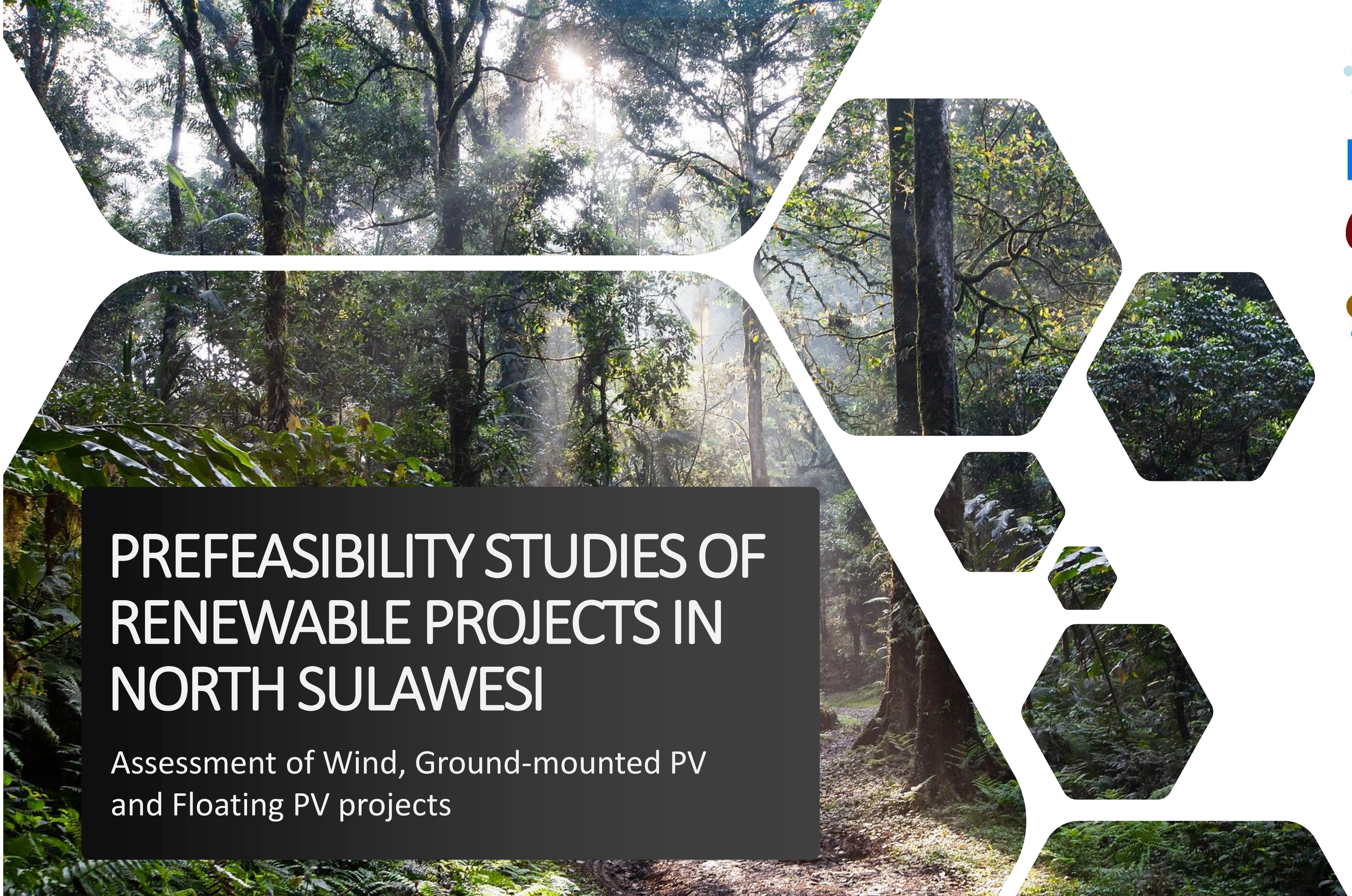

PREFEASIBILITY STUDIES OF RENEWABLE PROJECTS IN NORTH SULAWESI

Assessment of Wind, Ground-mounted PV and Floating PV projects

Danish Energy Agency

Viegand Maagøe

Ea Energy Analyses

INOVASI DINAMIKA PRATAMA

NATIONAL ENERGY COUNCIL REPUBLIC OF INDONESIA

SULAWESI UTARA

November 2021

BACKGROUND

Indonesia and Denmark have for years collaborated through a **Strategic Sector Cooperation** (government-to-government partnership) focused on the green transition of the energy sector. The purpose of the partnership is to bring Denmark's many years of experience with energy efficiency, renewable energy deployment and energy systems to Indonesia in order to assist the Indonesian government and relevant stakeholders in the green transition of the energy sector in Indonesia.

The partnership is anchored within the **Danish Energy Agency's Center for Global Cooperation**. The main partners in Indonesia include the Ministry of Energy and Mineral Resources (MEMR) and the National Energy Council (NEC). Other partners include the state-owned electricity company (PLN) and the regional energy planning office (DINAS).

The latest outcome of the partnership has generated the following outputs[1]:

- Capacity building through various seminars and workshops focused on lessons learned in Denmark on long-term modelling, RE integration and energy efficiency (2016-2020);
- Integration of Balmorel Power sector model in the modelling team at NEC (with inputs to the "Indonesian Energy Outlook"- from 2016 to 2020) and in DG Electricity (support to analyses and RUKN);
- Development of an Indonesian Technology Catalogue on power production technologies (2017, 2020);
- A Regional Outlook to 2030 and prefeasibility studies for the island of Lombok (2018);
- Three Regional Energy Outlook reports for South Kalimantan, Riau[2], North Sulawesi and Gorontalo[3] (2019);
- A Renewable Energy Pipeline for Indonesia to reach their 2025 goal (2021), in collaboration with EBTKE;
- A report with Guidelines for Prefeasibility studies (2021).

The Regional Energy Outlooks of Riau and North Sulawesi, completed in 2019 and constituting the first step of this work, showed significant potential for renewable energy as cost-efficient solutions for the green transition.

As part of the Strategic Sector Cooperation, a consortium consisting of Ea Energy Analyses and Viegand Maagøe, has been appointed to conduct **prefeasibility studies on renewable energy technologies in two provinces in Indonesia: Riau and North Sulawesi**. This report is one of two in total. In this report, the focus is on North Sulawesi. Three prefeasibility studies have been completed on the technologies: **wind power, ground-mounted solar PV and floating solar PV**.

The Danish Energy Agency and the Embassy of Denmark in Indonesia have played an active role in the developing the scope of the study, reviewing draft reports and planning of site visits. The consortium has received local assistance from PT Innovasi, an Indonesian based consultancy specialized in de-risking energy access investments for rural communities in Indonesia. The National Energy Council (NEC), the regional energy planning office (DINAS) and local PLN offices in Riau and North Sulawesi has helped facilitate contact and retrieve information from local stakeholders.

The study was initiated and completed in 2021. Four missions were carried out throughout the duration of the project; two in Riau and two in North Sulawesi. The missions were completed in April, June and October 2021. The consortium presented a first draft of this report during a meeting with the Danish Energy Agency and the Embassy of Denmark in September 2021. The final report was delivered in November 2021.

Notes:
1. The latest reports and outcomes, as well as a more detailed description of the cooperation can be found at: www.ens.dk/en/our-responsibilities/global-cooperation/country-cooperation/indonesia
2. https://ens.dk/sites/ens.dk/files/Globalcooperation/Publications_reports_papers/riau_reo.pdf
3. https://ens.dk/sites/ens.dk/files/Globalcooperation/Publications_reports_papers/north_sulawesi_and_gorontalo_reo.pdf

DISCLAIMER

The report is prepared for partners of the Strategic Sector Cooperation between Denmark and Indonesia and potential investors of renewable technologies in Indonesia. The conclusions of the report reflect the views of the Consortium (Ea Energy Analyses and Viegand Maagøe). The partners of the strategic cooperation hold no responsibility with respect to the findings of the reports.

Due to COVID-19, it has been a challenge to conduct site visits and collect data from local stakeholders. While the consortium managed to complete three missions, not all data needed for the calculations were obtained. As a result, the study mostly relies on desktop research. In order to validate the data and assumptions from the study, several reports have been reviewed. The local consultancy PT Innovasi has also provided significant support in the validation of assumptions and conclusions of the study. We generally find the results and assumptions to be valuable and we find them to be in line with similar studies.

The main source of information used in preparation of this study are PLN, The Danish Energy Agency and the Ministry of Energy and Mineral Resources.

The sites that have been chosen for the three technologies, namely wind power, ground-mounted solar PV and floating solar PV, have been identified based on the discussion with local partners and a series of site surveys conducted in the region. Available resources, possibility for grid connection, space available and other local limitations have been taken into account. Since this is a pre-feasibility study, we have not studied in detail the costs and possible restrictions on land use at the specific sites.

This study is a high-level screening of three technologies where the aim is to demonstrate if the project has enough potential to proceed with a more detailed feasibility study. Future investors should seek professional support before making any final investment decisions.

The technologies chosen for the study was selected based on input from the local partners, the Danish Energy Agency and the Consortium.

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SUMMARY FOR THREE TECHNOLOGIES

	Wind power plant	Solar PV plant (floating)	Solar PV plant (ground-mounted)
Expected ceiling tariff[1]	11 cUSD/kWh	8.25 cUSD/kWh	8.25 cUSD/kWh
Resource	3,091 FLH 35.3% CF	2,058 FLH_{AC} 23.5% CF_{AC}	2,142 FLH_{AC} 24.5% CF_{AC}
Capacity	50 MWe	20 MWe	20 MWe
CAPEX	74.2 mUSD	19.8 mUSD	19.2 mUSD
OPEX	4% of CAPEX per year	1.5% of CAPEX per year	1.5% of CAPEX per year

Notes:
1. Expected ceiling tariff is based on values from Draft of New Perpres with levls for FIT and ceilings for each technologies. Values are not confirmed yet and regulation is not in place. See pag.18 for more details.

SUMMARY FOR THREE TECHNOLOGIES

Wind power plant

IRR at ceiling tariff[1,2] (11 cUSD/kWh)	**10.7%**
Tariff needed for break-even	**9.4 cUSD/kWh**

- **Annual Energy Production** is a key factor for business case. High uncertainty could lead to challenge in financing, as well as reduction of returns after construction. Proper wind measurements are needed.
- **Attention to local context** and involvement of population is key for a successful development. Local population seems very open to wind projects.

Solar PV plant (floating)

IRR at ceiling tariff[1,2] (8.25 cUSD/kWh)	**8.1%**
Tariff needed for break-even	**8.2 cUSD/kWh**

- Considering the lower bound of CAPEX estimates from EPCs, the **break-even tariff can go as low as 7.7 cUSD/kWh**.
- Key risks include **PPA uncertainty** (new regulation is under discussion and there are no certain FIT level) FIT) and **grid integration challenges** faced by PLN, due to the variability of solar output.

Solar PV plant (ground-mounted)

IRR at ceiling tariff[1,2] (8.25 cUSD/kWh)	**9.7%**
Tariff needed for break-even	**7.3 cUSD/kWh**

- Considering the lower bound of CAPEX estimates from EPCs, the **break-even tariff can go as low as 5.9 cUSD/kWh**.
- Key risks include **PPA uncertainty** (new regulation is under discussion and there are no certain FIT level) FIT) and **grid integration challenges** faced by PLN, due to the variability of solar output.

Notes:
1. Expected ceiling tariff is based on values from Draft of New Perpres with levls for FIT and ceilings for each technologies. Values are not confirmed yet and regulation is not in place. See pag.18 for more details.
2. Real IRR shown here, to be compared to the estimated WACC (real) of 8%. An IRR above 8% means a profitable project with positive Net Present Value (NPV).

PROJECTS MATURES OVER FOUR PHASES; FROM IDEA, CONCEPT AND BUSINESS DEVELOPMENT TO EXECUTION

Idea development

The idea development phase consists of brainstorming and idea generation activities to give the project a more rounded shape.

The main purpose of this phase is to flesh out selected business ideas and structure the rest of the project.

Concept development

The concept development phase usually consists of two stages and related studies:

i. a prefeasibility study (PFS)
ii. a feasibility study (FS).

The PSF is a rougher version of a FS. The purpose of a PFS is to discard unattractive ideas and choose the best among many.

Business development

The business development phase usually consists of two stages

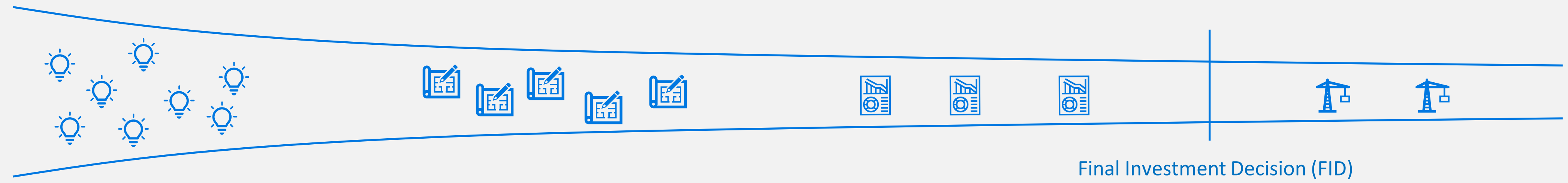
i. a validation stage
ii. a preparation stage

The best feasible idea is validated with detailed analyses of design and operations. Sourcing of permits and licenses follows.

Project execution

The project execution phase entails construction and installation of the plant, plus any other civil work needed for the project operations.

The number of possible projects shrinks during the project development phase, as different options are assessed. One (or a subset) of initial ideas will go to execution.



Sources: DEA, Ea, VM (2020)

PREFEASIBILITY STUDIES ARE SCREENINGS THAT IDENTIFY THE MOST FEASIBLE OPTION(S) OUT OF A SET

Prefeasibility study

A prefeasibility study is rough screening aiming at **identifying the most promising idea(s) and discard the unattractive options**. This reduces the number of options that are chosen to proceed with a more detailed feasibility study and eventually with business development, ultimately saving time and money. Often, the prefeasibility study returns only one most promising option.

The assessment of the business idea has different focuses: technical, regulatory, environmental, economic and financial aspects are analysed. A prefeasibility study is a **preliminary systematic assessment of all critical elements of the project** – from technologies and costs to environmental and social impacts.

Questions to be answered in a prefeasibility study include:

- Is the expected revenue enough to proceed with evaluating the project more in depth?
- Are there any regulatory issues of decisive importance for the project?
- Is it economically (and financially) worthwhile to go further with this idea?
- What is the project's expected environmental and social impact?
- What are the risks and uncertainties connected to the idea?

Usually, a prefeasibility study concerns the analysis of an **individual project** only, normally with well-defined boundaries. The whole energy system is usually assumed as given and thus related data can be used as input to the analysis.

Sources: DEA, Ea, VM (2020)

THE 8 STEPS OF A PREFEASIBILITY STUDY

The content and topics of a prefeasibility study can be broken down in 8 steps. The last 3 steps build upon the project details analysed in the first 5 steps.

1	**Background & scope**	Scope of the study, investment context, case descriptions, power system and stakeholder overview.
2	**Revenue streams**	Revenue sources, markets, support schemes or tariffs, other important regulatory aspects
3	**Resource evaluation**	Sourcing of fuel and fuel price (e.g. biomass), assessment of natural resources and expected energy yield
4	**Project size & restrictions**	Grid and system perspective, physical planning issues, space requirements, other relevant barriers
5	**Financial & technical key figures**	Estimation of CAPEX, OPEX, technical parameters (efficiency, lifetime)

6

Business case

Economic attractiveness for the investor (NPV, IRR..), robustness of the case (sensitivity analyses). Rough financial analysis.

7

Environmental & social aspects

Evaluation of the potential impacts on the area’s environment and other social implications.

8

Risk assessment

Assessment of project risks and potential mitigation factors.

Sources: DEA, Ea, VM (2020)

CONTENT

1.  Introduction to North Sulawesi and its power system

2.  Prefeasibility Studies on power generation technologies: Wind and Solar PV (grounded and floating)

1.

Introduction To North Sulawesi and its Power System

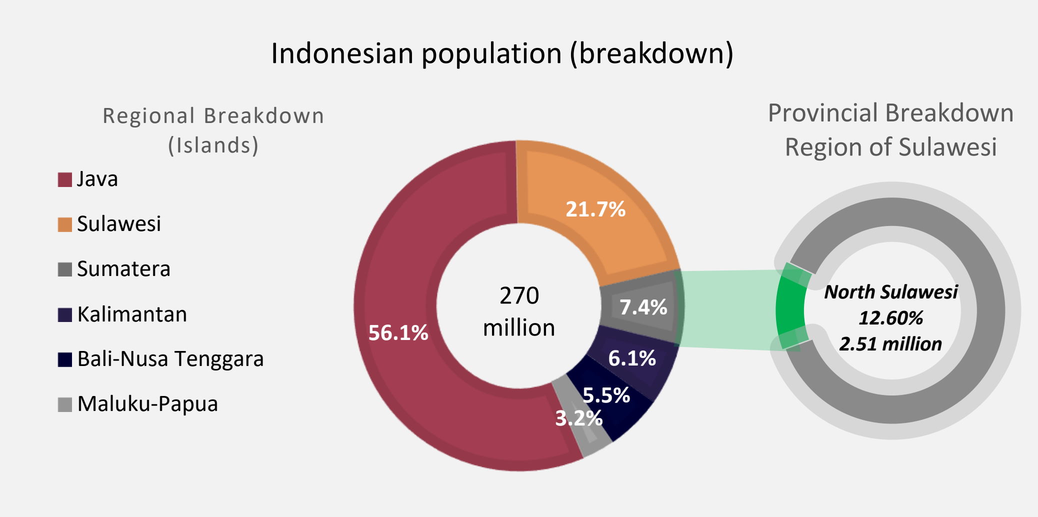
HIGH GENERATION COSTS IN NORTH SULAWESI AND SPECIAL ECONOMIC ZONES PROVIDE AN OPPORTUNITY

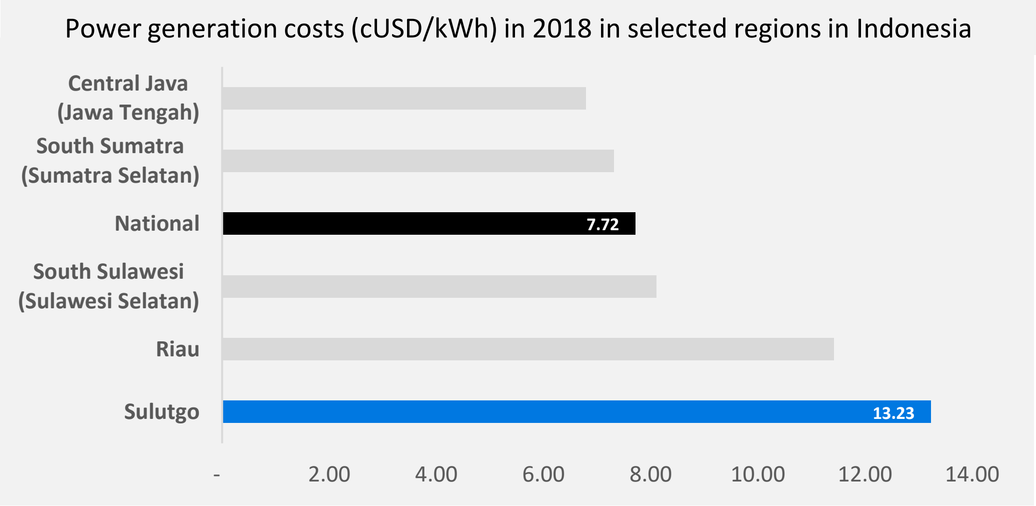
North Sulawesi: : As of 2021, Indonesia stands on the 4th tile of the most populated countries around the globe, behind China, India and the United States of America. Indonesia consist of 17,000 different small and large islands. The province of North Sulawesi, one of the six that composes the Sulawesi Region, houses around 2.51 million inhabitants, corresponding to 12.6% of Sulawesi population. The population growth rate in the period 2010-2019 has been 1.07% according to the latest available data.

Economy: The economy of North Sulawesi has been growing faster than the average economy of Indonesia in the last few years. The key contributors to regional GDP are agriculture (coconut, nutmeg, cloves), fishery, mining and tourism. The strategic position makes it potentially a good location to serve shipping routes to East Asia and America.

Special Economic Zones (SEZ): To stimulate the development of local GDP, Likupang and Bitung have been selected as Special Economic Zones. Likupang with a focus on tourism and Bitung on industrial development. These areas are given certain facilities (e.g. roads and ports) and fiscal incentives in order to increase the competitiveness and attract investments (see Appendix for more information).

Power prices: The power generation cost in the Sulutgo system (North Sulawesi and Gorontalo) was approximately 1.7 times higher than the national average in 2018 (last year in which it was published for entire Indonesia). The relatively high cost of generation is due to a reliance on diesel plants. In particular, between 2016 and 2020, due to power shortage in North Sulawesi, a 120 MW marine vessel powerplant (MVPP) running on fuel-oil has been rented by PLN and stationed in Amurang.
A figure disclosed by local authorities regarding 2020 BPP indicates a value of 10.18 cUSD/kWh **(1460 Rp./kWh).**





1 Background & scope
2 Revenue streams
3 Resource evaluation
4 Project size & restrictions
5 Financial & technical key figures
6 Business case
7 Environmental & social aspects
8 Risk assessment

Sources: BPS & UN (2021), BPS (2021), MEMR (2019), Government of North Sulawesi Province (2019)

NORTH SULAWESI HAS ACCESS TO 3 PORTS AND ROAD INFRASTRUCTURE IN LARGE PARTS OF THE PROVINCE

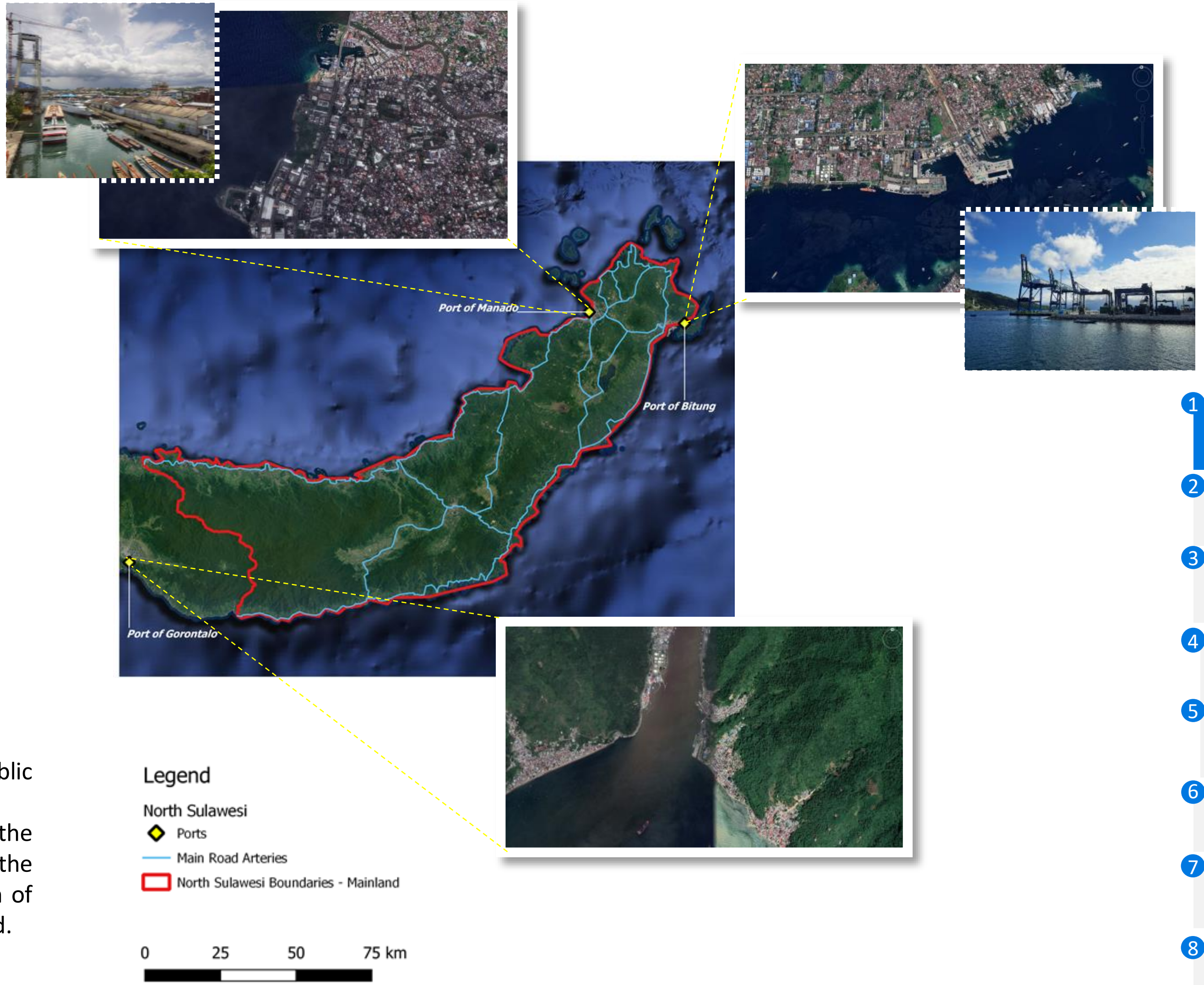
Roads: Several road links are crossing the province of North Sulawesi, with the main roads developed primarily in parallel to the north and south coastlines. The quality and density of roads is larger in the North of the province, being the area with the large majority of the population, and hosting both the capital Manado and its international airport.

