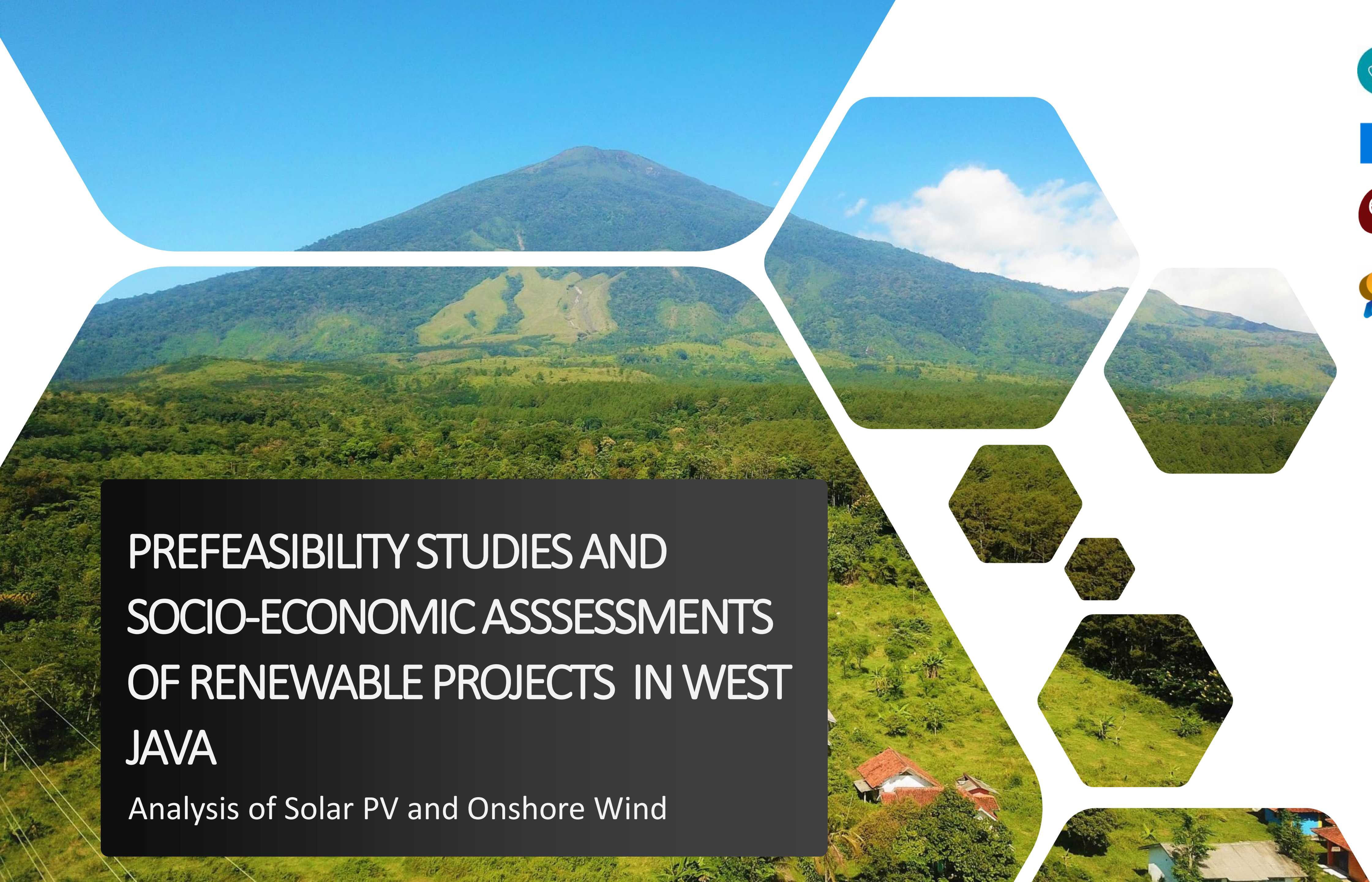

PREFEASIBILITY STUDIES AND SOCIO-ECONOMIC ASSSESSMENTS OF RENEWABLE PROJECTS IN WEST JAVA

Analysis of Solar PV and Onshore Wind

Danish Energy Agency

Viegand Maagøe

Ea Energy Analyses

INOVASI DINAMIKA PRATAMA

COWI

MAY 2025

BACKGROUND

Indonesia and Denmark are collaborating through a **Joint Indonesian-Danish Energy Partnership Programme (INDODEPP)**, which aims to support Indonesia's climate goals of reaching net zero emissions by 2060. The partnership is coordinated by the Danish Energy Agency's Center for Global Cooperation. In Indonesia, key partners include the Ministry of Energy and Mineral Resources (MEMR), the National Energy Council (NEC), the state-owned electricity company (PLN) and the provincial energy agencies (DINAS). Reports and studies produced under INDODEPP are available on the Danish Energy Agency's website[1].

The Sustainable Province Initiative (SPI), running from 2023 to 2026, is a program under INDODEPP that focuses on helping provincial governments identify and evaluate renewable energy potentials. Through SPI, the Danish Energy Agency, with the assistance of international and local consultants, is supporting West Java with the following activities:

1. Assessment of energy balances
2. Mapping of renewable energy resources
3. Long-term energy planning
4. Analysis of socioeconomic effects
5. Pre-feasibility studies of renewable energy projects

This report presents pre-feasibility studies for potential renewable energy projects in West Java. Following an initial pre-selection process, two projects have been selected for pre-feasibility studies:

1. A 140 MW_{ac} ground mounted solar PV plant located in Sumedang
2. A 40.5 MW onshore wind power plant located in Majalengka

[1] https://ens.dk/en/our-responsibilities/global-cooperation/country-cooperation/indonesia

The pre-feasibility studies are initiated by the Danish Energy Agency and developed by a consortium consisting of Ea Energy Analyses and Viegand Maagøe. 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. COWI has conducted the analysis of the socioeconomic effects.

The Danish Energy Agency and the Embassy of Denmark in Indonesia have played an active role in developing the scope of the study, reviewing draft reports and planning of site visits.

The project has received support from local partners, including DINAS ESDM, Bappeda and PLN. The local partners in West Java have provided data, and feedback in the selection of technologies and sites, reviewed the results and participated in site visits.

