not required for grid stabilisation.

Cost of large-scale battery park: The cost of the Australian battery park was USD 63 – or a specific cost of 0.63 MW. The service agreement is 15 years, but the park will likely have a longer technical lifetime, if properly maintained.

Large-scale batteries in Lombok: In Lombok, a battery could effectively flatten the load curve, increase demand in times of low demand and 'shave' peak load, potentially reducing the need for additional capacity to meet peak demand.

Source: The Guardian; KPMG analysis.

Hornsdale Wind Farm with battery

Jay Weatherill picture

Hornsdale Battery Park

Location: Hornsdale Wind Farm near Adelaide, South Australia. The Hornsdale Power Reserve site has an area of approximately 2 hectares, but the battery takes up less than a hectare.

Power load:	100 MW	Specific investment: 630 USD/kW or 488 USD/kWh
Capacity:	129 MWh	
Capital cost:	USD 63m	
Lifetime:	15-year warranty	
Construction timeline:	5 months	

The interconnector is assessed most fit-for-future – the batteries are the solutions assessed to be most fit-for-purpose

	Interconnector Lombok-Bali	Hydro pumped storage	Battery large scale
Investment	Higher initial CAPEX USD 150-200m for 300 MW Lifetime of 50-100 years	Higher initial CAPEX USD 100-120m for 100 MW Lifetime of 50-100 years	Lower initial CAPEX USD 70-100m for 100 MW Lifetime of 15-20 years
Functionality	High total capacity Delivers grid stabilising services	High total capacity Delivers grid stabilising services	Lower capacity Deliver limited stabilising services
Development	7-10 years	5-7 years	~ 1 year
Simplicity	Mature technology with low O&M costs Big construction	Mature technology with low O&M costs Big construction	Simple technology with low O&M costs Smaller construction
Social and environmental impact	Might have environmental impact on the sea. There is a risk that the overhead lines on Nusa Penida will impact locals.	Extensive environmental impact from damming the upper reservoir. People might have to relocate.	Only significant impacts / considerations relate to production of the batteries and the disposal after operational lifetime.
Fit-for-purpose/ Fit-for-future	Very relevant technology for the future. Will strengthen the grid, provide flexibility, lower prices and provide security of supply.	Relevant technology for purpose but with significant environmental impact. It should also be considered if the technology will be outdated during asset lifetime.	Very relevant technology for purpose. In case of an urgent problem, batteries can be quickly constructed.

Source: KPMG analysis


Google maps

4

Off-grid system on the island of Medang

The Medang island is an isolated off-grid system with only 12 hours of power supply each day

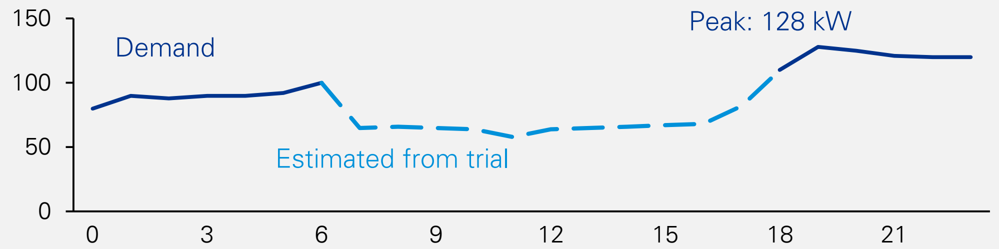
Medang island: The island of Medang is a small island with 4400 inhabitants located 70 km from Lombok. On the island is a single village that basically consists of a 4 km road with houses on each side. To travel there from Lombok you will have to sail to Sumbawa and drive four hours to the North coast, and thereafter sail 30 km to the island. This makes it expensive to transport goods to the island.

Current power supply: The current power supply is from a 395 kW diesel engine, which is placed in the centre of the village and currently operates the 12 hours from sundown to sunset (18.00-06.00). The reason for the few hours of operation is lack of diesel supply and high cost of diesel.

Power demand: The current demand in the 12 hours of operation is 1350 kWh and with a peak at 7 p.m. of 128 kW. PLN arranged a trial primo 2018 to estimate the full-day demand – resulting in a total demand of 2050 kWh.

Test case: Medang is an interesting island to test solutions for an off-grid system. PLN is currently studying a solution of PV/battery hybrid system on the island. A solution that, if found feasible, will be copied to nine other similar off-grid systems.