Two main links connecting Manado to Bitung are present in the vicinity, *Jl. Raya Manado – Bitung* and *Manado – Bitung Toll Road,* with the latter being a highway. The respective road widths & lengths are 7 m & 45 km for the former and 9 m (one-way) & 40 km for the latter, with asphalt coverage throughout. The estimated corresponding end to end journey length is 1 hour and 30 minutes via the urban road and 50 minutes via the highway.

Ports: 3 small size ports are situated across the mainland's regional boundaries, with close proximity to all sides of North Sulawesi. Port of Manado on the North-West, Port of Bitung on the North-East and Port of Gorontalo on the South-West side of the region.

The port of Bitung is incorporated within the greater 534 Ha (5.34 km^2) SEZ area of the city. A port expansion is planned to be undertaken, among other plans, in the period 2017-2031.

Logistics: All locations evaluated in this report are reachable through public infrastructure such as toll roads and commercial ferries.
For PV, none of the locations pose significantly difficult logistics challenges for the shipment, delivery, transport and construction efforts. In terms of logistics for the wind project, more challenges are expected in terms of shipment, transportation of equipment to the site, especially due to narrow roads that will need to be upgraded.



Sources: Own photos

ELECTRICITY DEMAND IS EXPECTED TO DOUBLE THE NEXT 10 YEARS

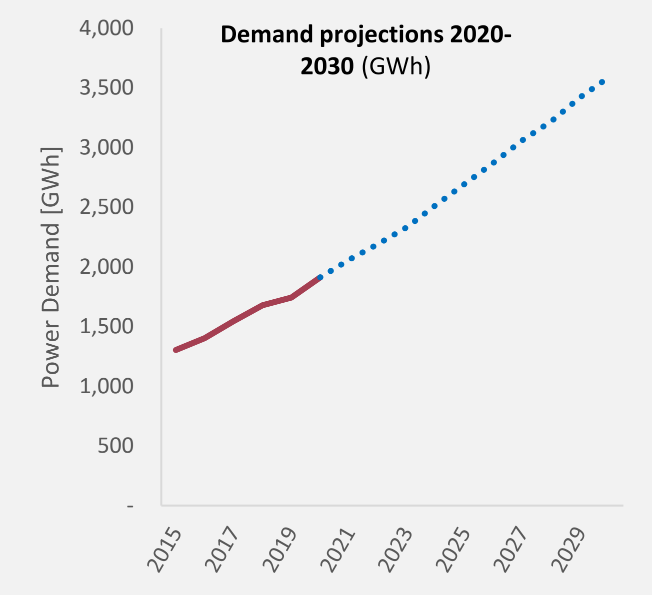
Electricity supply: Households and industrial activities account for almost three quarters of the observed annual load.

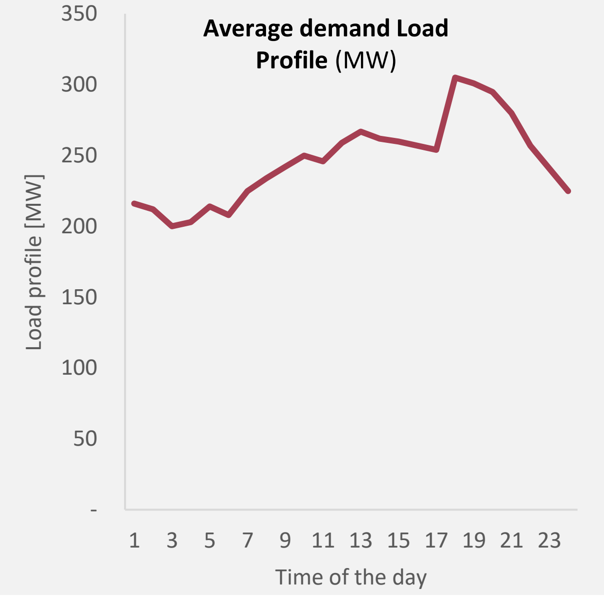
Those shares justify the observed peak load hour periods within the day, with households accounting significantly for the increased load during the back end of the day, while businesses and industry for the mid-day volumes.

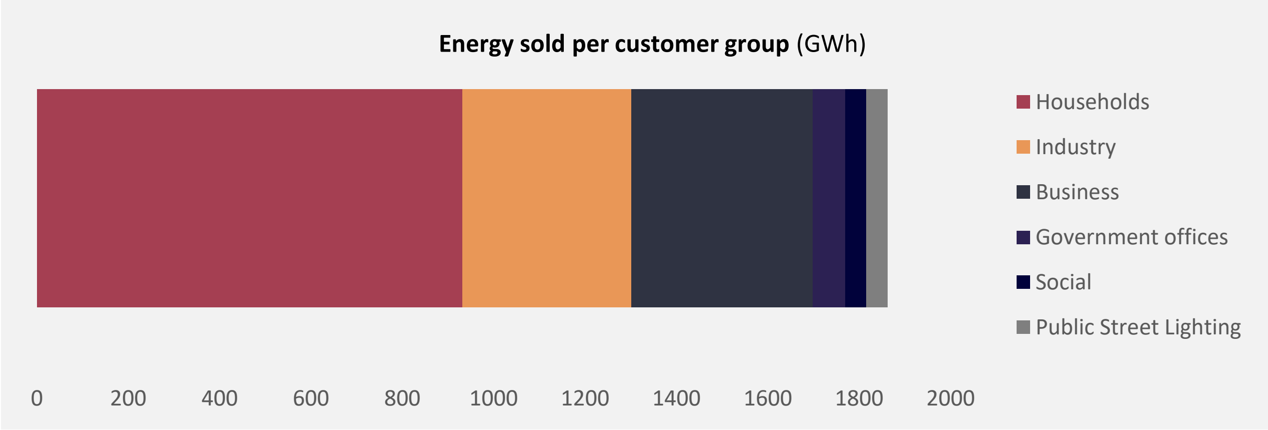
Electricity demand: Being part of a relatively newly industrialized country, electricity demand in North Sulawesi is expected to almost double in size within the next 10 years, based on RUPTL 2021. This should give confidence in the need for additional power in the province.

In the past, however, RUPTL has shown to overestimate the demand projections, potentially giving raise to oversupply situations in case the realized load is lower than what planned for. For example, the new RUPTL 2021, affected also by the emergence of Covid19, showed reduced power demand compared to RUPTL2019 that indicated a value of 4,153 GWh for 2028.

The daily load profile show a steep increase in the load around 19 at night, given a large part of the demand is residential. The steepness of the demand curve at night can potentially cause challenges in the operations of the system. The situation could be exacerbated in the future by increased RE volumes, especially PV.







1 **Background & scope**

2 **Revenue streams**

3 **Resource evaluation**

4 **Project size & restrictions**

5 **Financial & technical key figures**

6 **Business case**

7 **Environmental & social aspects**

8 **Risk assessment**

Sources: DEA & Ea (2019), PT PLN Persero (2021), PLN – local office (2021)

NORTH SULAWESI SYSTEM IS DOMINATED BY GEOTHERMAL AND COAL

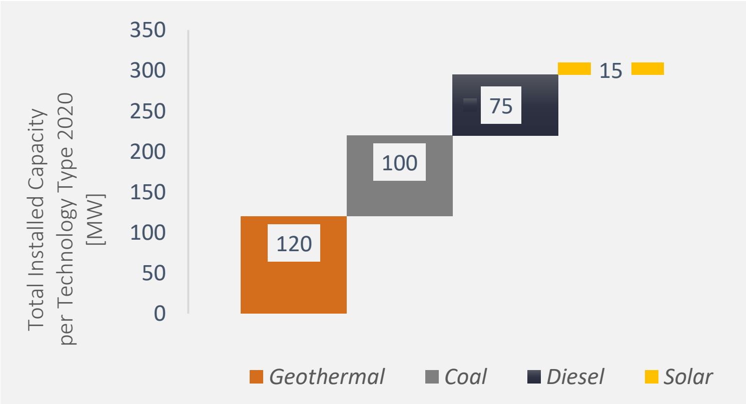
Sulutgo system: The Sulawesi Bagian Utara power system expands from the province of North Sulawesi to the neighboring Gorontalo, forming the common system known as Sulutgo.

Deployed power grid: An existing 150kV transmission lines set covers most of the north coast-line of North Sulawesi along with a 70kV pipeline covering the northern part between Manado, Bitung and Likupang. As of 2020, North Sulawesi's electrification rate according to MEMR rose to 99.98%.

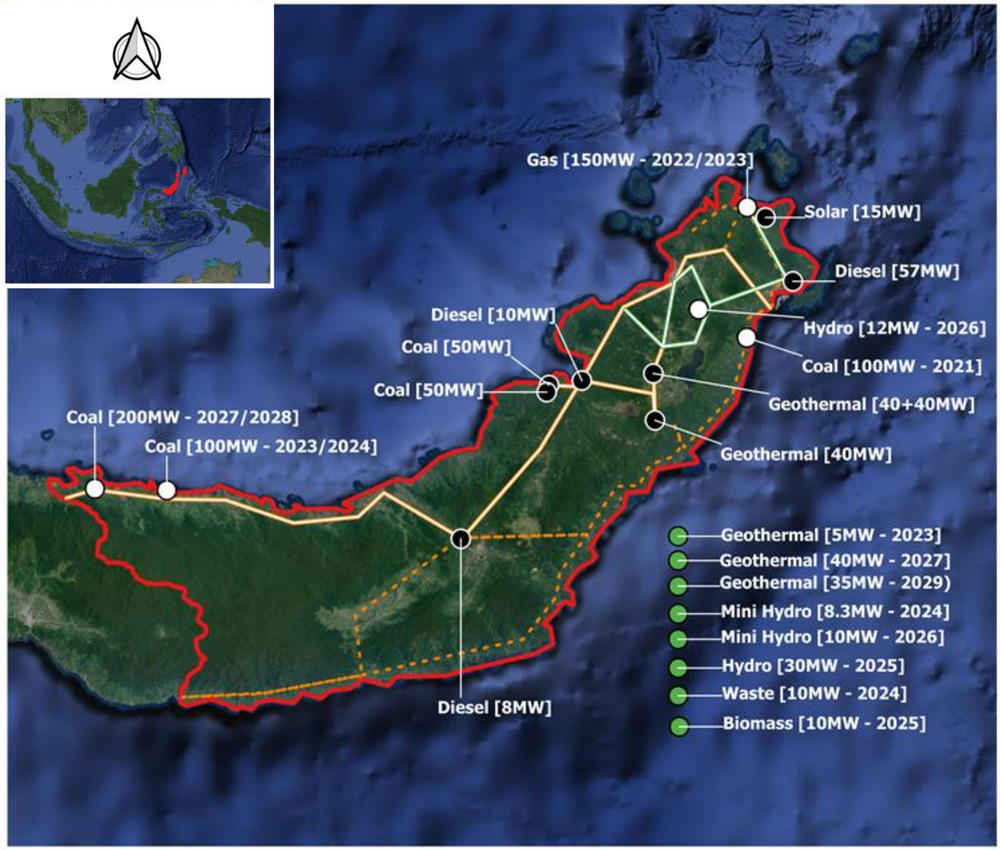
Additional transmission lines (150 KV) are planned along the western coast. The plan to create a major Sulawesi power grid, connecting Sulutgo to the province of Central Sulawesi at the Tolitoli substation, is progressing, with expected finalization around 2024.

Existing generation capacities: A total of 310 MW of power plant capacity are currently under operation from PLN, with 32.3% of them relying on coal and 24.2% on diesel in the 2020 baseline. The remaining assets are renewable plants, namely 120 MW of geothermal and a 15 MW solar PV plant.

Most of the power plants under-operation are on the middle and northern parts of the province, closer to the load.



Installed capacity in North Sulawesi in 2020 (MW)



Legend

North Sulawesi

Generation Capacities
- Planned Generation Capacities (Procurement)
- Planned Generation Capacities
- Existing Generation Capacities

Transmission Lines
- Existing Transmission Lines 70kV
- Existing Transmission Lines 150kV
- Planned Transmission Lines 150kV
- North Sulawesi Boundaries - Mainland

0 25 50 75 km

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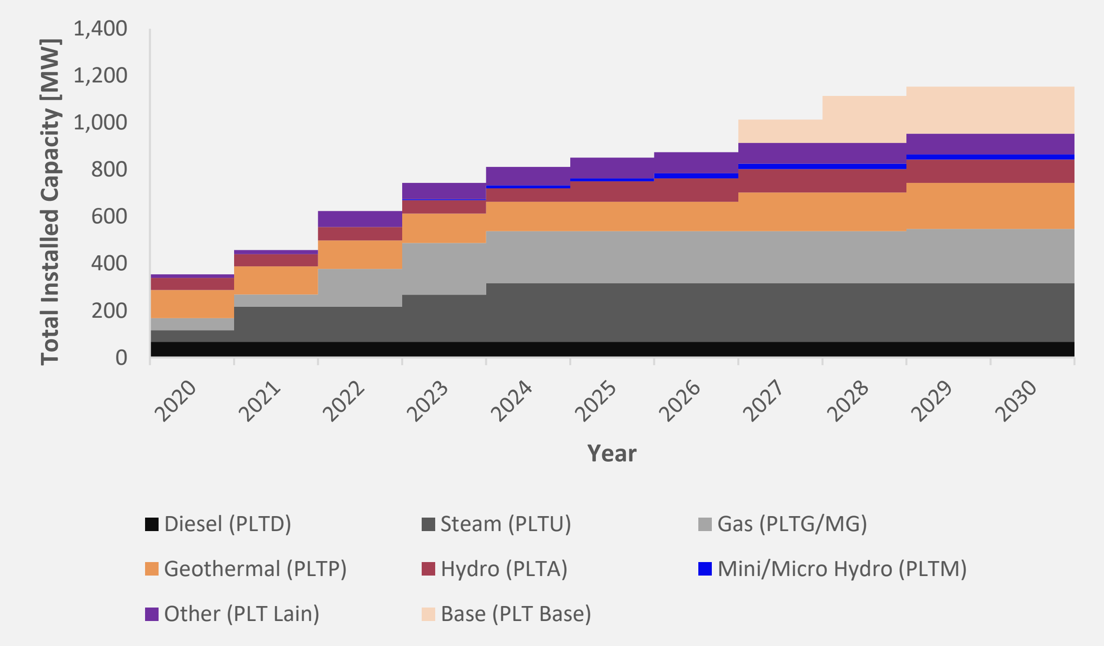
Sources: DEA & Ea (2019), PT PLN Persero (2021), PLN – local office (2021)

PLANS FOR FUTURE CAPACITY ARE STILL RELYING ON FOSSIL FUELS

Future generation capacities: Based on PLN's latest 10-year plan (2021-2030), 562 MW of additional plant capacity is planned to be added to the existing portfolio by 2028, of which 71.2% will be relying on coal, 26.7% on gas fuel and 2.1% will be a renewable hydro plant. Additional to the aforementioned, further 148 MW of RE plants are also planned to be up and running by 2029 and are currently under procurement procedures. Of these, 54% will be geothermal, 33% hydro, with the remaining being equally shared between waste incineration and biomass plants.



*Note: In RUPTL2021, **PLT Base** is defined as a renewable energy plant or a combination of gas and RE plants that can deliver baseload power at a cost comparable to coal plants. This can include gas, hydro, geothermal, or wind and solar combined with batteries.*

Geothermal (PLTP) in Lahendong:

- 6 units of 20 MW each: total of 120 MW
- Started operation in 2001 (Unit 1: 2001, Unit 2: 2007, Unit 3: 2009, Unit 4: 2011 and Units 5&6: 2016)
- Owned and operated by PGE (Pertamina Geothermal Energy), subsidiary of Pertamina
- Plans to further expand the plant with additional 55 MW (15 MW 2022-2024 and 40 MW 2026)

Solar PV (PLTS) in Likupang:

- 21 MWdc, 15 MWac
- Sizing factor 1.4
- Operational since 2019
- Covers and area of 29.2 Ha
- CF: 17.7% DC (1,555 FLH) and 24.8% AC (2,177 FLH)
- Total investment of 29.1 mUSD, and signed a PPA for 10 cUSD/kWh in 2018
- Owned by Vena Energy (former Equis)

Sources: PLN (2021), PGE (2021)

NORTH SULAWESI HAS A LARGE POTENTIAL FOR SOLAR, WIND, HYDRO AND GEOTHERMAL

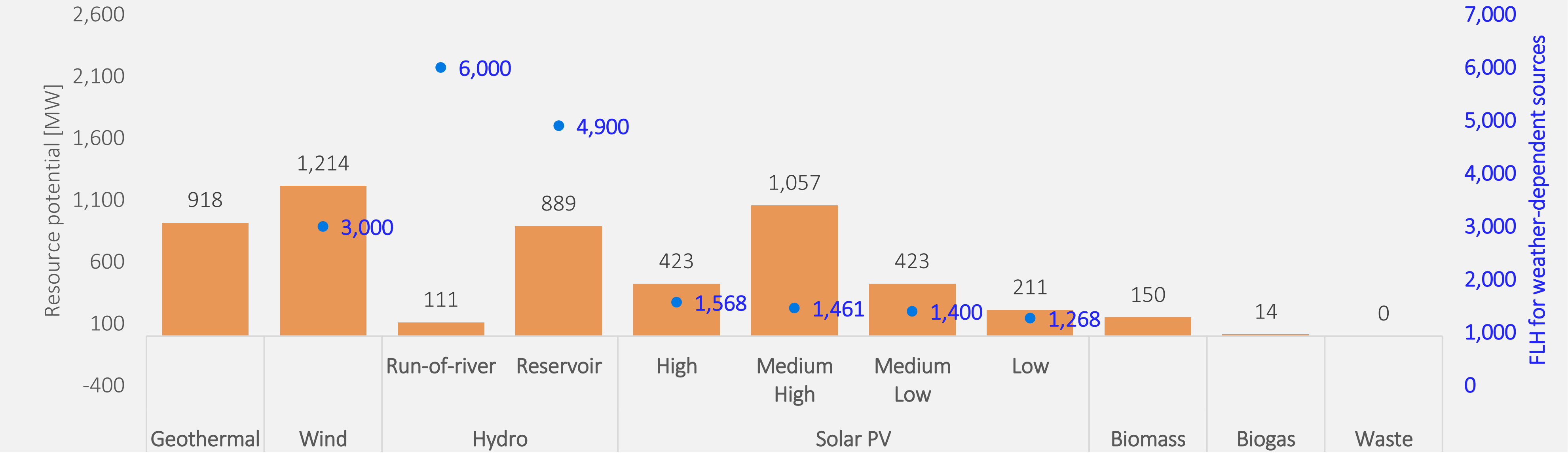
Resources in NS: North Sulawesi has high potential for renewable energy generation, particularly from geo-thermal, wind, hydro and solar PV.

Wind-potential: A considerably high capacity potential is available in the province for onshore wind, at 1214 MW. With locations reaching 3,000 FLH (above 6 m/s), wind proves to be a potentially promising energy source in the area.

Solar-potential: Solar irradiation is the most significant resource within this part of Indonesia. With FLH ranging between about 1270 and 1570 hours (FLH related to DC capacity) and a large resource potential, solar has the potential to largely contribute to the power supply in the region.

Hydro-potential: 1000 MW of hydro potential has been assessed as the local ceiling, with large opportunities for reservoir plants. Interestingly, the run-of-river type holds a considerably high level of FLH, based on historical data.

Geothermal-potential: North Sulawesi is one of the most promising areas in Indonesia for geothermal development. With 120 MW of plants already developed in the Lahendong area and drilling underway in Kotamobagu, the estimated total potential for this source is around 918 MW.



Sources: DEA & Ea (2019), MEMR (2017b)

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2.

Prefeasibility Studies On Generation Technologies

A CHANGE IN REGULATION IS ON THE WAY AND CREATES UNCERTAINTY IN THE ACHIEVABLE TARIFF

Regulation: The prices for electricity purchases from renewables is set by the national Ministry of Energy and Mineral Resources (MEMR). The most up to date regulation, No. 50/2017, sets the pricing regime per power producing technology type. As illustrated in the table to the right, the regional power purchasing price (PPA) of Independent Power Producers (IPP) is benchmarked according to the annual average regional generation costs, also referred to as BPP (Biaya Pokok Pembangkitan). In case a local BPP is higher than the national average, as is the case for North Sulawesi, the PPA price between PLN and IPPs for solar and wind can maximum be 85% of the local BPP. The length of the PPA contract for wind and solar is set to 20 years.

Tariffs based on current regulation (No.50/2017)

Current regulation (No.50/2017 and revisions)	BPP Sulutgo 2020	Expected PPA price (85% BPP)
Solar and Wind	10.18 cUSD/kWh (1460 Rp./kWh)	8.65 cUSD/kWh

Maximum tariff level: Following the current regulation and given a BPP for North Sulawesi and Gorontalo of 10.18 cUSD/kWh (1,460 Rp/kWh) in 2020, the calculated maximum tariffs for solar PV and wind would be 8.65 cUSD/kWh. It is derived by multiplying the regional BPP with the local cap of 85% for the two technologies. However, this level is much above some of the latest PV tariffs signed by PLN (e.g. 5.8-5.9 cUSD/kWh in Bali and Cirata) and are unlikely to be achievable in a negotiation with PLN.

Upcoming Perpres regulation: Following critics on the current PPA regulation, MEMR initiated discussions to revise the current scheme including, among other things, the introduction of Feed-In-Tariffs (FIT) to boost renewable energy technologies, with the aim of to reach the 2025 target of 23% RE.
Based on the draft of the regulation, the guaranteed price will depend on generation technology, size of plant, and whether batteries are included, as well as featuring a with a regional correction factor based on the location of the project to account for major costs in more remote systems. The length of the PPA contract for wind and solar is set to 20 years.
Technologies below 5MW would have access to *Direct appointment* and a Fixed FIT, while projects above 5 MW would follow a *Direct selection* mechanism with a price ceiling specified (Highest Benchmark Price or Price Cap), followed by auction/negotiation with PLN to reach the final FIT level.

Expected tariff: The solar PV and wind plant expected sizes are both above the limit for a fixed FiT, therefore would be subject to negotiation. Since the location factor of Sulawesi is 1.1 the expected PPA strike prices for the two technologies would be 11 cUSD/kWh for wind and 8.25 cUSD/kWh for solar PV, both floating and ground-mounted. Since these projects follow pricing structures that are subject to negotiation, it is difficult to predict a specific PPA price. For this reason, a sensitivity analysis is performed to calculate how low of a tariff could a developer accept, in order to break even with the project (NPV=0 and IRR=WACC).

Expected tariffs based on upcoming Perpres regulation

Highest Benchmark Price/ceiling - auction Wind (PLTB) (>10 MW)	Location factor, F* (Sulawesi)	Expected PPA price
10 cUSD/kWh x F*	1.1	11 cUSD/kWh

Highest Benchmark price/ceiling - negotiation Solar (PLTS) (>10 MW & ≤ 20 MW)	Location factor, F* (Sulawesi)	Expected PPA price
7.50 cUSD/kWh x F*	1.1	8.25 cUSD/kWh

** The location factor F is a multiplier for the level of the tariff and is determined for each regional systems.*

Sources: MEMR (2017a), MEMR (2020); CBLJ (2021)

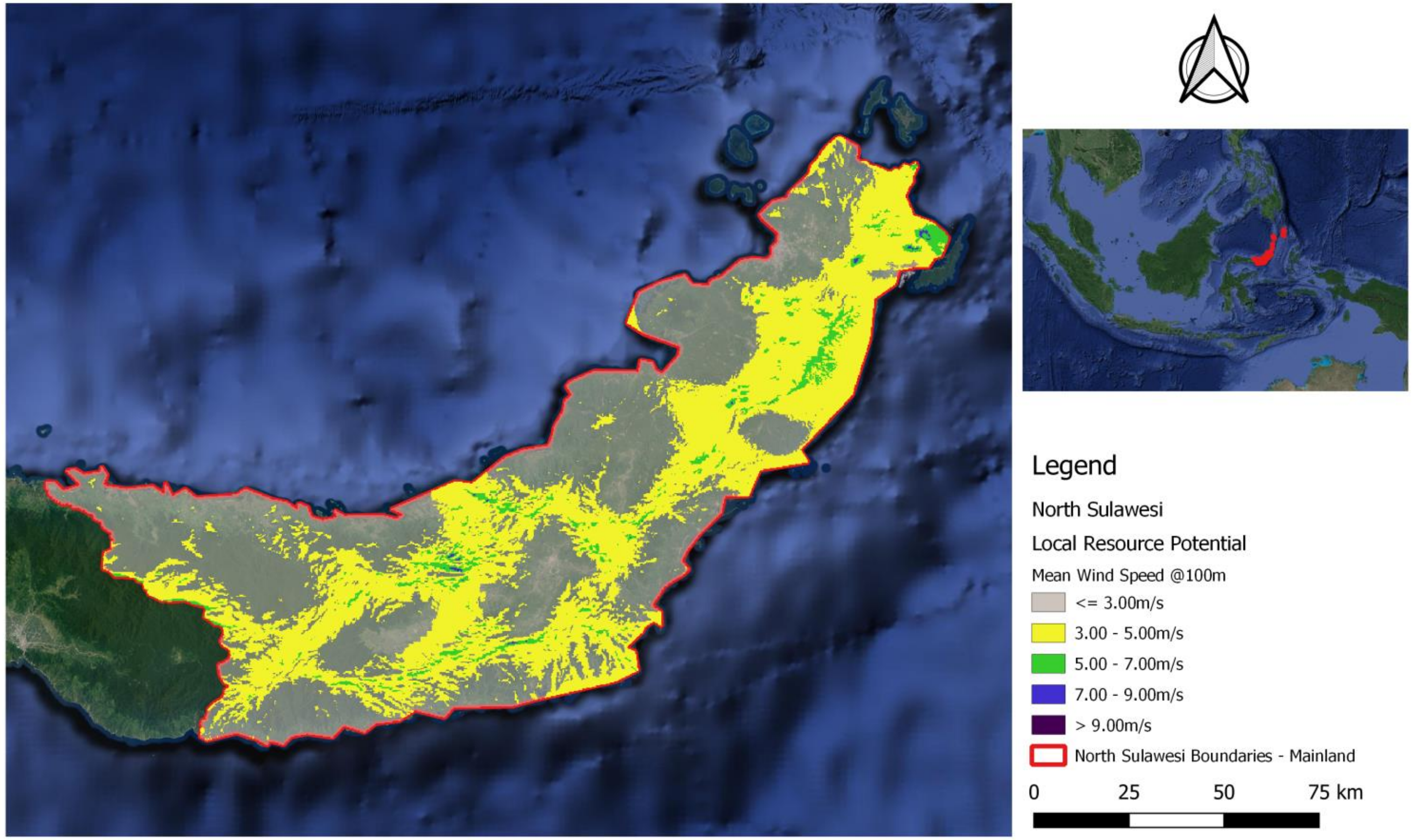
Onshore Wind Power Plant

Source: Unsplash

WIND RESOURCE REACHES 3,091 FLH IN BITUNG

Wind resource: Most of the province is characterized by quite low mean wind speeds, below or well below 5 m/s. However, in the NE side of the island, close to Bitung, wind speeds reach values close to and above 7 m/s. Excluding some mountainous areas in the central part of the province, far from main grid and in remote locations, the only area with good potential is located around Bitung and Lembeh island. The interest of Vena Energy in developing a project in the area of Gunung Dua Saudara confirms the localization of best potential site.