A key priority of the SPI program is to ensure that projects create value for Indonesian partners. Therefore, a range of activities involving our Indonesian partners have been carried out, including the conduction of workshops to gather local insights and perspectives on the findings and criteria used in the analysis.

Physical site visits have been conducted to assess local conditions in terms of resource availability and overall accessibility. These visits included meetings with Heads of Villages and other local community stakeholders to gather their views and perspectives on renewable energy development in their areas.

The project was completed in January 2025. The consortium presented a first draft of the report in November 2024 and the final report was delivered in January 2025.

DISCLAIMER

The report is prepared for partners of the Indonesian-Danish Partnership Program (INDODEPP) and potential investors of renewable technologies in Indonesia. The conclusions of the report reflect the views of the Consortium (Ea Energy Analyses, Viegand Maagøe and COWI). The local partners hold no responsibility with respect to the findings of the report.

The main source of information used in preparation of this study are PLN, The Danish Energy Agency and the Indonesian Ministry of Energy and Mineral Resources, and provincial agencies, including Dinas ESDM and Bappeda. Economic and technical assumptions used in the business case are primarily based on the Indonesian Technology catalogue from 2024. Assumptions have been validated with local studies and experiences. During the data validation process, several private investors with experience in developing renewable energy projects in Indonesia were consulted.

The Indonesian based consultancy PT Inovasi has provided significant support and local knowledge. They have been particularly active in the engagement of local communities and agencies through site visits and ongoing dialogue.

The sites chosen for the two technologies – utility-scale solar PV and onshore wind – have been identified using satellite imagery, maps, and physical site visits. The selection process considered factors such as available resources, potential for grid connection, proximity to existing power plants, and more. Indications of land costs and current land use were also taken into account; however, a more detailed analysis of the impact of land costs and usage should be included in a future feasibility study.

This study serves as a preliminary screening of projects, intended to assess whether the project holds sufficient potential to warrant a more detailed feasibility study. Prospective investors are advised to seek professional guidance 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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PROJECT SUMMARIES

Ground Mounted Solar PV in Sumedang

Area	
Regency	Sumedang
City	Marongge
Type of land	Plantation forest and dryland agriculture
Land zoning	Production forest
Land area	1.4 km2
Technical details	
Technology	Ground Mounted Solar PV
Solar ressource	1814 kWh/m2/year
Designed Capacity	140 MWac
Financial details	
Baseline CAPEX	108.10 mUSD
Baseline OPEX	1.0 mUSD/y
Baseline PPA price (0-10 year)	6.95 cUSD/kWh
Baseline PPA price (11-30 year)	4.17 cUSD/kWh
Baseline NPV	-5.0 mUSD
Baseline IRR	7.5%
Key risks	
PPA price uncertainty and cost escalation	

Onshore wind power in Majalengka

Area	
Regency	Majalengka
City	Cibodas
Type of land	Dryland agriculture
Land zoning	Agricultural use and protected area
Land area	3.2 km2
Technical details	
Technology	Onshore wind
Wind ressource	5-6,5 m/s
Designed Capacity	40.5 MW
Financial details	
Baseline CAPEX	70.6 mUSD
Baseline OPEX	1.6 mUSD
Baseline PPA price(0-10 year)	9.54 cUSD/kWh
Baseline PPA price (11-30 year)	5.73 cUSD/kWh
Baseline NPV	-18.6 mUSD
Baseline IRR	4.06%
Key risks	
PPA price uncertainty, cost escalation and environmental and land approvals	

CONCLUSIONS AND RECOMMENDATIONS: SOLAR PV IN SUMEDANG

Business case evaluation

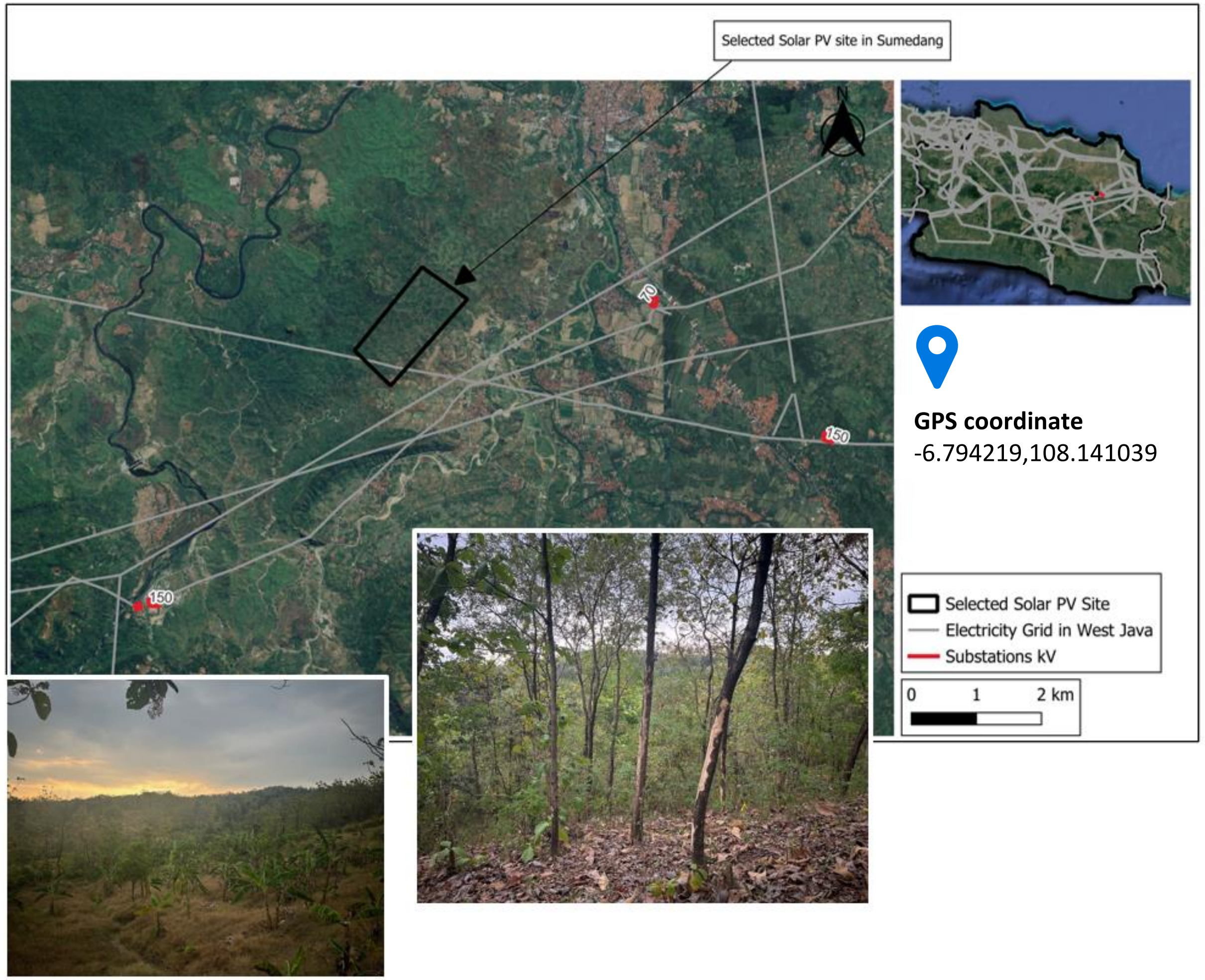
- The project has a positive socio-economic result with an ENVP of +239.7 mUSD, but a slightly negative project economic result returning an NPV of -5 mUSD, performing below “break-even” assuming a WACC of 8.23%.
- The business case is highly sensitive to changes in CAPEX and the annual production (capacity factor).
- A more detailed feasibility study is recommended.