Daily power profile (kW)



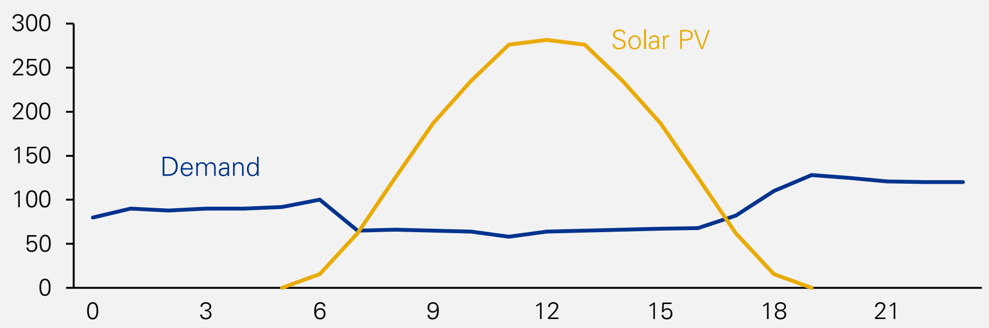
Source: PLN NTB; KPMG analysis

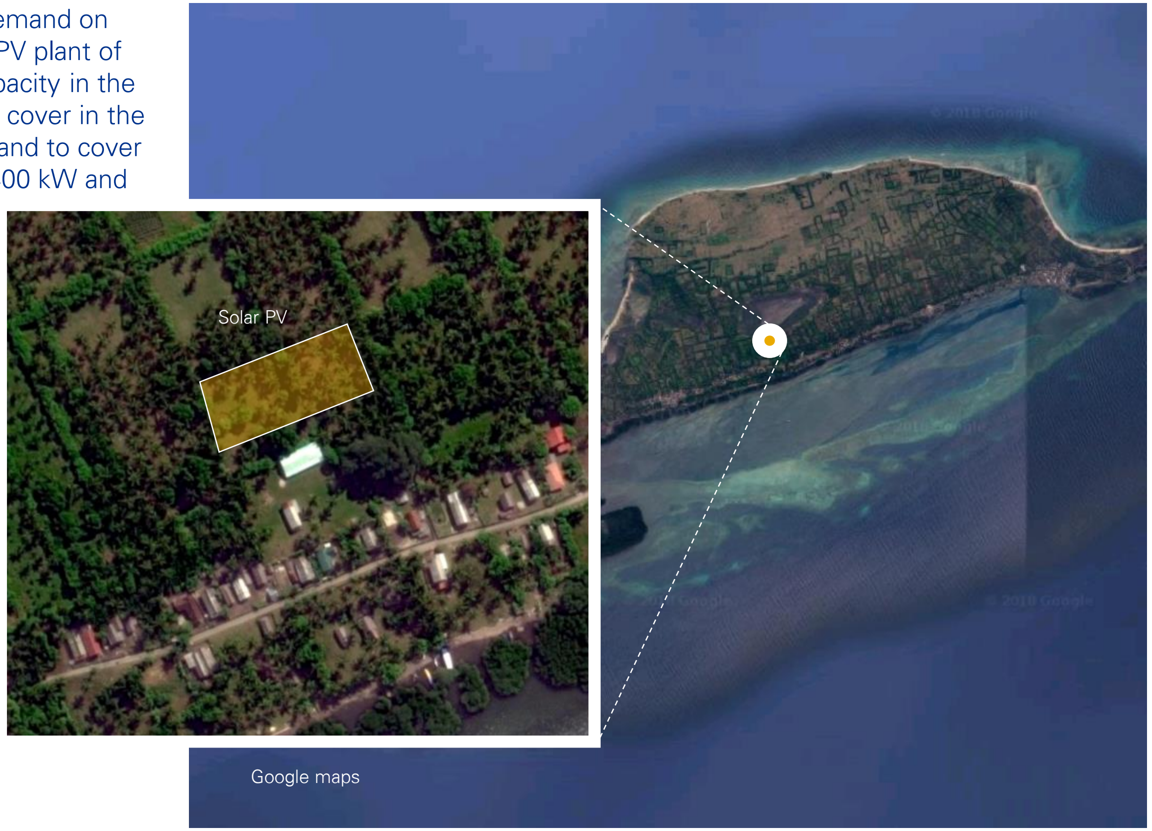
A hybrid system with 400 kW solar PV and 2000 kWh battery could cover the present and future demand on Medang

Solar PV/battery hybrid: A PV/hybrid system should be able to cover the entire power demand on Medang. A simple system analysis of the generation and demand curves results in a solar PV plant of 270 MW – to cover the demand of 2050 kWh (expected demand for 24 hours). The overcapacity in the daytime will be stored on a battery. The size of this should be the amount that PV does not cover in the morning and at night time. This is 1350 kWh. To make it fit for future increases in demand and to cover rainy seasons with less sunshine, we suggest the system to be over-dimensioned to 300-400 kW and 1500-2000 kWh.

Location: The 300-400 kW will cover an area of 0.5-0.7 ha. A suitable location could be north of the village, close to the existing diesel engine. That increases the possibility of an easy connection to the grid.

Daily power profile (kW)





Source: Inovasi, NEC technology catalogue; PLN NTB; KPMG analysis.