This area is shown as the best wind site both by data from the Global wind Atlas and the mesoscale modelling of Indonesia conducted by EMD international for the Danish Embassy in 2017.

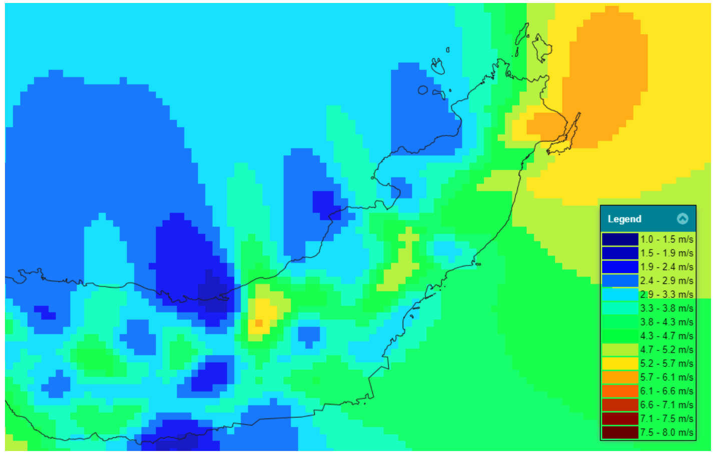


Sources: DTU (2021), EMD International (2017)

Location selection: Two options for plant siting are considered in the following steps: one to place the wind farm on the hills North of Bitung, in the Aertembaga district, the other in the island of Lembeh, blessed with equally good wind resource.

Technology consideration: Given the relatively low nature of wind speeds in the area, a low wind speed turbine technology is considered to maximize the yield from the sites. This type of technology is characterized by larger rotors resulting in low specific power rating, thus producing more power at lower wind speeds. The turbine selected is a Vestas V150 – 4.2 MW at 150 m hub height.

Yield calculations: Using the hourly wind speeds available from EMD international and the power curve of the turbine, the calculation of power production results in a FLH value of **3,091 h for the area of Bitung** while 3,026 h for Lembeh island.



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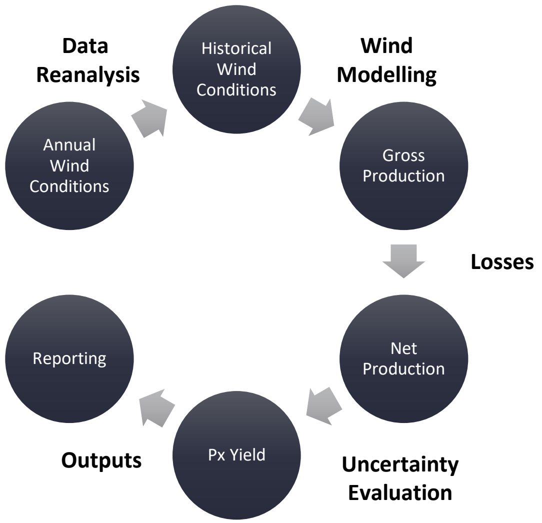
WIND PRODUCTION IS UNCERTAIN: THE P90 VALUE IS 2,611 FLH

Wind resource assessment: Starting from the hourly wind data and the power curve of the turbine deployed (Vestas V150-4.2 MW), a resource assessment including uncertainty evaluation is carried out to calculate the P50, P75 and P90 values. The process is carried out for the site of Bitung, which is later selected for the business case assessment.

Process: The process to calculate the energy yield at different confidence levels has been the following:

- **Gross production**: assessment of average generation from the wind using mesoscale data (2009-2015);
- **Net production**: application of systematic operational losses (standard value of 10% considered);
- **P50, P75, P90**: Consideration of uncertainty factors (table below) on production and calculation of confidence level on annual energy production.



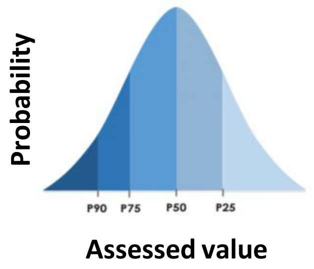
Considered Uncertainty Factors i (On AEP)			
On Wind Speed → On AEP*		On AEP	
Wind uncertainty (2-5%)	3.50 → 4.55%	Power Curve (5-10%)	7.50%
Long Term Adjustment (1-3%)	2.00 → 2.60%	Metering (0-5%)	2.50%
Vertical Extrapolation (0-5%)	2.50 → 3.25%	Wake Effects (0-5%)	2.50%
Horizontal Extrapolation (0-5%)	2.50 → 3.25%	Technical Losses (0-2%)	1.00%
		Air Density (0-2%)	1.00%

** Sensitivity factor of 1.3 dAEP/dWS assumed for the conversions between wind speed and AEP uncertainties.*

Uncertainty Level	Probability of Exceedance vs P50	Formula
$P75_{uncertainty}$	75%	$\sqrt{\sum_i (0.675 * Uncertainty_i)^2}$
$P90_{uncertainty}$	90%	$\sqrt{\sum_i (1.282 * Uncertainty_i)^2}$

Resulting values: The final value for P50 is the central estimate used for the Business Case and corresponds to **154.5 GWh** (**3,091 FLH**). Often at a later stage of the project, when financing needs to be secured, P90 is the preferred indicator since it entails a significantly higher certainty. The P90 is here equal to 130 GWh (2,611 FLH).

Value Level	Description	FLH Confidence	AEP Confidence [GWh/y]
$P50_{value}$	Value based on the already considered uncertainty within the calculated model	3,091	154.5
$P75_{value}$	$P50_{value} * (1 - P75_{uncertainty})$	2,838	141.9
$P90_{value}$	$P50_{value} * (1 – P90_{uncertainty})$	2,611	130.6



Sources: EMD International (2017), MEASNET (2016), SolarGis (2021)

A 50 MW WIND FARM SELECTED BASED ON GRID LIMITATIONS AND ECONOMIES OF SCALE

Grid conditions: The presence of the Special Economic Zone of Bitung in the area with the highest wind potential has several benefits, including an efficient supply of the projected industrial load in the economic area and the availability of a relatively strong connection point/grid.

Based on the figures from PLN, the substation of Bitung has a relatively high spare capacity to be used to host the infeed from wind power, as can be seen in the table below.

Capacity selection: The most likely range for a wind farm project in the area would be 40-80 MW. A **50 MW wind farm** has been chosen as the suitable reference case for the project under-examination, for a variety of reasons:

- The grid still faces limitations in terms of absorption of variable renewable energy (e.g. lack of automatic generation controllers, limited spinning reserve available for facing sudden change of generation)
- PLN has a relatively low experience with dispatching wind power plants
- The first wind farm projects in Indonesia (Sidrap and Tolo) were in the range of 72-75 MW
- A smaller wind farm would lack the economy of scale and minimum volume to justify the infrastructure investment (e.g. road access and other auxiliary work)

Substation	Transformer	Installed Power (MVA)	Highest Load (MVA)	Capacity (%)	Voltage Rating	Installed Power (MVA)	Installed Load (MVA)	Capacity (%)
Bitung	1	30	5.174	17%	70/20	80	12.13	15%
	4	20	11.059	55%	70/20			
	6	30	12.133	40%	70/20			

Spacing requirements: A wind farm of 50MW magnitude will require 14,000 m^2/MW according to the latest Indonesian data reported by DEA. This translates to 0.7 km^2 (70 Ha) of space considerations within the optimal considered area with the presence of 12 wind turbines of the selected 4.2 MW reference capacity.

Potential space assessment – Mainland vs Lembeh island: While the observed wind resource revolves to the same levels of magnitude at the North-Easter side of the province, a 50MW WT park would consume roughly 1/70th of Lembeh island's surface (opposite to Bitung), in contrast with the 1/14,000th that it would occupy within the province's mainland, spiking considerations of visual obstructions, among others.

Sources: DEA (2021), PLN – local office (2021)

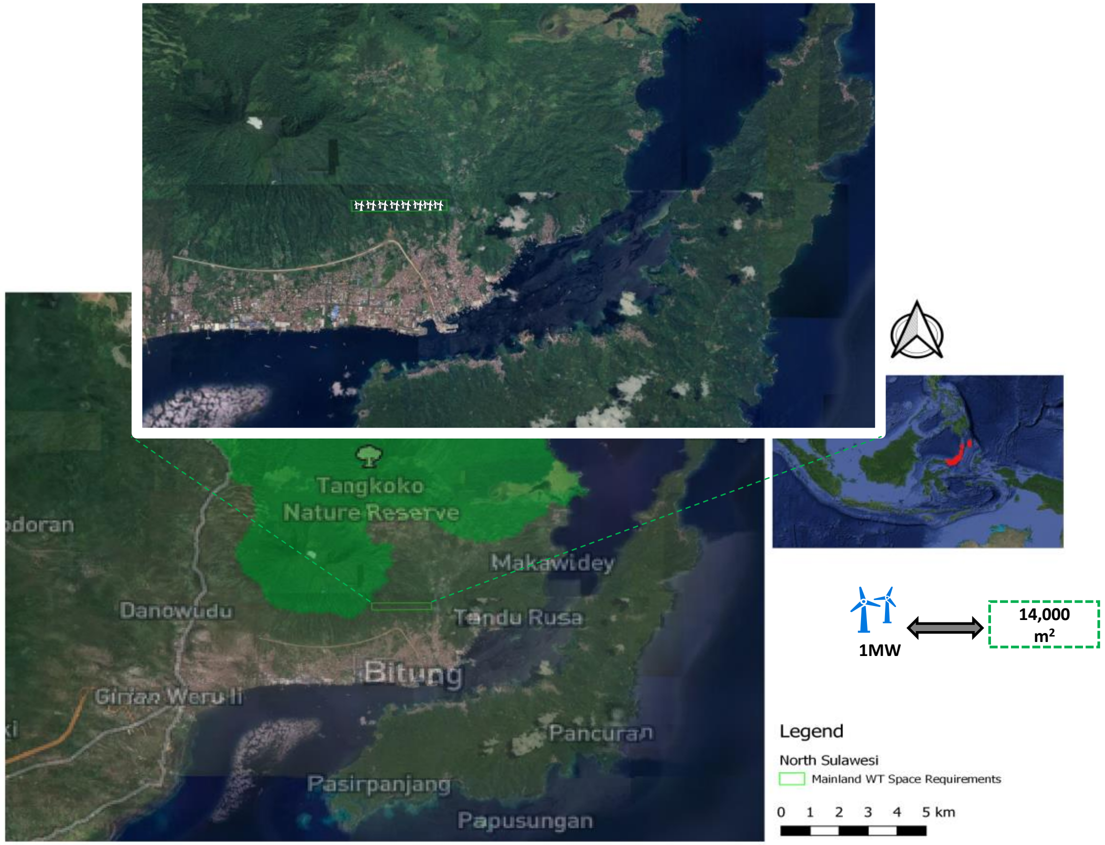
BEST SITING IS CLOSE TO BITUNG IN AERTEMBAGA DISTRICT

Advantages, opportunities: Installation of such projects on the mainland's vicinity are as a rule of thumb favored by easier logistics due to the better developed surrounding in contrast to more remote areas. Grid coverage, port availability and main road infrastructure are some of them to be named.

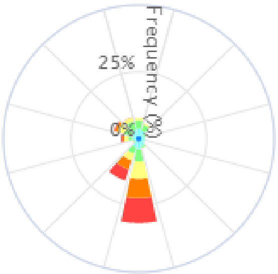
Disadvantages, threats: The area close to the Tangkoko national park is the one with best wind potential, potentially leading to public opposition, more difficult land acquisition and stricter environmental impact assessment standards. The complex terrain of the area alongside the land cost and availability may also prove to be challenging to the development of a successful project in the area.

Plant siting: Based on the experienced wind directions, as presented previously, the most probable plant siting within the province's mainland would be south facing with a horizontal alignment, should the space surroundings allow, as can be seen in the map to the right.

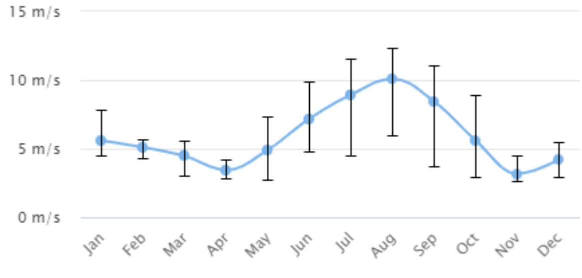
Road on Aertembaga



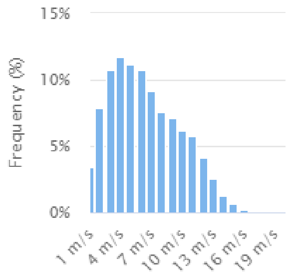
Wind Frequency Rose



Average Monthly Wind Speed Variation



Wind Speed Annual Distribution



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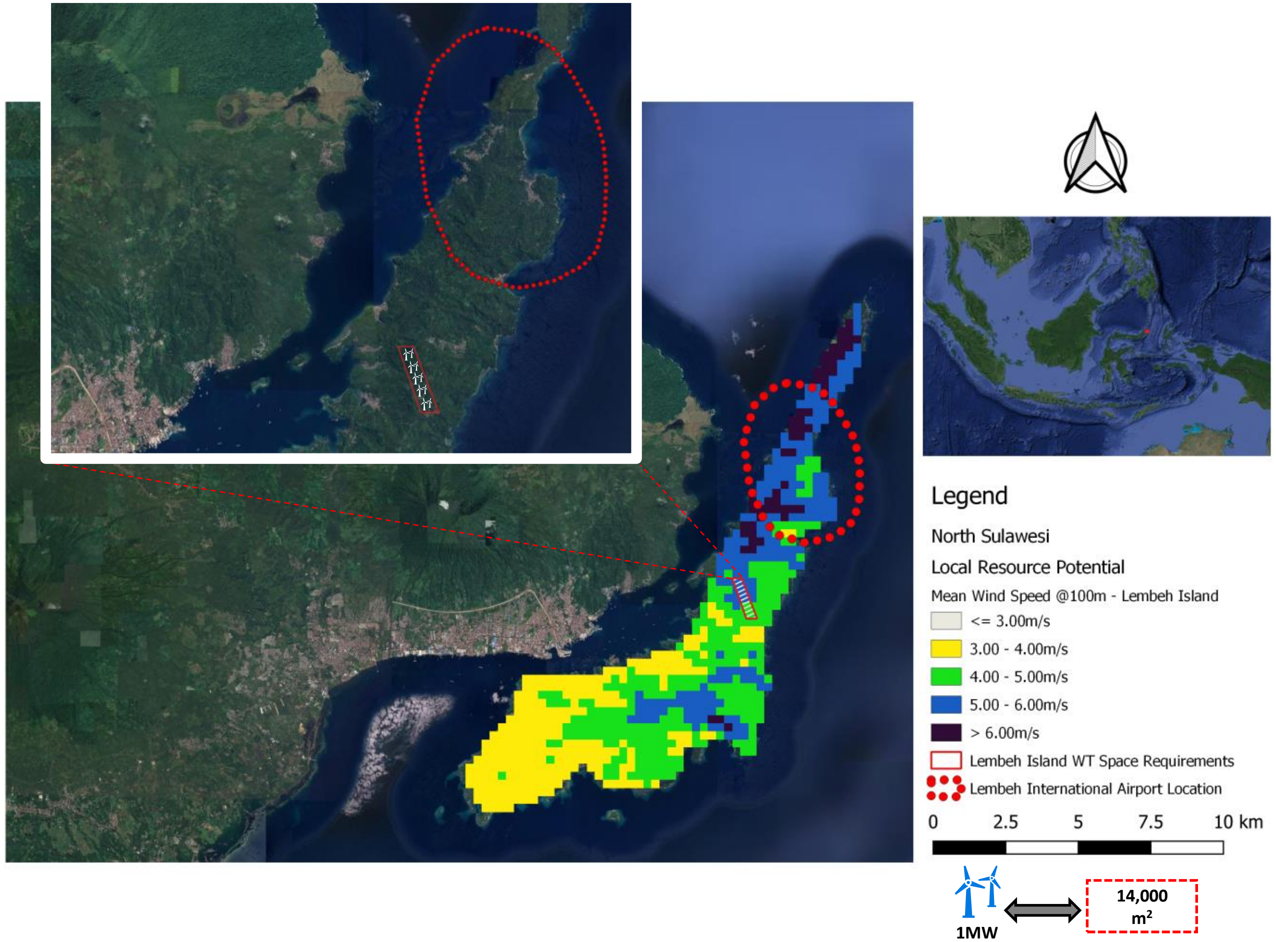
Sources: EMD International (2017), DEA (2021), Own photos

LEMBEH ISLAND IS AN ALTERNATIVE SITING, BUT NEW AIRPORT MIGHT BE A CHALLENGE

Advantages, opportunities: Space availability might be higher in Lembeh than in the mainland. Due to the imminent construction of an international airport on the island, a bridge and a road will be built that could ease the transportation of equipment to site. Finally, a power cable to mainland is already available and has spare capacity, potential alleviating upfront costs towards grid connection.

Disadvantages, threats: Overall, more challenging logistics are expected during the construction phase on the island due to lack of local port and less spacious road arteries. Moreover, the construction of the new international airport might end up being a show-stopper due to minimum required distance of wind turbines to the airport's surroundings. According to the standards followed by UK's London Gatwick airport, 30 km of buffer zone has to be set around the airport's perimeter and the closest WT. This limitation would make the wind project in Lembeh island considerably challenging due to the limited extent of the land (approx. 20 km).

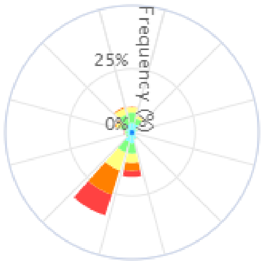
Plant siting: Assessing the best potential, the most probable plant sitting within the island would be south facing on an angled alliance to the NW (best avoiding potential cross-shadowing, as can be seen in the map to the right.



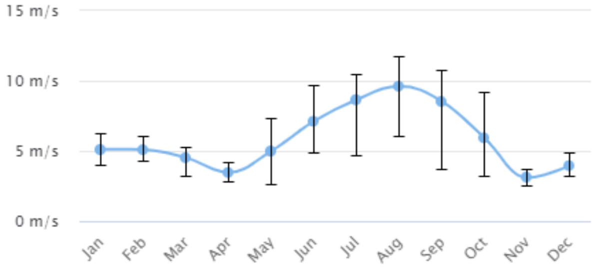
Main road in Lembeh

Power line Bitung-Lembeh

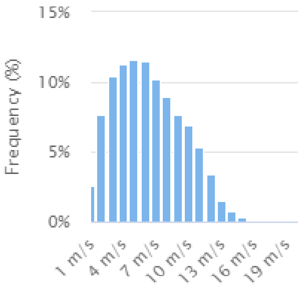
Wind Frequency Rose



Average Monthly Wind Speed Variation



Wind Speed Annual Distribution



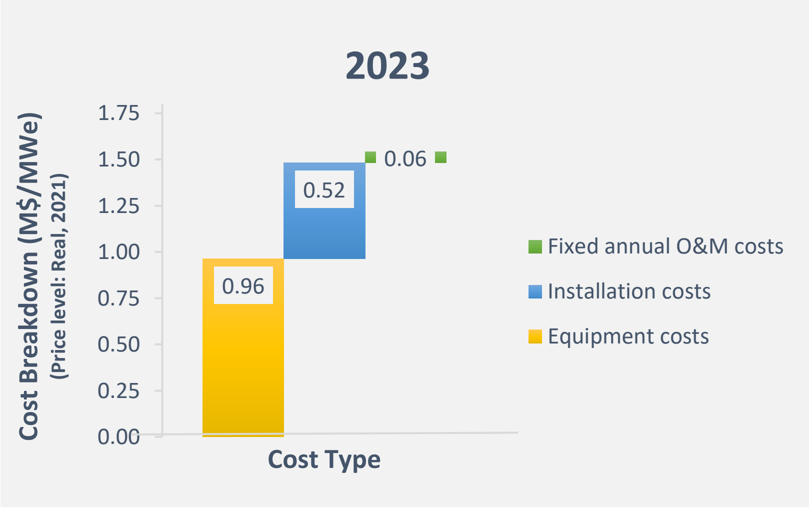
Sources: EMD International (2017), DEA (2021), Government of North Sulawesi (2019), Own photos

TECHNO-ECONOMIC DATA USED FOR THE BUSINESS CASE

Technical features	
Capacity	50 MWe
Technical lifetime	25 years
Plant availability	97.71%
Space requirements	14,000 m²/MWe
Capacity factor	Bitung: 35.3% (3091 FLH) Lembeh: 34.5% (3026 FLH)
Construction time	1.5 years
Outages	2.29%

Economic features	
CAPEX	1.48 M$/MWe
Fixed OPEX	59,320 $/MWe-year
WACC (real)	8.04%
Expected tariff	11.00 cUSD/kWh
Corporate tax rate	20%
Depreciation rate	6.25% (16 years of depreciation period)
Inflation rate (USD)	2.00%

**Figures reflect the estimated 2023 data (beginning of construction) in real 2021 price levels.*



Data from existing plants

Sidrap Wind Turbine plant (PLTB)
PLTB-Sidrap I, with a **construction year** dating back to **2015** and a COD of 2018, required an **investment of 150 mUSD** for a total capacity of 75MW, bringing the unit cost of investment up to **2.00 mUSD/MW**.

Tolo Wind Turbine plant (PLTB)
PLTB-Tolo I, went public in November 2019, while **construction** works started **in 2018.** A lump sum of **125 mUSD** reflect the **total investment costs**, rising the overall unit cost of investment up to **2.23 mUSD/MW**.

Others
While both of the aforementioned projects consist the 1st phases of each respective plan, second phases are already being planned. The **anticipated future capital costs** for the next phase of the former are **1.8 mUSD/MW**, according to the Ministry of Energy and Mineral Resources. However, this also includes storage technologies, pushing the CAPEX upwards.
Another recent project of 150 MW in Sukabumi, expected for completion in 2024, is anticipated to cost 3.3. trillion IDR (231 mUSD) corresponding to an investment cost of roughly **1.54 mUSD/MW**.

Sources: MEMR (2019a), Jakarta Post (2021)

AT CEILING TARIFF, THE WIND PROJECT IS PROFITABLE WITH AN IRR OF 10.7%

Business case at ceiling tariff: The starting point for the economic evaluation is considering the **ceiling tariff of 11 cUSD/kWh** for wind projects above 20 MW. This is the maximum potential remuneration of a wind project for the chosen size, based on the draft of the current regulation. It therefore represents the best-case scenario in terms of returns for the wind project.