Overall evaluation

- The site is attractive from a solar resource perspective in West Java.
- Due to low BPP of West Java and competition for renewable energy, it could be challenging to obtain a PPA price that make the project financially viable.
- Solar PV plants are subject to stringent local content requirements, which could inflate project costs.
- The site is challenging in terms of access and topography. This is a key risk, that could drive up CAPEX costs.
- The project returns a negative NPV (-5 mUSD), performing only just below “break-even”.

Recommendations

- Before more costs are put into development, discussions with public officials should be initiated to obtain more clarity on the process for environmental and land permits.
- Analyze current market developments in solar panel prices for imports and local sellers. If current price trends translate into lower CAPEX the project could return a positive NPV.
- Engage with the local officials to obtain information on development activities to explore synergies that could lower the costs of upgrading infrastructure.
- Engage with local suppliers to obtain prices for key services and materials.
- Sign options to lease with landowners to fix land acquisitions costs in the early development phase.



CONCLUSIONS AND RECOMMENDATIONS: WIND IN MAJALENGKA

Business case evaluation

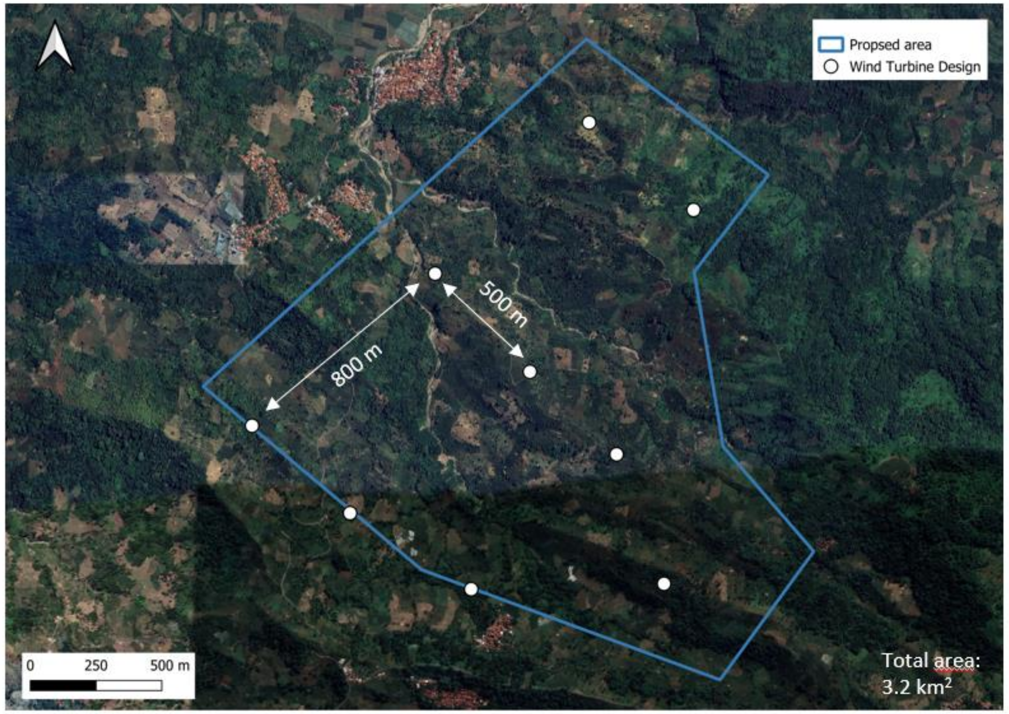
- The project has a positive socio-economic result with an ENVP of +65.3 mUSD, but a negative project economic result returning an NPV of -18.6 mUSD, and is not financially attractive under the study's baseline assumptions.
- To improve the bankability of the project within the regulated PPA ceiling price, CAPEX should be reduced significantly, and additional revenue sources should be explored to offset project costs.

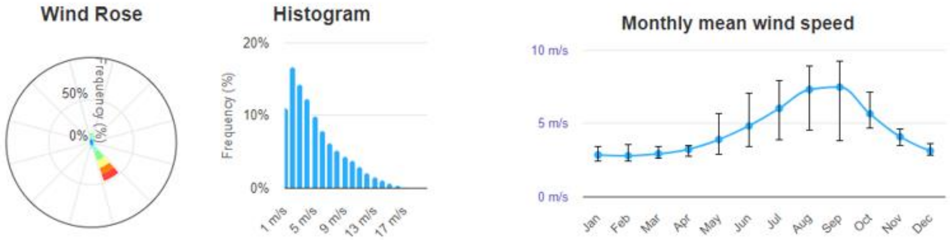
Overall evaluation

- The overall assumptions, and in particular, the relatively low wind speeds of the location, makes the case unattractive.
- Accessibility to the site is highly challenging due to narrow and aging roads, why significant investments in infrastructure upgrades would be required. The long distance to the nearest port could also inflate construction costs.
- The site is located in a forestry area, requiring significant tree trimming and land clearing to prepare the site. The potential impact on biodiversity and regulatory requirements related to preservation of natural resources could make it difficult to obtain necessary permits.