A PV/battery hybrid will result in an IRR of 4-8% based on fuel savings alone - additional benefit is security of supply

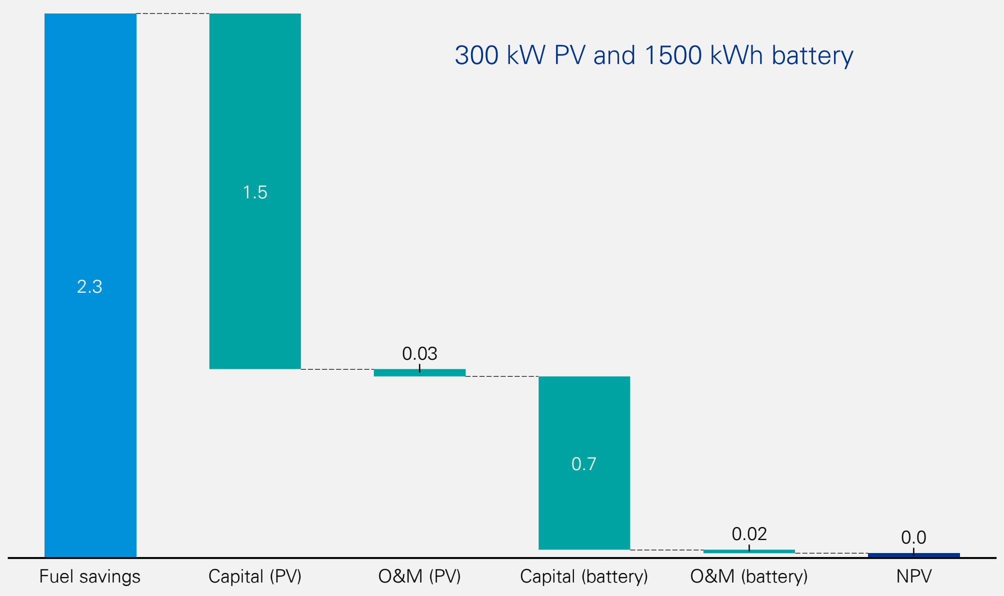
Fuel saving: The cost of diesel in Medang is 62 US¢/litre. Utilizing this in a diesel engine with an efficiency of 38% result in a cost price of 16 US¢/kWh. The expected full-day power demand is 2050 kWh, resulting in an annual fuel cost of USD 122,000, which can be saved by a solar PV/hybrid system. The demand is assumed to have a 1% annual growth.

PV cost: DESDM have installed multiple smaller PV systems. A 30 kW PV system in Lombok had a cost of 12,000 USD/kW. The large-scale 20 MW PV system analysed in the prefeasibility study have a cost of 1250 USD/kW. Using these two to calculate the economy of scale* results in a cost of the 300-400 kW PV system of 5000 USD/kW – or USD 1.5-2.0m. The system is assumed to have a lifetime of 25 years.

Battery cost: For the cost of the battery is used the Hornsdale Wind Farm case as a proxy.

Results: This result in an IRR of 4-8% for the system of 300-400 kW. This is built on the fuel savings alone. There are, off course, also some benefits of this system in the security of supply, due to the fact that the village will not rely on diesel from the mainland.