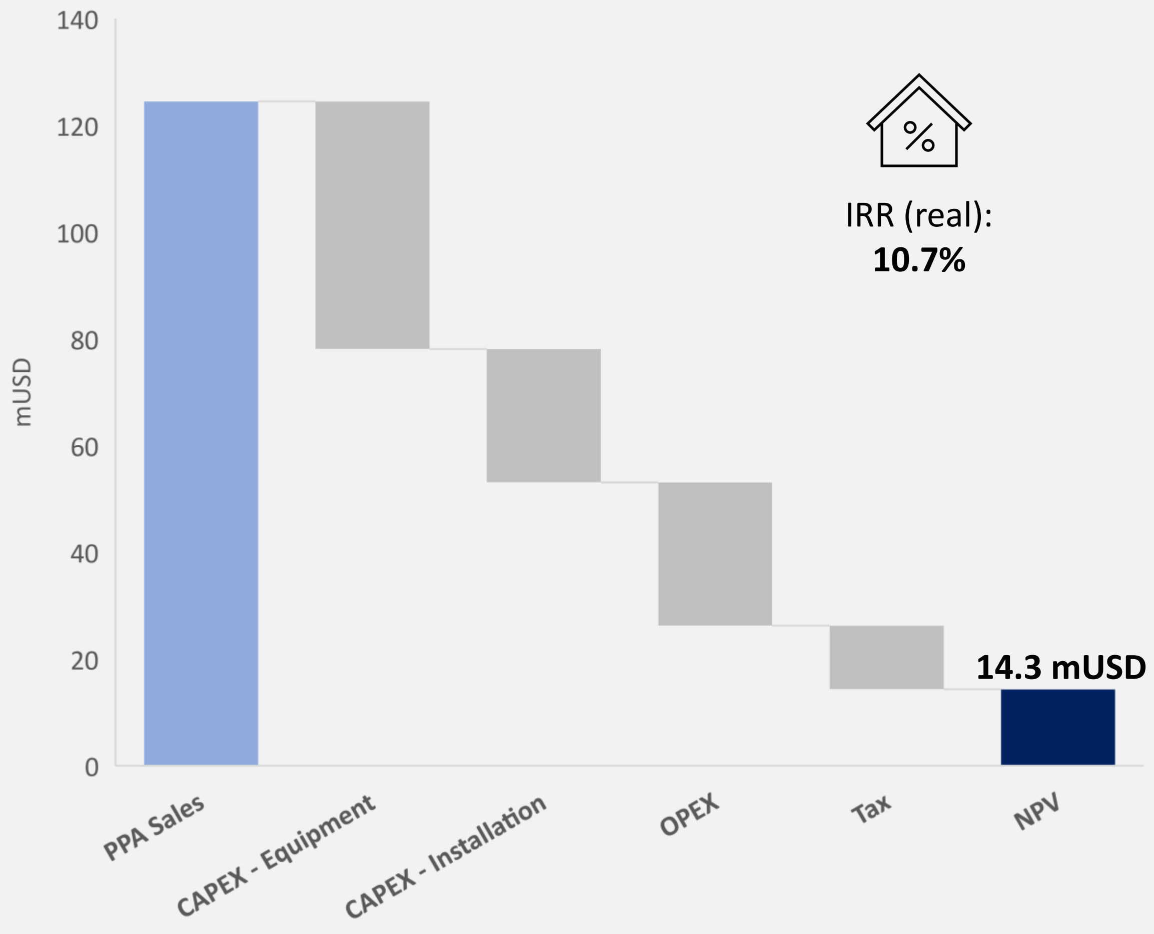
With this level of tariff and an expected annual production (P50) of 3,091, corresponding to a capacity factor of 35%, the total annual sales correspond to 17.0 mUSD. Since the PPA is not escalated, this level of annual sales are constant across the project lifetime in nominal terms.

The total CAPEX of 74 mUSD is the largest expense to offset, followed by OPEX of around 3 mUSD per year.

Results: The **resulting business case for a 50 MW wind plant in North Sulawesi is positive for a potential investor**, with 14.3 mUSD of Net Present Value and an Internal Rate of Return (real) of 10.7%, above the level of the estimated WACC.

NPV at ceiling tariff: **14.3 mUSD**
IRR at ceiling tariff: **10.7%**

Breakdown of NPV components at ceiling tariff[1] (mUSD)



Note: 1. The present value of each cashflow component (revenues and cost) is performed here to break down the contribution to the final NPV value for illustration purposes.

THE BREAK-EVEN TARIFF FOR THE WIND PROJECT IS 9.4 cUSD/KWH

Break Even Tariff: Two key factors are creating uncertainty in the potential tariff level to be expected by an investor in a wind project in North Sulawesi, namely:

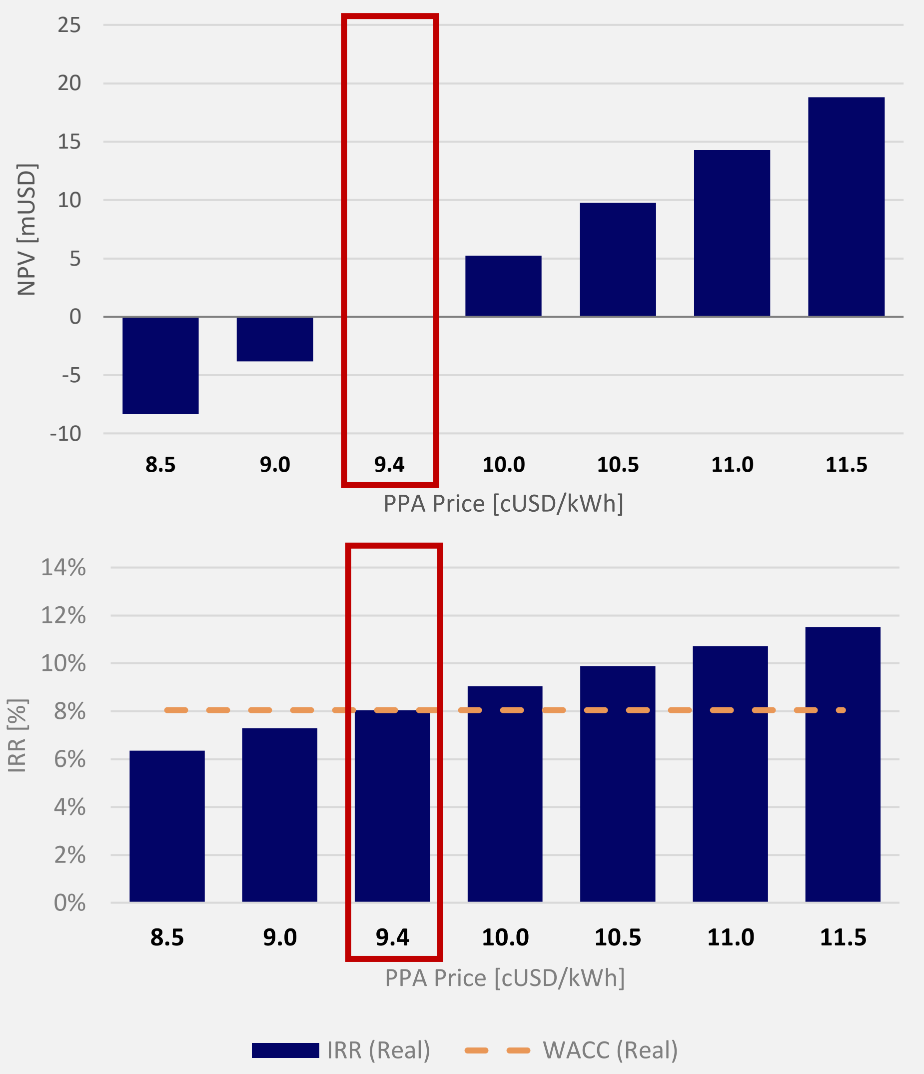
- The **provisional figures of new regulation** are still not confirmed, since the new presidential regulation is only at a draft stage;
- Most likely competition will stem for the development of the project and therefore an **auction process would take place**, where competitors will bid the minimum required tariff in order to develop the project.

For these two reasons, it is interesting to assess what would be the minimum tariff at which the project break even, guaranteeing an IRR equal to the expected WACC and a NPV of zero. We call this **Break-even Tariff**, and it virtually could represent the value of the bid to a potential auction for an investor that would aim at building the wind project under assessment with return in line with the expected WACC of 8%.

Results: The resultant break-even tariff for the analysed wind project in North Sulawesi is 9.4 cUSD/kWh, with the IRR varying between 6% and 12% when the tariff goes from 8.5 to 11.5 cUSD/kWh.

Break-even Tariff:
9.4 cUSD/kWh

Break-even tariff for the wind project (USD/MWh)



INTERNATIONAL CAPEX LEVELS LOWERS THE TARIFF TO 6.4 cUSD/KWH

Key uncertainty factors: When looking at the economic assessment for a wind project in such an early phase, several figures are highly uncertain. It is the case, for example, for the following factors:

- **Annual energy production (AEP)**: since no met mast measurements are available yet and the assessment is based on mesoscale modelling of wind speeds;
- **CAPEX:** the estimation of the capital costs is based on figures from previous projects and global trends, but actual project costs might largely vary depending on market conditions, supply chain and real project conditions.

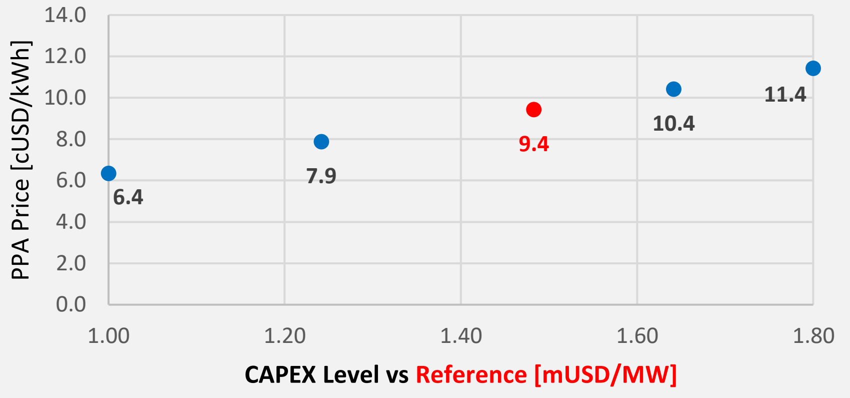
Operational expenditures are another uncertain factor, but the variability and impact on the results is much less significant, therefore it is not assessed in detail here.

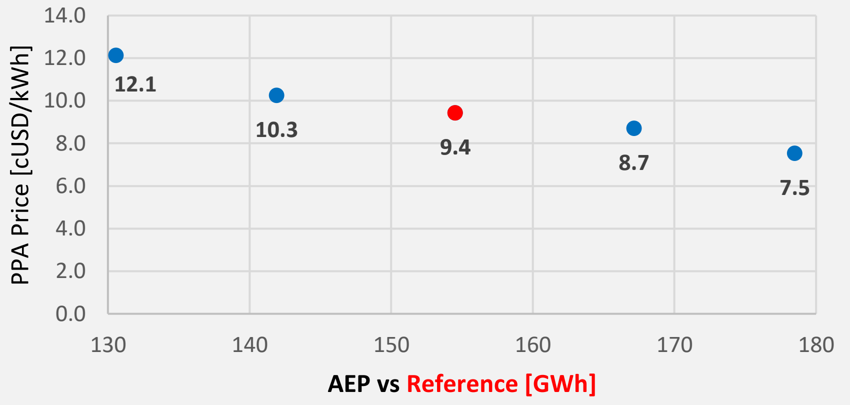
Sensitivity analysis: A sensitivity analysis is carried out on the break-even tariff, to assess the **potential variation of the auction bid if assumptions on key parameters vary** compared to the reference assumption in the study. While one parameter is varying, the other are kept constant, to isolate the impact of the single factor on the final expected tariff. The chosen variation for the key parameters is the following:

- CAPEX is varied **from 1 to 1.8 mUSD/MW**, corresponding to a range of -33% to +21% of the reference assumption. The lower bound is represented by the total installed cost reached internationally in Europe and US *(Irena)*.
- AEP is **varied between 130.6 and 178.5 GWh**, based on calculations of P75 & P90 cases versus the base case P50. Lower bound represents the break-even tariff assuming P90.

Results: The results of the sensitivity indicate that the **business case is largely affected by the assumptions on AEP and CAPEX**.
With a capex in line with the lower end of international figures, tariff can be reduced to 6.4 cUSD/kWh, while if the project costs increase to 1.8 mUSD/MW, the needed tariff is 11.4. The tariff needed at P90 level is 12.1 cUSD/kWh, but if higher production materializes, it can go as low as 7.5.
OPEX plays a more limited role in the business case but can still impact 7-8% the needed tariff.

Sensitivity on break-even tariff (cUSD/kWh)





Tariff can go as low as **6.4 cUSD/kWh** assuming international cost figures for wind CAPEX.
If P90 needs to be considered, the tariff increases to **12.1 CUSD/kWh**.

Sources: IRENA (2021)

LOCAL SURVEYS SHOW A POSITIVE ATTITUDE TOWARDS WIND

Social and economic impacts: Most of the local households are sustained by coconut farming, with the majority of the land used to grow coconut trees for production of copra (dried coconut kernels) and a few cassava and corn crops. Wind project using land lease scheme has the **opportunity to bring an economic benefit to the area** that is potentially higher than the current economic activities, but it is important to involve local population in the transition of local land use.

Having a production cost lower than the current BPP of North Sulawesi (9.4 as break-even tariff, versus a BPP of 10.2 cUSD/kWh), the addition of the wind project has the potential to **reduce the cost of generation** in the province, potentially impacting positively local communities and energy tariffs.

The construction and operation phase of the project can bring **local qualified employment**. For a wind farm of similar size, Tolo 1 in South Sulawesi (72 MW), 581 local workers (62%) out of 938 total workers involved at the peak of construction period. Moreover, additional local staff will be involved in the operation and maintenance of the plant post-construction.

Environmental impact: Among the largest negative impacts of a potential wind farm in the area are visual impact, noise impacting neighbors and land use, including potential clearing of forest and/or agricultural land to make room for the production facilities. The presence of large blades can also, in some cases, create a danger for animals like birds and bats. This can be exacerbated by the proximity of the national park. The attitude of local population during interviews (including visual cues regarding potential visual impact) were mostly positive, but substantial clearing of space will be needed in the area to make room for a 50 MW wind farm.

On the positive side, a wind project in the area can **reduce the reliance on fossil fuels**, namely coal and oil, which still account for a large portion of power generation in North Sulawesi. This translate into a reduction of local pollution (PM2.5, SOx) and a mitigation of greenhouse gas emissions.

Considering the average emission factor of Sulawesi grid from RUPTL, equal to 0.896 tonCO_2/kWh, the annual **CO_2 savings from the project would amount to 138 kton**.

Project acceptance: During site surveys, interview with relevant stakeholder were conducted. Example of stakeholders include: Head of District Office, Head of Village, Landowner and Farmer. A total of 27 stakeholder have been interviewed in North Sulawesi.

The attitude of local population towards a wind project is very positive given that there is an expectation of economic development impacts due to the project. The community leaders have a good understanding of wind power plants and have been familiar with the South Sulawesi wind projects through media and personal network. Landowners, farmers and local community members have only been familiar with the South Sulawesi project through media, but they are excited to have wind power plants in their backyard.

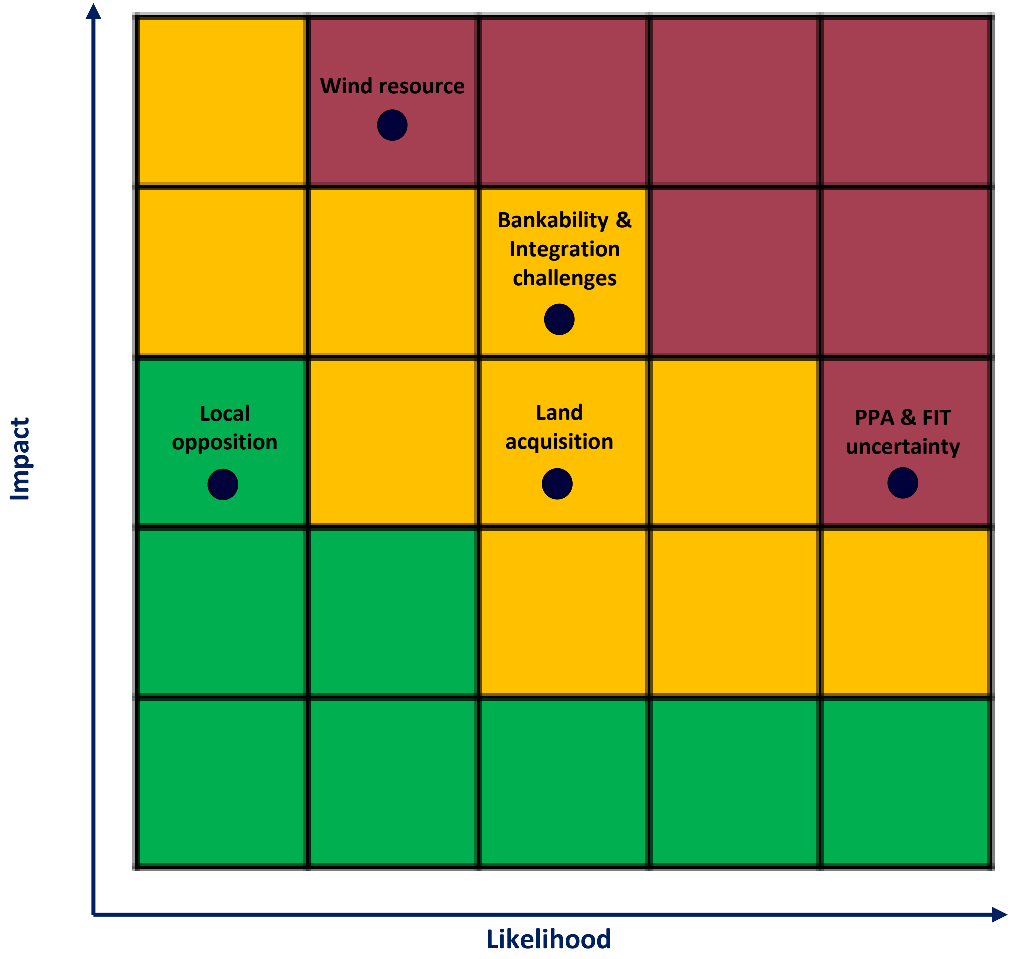
Throughout the interviews, pictures of the South Sulawesi wind projects have been shown to ensure there is a clear expectation of the turbine's scale and impact to their surroundings. For the local community, it can be a source of pride to have the wind turbine be part of their local landscape.

Sources: Local surveys result, DEA (2021), VENA Energy (2021), PLN Persero (2021)

KEY PROJECT RISKS ARE PPA UNCERTAINTY, WIND RESOURCE, BANKABILITY AND GRID INTEGRATION

Based on the site visits conducted during the project, the survey of local stakeholder and population, as well as the results of the economic analysis, the key risk factor for the project are outlined in the risk register and risk matrix below.

Risk name	Description	Impact	Action
PPA & FIT uncertainty	New regulation is under discussion and no certain levels of FIT have been published. Moreover, eventual competition on the bid could result in a tariff that is likely below the ceiling price.	Postponement of PPA signature and higher development costs. Competition can reduce the obtainable tariff.	• Ensure dialogue with PLN and ministry on regulation progress; • Prepare for adjustments to the revenue scheme.
Wind resource	Annual production after commissioning might be lower than assessed at prefeasibility or feasibility stage. Post-construction risk.	Returns from the project severerely affected.	• Conduct measurement campaign and study local wind conditions; • Use estimates with higher certainty (e.g. P75-P90).
Bankability issues	Lack of final approval from financing institution, potentially due to uncertainty on project return (e.g. low wind resource at P90 value)	Challenge to receive financing for the plant.	• Maintain communication with potential financial institutions regarding requirements for bankability, especially in relation to update of current regulation; • Reduce uncertainty on annual energy production by conducting measurement campaigns.
Grid integration challenges	PLN is concerned about the impact on grid operation and stability of local grids. This could lead to curtailment of production or a requirement for inclusion of a battery storage.	No PPA signed with PLN, Curtailment of production.	• Engage with PLN from early on in the process; • Develop proper integration study; • Prepare a plan to potentially add some battery system to the project.
Local opposition	Local population migh be against the project for reasons related to visual impact and influence on local economy (e.g. agricolture and forestry). The construction of the new airport might create situations of conflict with upcoming infrastructure investments.	Delayed project development or problems during construction.	• Develop a strategy to involve local population from an early project stage; • Reserve a budget for projects aimed at transferring some of the benefit to local communities in the form of services, infrastructure development or others.
Land acquisition issues	Land acquisition is a challenge in Indonesia due to conflict with other activities such as agricolture and forestry. Another challenge stems from the lack of official registries related to ownership of land.	Delayed project development or stop on PPA signature for lack of land ownership rights.	• Map land ownership; • Engage with local population from an early project stage.



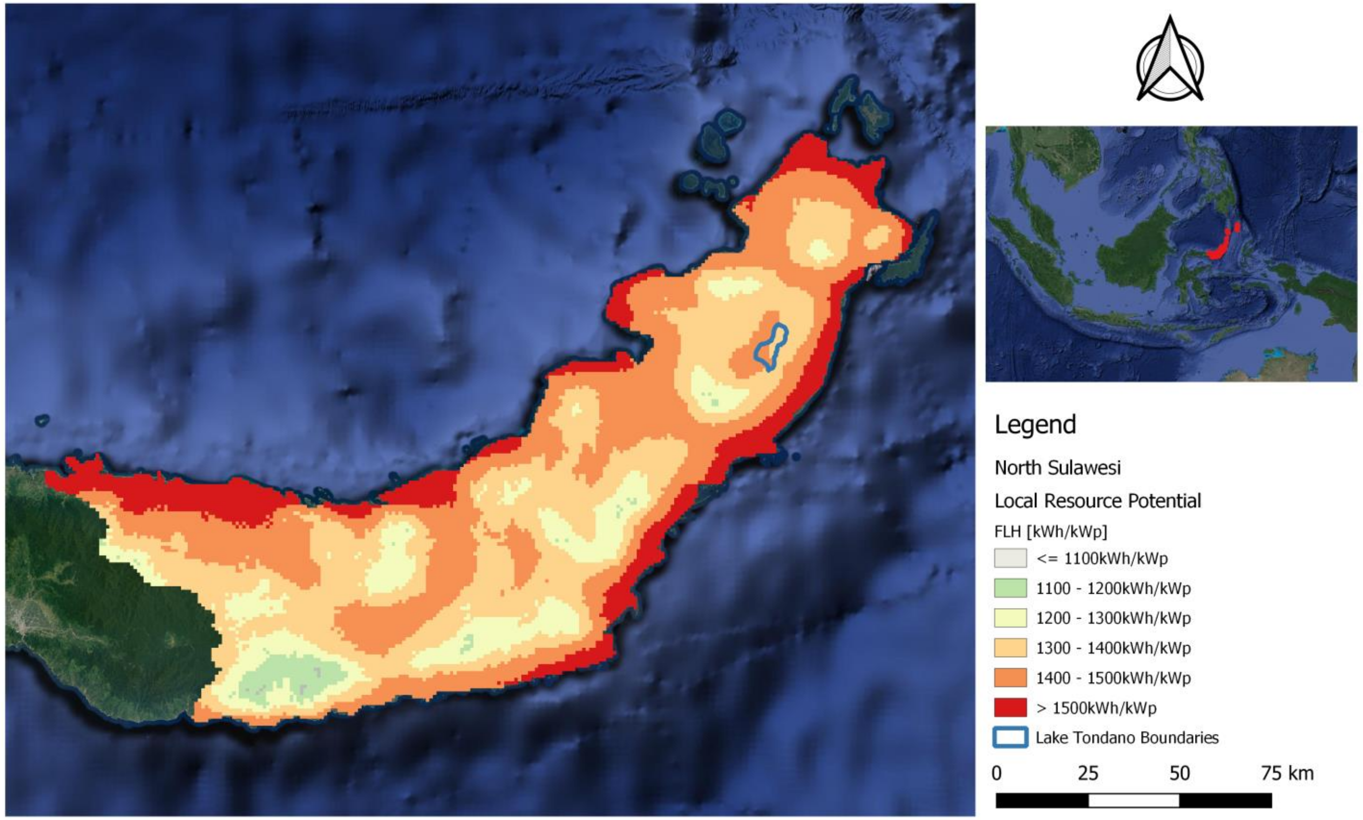
SOLAR PV
POWER PLANT
-
GROUND MOUNTED

Source: VENA Energy (Likupang plant)

SOLAR PRODUCTION IS EXPECTED TO BE 2,120 KWH/KW

Solar irradiation distribution: The daily mean incoming global horizontal irradiation (GHI) on a flat ground level is distributed in a roughly uniform manner across the province, with the highest values found at the outskirts of the local boundaries, as expected due to increased reflection effects from the sea surface. Moving closer inland, GHI tends to decrease as can be seen in the figure, dropping to values as low as 2.5 kWh/m²

The experienced FLH, following the above patterns, are distributed in a similar manner and can be seen in the figure below. The maximum provincial potential rises up to approximately 1500 full load hours (FLH with respect to peak capacity) per year.

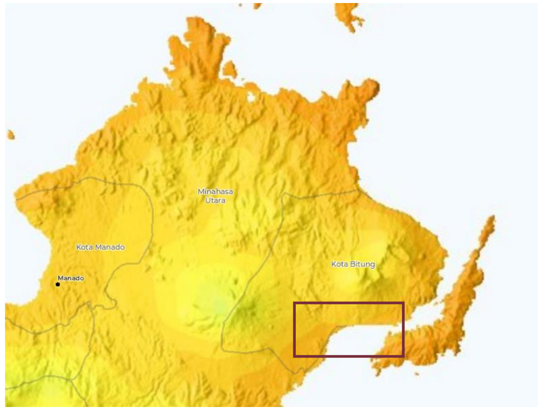


Location selection: Given the relatively uniform distribution of GHI, the choice of location is less pivotal than for wind power in terms of resource quality. Other factors will play an important role such as proximity to the grid, space availability and presence of substantial load. Few coastal areas stand out for the high irradiation, among which Likupang, that already hosts the aforementioned 15 MW solar PV plant. Other high irradiation areas such as North and East Bolaang Mongondow Regency are far from the load centers.

Considering these and other aspects, such as the presence of the Special Economic Zone, the location selected for the development of ground mounted solar PV is the area around **Bitung**. An alternative location for the development of PV is Lembeh island, that have lower land prices and is still connected to the main grid through a 150kV interconnector.

Potential production: When assessing the production of a PV plant, it is very important to distinguish between AC and DC rating (see sizing factor description in next page).

The Global Solar Atlas indicates **potential productions in the area of around 1514 kWh/kWdc. This corresponds to 2,146 kWh/kWac**, which is the value that will be used for the study.