Recommendations

- West Java has many renewable energy resources, including solar, geothermal and hydro and combined a high potential for transitioning its energy system.
- Meanwhile, West Java features low wind speeds in most of the province, except in a few places along the southern coast.
- Consider abandoning this project since there are regions in WJ with more attractive wind resources.





GPS coordinates:
-6.886515; 108.241953

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.

DEA, Ea Energy Analyses & Viegand Maagoe (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 pre-feasibility 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 pre-feasibility 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 pre-feasibility 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.

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 on 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.

DEA, Ea Energy Analyses & Viegand Maagoe (2020)

Introduction - Socio-economic analysis of renewable energy projects in West Java

Setting the context and this socio-economic analysis

The Sustainable Province Initiative (SPI), implemented from 2023 to 2026 under the Joint Indonesian-Danish Energy Partnership Programme (INDODEPP), aims to assist provincial governments in identifying and evaluating renewable energy potentials. The SPI is led by the Danish Energy Agency in collaboration with international and local consultants. In West Java, the initiative focuses on delivering the following key activities and outputs:

1. Assessment of energy balances
2. Mapping of renewable energy resources
3. Long-term energy planning
4. **Analysis of socio-economic effects**
5. Pre-feasibility studies of renewable energy technologies

This report specifically analyzes the socio-economic effects of two renewable energy projects selected for pre-feasibility studies:

1. A 140 MW ground mounted Solar PV plant located in Marongge, Sumedang, West Java.
2. A 40.5 MW onshore wind power plant located in Cibodas, Majalengka, West Java.

The pre-feasibility studies, titled *"Pre-Feasibility Studies of Renewable Projects in West Jawa: Analysis of Solar PV and Onshore Wind,"* were developed by a consortium comprising Ea Energy Analyses and Viegand Maagøe, with local support from PT Innovasi, an Indonesian consultancy. This document on socio-economic analysis was prepared by COWI, with contributions from Lars Grue Jensen and local consultant Nanda Mariska.

The project is coordinated by the Danish Energy Agency (DEA) as part of INDODEPP, with active involvement from the Embassy of Denmark in Indonesia and local Indonesian stakeholders, including the Energy and Mineral Resources Agency (DINAS ESDM), the Regional Development Planning Agency (Bappeda), and Perusahaan Listrik Negara (PLN).

Socio-economic analysis of renewable projects

This report provides a comprehensive socio-economic analysis of two renewable energy projects in West Java: the 140 MW solar PV project in Sumedang and the 40.5 MW onshore wind project in Cibodas, Majalengka. The study explores their impacts on job creation, local economic growth, and environmental sustainability.

Socio-economic analysis of renewable projects (cont.)

Aligned with Indonesia's climate goals of achieving net zero emissions by 2060, these projects aim to foster sustainable energy development while enhancing local livelihoods. Incorporating stakeholder input and adhering to global best practices, this analysis supports strategic decision-making and project implementation.

Geography and demography:

Jawa Barat Province (referred to here as "West Java") is located on the west side of Java Island. Administratively, West Java province comprises of 18 regencies and 9 cities, with a total population of 50,345,200 inhabitants as of 2024.

For the solar PV site, the regency of Sumedag is considered. Sumedang consists of a total area of 1.566.200 km2, which is around 4 percent of the areas of West Java. There is a population around 1.187.130 inhabitants. The potential Solar PV site is located in Marongge Village, near Nagrak village, in the Tomo District. The potential wind power site is inside the boundaries of the Maja-sub district in Cibodas Village in Majalengka District, and two villages, the Citayam Kaler village and Cinangka village, are located near to the site

Purpose of Socioeconomic Analysis and Overall Findings

The purpose of a socioeconomic analysis of renewable energy projects is to evaluate their economic feasibility, societal benefits, and environmental impact.

The 140 MW Solar PV project in Sumedang showcases strong economic viability, delivering significant societal and environmental benefits. With resilience to key economic variables and annual CO_2 emission reductions of 200,894 tonnes, it stands as a vital contributor to Indonesia's renewable energy transition and long-term climate goals.

The West Java Wind Project demonstrates moderate economic viability with potential for improvement, requiring policy support and risk management. Despite financial challenges, the project aligns with Indonesia's renewable energy goals, contributing to emissions reduction and energy diversification.

METHODOLOGY - SOCIO-ECONOMIC ANALYSIS

Introduction to socio-economic or Cost-Benefit Analysis of Energy Projects:

Cost-Benefit Analysis (CBA) is a key tool for assessing the feasibility and value of energy projects, such as power plants, renewable installations, and grid upgrades. These projects require significant investment and have long-term impacts. CBA provides a structured framework to compare costs and benefits, ensuring that resources are directed toward projects with the highest net societal value. The CBA is done according to the standard procedures as outlined in the Asian Development Bank (Asian Development Bank, 2013) and the European Commission. (2014).

CBA translates impacts into monetary terms, addressing economic, environmental, and social dimensions. Economically, it evaluates resource efficiency through metrics such as Economic Net Present Value (ENPV), the Economic Rate of Return (ERR), and the Cost-Benefit Ratio (C/B ratio). These indicators help prioritise projects that deliver the highest returns relative to costs while considering opportunity costs to guide effective allocation of capital.

Environmentally, CBA accounts for externalities like emissions and resource depletion, aligning projects with sustainability goals. Monetising these impacts enables a comprehensive comparison of environmental costs and benefits. Socially, CBA considers implications such as improved access to energy and potential harms like community displacement, supporting equitable decision-making.

As a decision-support tool, CBA enhances transparency and accountability in energy planning. It ensures investments maximise societal value while addressing challenges like climate change and energy poverty, aligning projects with broader policy objectives. The projects support Indonesia's commitment to reaching net-zero emissions by 2060 and contribute to increasing the share of renewable energy in the national energy mix, aligning with Indonesia's energy targets for 2025 and 2050.