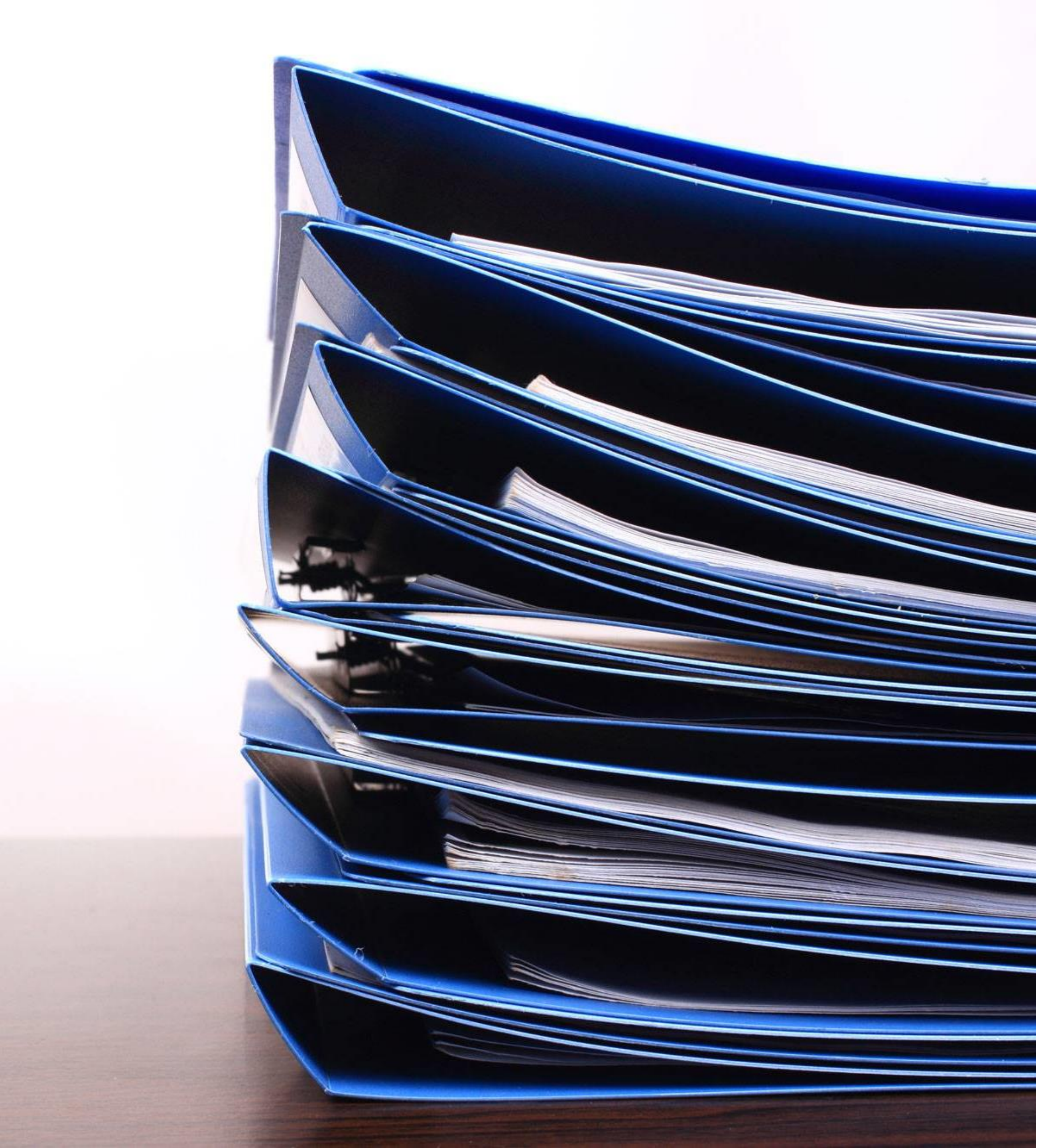
NPV breakdown (USDm)



WACC of 8%.

** Economy of scale: (CostA/CostB) = (CapacityA/CapacityB)^alpha.*

Source: PLN NTB; National Energy Council's Technology Catalogue; KPMG analysis



References and sources

We have collected primary data from a large number of sources during the course of this study:

Interviews have been conducted with and data have been received by:

- PLN NTB – Pak Susilo Disjaya, Manager of System Planning
- DLHK – Pak Ida Bagus Gede Sutawijaya
- DESDM – Ibu Niken Arumdati, Head of New and Renewable Energy Development
- Inovasi – Pak Andre Susanto, Director
- PBBT – Pak Joko Santosa, Engineer
- Vestas Wind Systems – Arka Wiriadidjaja, Regional Sales Manager in South East Asia
- Martin Bencher Group – Jesper Josephsen Meldgaard, General Manager

This study has used the following publications, data and other studies as references

Publications:

ABC News	ABC News, Bali beaches swamped by garbage as tourists, hotel workers sweep up each morning (2018)
ADB	Proposed Loan and Administration of Loans Special Purpose Vehicles owned by Equis Energy Eastern Indonesia Renewable Energy Project (2018)
Alvan-Lopez	Alvan-Lopez, The Cost of Pumped Hydroelectric Storage, Stanford University (2014)
ASEAN	ASEAN Centre of Energy – LCOE of Selected Renewable Technologies in ASEAN Member States (2016)
Baker McKenzie	Baker Mckenzie, Indonesian Government Improves PPA Risk Allocation Regulation (2018)
BBC	BBC, Giant plastic berg blocks Indonesian river (2018)
Damdaran	Damodaran CRP data
DEA	Danish Energy Agency GIS analysis
DLHK NTB	Local office on Environment & Forestry (DLHK NTB) - Interview and data
DESDM NTB	Local office of Ministry of Energy & Mineral Resources (DESDM NTB) - Interview and data
Ea Energy Analyses & IDEAS Consulting Services	Biomass for energy prefeasibility study (2018)
FCN & E.ON Research Center	Bridging the Gap between Onshore and Offshore Innovations by the European Wind Power Supply Industry: A Survey-based Analysis (2012)
Google Earth	Google Earth altitude function
Galvan-Lopez	Galvan-Lopez, The Cost of Pumped Hydroelectric Storage, Stanford University (2014)
The Guardian	South Australia's Tesla battery on track to make back a third of cost in a year (2018)
Ibbotson	Ibbotson SBBI Market Report
Inovasi	Inovasi, Solar PV – Diesel Hybrid – Win-win business models and PPA arrangement
Inside Indonesia	Inside Indonesia - Saving Lombok’s beaches (2018)
IRENA	IRENA – Renewable Power Generation Costs in 2017 (2018)
Jakarta Post [1]	Jakarta Post - Jokowi inaugurates first Indonesian wind farm in Sulawesi (2018)
Jakarta Post [2]	Jakarta Post - Gili Trawangan spoiled by garbage (2018)
Jay Weatherill	Former Premier of South Australia via Twitter