Capacity factors:

AC: **24.2%** (2,120 FLH)
DC: **17.3%** (1,514 FLH)

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Sources: ESMAP & World Bank (2021)

DAILY PRODUCTION IS RELATIVELY CONSTANT THROUGHOUT THE YEAR

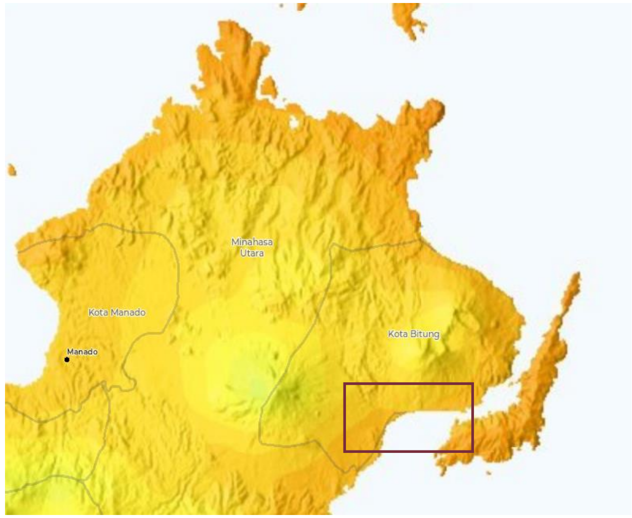
Parameters assumed for the PV:

Tilt: **3º**
Azimuth: **180º**
Losses assumed: **7.2%**

Capacity factors:

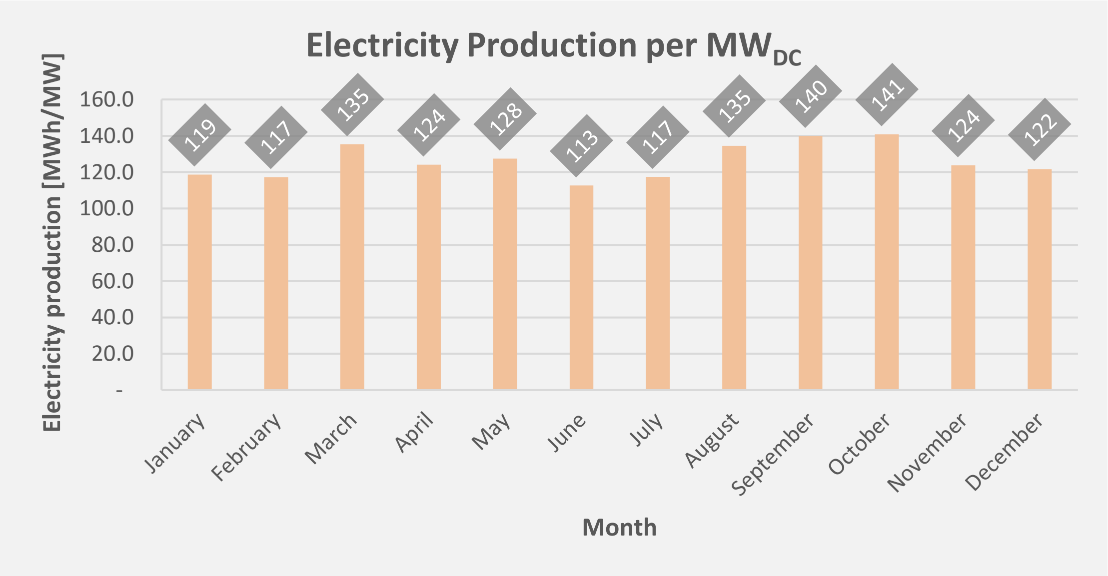
AC: **24.2%** (2,120 FLH)
DC: **17.3%** (1,514 FLH)

The capacity factor of the existing PLTS in Likupang is now 24.8% (AC) confirming that the value selected is a reasonable estimate



Monthly production: The average potential daily unit production (MWh/MW) deviates on a monthly basis by an average of 14% in the course of a year, signalizing a quite stable electricity production annually. This guarantees a stable monthly output that can supply the load relatively constantly on a seasonal basis. This is an advantage compared to wind power in the region, which is concentrated on the period May-September. Months with the highest solar production are March to May and August to October.

Annual production: When looking at the daily production of solar across the year, one can note that the highest production is observed within the window 10:00 to 13:00 and that by 18:00 the production of solar drops to zero. This is the time where power is most needed to supply the evening peak of power demand and create challenges in the power system to fulfill the load ramps needed.



Hourly electricity production profile [kWh/MW_{DC}]

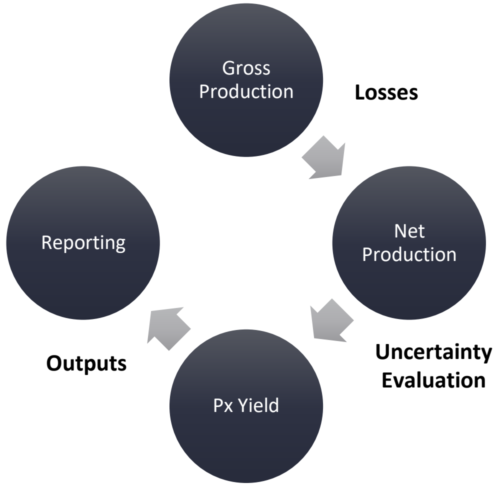
Daily Hour	January	February	March	April	May	June	July	August	September	October	November	December
0:00	0	0	0	0	0	0	0	0	0	0	0	0
1:00	0	0	0	0	0	0	0	0	0	0	0	0
2:00	0	0	0	0	0	0	0	0	0	0	0	0
3:00	0	0	0	0	0	0	0	0	0	0	0	0
4:00	0	0	0	0	0	0	0	0	0	0	0	0
5:00	0	0	0	4	5	3	2	2	6	10	9	4
6:00	58	57	69	95	99	81	69	83	116	143	134	98
7:00	210	216	237	267	259	222	207	238	291	322	307	257
8:00	346	365	398	415	406	354	335	383	450	476	451	400
9:00	454	482	511	519	515	452	435	505	575	584	534	493
10:00	500	544	564	561	570	509	502	580	639	640	561	530
11:00	516	564	587	549	571	524	528	606	645	619	541	525
12:00	487	535	563	503	518	486	503	579	608	551	490	489
13:00	448	502	519	453	445	430	453	521	532	479	433	431
14:00	378	421	434	376	361	344	364	416	409	374	345	350
15:00	272	308	305	262	247	234	249	281	269	244	227	236
16:00	140	163	157	129	111	108	123	134	119	99	94	107
17:00	18	32	24	7	6	9	18	11	6	4	4	5
18:00	0	0	0	0	0	0	0	0	0	0	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0

Sources: ESMAP & World Bank (2021)

UNCERTAINTY IN THE PRODUCTION: P90 VALUE IS 1858 FLH_{AC}

Solar resource assessment: To perform a resource assessment, including confidence intervals, the starting point for evaluation of irradiation and losses has been the Global Solar Atlas, while additional uncertainty factors in relation to model used and the interannual variability are considered in the following calculations.

Process: The process to calculate the energy yield at different confidence levels has been the following:
- Gross production: data from Global Solar Atlas for selected location
- Net production: assumption of systematic operational losses (7.1%) applied through Global Solar Atlas
- P50, P75, P90: Consideration of uncertainty factors on production and calculation of confidence level on annual energy production



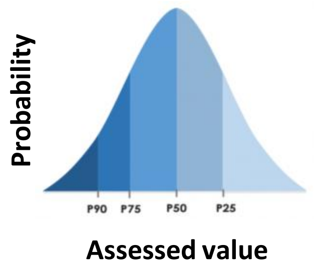
Considered Uncertainty Factors i	
Solar Radiation Model Uncertainty	8.00%
Energy Simulation Model Uncertainty	5.00%
Inter-Annual Variability of Expected Energy	2.00%

**Global Solar Atlas has provided the FLH results as an average of a series of years. DC losses (soiling 3.5%, cables 2.0%, mismatch 0.3%) and AC losses (transformer 0.9%, cables 0.5%) are already considered in the core model.*

Uncertainty Level	Probability of Exceedance vs P50	Formula
$P75_{uncertainty}$	75%	$\sqrt{\sum_i (0.675 * Uncertainty_i)^2}$
$P90_{uncertainty}$	90%	$\sqrt{\sum_i (1.282 * Uncertainty_i)^2}$

Resulting values: The final value for P50 is the central estimate used for the Business Case and corresponds to **42.4 GWh** (**2,120 FLH**). Often at a later stage of the project, when financing needs to be secured, P90 is the preferred indicator since it entails a significantly higher certainty. The P90 is here equal to 37.2 GWh (1,858 FLH)

Value Level	Description	FLH_{AC} Confidence	AEP Confidence [GWh/y]
$P50_{value}$	Value based on the already considered uncertainty within the calculated model	2,120	42.4
$P75_{value}$	$P50_{value}$ * (1 - $P75_{uncertainty}$)	1,982	39.6
$P90_{value}$	$P50_{value}$ * (1 – $P90_{uncertainty}$)	1,858	37.2



1 Background & scope
2 Revenue streams
3 Resource evaluation
4 Project size & restrictions
5 Financial & technical key figures
6 Business case
7 Environmental & social aspects
8 Risk assessment

Sources: ESMAP & World Bank (2021), MEASNET (2016), SolarGis (2021)

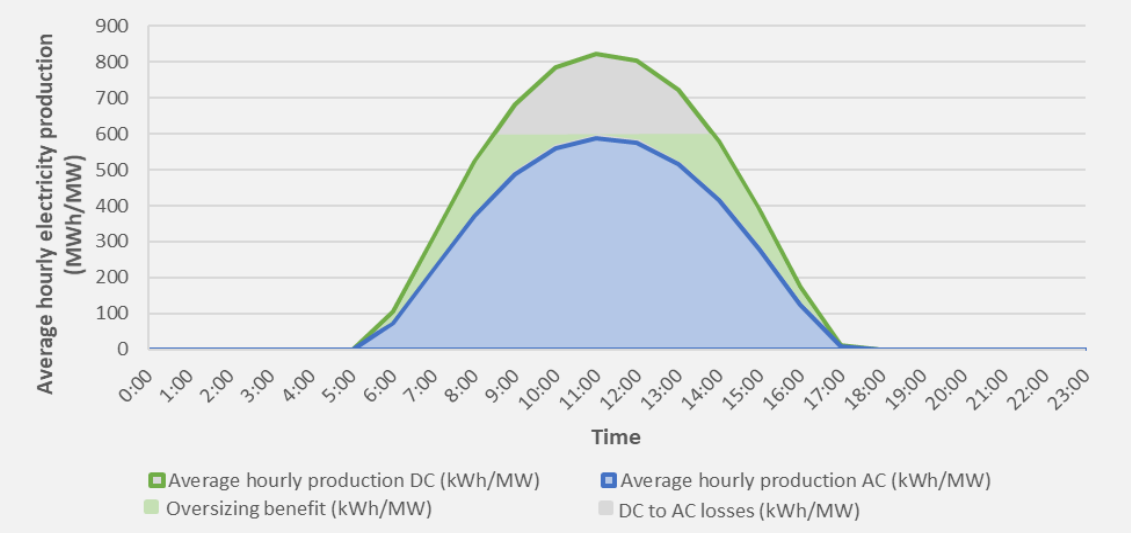
20 MW AC PLANT CHOSEN FOR THE STUDY, WITH 1.4 SIZING FACTOR

DC to AC sizing: As mentioned before, when assessing the cost and production of a PV plant, it is very important to distinguish between the capacity and the capacity factor for the DC part and for the AC part. Oftentimes, the AC capacity output is significantly lower than the DC rating. This is done because 1 MW of DC capacity often translate to a lower capacity at the inverter due to losses. The inverter also works at higher efficiency at higher loads. The oversizing of the DC side compared to AC side brings along savings in the inverter and grid connection, as well as more efficient operation. A DC/AC factor, also called sizing factor, of 1.1-1.5 is common nowadays.

Data from existing plants: The Likupang solar plant has a capacity of 21 MWdc and 15 MWac, corresponding to a sizing factor of 1.4, value that is also chosen for this assessment.

Capacity selection: A **20 MWac PV plant has been chosen as the suitable reference case** for the project under examination, for several reasons:

- The grid still faces limitations in terms of absorption of variable renewable energy (e.g. lack of automatic generation controllers, limited spinning reserve available for facing sudden change of generation).
- PLN has a relatively low experience with dispatching solar power plants.
- A similar size has been approved for PLTS Likupang already.
- Distributing a future higher solar capacity in smaller plants increase the diversification of the solar resource, thus smoothening the output seen from the control center.
- A smaller solar plant would reduce the economy of scale.



Grid conditions: The presence of the Special Economic Zone of Bitung in the area with the highest wind potential has several benefits, including an efficient supply of the projected industrial load in the economic area and the availability of a relatively strong connection point/grid.

Based on the figures from PLN, the substation of Bitung has a relatively high spare capacity to be used to host the infeed from solar power, as can be seen in the table below.

Substation	Transformer	Installed Power (MVA)	Highest Load (MVA)	Capacity (%)	Voltage Rating	Installed Power (MVA)	Installed Load (MVA)	Capacity (%)
Bitung	1	30	5.174	17%	70/20	80	12.13	15%
	4	20	11.059	55%	70/20			
	6	30	12.133	40%	70/20			

Sources: PLN – local office (2021), DEA (2021), VENA Energy (2021)

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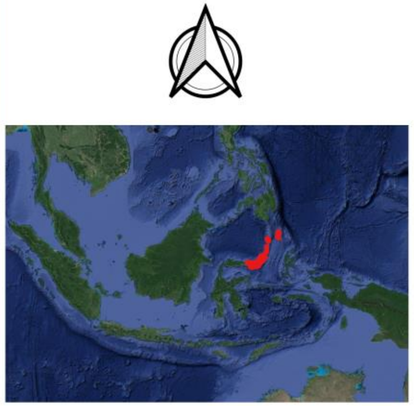
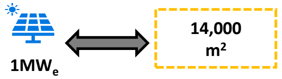
A POTENTIAL LOCATION CLOSE TO BITUNG IS IN THE MADIDIR DISTRICT





Legend

North Sulawesi

Ground Mounted PV Space Requirements

0 1 2 3 4 5 km

Siting considerations: Beside the consideration of irradiation, which is the key factor for the selection of a site, proximity to a suitable grid network and load size, as well as availability of land are important factors.

Location of the ground-mounted PV plant: As mentioned earlier, the selection of the area for the development of a ground-mounted PV plant is the Bitung area.
After an evaluation of potential location in regencies and districts around the city, the most suitable area selected is in the Madidir district, in particular in the following areas: Wangurer Barat and Wangurer Utara.

Most of the land have coconut trees, a few of cassava farms and corn fields. Depending on the scheme for the project, leasing land from the landowners can potentially bring more economic value to the community than their current farming practices.

Spacing requirements: A ground-mounted PV plant of 20MWac magnitude (28MWdc with a sizing factor of 1.4) will require 14,000m^2/MWdc, according to the latest Indonesian data reported by DEA. This translates to 0.39km^2 (39 Ha) of space considerations within the optimal considered area.

Data from existing plants: A project of a similar scale in the province is located in Likupang (PLTS Likupang), where a 21MWdc ground mounted solar PV park occupies approximately a surface of 39 Ha.

Sources: DEA (2021), Local surveys

TECHNO-ECONOMIC DATA USED FOR THE BUSINESS CASE

Technical features	
Capacity	28 MWdc 20 MWac
Technical lifetime	37 years
Plant availability	99.5%
Space requirements	14,000 m²/MWdc
Capacity factor	24.2% (AC) 17.3% (DC)
Construction time	0.5 years
DC/AC Inverter lifetime	15 years

Economic features	
CAPEX	0.69 M$/MWdc 0.96 M$/MWac
Fixed OPEX	10,279 $/MWdc-year 14,391 $/MWac-year
WACC (real)	8.04%
Expected tariff	8.25 cUSD/kWh
Corporate tax rate	20%
Depreciation rate	6.25% (16 years of depreciation period)
Inflation rate (USD)	2.00%

**Figures reflect the estimated 2022 data (beginning of construction) in real 2021 price levels , provided via local EPC contacts.*

Comparison of CAPEX sources: Several sources indicate different CAPEX estimations for Indonesia and more specifically North Sulawesi. Assuming construction in 2022, the following costs apply:

Source	CAPEX	Notes
Technology catalogue for Indonesia	0.68 M$/MWdc 0.96 M$/Mwac	Value for whole Indonesia, based on extrapolation of PPAs and other international sources. Interpolation between 2020, 2030 and 2050. Sizing factor adjusted upwards to 1.4.
EPC contractors in North Sulawesi	0.69 M$/MWdc 0.96 M$/MWac	Average value for 2021 based on elicitation of EPC prices from 4 providers (Ranges mentioned: 0.61-0.65, 0.8-0.9, 0.65-0.7, 0.7-0.8).
PLTS Likupang (2018)	1.39 M$/MWdc	For comparison, the CAPEX of PLTS Likupang, which started operation in 2018 is shown. Currency here is at time of construction.

Note: Figures reflect the estimated 2022 data (beginning of construction) in real 2021 price levels. Likupang data reflect currency and costs at time of construction.

FID and COD: The assumed final investment decision (FID) is 2022 and the commercial operation date (COD) is 2024 with construction stretching between 2022 and 2023.

Land cost: Indication from the site surveys shows that land located within the interest area of Madidir district, found at the southern side of Bitung, reflect an average price of land acquisition at approximately 241,500.00Rp/m² (16.70 USD/m²).

Subsequent knock-on costs that may occur reflect the compensations of cutting down coconut trees, rising to 250,000.00 - 300,000.00Rp/tree (17.86 – 21.43 USD/tree).

PV module price considerations

Increased component cost trajectories

Solar module procurement has experienced a slight inflation within the past year, mainly due to shortages in polysilicon and glass materials. Bids for module attainment have climbed up by 14% on average within the Chinese market over 2020 pushing the price to 0.28$/W.

Although the material shortage has been expected to be short-term, the ladscape hasn't improved up to date, rather worsened. Domino effects have notably also reached the European market, where since January 2021, all types of crystalline module bids jumped upwards in a range between 6 and 13%.

Sources: PV-Tech (2021), PVxChange (2021), VENA Energy (2021), Local surveys, Interviews with EPC contractors in North Sulawesi.

AT CEILING TARIFF, THE GROUND-MOUNTED PV PROJECT IS PROFITABLE WITH AN IRR OF 9.7%

Business case at ceiling tariff: The starting point for the economic evaluation is considering the **ceiling tariff of 8.25 cUSD/kWh** for solar projects until up to 20 MW. This is the maximum potential remuneration of a solar project for the chosen size, based on the draft of the current regulation. It therefore represents the best-case scenario in terms of returns for the solar project.

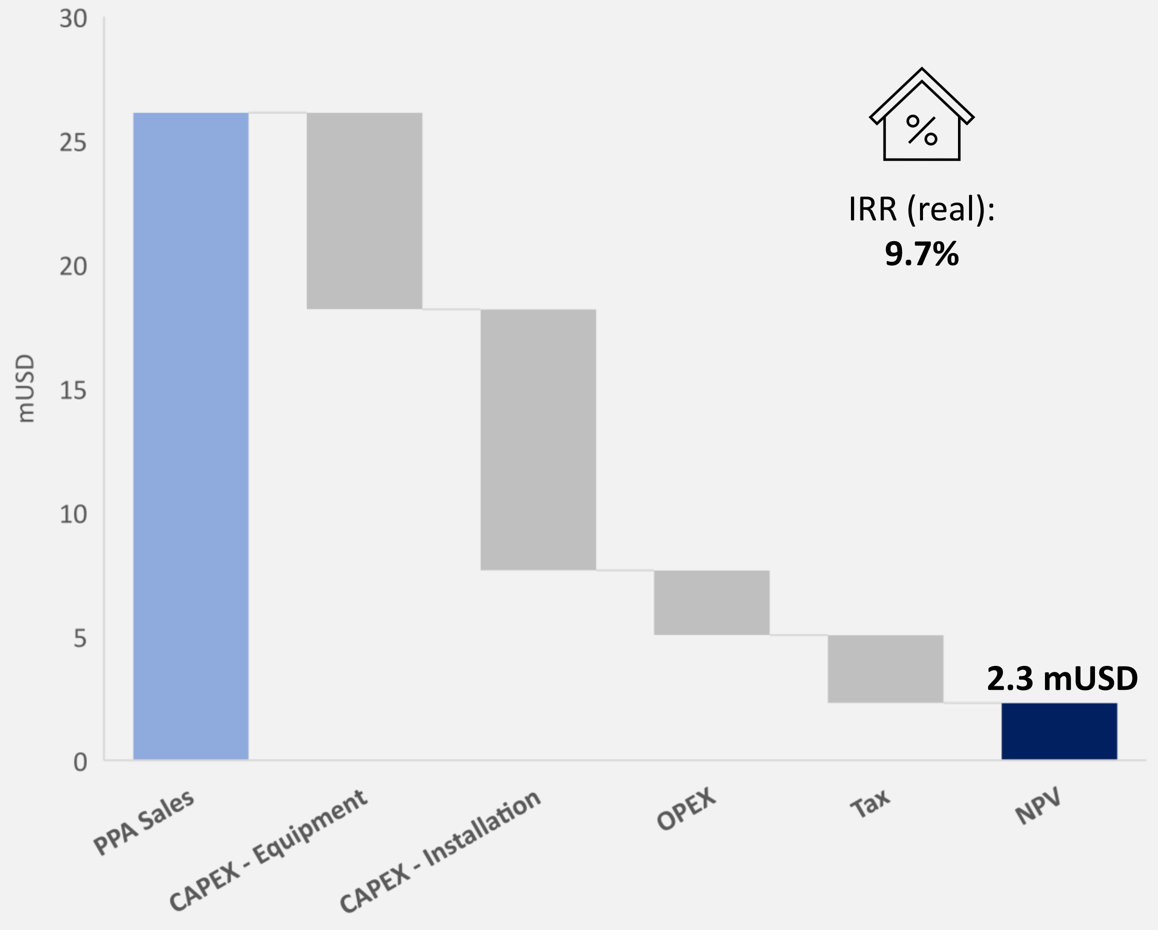
With this level of tariff and an expected annual production (P50) of 2,120 FLH_{AC}, corresponding to a capacity factor of 24.2%, the total annual sales correspond to 3.5 mUSD. Since the PPA is not escalated, this level of annual sales are constant across the project lifetime in nominal terms.

The total CAPEX of 19.2 mUSD is the largest expense to offset, followed by OPEX and taxation at around 2.6-2.7 mUSD per year each.

Results: The **resulting business case for a 20 MW ground-mounted solar plant in North Sulawesi is positive for a potential investor**, with 2.3 mUSD of Net Present Value and an Internal Rate of Return (real) of 9.7%, above the level of the estimated WACC of 8%.

NPV at ceiling tariff: **2.3 mUSD**
IRR at ceiling tariff: **9.7%**

Breakdown of NPV components at ceiling tariff (mUSD)



Note: 1. The present value of each cashflow component (revenues and cost) is performed here to break down the contribution to the final NPV value for illustration purposes.

THE BREAK-EVEN TARIFF FOR THE PV PROJECT IS 7.3 cUSD/KWH

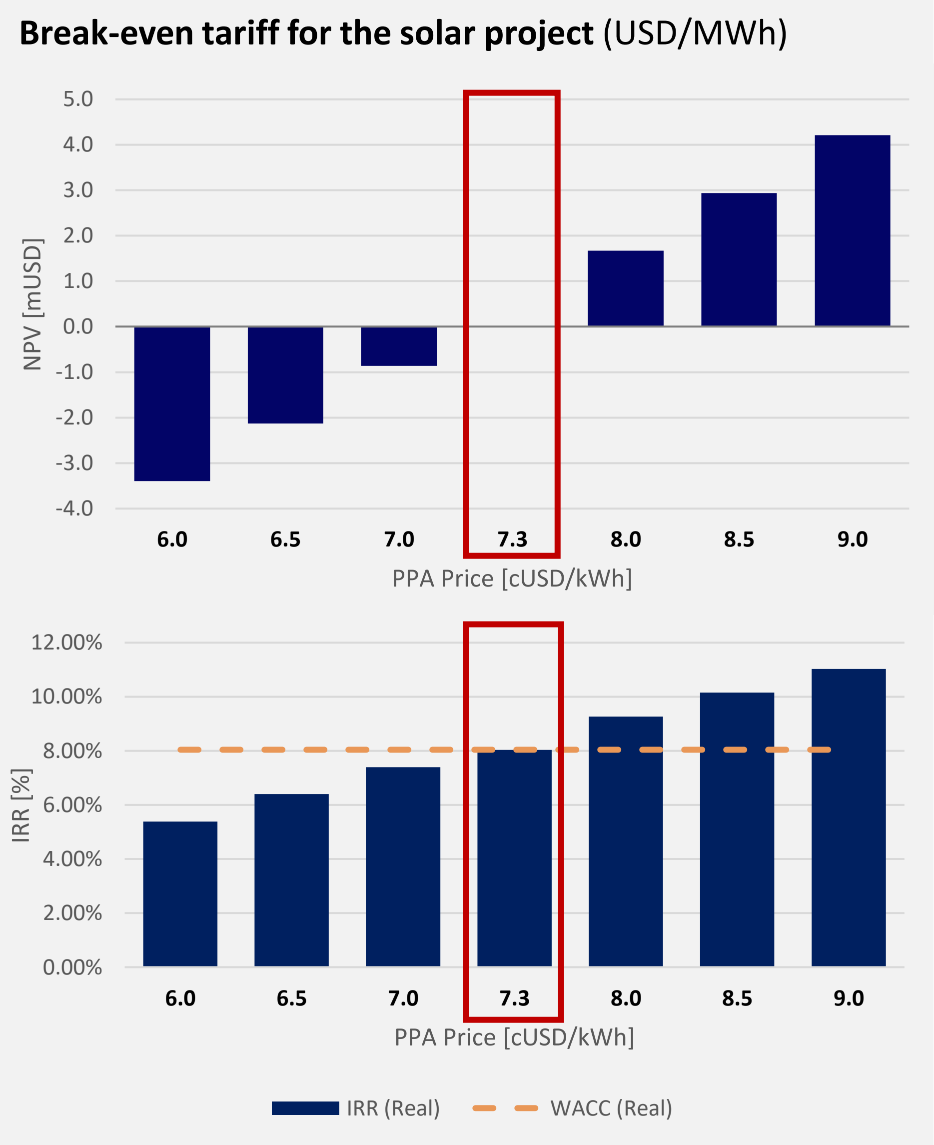
Break Even Tariff: Two key factors are creating uncertainty in the potential tariff level to be expected by an investor in a solar project in North Sulawesi, namely:

- The **provisional figures of new regulation** are still not confirmed, since the new presidential regulation is only at a draft stage;
- Most likely competition will stem for the development of the project and therefore an **auction/negotiation process would take place**, where competitors will bid the minimum required tariff in order to develop the project.