Main steps in a socio-economic or cost-benefit analysis:

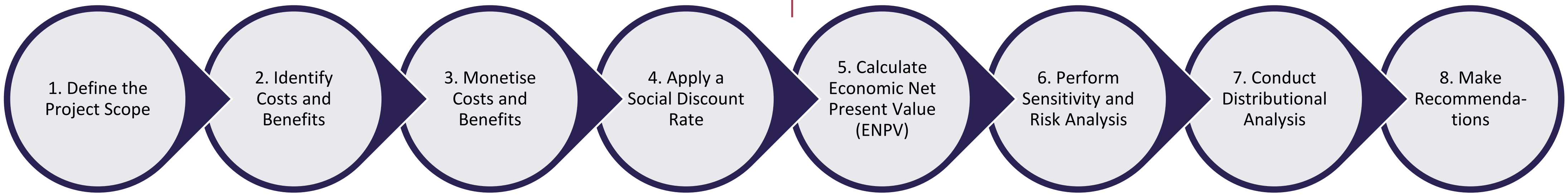
A socio-economic or CBA analysis is a systematic approach used to evaluate the economic viability of projects or policies. It involves quantifying and comparing the costs and benefits to determine whether a project delivers net benefits to society. The figure below outlines the main steps in conducting a comprehensive CBA, ensuring a robust framework for decision-making.

Qualitative interviews:

Assessing the impact of the two potential renewable energy projects requires considering not only factors that fit into calculations but also gaining a deeper understanding on potential affect on the local community. This includes understanding the social dynamics and local communities, how the community uses the land, and the environmental conditions in the area. To gain deeper qualitative insights, local consultants conducted interviews with relevant stakeholders and experts, such as sub-district chiefs, village heads, and representatives from local organizations. A complete list of interviews conducted in West Java to support this study can be found in the Appendix .

Social economics vs Business economics

Social economics focuses on society as a whole, considering overall welfare, externalities, and societal costs and benefits. Business economics focuses on individual businesses, aiming to maximize profit and financial performance.



- Clearly outline objectives, scale, and components.
- List financial and non-financial costs and benefits.
- Assign monetary values; use market or shadow pricing.
- Convert future costs/benefits to present values
- Sum discounted benefits and costs; determine viability.
- Assess the impact of assumption changes and risks.
- Analyse stakeholder impacts, including poverty.
- Provide clear feasibility recommendations.

Figure – Main steps of the CBA

Methodology – Job Creation

The quantification of the social impacts involves estimating the job creation from the construction phase and subsequent operations phase of renewable energy sites. The job creation is calculated based on an employment model, that COWI has developed and provided training in during a mission March 2024. This section will briefly highlight the methodology, which is also highlighted in the figure below. The main assumptions for the model are summarized in the right-hand table.

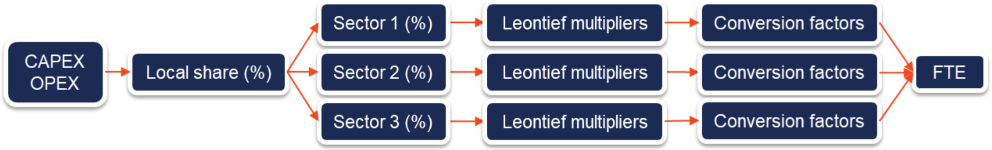


Figure – Dataflow of the employment model

The main input to the model is the CAPEX and OPEX estimates, which is the direct economic impact to the regional economy. Based on assumptions on the need for import the local share of the investments are split in 3 main sectors. These sector specific investments are multiplied with Leontief multipliers to find the indirect economic impact to the local economy. A Leontief multiplier is a measure in input-output analysis that quantifies the total effect of a change in final demand for one sector on the entire economy. It reflects both the direct and indirect impacts of production in one sector on other sectors, based on inter-industry dependencies. The Leontief multipliers are based on regional input-output tables.

The direct investment (CAPEX and OPEX) and the indirect economic impact is converted to full time equivalents (FTE), using sector specific conversion factors. A full-time equivalent represents the workload of an individual working full time for one year. The conversion factor is calculated based on production output and employment numbers from the National Account for Indonesia from the Asian Development Bank (Asian Development Bank, 2022).

The direct and indirect employment effects are measured in terms of full-time equivalents. During the construction phase, workers are needed to manufacture the equipment for the electricity generation facilities, transport materials as well as install and construct the facilities. These jobs are the direct effect.

Additionally, the investments will also result in an employment effect related to the extraction of raw materials, manufacturing of tools, provision of support, as well as health and other support to the workforce directly engaged in the construction. This effect is the indirect employment effect. Thus, the investment will directly increase the activity on the main three sectors, which will increase the (indirect) activity in most other sectors in the economy. The calculation does not take into account whether there are sufficient workers to fill the jobs or whether the employment of the workers postpones other construction projects.

As the model estimates the employment based on CAPEX estimates, it considers more jobs for the construction phase than those created directly during the actual construction of the renewable energy power plants. It also includes the jobs created in manufacturing the plant equipment as well as the transport to the construction site. Depending on the scope of other job creation estimates, the estimates might vary.

A benefit of the employment model is that it estimates the local economic impact and translates it to jobs based on Indonesian economic and employment data. However, as the CAPEX/OPEX estimates provided are based on international experience, it is important to consider the contrasting context of Indonesia to other countries with more experience in renewable energy construction. For example, in a European context, productivity is influenced by well-established infrastructure, advanced technologies, and a high degree of automation. European countries benefit from economies of scale in the offshore wind industry, enabling efficient production processes and higher productivity levels. This, in turn, affects the number of jobs created.

The local share is based on the updated local content requirements given in this report. However, the local share on the operation and maintenance of the plants are assumed to be able to increase as the jobs created are more permanent, and it is thus realistic to find or train local competencies to solve the tasks. The technical assumptions behind the employment model are provided in the table below.

Table – Main assumptions in the employment model

Sector	Assumed sector split		Local share		Sector specific conversion factor
	Wind	Solar PV	CAPEX (%)	OPEX (%)	(mil. USD/FTE)
YTDL Machinery and Equipment Industry	80%	45%			0.0115
Construction	10%	45%	15%	80%	0.0139
Land Transportation	10%	10%			0.0104

INTRODUCTION TO WEST JAWA AND ITS POWER SYSTEM

WEST JAVA, ONE OF INDONESIA'S MOST POPULOUS PROVINCES, BOASTS A HIGHLY DIVERSE ECONOMY, ACHIEVING 5% GDP GROWTH IN 2023

Population: West Java, located on Java Island, consists of 27 administrative regions/cities. In 2023, its population reached 49.9 million. Bogor, with 5.6 million residents, is the most populous regency in West Java.