This study has used the following publications, data and other studies as references

Korea Engineering Consultants Corp	Waste incineration power plant of 10 MW in Lombok, Indonesia – Feasibility study
Martin Becher Group	Martin Bencher Group, Martin Bencher Group interview
MMR No. 10/2017	MEMR Decree No. 10/2017, PR No. 35/2018
MEMR Decree No. 1772K	MEMR Decree No. 1772K/20/MEM/2018
MEMR No. 3/2015	MEMR Regulation Number 03/2015
MEMR No. 44/2015	MEMR Regulation Number 44/2015
MEMR No. 5/2017	MEMR Regulation Number 05/2017
MEMR No. 10/2017	MEMR Regulation Number 10/2017
MEMR No. 49/2017	MEMR Regulation Number 49/2017
MEMR No. 50/2017	MEMR Regulation Number 50/2017
MEMR No. 10/2018	MEMR Regulation Number 10/2018
Mitsubishi Research Institute	Feasibility Study on Rice Husk Power Generation System for Low-carbon Communities in Ayeyarwady Region, Myanmar (2015)
NEC Technology Catalogue	National Energy Council – Technology Data for the Indonesian Power Sector (2017)
Neoen	Neoen, Translation of Document De Base dated 18 September 2018 (2018)
NREL PV benchmark	National Renewable Energy Laboratory - U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017 (2017)
NuGen Engineering Ltd.	Feasibility Study for a 10 MW Biomass Fired Power Plant (2010)
Oceanography	Oceanography – Ocean Internal Waves Observed in the Lombok Strait (2005)
PT. MGB Hi-Tech Indonesia	Waste incineration power plant of 10 MW in Lombok, Indonesia – Feasibility study
Pusyantek BPPT	Study on Cost Estimation of Bali-Lombok Interconnection Transmission Line Project (prepared for purpose for KPMG)
RUPTL 2018-2027	10-year business plan 2018-2027 (RUPTL)
PR No 35/2018	Presidential Regulation No. 35/ 2018
Presidential No 44/2016	Presidential Regulation No. 44/ 2016
Presidential No 5/2017	Presidential Regulation No. 5/2017

This study has used the following publications, data and other studies as references

Presidential No. 54/2012	Presidential Regulation No. 54/2012
Siemens	Siemens – HVDC Transmission Factsheet (2011)
Singh et al.	Fluidised bed combustion and gasification of rice husk and rice straw – a state of art review (2011)
UK Department of Environment,	UK Department of Environment, Food and Rural Affairs – Economies of Scale - Waste Management Optimisation Study (2007)
UMBRA	UMBRA - MEMR Regulation 10/2018: A Game Changer for PPAs Bankability? (2018)
US Tresury	US Treasury
Vestas	Vestas Wind Systems interview
WindProspect	Online windmap of Indonesia developed by EMD for the Embassy of Denmark to Indonesia and MEMR
The World Bank Group [ESMAP]	The World Bank (ESMAP) – Solar Resource and Photovoltaic Power Potential of Indonesia
The World Bank	The World Bank (Report No. 109237 – ID, For a First Indonesia logistics reform development policy loan)
World Energy Council	World Energy Resource - Waste to Energy (2016)

Background material

New PPA template may change tariff structure and expected key terms create some bankability concerns

MEMR Regulation 50/2017 outlines the maximum tariff and the procurement process for different renewable resources in Indonesia and calls for PLN to publish a template PPA for renewables. Unfortunately, as of October 2018, we do not believe that this template has been published. This creates some doubt as to the payment methodology and key terms that will be included in future procurement of renewables.

Historically, Indonesia has set tariffs for power projects via an additive methodology (e.g. A (capacity charge) + B (fixed O&M) + C (Fuel) + D (variable O&M) + E (transmission)), with these different components having different escalation factors. For instance, capacity charge will usually be fixed in USD terms (or fixed in IDR and indexed to movements in the exchange rate with the US$) but with no inflation indexation, while O&M charges (components B and D) may be indexed to foreign and domestic inflation. However, recent renewables legislations have provided for no escalation in tariffs. This includes MEMR Reg. No 19/2016 – which defined the terms for the (now cancelled) FIT for solar and Regulation 35/2018 which sets the FIT for specific WTE projects (although these projects do not include Lombok).

Given the current lack of clarity around the PPA and tariff structure, for this study, we are taking the more conservative assumption and assume that there will be no inflation escalation but assume that tariffs will be fixed in USD terms. If included in the updated PPA, inflation of O&M tariffs may provide some upside but in our experience, the capacity charge for renewables is by far the largest aspect with the O&M portion of the tariff usually quite small (approx.10% for wind and solar).