For these two reasons, it is interesting to assess what would be the minimum tariff at which the project break even, guaranteeing an IRR equal to the expected WACC and a NPV of zero. We call this **Break-even Tariff**, and it virtually could represent the value of the bid to a potential auction/negotiation for an investor that would aim at building the solar project under assessment with return in line with the expected WACC of 8%.

Results: The resultant **break-even tariff for the analysed solar project in North Sulawesi is 7.3 cUSD/kWh**, with the IRR varying between 5.4% and 11% when the tariff goes from 6 to 9 cUSD/kWh.

Break-even Tariff:
7.3 cUSD/kWh



LOWER BOUND OF CAPEX FIGURES LOWERS TARIFF TO 5.9 cUSD/KWH

Key uncertainty factors: When looking at the economic assessment for a solar project in such an early phase, several figures are highly uncertain. It is the case, for example, for the following factors:

- **CAPEX:** the estimation of the capital costs is based on figures from EPC, but actual project costs might largely vary depending on market conditions, supply chain and real project conditions;
- **Capacity factors**: since evaluation of irradiance and potential annual production is based on modelled data at this stage;

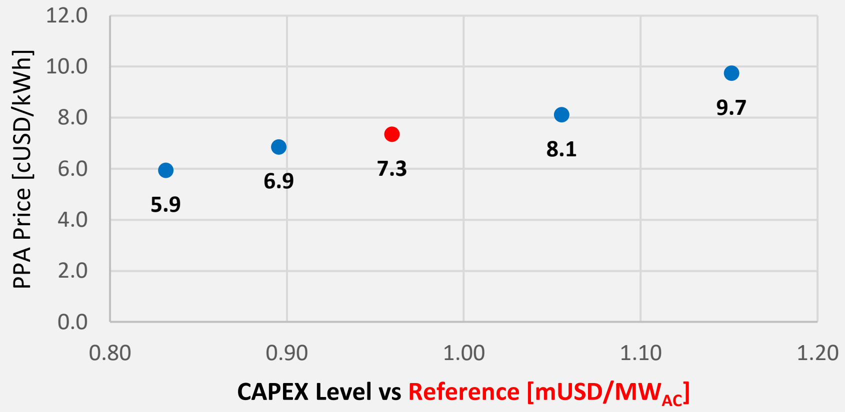
Operational expenditures are another uncertain factor, but the variability and impact on the results is much less significant, therefore it is not assessed in detail here.

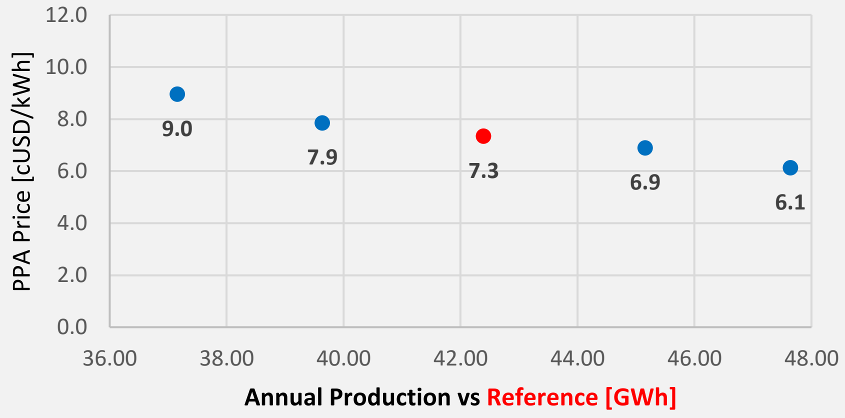
Sensitivity analysis: A sensitivity analysis is carried out on the break-even tariff, to assess the **potential variation of the auction bid if assumptions on key parameters vary** compared to the reference assumption in the study. While one parameter is varying, the other are kept constant, to isolate the impact of the single factor on the final expected tariff. The chosen variation for the key parameters is the following:

- CAPEX is varied from **0.83 to 1.15 mUSD/MW$_{AC}$**, corresponding to a range of -13% to +20% of the reference assumption. The range selected is the cost range indicated by EPC contractors for a project in North Sulawesi.
- Annual production is varied between **37.2** and **47.6 GWh**, based on calculations of P75 & P90 cases versus the base case P50. Lower bound represents the break-even tariff assuming P90.

Results: The results of the sensitivity indicate that the **business case is largely affected by the assumptions on CAPEX and capacity factors/annual production**.
Considering an annual production value equal to P90 (1,858 FLH$_{AC}$) the break-even tariff moves up to 9.0 cUSD/kWh, above the threshold of the ceiling tariff. Similarly, CAPEX plays an important role with the range of bids 5.9-9.7 cUSD/kWh for the variation of the capital expenditures indicated by EPC. OPEX plays a more limited role in the business case but can still impact 3-4% the needed tariff with a change of -20 to +20% OPEX.

Sensitivity on break-even tariff (cUSD/kWh)





Tariff can go as low as **5.9 cUSD/kWh** with lower bound of CAPEX (0.83 mUSD/MW$_{AC}$)
If P90 needs to be considered, the tariff increases to **9 cUSD/kWh**.

LOCAL SURVEYS SHOW A POSITIVE ATTITUDE TOWARDS PV

Social and economic impacts: Most of the local households are sustained by coconut farming, with the majority of the land used to grow coconut trees for production of copra (dried coconut kernels) and a few cassava and corn crops. PV project using land lease scheme has the **opportunity to bring an economic benefit to the area** that is potentially higher than the current economic activities, but it is important to involve local population in the transition of local land use.

Having a production cost lower than the current BPP of North Sulawesi (7.3 as break-even tariff, versus a BPP of 10.2 cUSD/kWh), the addition of the PV project has the potential to **reduce the cost of generation** in the province, potentially impacting positively local communities and energy tariffs.

The construction and operation phase of the project can bring **local qualified employment**. For a plant of similar size, Likupang Solar PV in North Sulawesi, more than 200 local workforces were employed during construction and during operation 22 employees on site plus 14 employees remotely are needed.

Environmental impact: Among the largest negative impact of a potential PV plant in the area is visual impact and land use, including potential clearing of forest and/or agricultural land to make room for the production facilities. The attitude of local population during interviews, including visual cues regarding potential visual impact from the project were mostly positive.

On the positive side, a PV project in the area can **reduce the reliance on fossil fuels**, namely coal and oil, which still account for a large portion of power generation in North Sulawesi. This translate into a reduction of local pollution (PM2.5, SOx) and a mitigation of greenhouse gas emissions.

Considering the average emission factor of Sulawesi grid from RUPTL, equal to 0.896 tonCO_2/kWh, the annual **CO_2 savings from the project would amount to 38 kton**.

Project acceptance: During site surveys, interview with relevant stakeholder were conducted. Example of stakeholders include: Head of District Office, Head of Village, Landowner and Farmer. A total of 27 stakeholder have been interviewed in North Sulawesi.

The attitude of local population towards a PV project is very positive especially given that there is precedence at Likupang and Gorontalo. All the respondents of the interviews were receptive to additional solar PV installations. This is due to the positive impacts that previous solar PV projects have brought such as additional jobs to the locals during construction and after operations.

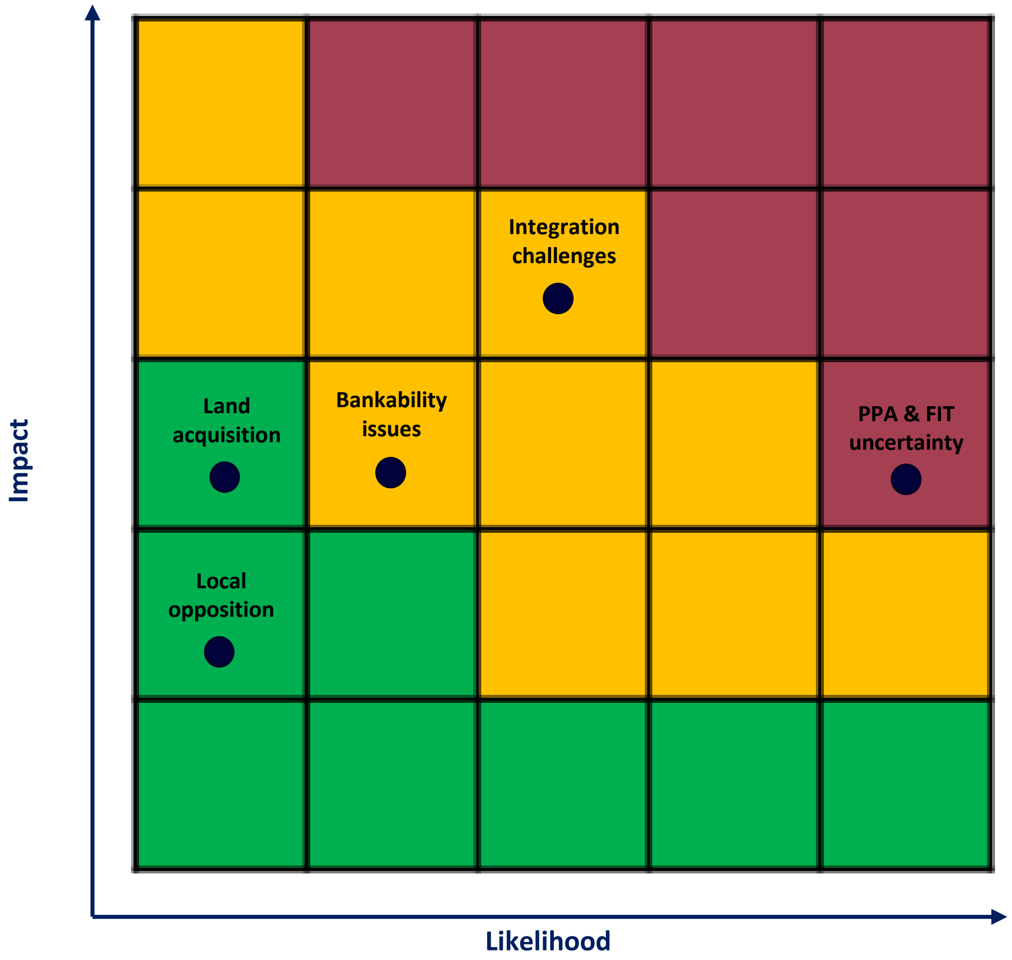
Moreover, institutional support for renewable energy is strong at every level of the local government, which sees renewable energy as an opportunity to increase tourism and label North Sulawesi as a green destination. This is especially the case also for the Special Economic Zone in Bitung, where on top of institutional support, companies that come to establish production would be interested in accessing low cost and green generation.

Sources: Local surveys result, DEA (2021), VENA Energy (2021), PLN Persero (2021)

KEY PROJECT RISKS ARE PPA UNCERTAINTY AND GRID INTEGRATION

Based on the site visits conducted during the project, the survey of local stakeholder and population, as well as the results of the economic analysis, the key risk factor for the project are outlined in the risk register and risk matrix below.

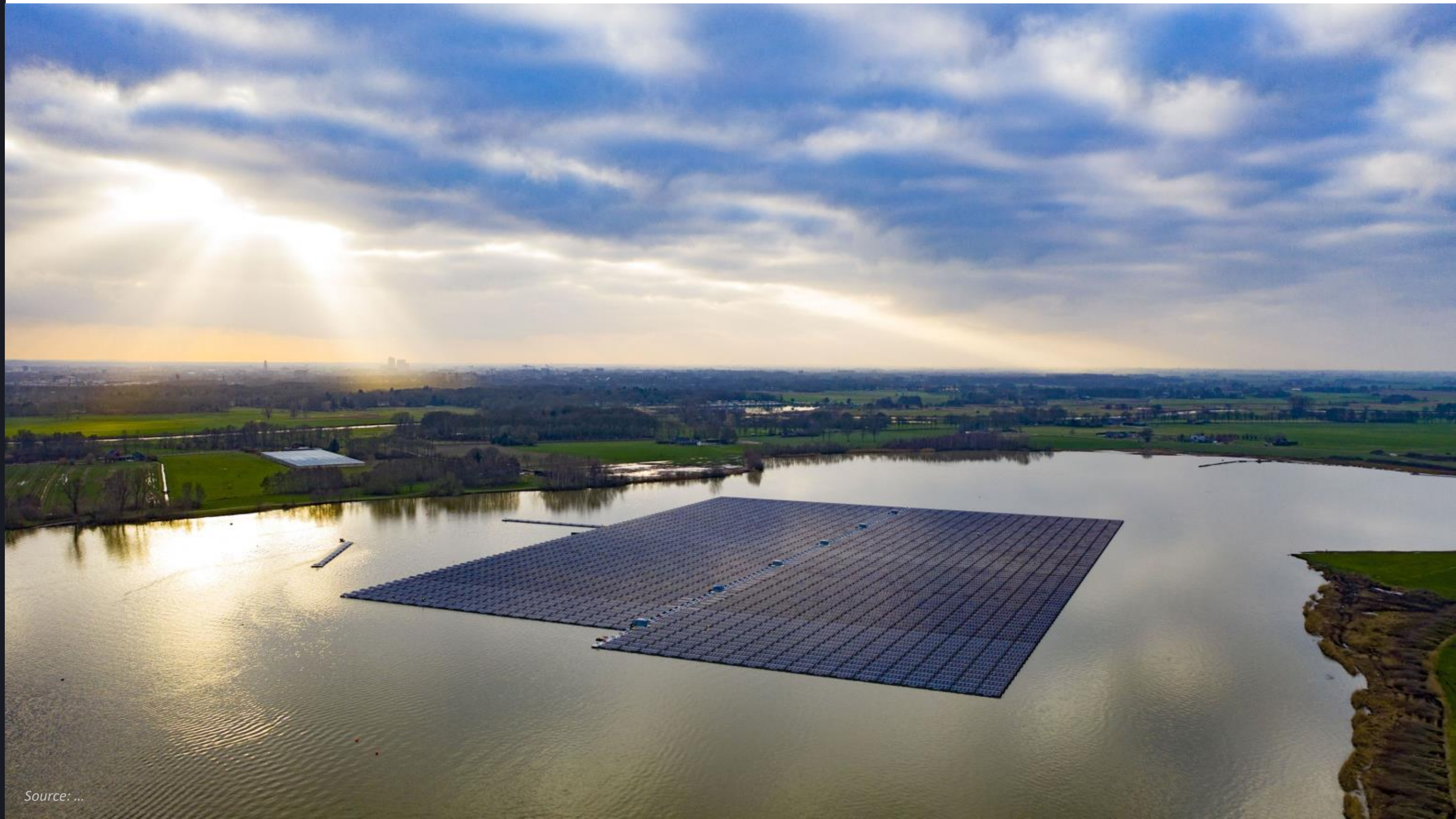
Risk name	Description	Impact	Action
PPA & FIT uncertainty	New regulation is under discussion and no certain levels of FIT have been published. Moreover, eventual competition on the bid could result in a tariff that is likely below the ceiling price.	Postponement of PPA signature and higher development costs. Competition can reduce the obtainable tariff.	• Ensure dialogue with PLN and ministry on regulation progress; • Prepare for adjustments to the revenue scheme.
Grid integration challenges	PLN is concerned about the impact on grid operation and stability of local grids. This could lead to curtailment of production or a requirement for inclusion of a battery storage.	No PPA signed with PLN, potential curtailment of production.	• Engage with PLN from early on in the process; • Develop proper integration study; • Prepare a plan to potentially add some battery system to project.
Bankability issues	Lack of final approval from financing institution, potentially due to uncertainty on project return. Banks have in the past expressed concerns regarding the BOOT scheme that PLN preferred before 2020. A new option for BOO has been introduced by new regulation revision.	Challenge to receive financing for the plant.	• Maintain communication with potential financial institutions regarding requirements for bankability, especially in relation to update of current regulation.
Local opposition	Local population migh be against the project for reasons related to visual impact and influence on local economy (e.g. agricolture and forestry).	Delayed project development or problems during construction.	• Develop a strategy to involve local population from an early project stage; • Reserve a budget for projects aimed at transferring some of the benefit to local communities in the form of services, infrastructure development or others.
Land acquisition issues	Land aquisition problems are less likely for ground-mounted solar compared to wind, since there is a potential to use land under SEZ	Delayed project development or stop on PPA signature for lack of land ownership rights.	• Develop dialogue with Special Economic Zone authorities.



Solar PV Power Plant

-

Floating

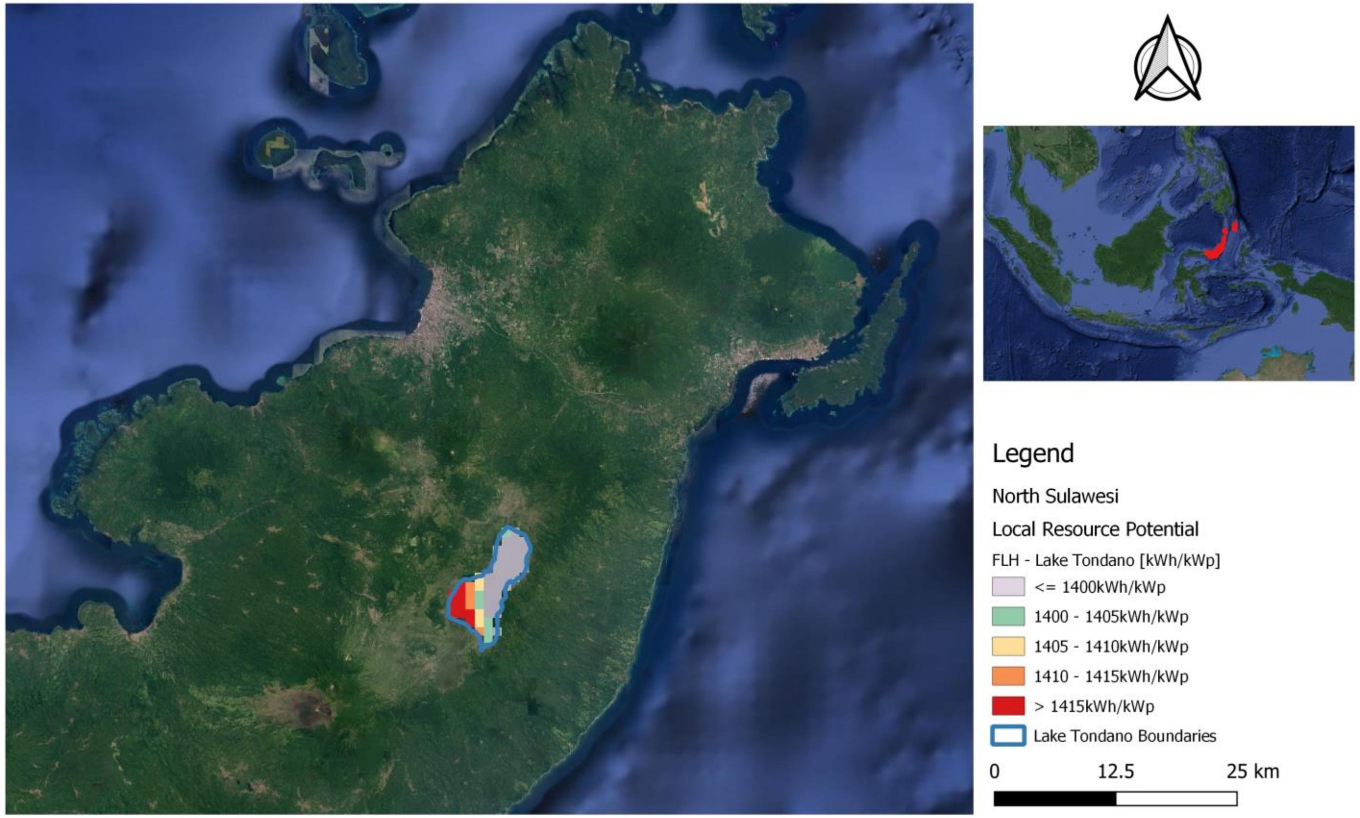


Source: ..

TONDANO LAKE IS THE SELECTED LOCATION FOR FLOATING SOLAR

Water bodies in North Sulawesi: Floating solar PV on water bodies have attracted much of an attention over the latest years, reducing the visual impact and the land use compared to ground-mounted PV. North Sulawesi has several water bodies, with the largest and most notable one being Lake Tondano, in the Minahasa regency.

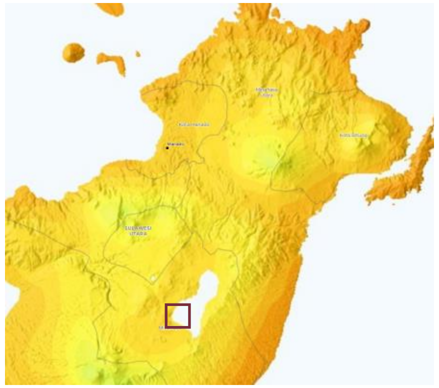
Lake Tondano: The choice of Lake Tondano as a potential site for development of floating PV in this study also follows the interest of the local government to further promote the area for tourism and their belief that an eventual floating PV project on the premise might attract the interest of local tourists.



Location selection: The daily mean incoming global horizontal irradiation (GHI) on a flat level is has the highest value in the SW side close to Kaima, reaching up to 4.9 kWh/m², making it the most interesting location to assess a potential floating solar PV plant. The irradiation in this area is slightly lower compared to other coastal areas, for example the one chosen for ground-mounted PV. This will lead to slightly lower capacity factors resulting to approximately 1,470 FLH per year.

Water depths of at least 5m are in general recommended for floating solar applications, with the present lake offering an average depth of 24m.

Production for floating PV: Compared to ground-mounted PV, floating works at a lower temperature due to the cooling effect of the water, thus operating at a higher efficiency. However, the availability of the plant is lower due to more hazardous conditions and a higher intervention cost in case of outages. For larger plant there is also an expectation for some mismatch losses in case several floater are used and a mismatch between rows of panels is created.



Capacity factors:

AC: **23.5%** (2,058 FLH)
DC: **16.8%** (1,470 FLH)

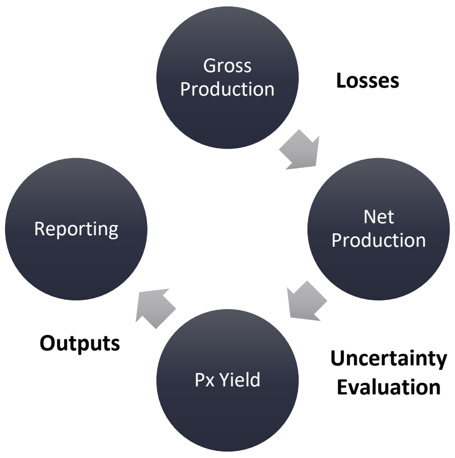
Sources: ESMAP & World Bank (2021)

CENTRAL PRODUCTION ESTIMATE IS 2058 FLH AND P90 IS 1804

Solar resource assessment: To perform a resource assessment, including confidence intervals, the starting point for evaluation of irradiation and losses has been the Global Solar Atlas, while additional uncertainty factors in relation to model used and the interannual variability are considered in the following calculations.

Process: The process to calculate the energy yield at different confidence levels has been the following:

- Gross production: data from Global Solar Atlas for selected location
- Net production: assumption of systematic operational losses applied (assumed lower than Global Atlas since the size of the plant is smaller than assumed on the website and some losses can be reduced)
- P50, P75, P90: Consideration of uncertainty factors on production and calculation of confidence level on annual energy production



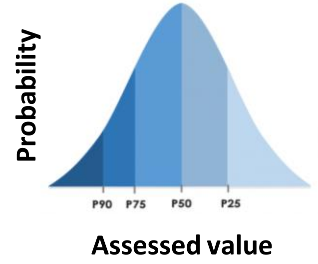
Considered Uncertainty Factors i	
Solar Radiation Model Uncertainty	8.00%
Energy Simulation Model Uncertainty	5.00%
Inter-Annual Variability of Expected Energy	2.00%

**Global Solar Atlas has provided the FLH results as an average of a series of years. Assumed DC losses (soiling 3.5%, cables 2.0%, mismatch 0.3%) and AC losses (transformer 0.9%, cables 0.5%).*

Uncertainty Level	Probability of Exceedance vs P50	Formula
$P75_{uncertainty}$	75%	$\sqrt{\sum_i (0.675 * Uncertainty_i)^2}$
$P90_{uncertainty}$	90%	$\sqrt{\sum_i (1.282 * Uncertainty_i)^2}$

Resulting values: The final value for P50 is the central estimate used for the Business Case and corresponds to **41.2 GWh** (**2,058 FLH_{AC}**). Often at a later stage of the project, when financing needs to be secured, P90 is the preferred indicator since it entails a significantly higher certainty. The P90 is here equal to 36.1 GWh (1,804 FLH_{AC}).