Geography: West Java covers an area of 37,060 km². In 2021, its population density was 1,379 people per km², making it one of the most densely populated regions in Indonesia.

Economy: West Java's economy is diverse and driven by several key sectors with the main economic sectors being manufacturing, tourism, agriculture, construction, trade and services and mining and quarrying. No less than 60 percent of Indonesia's manufacturing sector are located in West Java. This sector covers a broad range of activities including textiles, food and beverage, automotive, aviation and electronics.

Rice and tea production are main agriculture sectors in West Java. The province volcanic soil makes the province highly attractive for tea production. As a result, West Java produces 70 per cent of Indonesia's total tea output. West Java's rice production, totaling 9 million tons in 2023, accounts for 17 percent of Indonesia's total rice output.

Java Island accounted for 57.7 percent of Indonesia's economy in 2024, with a growth rate of 4.96 percent in 2023. In comparison, West Java alone posted a slightly higher growth rate of 5 percent in 2023.

Indonesia Chamber of Commerce; BPS Statistics Indonesia

WEST JAVA'S EXPANDING TRANSPORTATION NETWORK: A DIVERSE AND GROWING INFRASTRUCTURE SUPPORTING ECONOMIC CONNECTIVITY

Roads : West Jawa has an extensive road network, constituted of highways, primary roads (illustrated on the map) and several smaller roads spread throughout the island. One of the major roads of Indonesia, Indonesia's National Route 1, passes through West Java.

Railroads: West Java's rail network supports both passenger and freight transport. The province is currently expanding its railway infrastructure and has recently launched the first phase of a high-speed passenger train. This new train connects Jakarta to Bandung, covering a distance of 138 km. Future plans aim to extend the high-speed rail network, enabling seamless travel across the entire province of West Java.

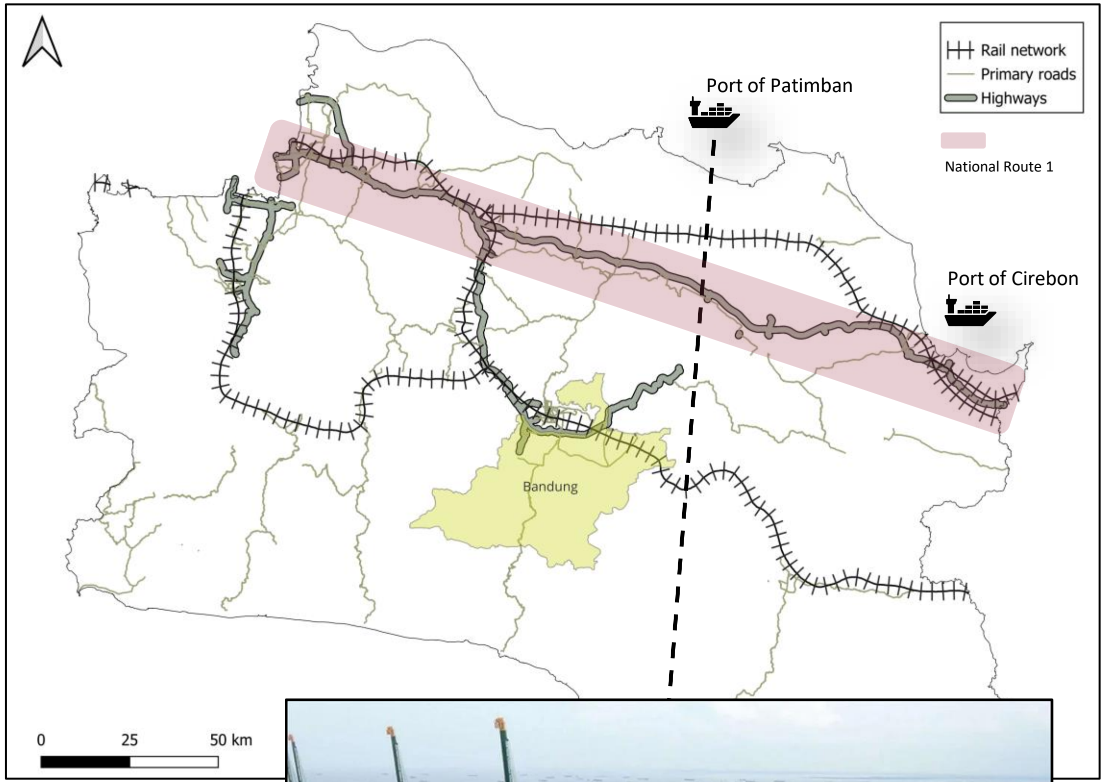
Ports: Located along the northern shores of West Java, are two industrial ports: Patimbam and Cirebon.

Patimban Port

The construction of Indonesia's next largest port, located in Sumebang, West Java, began construction in 2018. After finishing the fist phase of construction, the port commenced operation in 2020. The national strategic project, named Patimban Part, is located 120 km east of Jakarta and expects to ease the pressure on existing ports near Indonesia's capital. The port is directly connected to a network of roads and is expected to boast Java's manufacturing industry and fuel economic growth in the region.

Cirebon Port

Cirebon Port is multipurpose port located in the northeastern part of West Java and frequents 1100 vessels carrying 1.8 million tons of cargo annually. Cirebon has terminals for vegetable oils, coal and asphalts and passenger freight.



Marine Insight (2022); Suryacipta (2024)

WEST JAVA'S CURRENT POWER SYSTEM

Deployed grid: West Java is part of the Javi-Bali electricity system and operates through 70 kV, 150 kV and 500 kV systems. PLN plans to expand the 500 KV and 150 kV systems.