Historically, Indonesian PPAs have been successful in creating bankable projects (especially for thermal power). The recent financing of the Equis Energy solar portfolio in Lombok by the ADB provides some template for success and indicates that multilaterals are keen to support the growth of the industry. However, we understand that this project would have been developed under a PPA template that was developed before MEMR Reg 50 and MEMR regulations, 10/2018, 49/2017 and 10/2017, which sets out key terms for PPAs across the Indonesian power sector. Reg. 10/2018 removed some key risks that had been present in MEMR Reg 10/2017 with regard to government force majeure, but we understand that market participants remain concerned with risk allocations from PLN force majeure and prevention of share sales.

Source: MEMR No. 50/2017; MEMR No. 10/2018 , MEMR No. 49/2017, MEMR No. 10/2018, UMBRA, Baker McKenzie, KPMG analysis.

Key Terms	Rule	Regulation
Tariff	As defined for the technology and procurement process	MEMR 50/2017
Contract term	20 years on a build-own-operate-transfer (BOOT) basis	MEMR 50/2017
Transmission costs	Borne by the developer	MEMR 50/2017
Payment Currency	All payments must be made in Indonesian Rupiah. We assume payments converted from USD to IDR on a specified date at the JISDOR.	MEMR 19/2016
Escalation	Assumed to be no escalation	MEMR 19/2016

Major Risk Factor	Rule
Government Force-Majeure	PLN to bear responsibility
Prolonged PLN Force-Majeure preventing power off-take	PLN is relieved of its obligations
Curtailment	PLN obligated to take power from renewable energy sources of up to 10 MW on a must-run basis
Prevention of sale before COD	Developers are not allowed to transfer shares before plant reaches COD and require PLN approval

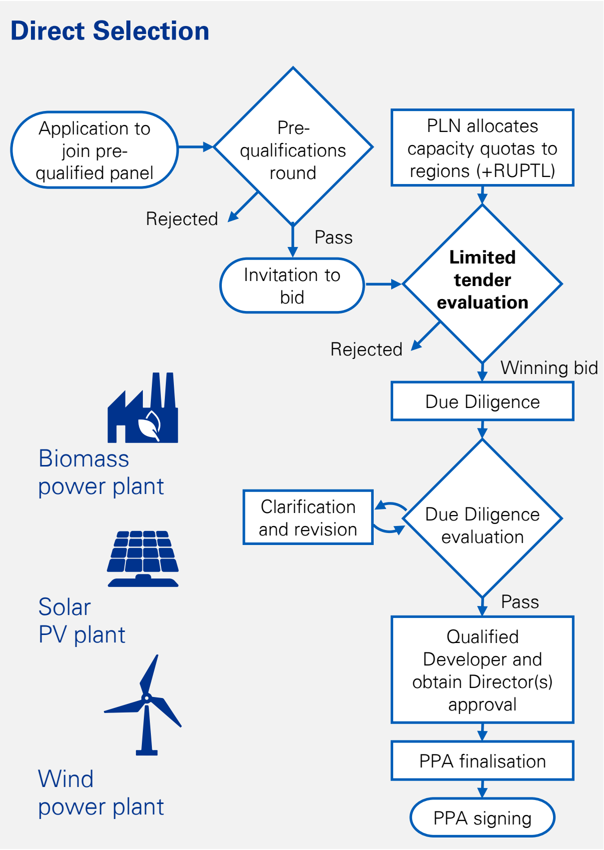
Changing appointment processes limits opportunities for unsolicited proposals other than waste incineration

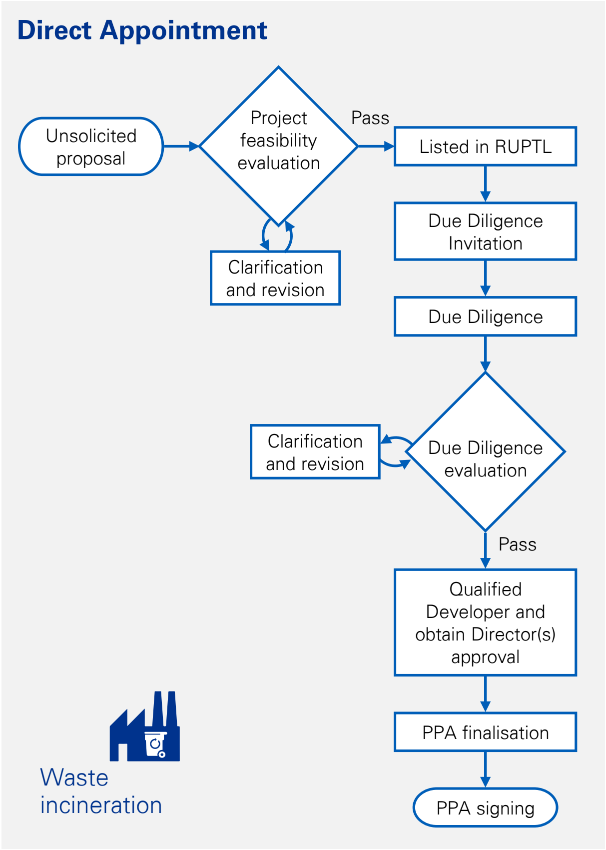
Historically, renewable energy projects could be procured under the Direct Appointment process (see chart on right) whereby project sponsors could propose unsolicited projects to PLN and therefore develop the project in-house while continuing to negotiate with PLN to have their project included in the RUPTL. However, under MEMR Reg. 50/2017 on renewable energy, the government has redefined the avenues by which PLN can appoint project developers.