Value Level	Description	FLH_{AC} Confidence	Production Confidence [GWh/y]
$P50_{value}$	Value based on the already considered uncertainty within the calculated model	2,058	41.2
$P75_{value}$	$P50_{value} * (1 - P75_{uncertainty})$	1,924	38.5
$P90_{value}$	$P50_{value} * (1 – P90_{uncertainty})$	1,804	36.1



Sources: ESMAP & World Bank (2021), MEASNET (2016), SolarGis (2021)

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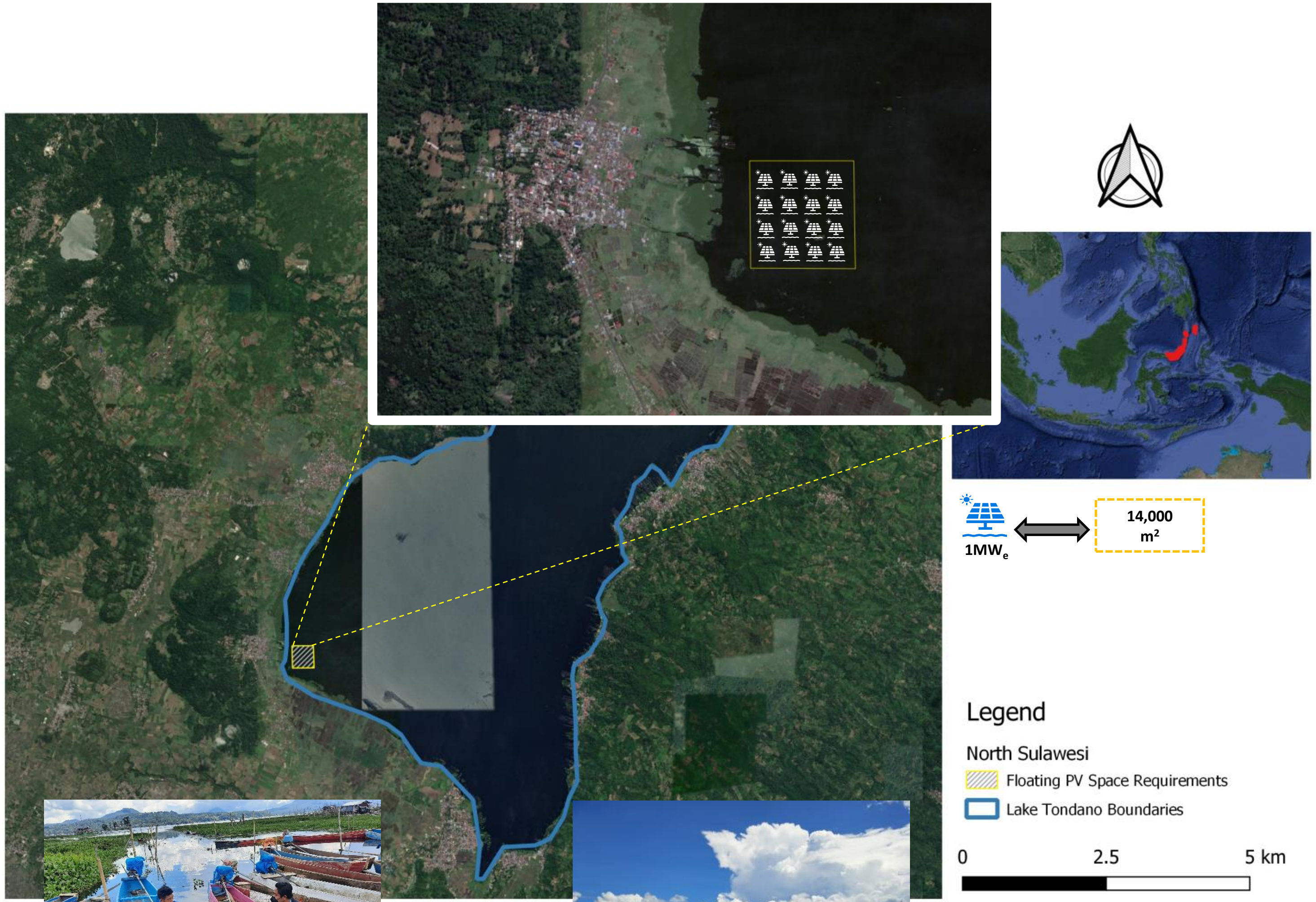
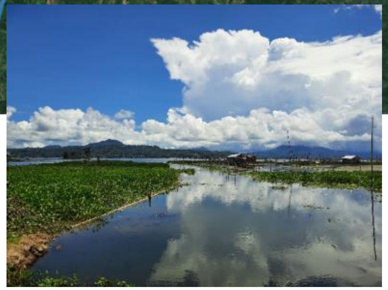
A 20 MW AC PROJECT ON THE WEST SIDE OF THE LAKE IS CONSIDERED





Location at Lake Tondano: Lake Tondano is deemed suitable for floating solar applications and have been confirmed by local government stakeholders as potentially available. The lake provides a large area for solar PV installation and have relatively easy access to PLN's North Sulawesi main grid. The western part of the lake, close to Kaima, provide the area with the highest irradiation therefore the site is chosen for the assessment.

The roads to Lake Tondano is a 2-lane highway that can be narrow in some locations, however, commonly available container trucks will be able to navigate the roads quite easily.

Sizing: For similar reason compared to ground-mounted solar PV, namely grid integration challenges, manageable project size and diversification of resource, the same capacity and sizing factor of the ground mounted PV is assumed here, namely a **20MWac plant, with a sizing factor of 1.4** (28 MWdc).

Spacing requirements: A floating PV plant of 20MWac magnitude (28MWdc with a sizing factor of 1.4) , according to the latest Indonesian data reported by DEA. This translates to 0.39 km^2 (39 ha) of space considerations within the optimal considered area, occupying approximately 1/50th of the surrounding lake, Lake Tondano. This spacing falls within the space occupation margins imposed on water bodies by the Ministry of Public Works and Housing, namely 5% of the total surface.

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Sources: DEA (2021), Local surveys

TECHNO-ECONOMIC DATA USED FOR THE BUSINESS CASE

Technical features	
Capacity	28 MWdc 20 MWac
Technical lifetime	25 years
Plant availability	98%
Space requirements	14,000 m²/MWe
Capacity factor	23.5% (AC) 16.8% (DC)
Construction time	0.8 years
DC/AC Inverter lifetime	15 years

Economic features	
CAPEX	0.71 M$/MWdc 0.99 M$/MWac
Fixed OPEX	10,589 $/MWdc-year 14,825 $/MWac-year
WACC (real)	8.04%
Expected tariff	8.25 cUSD/kWh
Corporate tax rate	20%
Depreciation rate	6.25% (16 years of depreciation period)
Inflation rate (USD)	2.00%

Figures reflect the estimated 2022 data (beginning of construction) in real 2021 price levels , provided via local EPC contacts.

Comparison of CAPEX sources: Several sources indicate different CAPEX estimations for Indonesia and more specifically North Sulawesi. Assuming construction in 2022, the following costs apply:

Source	CAPEX	Notes
Technology catalogue for Indonesia	0.78 M$/MWdc 1.09 M$/Mwac	Value for whole Indonesia, based on extrapolation of PPAs and other international sources. Interpolation between 2020, 2030 and 2050. Sizing factor adjusted upwards to 1.4.
EPC contractors in North Sulawesi	0.71 M$/MWdc 0.99 M$/Mwac	Average value for 2021 based on elicitation of EPC prices from 2 providers (Ranges mentioned: 0.70-0.75, 0.75-0.85).
Cirata PV plant (2020-2021)	0.87 M$/MWdc	Large floating solar plant in Java. Signed PPA for 5.90 cUSD/kWh with construction beginning in 2021 and COD 2022.

Figures reflect the estimated 2022 data (beginning of construction) in real 2021 price levels.

FID and COD: The assumed final investment decision (FID) is 2022 and the commercial operation date (COD) is 2024 with construction stretching between 2022 and 2023.

Cost for lease of water space: No information on specific cost and procedure to guarantee the lease of water space for energy production has been assessed at this stage and the topic should be further explored at a feasibility stage. The case and process of Cirata floating solar plant, which began construction in 2020 and with expected COD in 2022 could provide input on this aspect.

PV module price considerations

Increased component cost trajectories

Solar module procurement has experienced a slight inflation within the past year, mainly due to shortages in polysilicon and glass materials. Bids for module attainment have climbed up by 14% on average within the Chinese market over 2020 pushing the price to 0.28$/W.

Although the material shortage has been expected to be short-term, the ladscape hasn't improved up to date, rather worsened. Domino effects have notably also reached the European market, where since January 2021, all types of crystalline module bids jumped upwards in a range between 6 and 13%.

Sources: PV-Tech (2021), PVxChange (2021), VENA Energy (2021), Local surveys, Interviews with EPC contractors in North Sulawesi.

AT CEILING TARIFF, THE FLOATING PV PROJECT IS PROFITABLE WITH AN IRR OF 8.1%

Business case at ceiling tariff: The starting point for the economic evaluation is considering the **ceiling tariff of 8.25 cUSD/kWh** for solar projects until up to 20 MW. This is the maximum potential remuneration of a solar project for the chosen size, based on the draft of the current regulation. It therefore represents the best-case scenario in terms of returns for the solar project.

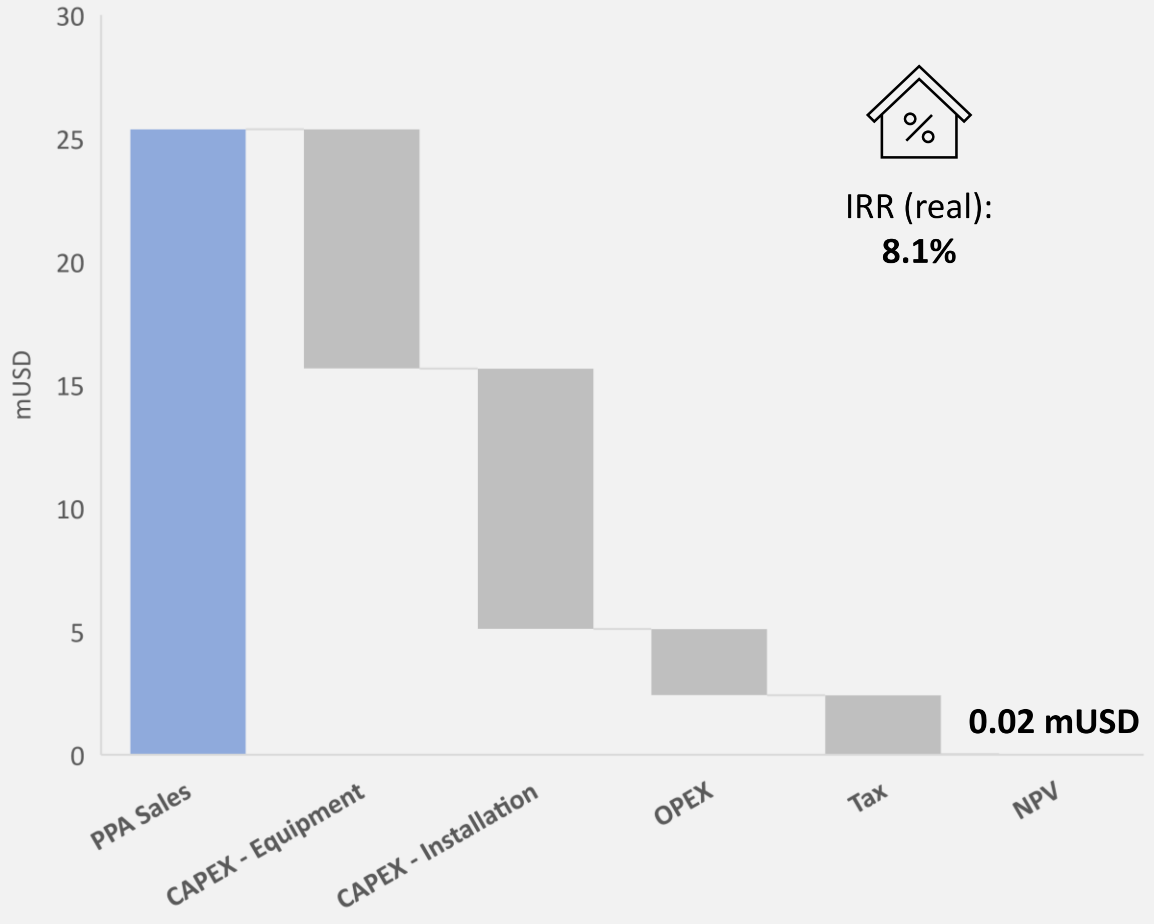
With this level of tariff and an expected annual production (P50) of 2,058 FLH_{AC}, corresponding to a capacity factor of 23.5%, the total annual sales correspond to 3.4 mUSD. Since the PPA is not escalated, this level of annual sales are constant across the project lifetime in nominal terms.

The total CAPEX of 19.8 mUSD is the largest expense to offset, followed by OPEX and taxation at around 2.7 and 1.9 mUSD/year respectively.

Results: The **resulting business case for a 20 MW floating solar plant in North Sulawesi is positive for a potential investor**, with 0.1 mUSD of Net Present Value and an Internal Rate of Return (real) of 8.1%, above the level of the estimated WACC.

NPV at ceiling tariff: **0.02 mUSD**
IRR at ceiling tariff: **8.1%**

Breakdown of NPV components at ceiling tariff (mUSD)



Note: 1. The present value of each cashflow component (revenues and cost) is performed here to break down the contribution to the final NPV value for illustration purposes.

THE BREAK-EVEN TARIFF FOR FLOATING PV PROJECT IS 8.2 cUSD/KWH

Break Even Tariff: Two key factors are creating uncertainty in the potential tariff level to be expected by an investor in a solar project in North Sulawesi, namely:

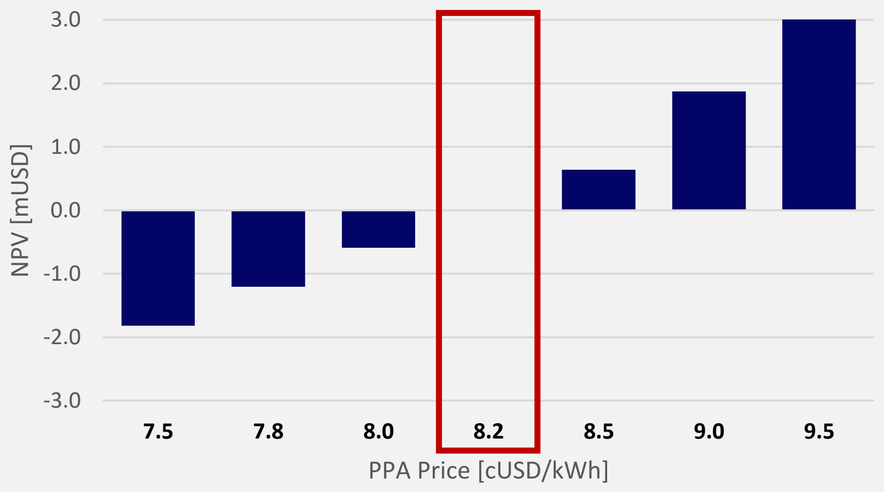
- The **provisional figures of new regulation** are still not confirmed, since the new presidential regulation is only at a draft stage;
- Most likely competition will stem for the development of the project and therefore an **auction/negotiation process would take place**, where competitors will bid the minimum required tariff in order to develop the project.

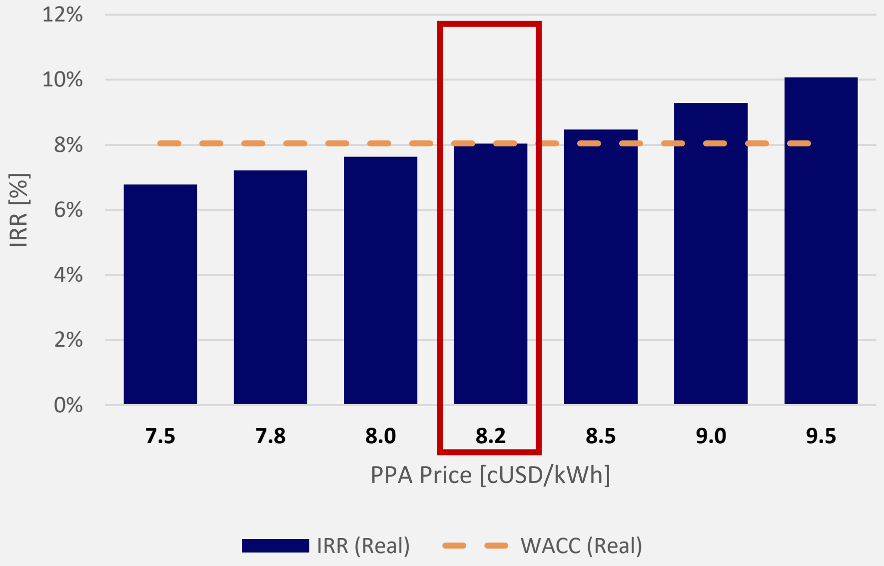
For these two reasons, it is interesting to assess what would be the minimum tariff at which the project break even, guaranteeing an IRR equal to the expected WACC and a NPV of zero. We call this **Break-even Tariff**, and it virtually could represent the value of the bid to a potential auction/negotiation for an investor that would aim at building the solar project under assessment with return in line with the expected WACC of 8%.

Results: The resultant break-even tariff for the analysed floating solar project in North Sulawesi is 8.2 cUSD/kWh, with the IRR varying between 7 and 10% when the tariff goes from 7.5 to 9.5 cUSD/kWh.

Break-even Tariff:
8.2 cUSD/kWh

Break-even tariff for the solar project (USD/MWh)





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LOWER BOUND OF CAPEX FIGURES LOWERS TARIFF TO 7.7 cUSD/KWH

Key uncertainty factors: When looking at the economic assessment for a solar project in such an early phase, several figures are highly uncertain. It is the case, for example, for the following factors:

- **CAPEX:** the estimation of the capital costs is based on figures from EPC, but actual project costs might largely vary depending on market conditions, supply chain and real project conditions;
- **Capacity factors**: since evaluation of irradiance and potential annual production is based on modelled data at this stage;

Operational expenditures are another uncertain factor, but the variability and impact on the results is much less significant, therefore it is not assessed in detail here.

Sensitivity analysis: A sensitivity analysis is carried out on the break-even tariff, to assess the **potential variation of the auction bid if assumptions on key parameters vary** compared to the reference assumption in the study. While one parameter is varying, the other are kept constant, to isolate the impact of the single factor on the final expected tariff. The chosen variation for the key parameters is the following:

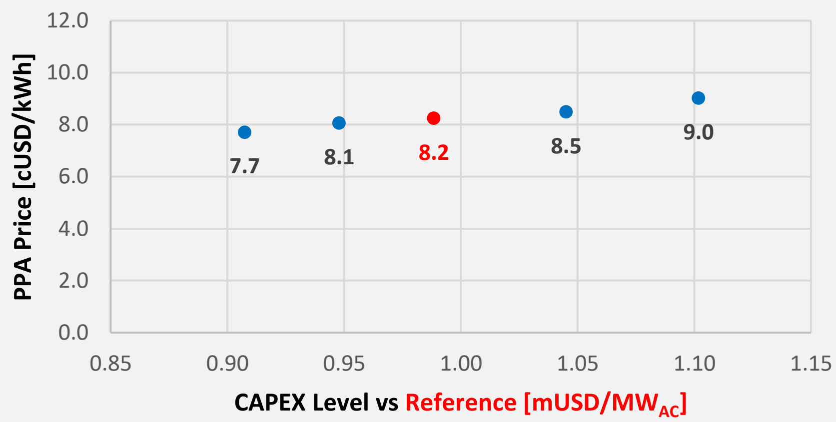
- CAPEX is varied **from 0.91 to 1.1 mUSD/MW$_{AC}$**, corresponding to a range of -8% to +11% of the reference assumption. The range selected is the cost range indicated by EPC contractors for a project in North Sulawesi.
- Annual production is **varied between 36.1 and 46.3 GWh**, based on calculations of P75 & P90 cases versus the base case P50. Lower bound represents the break-even tariff assuming P90.

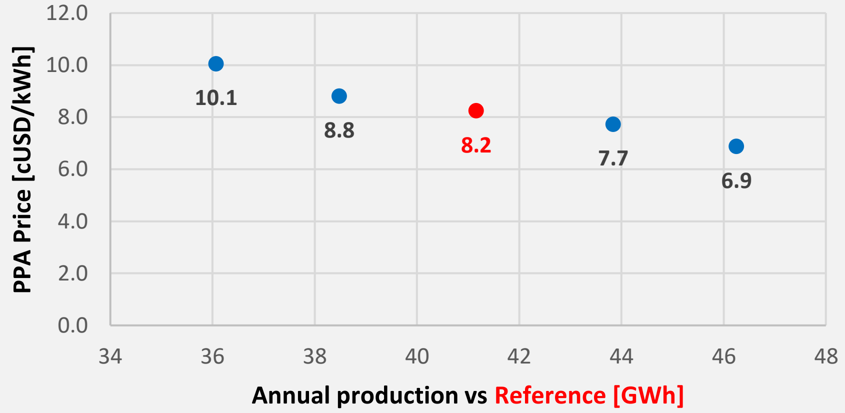
Results: The results of the sensitivity indicate that the **business case is largely affected by the assumptions on CAPEX and capacity factors/annual production**.

Considering an annual production value equal to P90 (1,804 FLH$_{AC}$) the break-even tariff moves up to 10.1 cUSD/kWh, above the threshold of the ceiling tariff. Similarly, CAPEX plays an important role with the range of bids 7.7-9.0 cUSD/kWh for the variation of the capital expenditures indicated by EPC.

OPEX plays a more limited role in the business case but can still impact approximately 3% the needed tariff with a change of -20 to +20% OPEX.

Sensitivity on break-even tariff (cUSD/kWh)





Tariff can go as low as **7.7 cUSD/kWh** with lower bound of CAPEX (0.91 mUSD/MW$_{AC}$)
If P90 needs to be considered, the tariff increases to **10.1 cUSD/kWh**.

Sources: IRENA (2021)

LOCAL SURVEYS SHOW LOCAL ATTITUDE SHOULD NOT BE A MAJOR ISSUE

Social and economic impacts: People from 5 districts (Tondano District, East Tondano District, Eris District, Kakas District, Remboken District and South Tondano District) and 24 villages around the edges of the lake depend on this lake for their daily need such as fish, clean water, drink water and others tourist activity. The lake is a home for plenty of freshwater fish and fishing is one of the most important local activities.

Having a production cost lower than the current BPP of North Sulawesi (7.3 as break-even tariff, versus a BPP of 10.2 cUSD/kWh), the addition of the PV project has the potential to **reduce the cost of generation** in the province, potentially impacting positively local communities and energy tariffs.

The construction and operation phase of the project can bring **local qualified employment**. For a plant of similar size, Likupang Solar PV in North Sulawesi, more than 200 local workforces were employed during construction and during operation 22 employees on site plus 14 employees remotely are needed.

Environmental impact: Among the largest negative impact of a potential PV plant in the area is visual impact and occupation of the lake surface, which is currently used for fishing. A potential positive externality of the construction of the floating PV relates to the large presence of the **invasive water hyacinth**. North Sulawesi provincial government is looking for the best possible solution to handle the problem and would be positive in case floating PV developer regularly contributes to eradication of the plant from part of the lake.

On the positive side, a PV project in the area can **reduce the reliance on fossil fuels**, namely coal and oil, which still account for a large portion of power generation in North Sulawesi. This translate into a reduction of local pollution (PM2.5, SOx) and a mitigation of greenhouse gas emissions.

Considering the average emission factor of Sulawesi grid from RUPTL, equal to 0.896 tonCO_2/kWh, the annual **CO_2 savings from the project would amount to 37 kton**.

Project acceptance: During the site survey, three districts around Tondano lake were visited to get some information related to social and environment issues in relation to the development of a Floating Solar PV power plant (questionnaire in the appendix). Seven respondents were interviewed where two of them are a Head of Village *(Hukum Tua)* and the rest are fisherman and businessmen on tourist sector.

The attitude of local population towards a floating PV project is quite neutral as they have never thought of putting solar PV on the lake before. When shown pictures including Indonesia's planned large floating solar, initially there is concern regarding the amount of surface area that would be used. Once explained that the lake's 48 km^2 area will only be covered by 0.28 km^2 (0.5%) of solar panels and 99.5% of the lake is still available for day-to-day activities, there were no remaining concerns. Some even asked if there are any opportunities to work on the PV plant as operators.