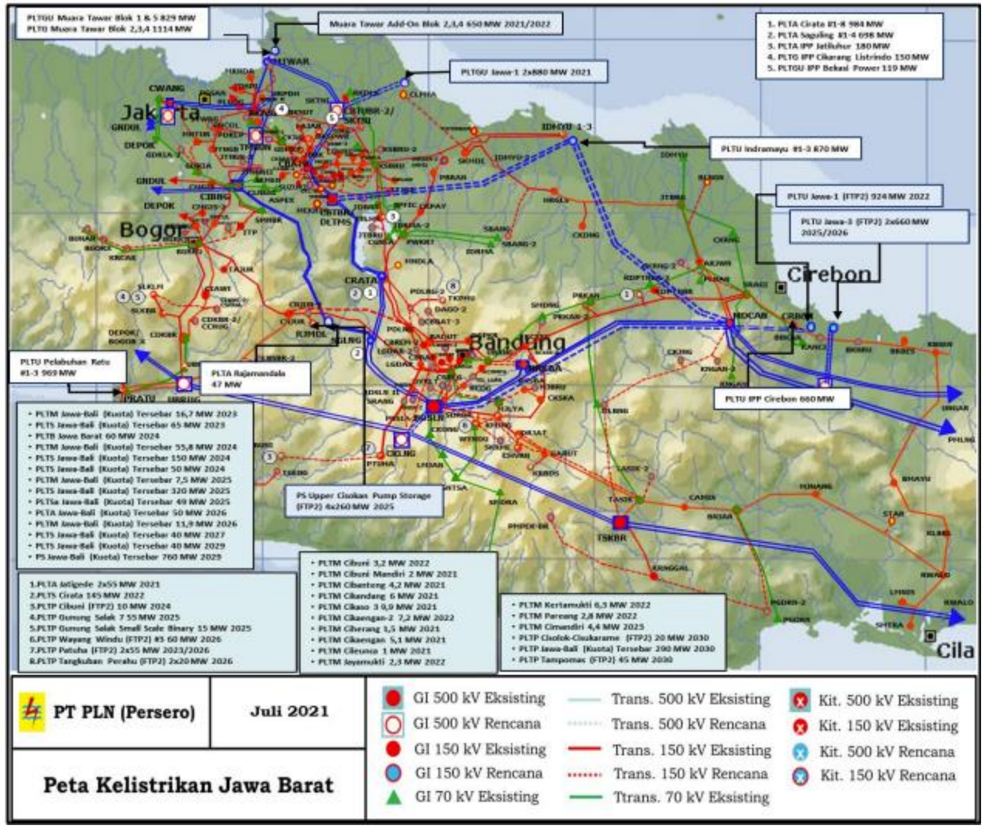
The grid of West Jawa is consist of 7 subsystems and is supported by 10 extra high voltage substations with a total capacity of 12,500 MVA. These substations are located in key areas such as Bekasi, Cirata, Bandung, Tasikmalaya, and Depok, ensuring the distribution of electricity across the province.

Existing generation capacities: Power supply in West Java is provided by PLN and independent power producers (IPPs) supplying power to PLN's grid. In 2020, the combined installed capacity totaled 8352.7 MW. After accounting for losses, maintenance, and other operational factors, the net capacity available for grid supply was 6026.7 MW, matching the peak load demand in 2020.

The generation capacity includes several power plants from renewable and non-renewable sources. According to the RUTPL 2021-2030, 75 per cent of the total generation derive from fossil fuels, including coal, natural gas and diesel. The renewable share derives mostly from hydro power plants.

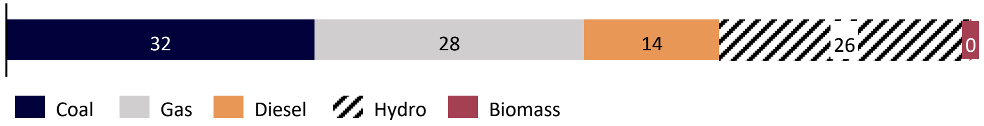
Renewable energy targets: In the regional energy general plan (RUED) West Java set a target of 20 pct. renewable energy share in 2025 and 28 pct. by 2050. With 26 pct. renewable energy in the energy mix in 2023, West Java has met its 2025 target and is well on track to meet the 2050 target.

Future generation capacities: West Java holds significant potential for renewable energy generation, particularly from hydropower and geothermal but also from solar PV and wind power. The solar PV potential include both floating and ground mounted PV. According to the latest Electricity Plan (RUPTL 2021-2030), the total planned capacity, including both existing and new projects, is 5,500 MW with 780 MW coming from solar and wind. In 2023, a large-scale floating solar PV project was inaugurated in Cirata, Purwakarta Regency . The plant has a total capacity of 192 MWp.



The map is derived from PT PLN's Electricity Supply Business Plan (RUPTL) for 2021-2030.