It is understood from this regulation that, of our four selected technologies, only waste-to-energy projects are now able to be procured under the Direct Appointment methodology. Other forms of renewable/ alternative power will now need to be procured following the Direct Selection method (see chart on right).

The key differences between the Direct Appointment and Direct Selection methodologies is that under Direct Selection, projects must undergo a limited tender by PLN with chosen project sponsors coming from a pre-qualified panel of project developers. For Solar and Wind, each tender will consist of a minimum of 15 MW (capacity quota). Our understanding from PLN NTB is that projects up to 5 MW in Lombok, the PLN NTB will be in charge of the selection – above 5 MW, the authority goes to PLN head office.

Under this method, it appears that PLN will need to take the lead in selecting where and how much capacity will be tendered. Project developers from the approved panel will then be able to put forward their projects and competitively bid for the available capacity. We understand that this will then be followed by a due diligence procedure for the winning bids, although the methodology for the selection of projects to take to tender, the form of the tender and the transparency on which projects are put out to tender currently remain unclear.





Source: PLN NTB; MEMR No. 3/2015, MEMR No. 50/2017, MEMR No. 44/2015 MEMR, No. 3 2015, KPMG analysis.

Depending on the size of the project, different foreign ownership and local content restrictions will apply

Independent Power Producers (IPPs) in Indonesia are required to comply with the foreign ownership limits in the Indonesia Negative Investment List 2016. The maximum permitted foreign capital ownership in an IPP depends on the power plant's type and capacity.

Waste incineration power plant projects are not subject to the same maximum foreign capital ownership restrictions, as they fall under a different KBLI (Indonesia Standard Industrial Classification) than solar, wind and biomass power plants.

While power plants generally fall under the line of business of KBLI No. 35101, waste-to-energy projects fall under the line of business of KBLI No. 38211. As such, while general power plants face certain foreign ownership restrictions, waste-to-energy plants are currently open for 100% foreign ownership.

As per Ministry of Industry Reg. No. 54 of 2012, and No. 5 of 2017, IPPs are required to comply with minimum local content requirements for the goods and services used for the development of electricity infrastructure and local content requirements during construction. The minimum levels of local content required for goods and services and during the construction phase are obligatory for both biomass and solar projects. Wind and waste-to-energy projects are not specifically mentioned in the local content requirements.

We understand that PLN will prioritise procurement of IPPs that meet local content requirement, but that exemptions are possible where:

- the necessary goods cannot be produced in Indonesia
- the technical specifications cannot be met
- there is insufficient production of necessary goods.

Foreign requirement

	Maximum foreign capital ownership (% of capital)	Minimum use of local content+ (% of value)
Biomass power plant	Not allowed* (<1 MW) 49% (1-10 MW) 95%# (>10 MW)	42% (<15 MW) 40% (15-50 MW) 33% (50-150 MW) 29% (>150 MW)
Solar PV plant	Not allowed* (<1 MW) 49% (1-10 MW) 95%# (>10 MW)	41 (on-grid)
Wind power plant	Not allowed* (<1 MW) 49% (1-10 MW) 95%# (>10 MW)	No requirement stated
Waste incineration	100% (all)	No requirement stated

** Foreign capital ownership is not allowed in capacities of less than 1 MW.*
 # 100% for PPP and/or during concession period
+ Values shown are combined values of required content for goods and services.

Source: PR No. 44/ 2016, BKPM, Ministry of Industry Reg. No. 54 of 2012, and No. 5 of 2017

Tax incentives may be available on a case-by-case basis – this study assumes 25% tax and 6.25% depreciation

As of December 2018, the headline corporate tax rate in Indonesia is 25% of taxable income. In Indonesia, different IPP assets will be depreciated at different rates depending on their category in the tax regulation. Although some assets (for example buildings) may be subject to different rates, the majority of IPP assets (for example major machinery) are usually classified as Non-building assets and treated as having a useful life of 16 years, at a straight-line depreciation rate of 6.25% (100%/16 years).

We have chosen to apply the headline corporate tax rate of 25% and a depreciation rate of 6.25% per year across the entire asset base for this pre-feasibility study.