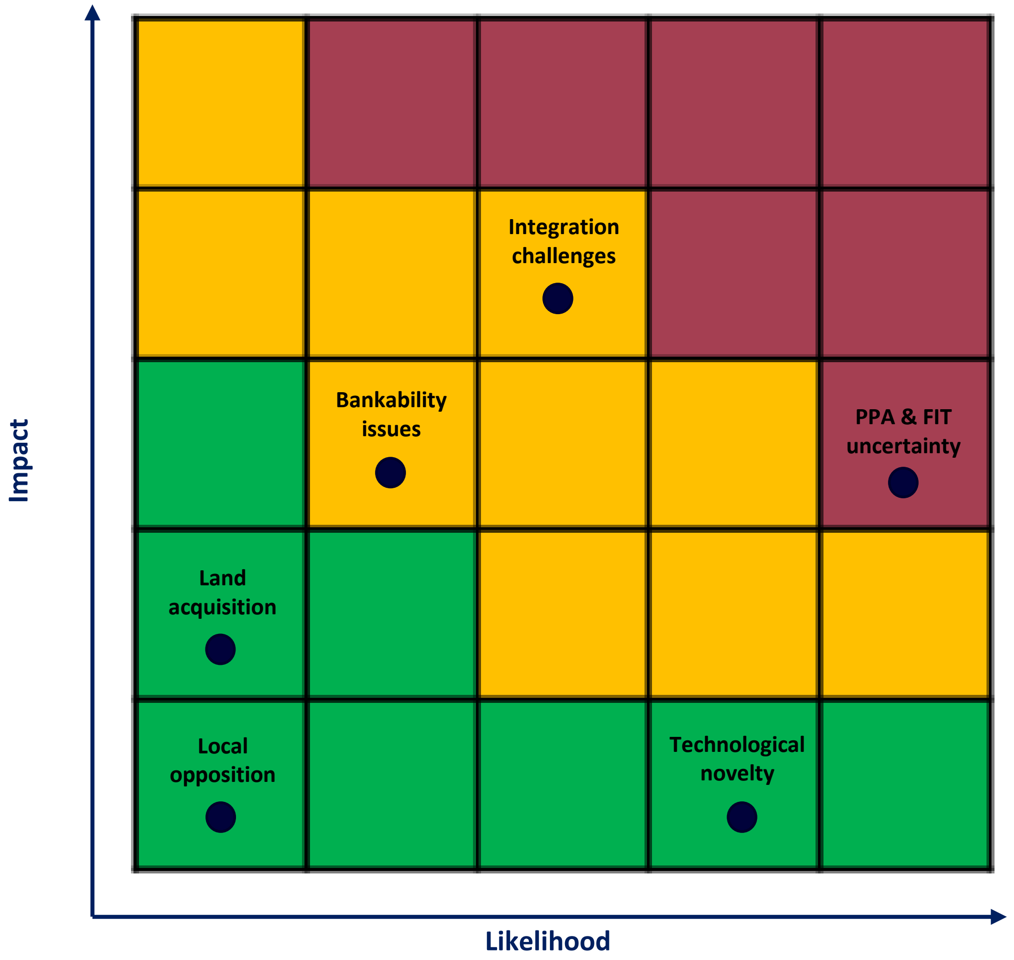
Moreover, institutional support for renewable energy is strong at every level of the local government, which sees renewable energy as an opportunity to increase tourism and label North Sulawesi as a green destination. This is especially the case for floating PV in Tondano lake, which area is targeted for a large development of touristic activities.

Sources: Local surveys result, DEA (2021), VENA Energy (2021), PLN Persero (2021)

KEY PROJECT RISKS ARE PPA UNCERTAINTY AND GRID INTEGRATION

Based on the site visits conducted during the project, the survey of local stakeholder and population, as well as the results of the economic analysis, the key risk factor for the project are outlined in the risk register and risk matrix below.

Risk name	Description	Impact	Action
PPA & FIT uncertainty	New regulation is under discussion and no certain levels of FIT have been published. Moreover, eventual competition on the bid could result in a tariff that is likely below the ceiling price.	Postponement of PPA signature and higher development costs. Competition can reduce the obtainable tariff.	• Ensure dialogue with PLN and ministry on regulation progress; • Prepare for adjustments to the revenue scheme.
Grid integration challenges	PLN is concerned about the impact on grid operation and stability of local grids. This could lead to curtailment of production or a requirement for inclusion of a battery storage.	No PPA signed with PLN, potential curtailment of production.	• Engage with PLN from early on in the process; • Develop proper integration study; • Prepare a plan to potentially add some battery system to project.
Bankability issues	Lack of final approval from financing institution, potentially due to uncertainty on project return. Banks have in the past expressed concerns regarding the BOOT scheme that PLN preferred before 2020. A new option for BOO has been introduced by new regulation revision.	Challenge to receive financing for the plant	• Maintain communication with potential financial institutions regarding requirements for bankability, especially in relation to update of current regulation.
Local opposition	Local population migh be against the project for reasons related to visual impact and influence on local economy (e.g. agricolture and forestry).	Delayed project development or problems during construction	• Develop a strategy to involve local population from an early project stage; • Reserve a budget for projects aimed at transferring some of the benefit to local communities in the form of services, infrastructure development or others.
Land acquisition issues	Land aquisition problems are less likely for floating solar. However, regulation in terms of utilization of water bodies need to be carefuly assessed.	Delayed project development or stop on PPA signature for lack of land ownership rights	• Develop early dialogue with local agencies and population
Technological novelty	Floating solar is a relatively new technology and there is little experience in Indonesia and in local EPC	Lower performance and higher outages than expected	• Ensure minimum levels of availability and project performance; • Learn from newly developed floating plants e.g. Cirata



GROUND MOUNTED VS FLOATING SOLAR PV

Floating Solar PV

Pros

- ✓ Improved electric efficiency due to the water bodies' cooling effects
- ✓ Better performance due to reduced shading
- ✓ Does not occupy valuable onshore space, which can be further used for other sector activities (e.g. construction, agriculture, etc.)
- ✓ Potential coupling with hydro reservoirs, to take advantage of power infrastructure synergies, balancing of output and reduced water evaporation of the reservoir

Cons

- ✓ Higher CAPEX & OPEX in contrast to ground mounted PVs (16% and 30% respectively on average, for the 2020 - 2050 period price projections)
- ✓ Specific water depth requirements all year round
- ✓ Relatively higher electricity related safety concerns
- ✓ Higher degradation potential
- ✓ More critical site selection requirements: both due to limitation of siting to water bodies, and due to need for thorough wind and tidal analysis
- ✓ Recent technology development, leading to less existing experience and references
- ✓ Less scalable potential

Ground-mounted Solar PV

Pros

- ✓ Lower CAPEX & OPEX in contrast to ground mounted PVs (16% and 30% respectively on average, for the 2020 - 2050 period price projections)
- ✓ Largely deployed technology with access to vast experience
- ✓ Less demanding site selection and potential to install where irradiation is highest
- ✓ Easier grid access
- ✓ More versatile installation potential
- ✓ Simpler technical analysis requirements within the planning phase alongside quicker construction times
- ✓ Ability to follow the solar trajectory and adjust to optimal inclination

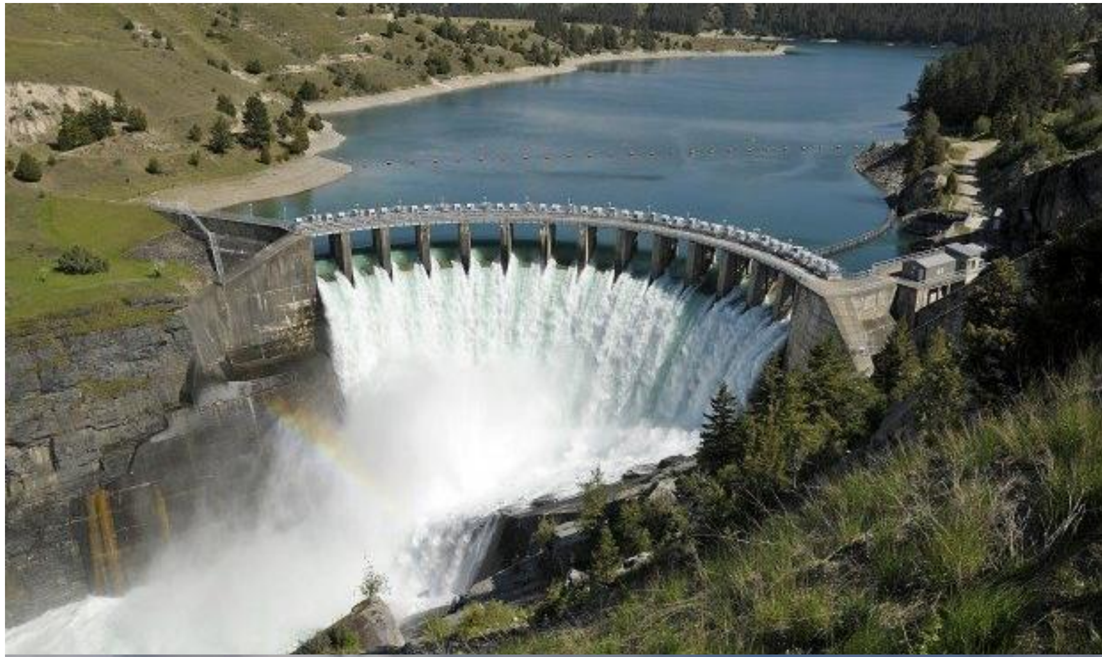
Cons

- ✓ Lower annual energy yield
- ✓ Considerable shading effects
- ✓ Higher maintenance requirements
- ✓ Land acquisition competition with other sectors (e.g. construction, agriculture, etc)

Sources: DEA (2021)

Other Technologies

Hydro



Geothermal

EVALUATION OF OTHER TECHNOLOGIES

Hydropower

Opportunities: As described in the most recent Regional Energy Outlook, hydropower is **one of the technology with the largest potential** in the region, especially reservoir hydro.

Hydro reservoirs can provide both **bulk power generation and flexibility** in the power generation, which complements well with variable renewable energy sources. Coupling hydro reservoir, characterized by fast ramping capability, with solar PV or wind could **help alleviate the integration challenges** with the variable renewable sources. This is true both in terms of medium- and long-term balancing, but also in terms of provision of spinning reserve.

The planning document **RUPTL includes a long list of potential hydropower sites.**

Challenges: Most of the hydro potential is **located in areas around the natural reserve** of Gunung Ambang, in the center of the region, which might restrict a wide deployment of such technology.

Long planning processes might not appeal to investors and makes it harder for new hydro projects to contribute with the 2025 target of 23% renewable energy of Indonesia.

Previous project developments (Seko, South Sulawesi) faced significant **local stakeholder opposition**, with the local community head vocalizing the concerns over such activity. Main source of concerns: the division of village areas through the flow-driver channels.

Hydroelectric dams **reduces the availability of land** currently serving agricultural activities such as rice and vegetable planting. Preservation of historic land and the local value of inherited areas may prove to instigate further objections to such projects.

Geothermal

Opportunities: Similarly to hydro, geothermal energy has a **very large potential** in North Sulawesi, with multiple sites currently under exploration.

The **technology is well-known and established** in the province as it represents the majority of the current installed capacity of North Sulawesi.

Geothermal can provide **green bulk baseload generation**.

Geothermal premises can also be used for **leisure activities and tourism**, as well as stimulate local economy (e,g. thermal baths, essential oil industry). Such activities ultimately go hand-in-hand with the sustainable EBT development goals.

Challenges: Despite the rich geothermal potential across the province, **long planning processes** and **uncertainty over the quantity and quality of the local resources** can create barriers to the development of geothermal projects.

Approximately 60% of the upfront costs reflects **drilling and exploration activities thus creating highly risky first steps**. Geothermal project developer has long requested a support to cover part of the exploration risk.

The **potential is mostly concentrated** in two areas: Lahendong (120 MW already developed) and Kotamobagu.

With the local economy being tourism oriented to a major extent, geothermal power plants may occur to be **less attractive than other RE alternatives** such as PV, WT or even Hydro plants. That's due to the risk of presence of chemical challenges, such as dangerous gases or acid.

Sources: DEA (2021), DEA & Ea (2019), PGE (2021)

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GLOSSARY AND DEFINITIONS

Net Present Value (NPV)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.
Formula notation: CF_0 is the cash flow at year 0 and CF_t is the cash flow at year t, r is the discount rate considered and T the total lifetime of the plant.

$$\boldsymbol{NPV} = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

Internal Rate of Return (IRR)

The internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis.

$$0 = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+\boldsymbol{IRR})^t}$$

Weighted Average Cost of Capital (WACC)

The weighted average cost of capital (WACC) is a calculation of a firm's cost of capital in which each category of capital is proportionately weighted.
Formula notation: E and D are the total Equity and Debt, R_e and R_d the return on equity and debt respectively and T the tax rate in the country.

$$\boldsymbol{WACC} = \frac{E}{E+D} * R_e + \frac{D}{E+D} * R_d * (1-T)$$

Levelized Cost of Electricity (LCoE)

The LCOE can also be regarded as the minimum constant price at which electricity must be sold in order to break even over the lifetime of the project.
Formula notation: I_t, M_t and F_t are respectively the investment, maintenance and fuel cost at the year t, E_t is the output of the plant at the year t, r is the discount rate considered and T the total lifetime of the plant

$$\boldsymbol{LCOE} = \frac{total\ discounted\ cost\ over\ lifetime}{total\ lifetime\ discounted\ output} = \frac{\sum_{t=1}^{T} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{E_t}{(1+r)^t}}$$

Full load hours and Capacity factor

Full load hours (FLH) is a convenient notion expressing the equivalent number of hours of production at rated capacity that would give the same annual generation. Multiplying the FLH value by the installed capacity gives the production throughout one year.
The concept is equivalent to that of capacity factor (%); to convert capacity factor to FLH simply multiply the capacity factor by the total number of hours in a year (8760).

$$\boldsymbol{FLH}\ [h] = \frac{Annual\ generation\ [MWh]}{Rated\ power\ [MW]}$$

$$\boldsymbol{CF}[\%] = \frac{FLH}{8760}$$

LIST OF ACRONYMS

AEP	*Annual Energy Production*
CAPEX	*Capital Expenditures*
CHP	*Combined Heat and Power*
DCF	*Discounted Cash Flow*
EPC	*Engineering, procurement, and construction (Contractors)*
FID	*Final Investment Decision*
FS	*Feasibility study*
GHI	*Global Horizontal Irradiation*
GIS	*Geographical Information System*
LCOE	Levelized Cost Of Electricity
OEM	Original Equipment Manufacturer
OPEX	*Operational Expenditures*
PBT	*Pay-Back Time*
PFS	*Prefeasibility Study*
PPA	*Power Purchase Agreement*
PV	*Photovoltaics*
SEZ	*Special Economic Zone*
USD	*United Stated Dollars*
WACC	*Weighted Average Cost of Capital*

ADDITIONAL MATERIAL

WACC OF 8.04 % IN REAL TERMS ARE ASSUMED FOR THE CALCULATIONS

The weighted cost of capital (WACC) is the expected costs of an investment under a given capital structure. The capital structure is composed of the costs of debt and the cost of equity. For a project to be financially feasible, the internal rate of return (IRR) must be greater than WACC.

This study applies the same assumptions for calculation of WACC as a similar pre-feasibility study on Lombok in Indonesia prepared by KPMG. The break-down of the WACC calculation from the Lombok study is illustrated in the figure to the right. Opposed to the Lombok study, the NPV calculations of this study are based on real prices, hence a real WACC of 8.04 % is applied for the three technologies in this study.

In comparison, the Renewable Energy Outlook for Riau assumes WACC to be 8 % in the Green Transition scenario. Since this WACC is assumed to be nominal, our assumption may be a conservative.

Changes in WACC generally have a greater impact on the business cases of technologies, which are relatively capital intensive. This would be the case for solar, wind and biogas. For biomass technologies, O&M and fuel costs constitutive a relatively high percentage of the total project costs. The business case for biomass technologies is therefore expected to be less affected by changes in WACC.

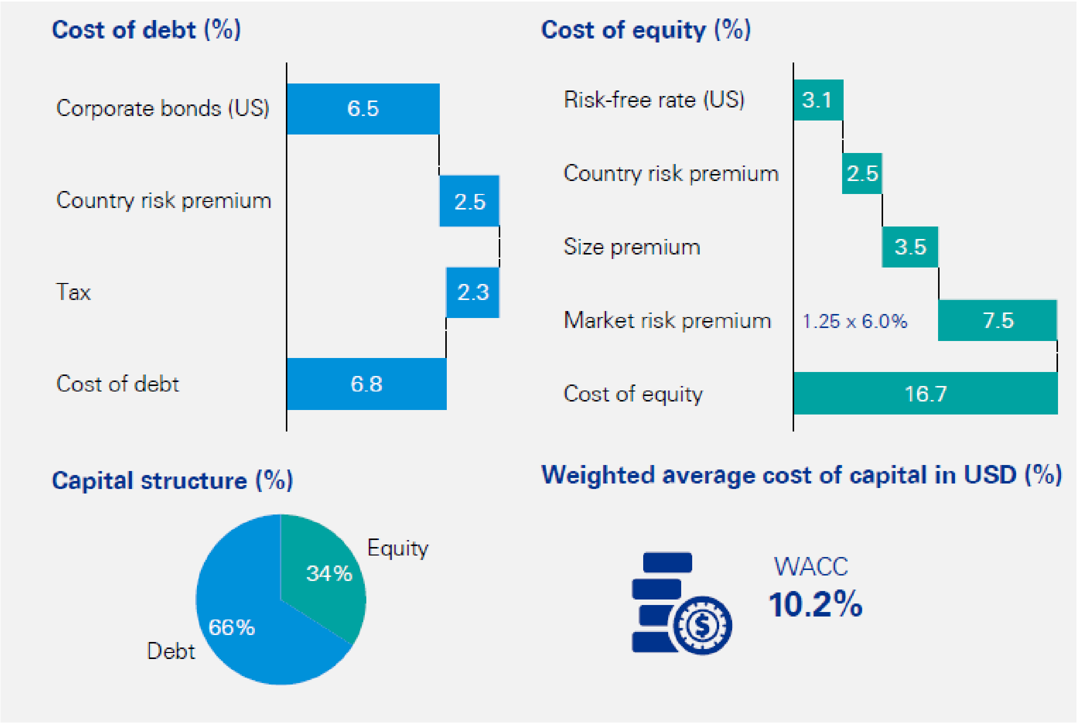


Illustration: KPMG (2019).

Sources: KPMG (2019); REO (2019)

NORTH SULAWESI SPECIAL ECONOMIC ZONES

Special Economic Zones (SEZ)

Context

Special Economic Zones are, as the word “special” reveals, areas within a country which are subject to unique financial regulations, differentiating them from the subsequent national entity.

Benefits of Special Economic Zones

Governmental focus on local SEZs acts as a support mechanism to local economies, aiming to provide a boost to its industralisation by attracting foreign investments and consequently creating more job opportunities.

Source: GGGI (2019), “Technical Assessment of Green Growth Policy Options and Investment Opportunities in Special Economic Zone Bitung”.

Bitung SEZ

Developments in North Sulawesi, deployed under the SEZ “umbrella”, are aiming directly to improve the local livelihoods. Works such as the highway link to the province’s capital (Manado), the airport construction and of course the expansion of both the local industrial zone and seaport as well as power generation capacities, consist a fertile ground towards the creation of solid links to the global economy.

These plans will ultimately enable Bitung to becoming a strategic location for both economic and manufacturing activities, by also utilizing the local agricultural as well as nature resources.

Site Assessments

Purpose: Since the project started, there have been efforts to find suitable areas for the installation of utility scale solar PV and/or wind projects in North Sulawesi.

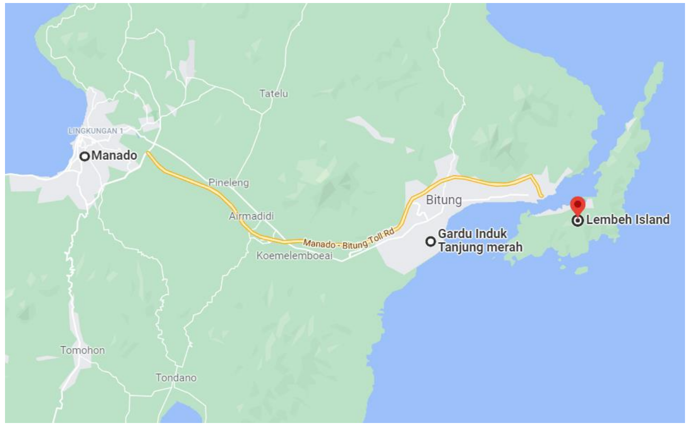
Initial visits and requests by local stakeholders have been for small hybrid PV-Diesel systems (<5MW) that are better suited for PLN installations rather than private sector investments. Through various desk studies and additional discussions with local stakeholders three locations have been identified as potentially suitable for utility scale solar PV projects: Bitung, Lembeh Islands, and Tondano Lake.

Bitung being an industrial park designated as a national Special Economic Zone provide a B2B opportunity to sell solar PV electricity to their tenants interested in decarbonizing their operation. Additionally, since the industrial park is connected to PLN, until the solar PV energy has been fully subscribed by the tenants, excess energy can be sold to PLN.

Lembeh Island provide an opportunity for private investors due to their relatively inexpensive land prices while being connected to PLN's North Sulawesi main grid through 150kV overhead line.

Lake Tondano is deemed suitable for floating solar applications and have been confirmed by local government stakeholders as potentially available. The lake provides a large area for solar PV installation and have relatively easy access to PLN's North Sulawesi main grid

Logistics: All three locations are reachable through public infrastructure such as toll roads and commercial ferries. None of the locations pose significantly difficult logistics challenges for the shipment, delivery, transport and construction efforts of utility scale solar PV projects. While the roads to Lake Tondano is a 2-lane highway that can be narrow in some locations, Commonly available container trucks will be able to navigate the roads quite easily. Access to Lembeh Island can be done through commercial ferries that can carry commercial trucks suitable for transporting the solar PV equipment to the project site.



Manado to Bitung, Lembeh Island and 150kV substation

150kV line to Lembeh Island from the mainland

Port of Bitung

Site Assessments

Land availability: Both Bitung and Lembeh Island was visited and explored thoroughly to find suitable locations for both land prices and availability. Several districts in Bitung area were visited and while there are some minor differences, prices and land availability are similar.

Very few people own large tracts of land more than 2 hectares. Land prices range from US$ 3.5/m2 to US$ 27/m2. Most of the land are being used for farming, mostly coconut trees and some cassava and other crops. Typically, there will be a compensation charge of around US$ 17 to US$ 21 per coconut tree.

Socio-economic: Most people in Bitung are farmers, workers in the city, and fishermen. There is a growing tourism industry in Lembeh island and Tondano Lake. Electricity from renewable energy at larger scale viable for international investments will likely be connected to PLN's North Sulawesi main grid. This can result in lower generation cost to PLN and ensure there is enough reliable electricity for PLN to serve its consumers throughout North Sulawesi

Land Zoning: Some of the areas in the North part of Bitung is part of the Lengguru National Park. The areas surveyed and assessed were outside of the national park boundary and expected to be zoned (or can be changed to the correct zoning) appropriate for renewable energy power plant installation and business activity. Most of the land is currently zoned for productive agricultural and there has been examples throughout Indonesia where the zoning is changed to accommodate renewable energy power plant installation.

Community Acceptance: Many of the community members were interviewed for their knowledge, familiarity, and acceptance of renewable energy. This includes providing visual aids to show the scale of solar PV and wind turbine sizes that are possible to be installed in the area. Most of the people we surveyed were familiar with solar PV in their small-scale applications. While surprised at the scale of the potential projects, many are still accepting and pledge verbally to provide support during construction and after its operations

Site Assessments

Summary: While the team surveyed many more areas than is shown in the summary report, Bitung area outside of the special economic zone provide good potential for solar PV and wind in one of the districts. Lembeh Island also provide an opportunity for solar PV and wind power installations except for the unpredictability of land prices due to the fast-growing tourism industry. Another challenge in Lembeh island is the prevalence of sloping hills that may require significant land clearing and flattening activities prior to construction. In Tondano Lake, there is good potential for floating solar PV to be installed and having the system coexist with the exiting local activities such as fishing and crafts using the local commodities.

Area	**Tondano Lake**	**Lembeh Island**
Width of Road (m)	6	4
Price of Land per m2 (Rp)	N/A	N./A
Price of Land per m2 (USD)	N/A	N/A
District/Village Area (Ha)	4,800	5,000
Suitable Power Plant	Floating Solar PV	Wind & Solar PV

	Bitung					
District	Aertembaga		Maesa		Madidir	
Village	Aertembaga Dua	Pinangunian	Kakenturan Dua	Kakenturan Satu	Wangurer Barat	Wangurer Utara
Width of Road (m)	6	4	4	4	6	6
Price of Land per m2 (Rp)	50.000	20.000-40.000	223.000	300.000 -400.000	325,000	234,000
Price of Land per m2 (USD)	3.5	1.5-3	16	21-28	23	16
District/Village Area (Ha)	799	1027	146	134	246	75
Suitable Power Plant	Wind & Solar PV	Wind & Solar PV	Solar PV	Solar PV	Solar PV	Solar PV

INTERVIEWS WITH LOCAL STAKEHOLDERS

Local stakeholders interviews: During site surveys, interview with some of the relevant stakeholder were conducted. Example of stakeholders include: Head of District Office, Head of Village, Landowner and Farmer. A total of 27 stakeholder have been interviewed in North Sulawesi across the three locations selected: Bitung, Tondano lake and Lembeh.

Interview questions: A 15-question interview has been conducted, supported by visual aids, such as potential pictures of the project for visual impact assessment:

1. What do the roads and logistics look like for wind turbine/PV delivery?
2. How many people live in the area? What kinds of work that majority people do for living?
3. How many people have electrical/mechanical/civil building skills?
4. Any young people graduated from vocational school or university majoring engineering around here?
5. Are there any locations suitable for wind/PV between 50 - 100 hectares?
6. How many owners for the land in the aforementioned location?
7. What are most common uses of the land? Farming?
8. How easy would it be to acquire the land from existing owner(s)?
9. What is the average cost/range of price for land in the area?
10. Are there endangered animals or plant in the area?
11. How suitable is the land for wind/PV? Photos of the land conditions on the spot
12. Environmental risks? Flood, mud slide, high winds, earthquake?
13. What are the typical compensation costs (if any) of cutting the trees or other local cultural compensations for land use that need to be considered?
14. How do you feel about having a large wind turbines or PV project in your area (show picture for scale)?
15. How often and how long do you experience PLN blackout?