Being an IPP VAT-able entrepreneur, under Indonesian tax law renewable producers are usually exempted from VAT. We have therefore not included VAT payments in our study.

Import duty exemption is also likely to be available for new companies for manufacturing as long as it can be shown that the imported equipment is either:

- Not currently produced in Indonesia
- Produced domestically but:
  - The specification does not meet the requirements
  - Domestic production capacity does not sufficiently meet the industry needs.

We have therefore not considered import duty to be significant within our study.

Additional tax incentives may be available in the form of reduced income tax, accelerated depreciation (usually at twice the standard depreciation) and extended tax holidays. However, to acquire these incentives the project will have to show that it constitutes a high value (USD>70m) and/or has large labour absorption and significant local content. Given the variety of projects being studied and requirements for the incentives, we have chosen not to include these incentives in this study, but tax incentives may provide additional up-side for project developers.

As a pre-feasibility study, we have only taken a high-level overview of the tax structure in Indonesia. While we endeavour to provide accurate information, the actual tax position for a specific project is liable to vary on a case-by-case basis and will change over time. Full tax advice from a professional tax advisor should be gathered before deciding to proceed with a project.

Source: KPMG analysis.

Taxation

	Headline corporate tax (%)	Depreciation rate (%)
Biomass power plant	25%	6.25%
Solar PV plant	25%	6.25%
Wind power plant	25%	6.25%
Waste incineration	25%	6.25%

WACC of 10.2% (USD) found for renewable generation assets in Lombok

The weighted average cost of capital (WACC) is an essential element for calculating the project NPV. The WACC is the rate that a company is expected to pay on average to all its security holders to finance its assets. Therefore for a project to be financially feasible its returns (on a project basis) must exceed the WACC.

The WACC is based on two capital elements, cost of debt and cost of equity. From a peer group of 12 comparable Asian power sector companies, it is assessed that a capital structure of 34% equity and 66% debt provides a reasonable central case for the analysed projects.

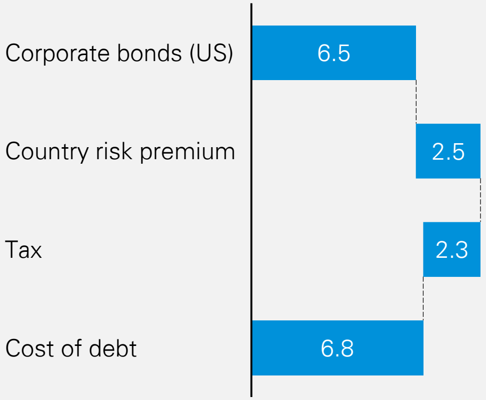
The calculation of the cost of debt is based on US 10-year corporate bonds for BB rated energy companies (6.5%). Country risk premium is added to reflect macroeconomic factors such as political stability (2.5%) and adjusted for the impact of tax-deduction on debt (2.1%).

The cost of equity is based on the risk-free rate, which, for this is study, is taken from the 3-month average of US Treasury 10-year bonds. Country risk premium is added to reflect macroeconomic factors such as political stability (2.5%). Size premium is added to adjust for the small investment size (3.5%). The market risk premium is a product of Beta (levered) from the before-mentioned peer group of 1.25x (asset beta 0.51) and a market risk premium of 6.0%.

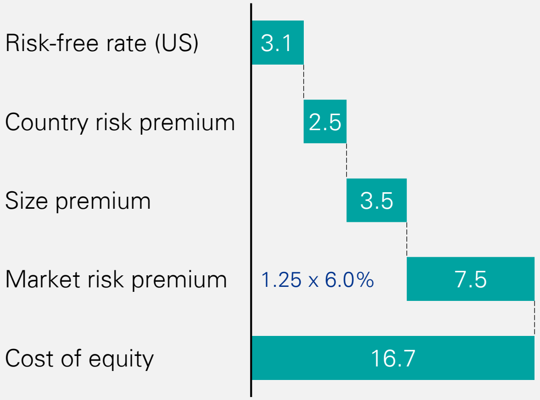
This yields a WACC of 10.2% for the four generation projects in this study.

Ultimately, there will be numerous factors that influence the WACC for each company/project, including, for example the method of finance (project vs. corporate) or the ability to bring co-investors with lower yield demands (e.g. donor funds). For this reasons we have focused on the project IRR throughout this report but have provided this WACC as a reference and for calculating project NPV

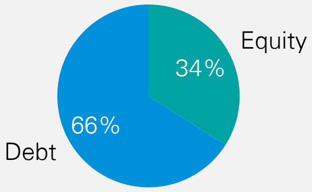
Cost of debt (%)



Cost of equity (%)



Capital structure (%)



Weighted average cost of capital in USD (%)

WACC
10.2%

Source: Damodaran CRP data; US Treasury; Ibbotson; KPMG analysis.

kpmg.com/socialmedia