Installed capacity in West Java, 2020 [%], RUPTL

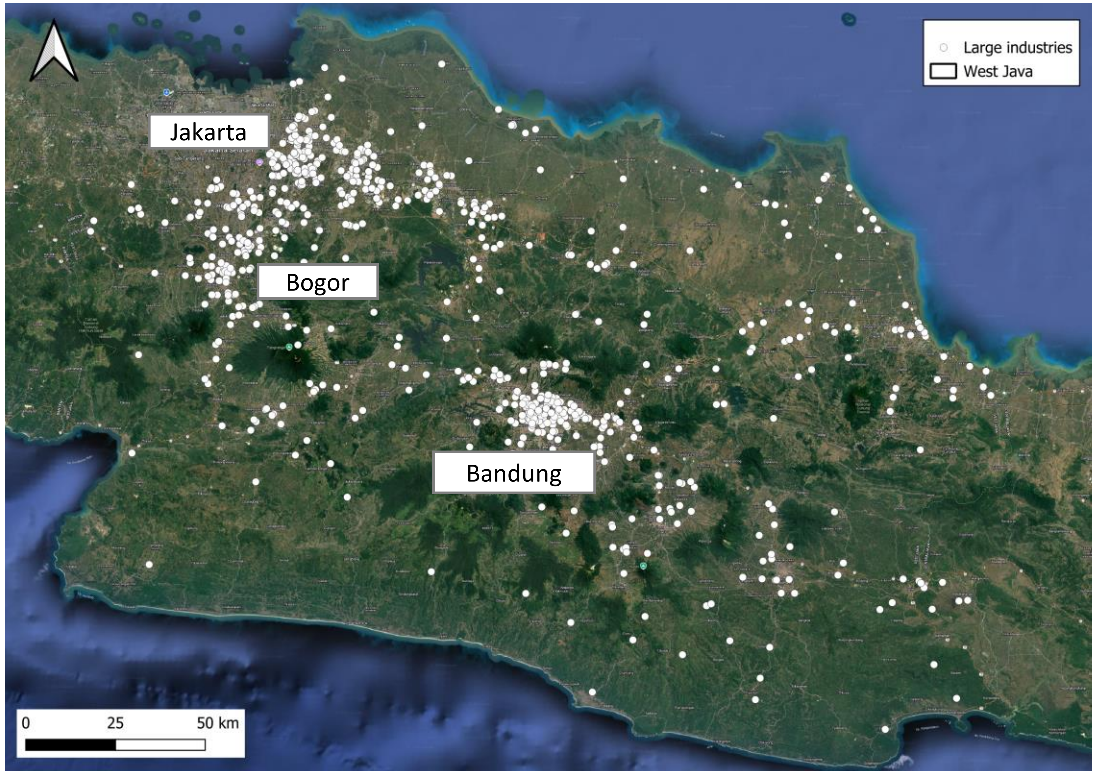


PT PLN – 'RUPTL' (2021); Cabinet Secretariat of the Republic of Indonesia (2023); DESDM (2024); IESR (2024);

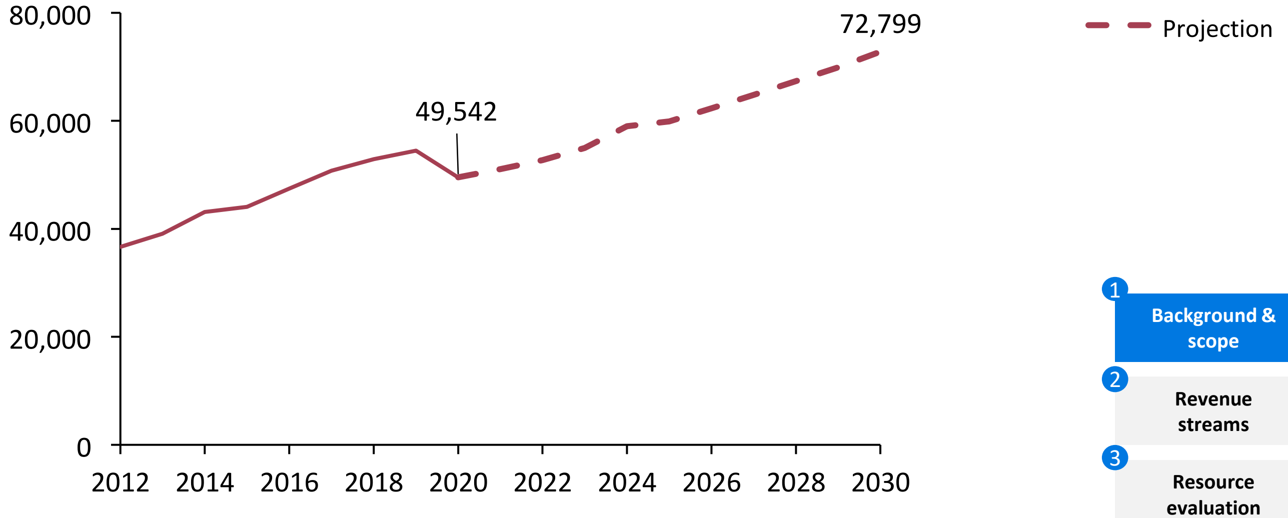
WEST JAVA'S FUTURE POWER SYSTEM

Electricity demand: West Java's total electricity demand reached approximately 50 TWh in 2020, with 84 percent of the demand coming from households and industries. By 2030, electricity demand is projected to exceed 72 TWh.

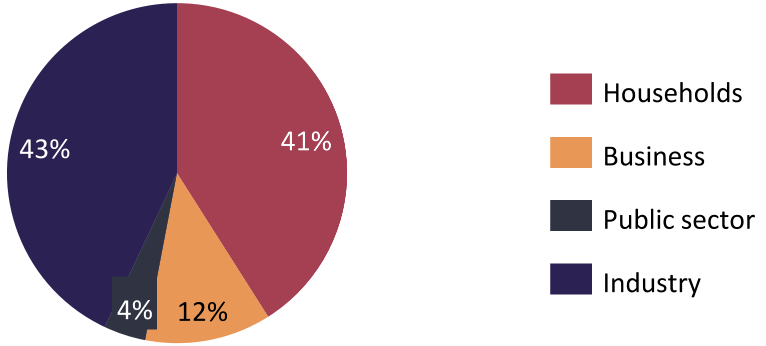
Electricity demand is dominant around the major cities of Jakarta, Bandung and Bogor. Below shows large industrial demand centers in West Java.



Historic and projected electricity demand in West Java, 2012-2030 [GWh]



Electricity demand in West Java by consumer category, 2020 [%]



DESDM (2024); PLN RUPTL 2021-2030

ELECTRICITY TARIFFS, GENERATION COSTS, AND RENEWABLE ENERGY PROCUREMENT IN INDONESIA

Electricity tariffs: Electricity tariffs must be approved by Parliament and PLN's financial position is thus affected by the political process. Whenever electricity tariffs are higher than the cost of generation, PLN receives compensation through the Ministry of Finance. Following the Government's decision to revoke subsidies for selected customer groups, average electricity tariffs have increased resulting in a reduction in subsidies to PLN in between 2012 and 2022.

Average generation costs (BPP): The average generation cost (BPP) reflects PLN's expenses for procuring power from various subsystems. Since PLN generates its own power, the BPP is a combination of PLN's internal generation costs and the cost of purchasing power from third-party providers. Given that coal dominates Indonesia's energy mix, the BPP is closely tied to coal production costs. In 2020, the BPP in West Java was 6.23 cUSD/kWh making it one of the lowest in Indonesia.

Procurement mechanism: Under Presidential Regulation (Perpres 112/2022), the renewable procurement for solar and wind energy follow the direct selection process, where PLN chooses the IPP offering the most attractive PPA price in a competitive tender process.

Ceiling price: With the introduction of Presidential Regulation (Perpres 112/2022) the government has set a ceiling price for the PPA price where the ceiling price indicates the maximum power price that can be negotiated with PLN. The regulated ceiling price drops significantly from year 11 until the end of the contract term.

RE technology type and capacity influence the PPA ceiling. It follows that the ceiling price for smaller scale projects is higher than for large scale projects. The PPA price also reflects LCOEs for RE technologies, why the ceiling price is higher for wind power projects compared to solar PV projects.

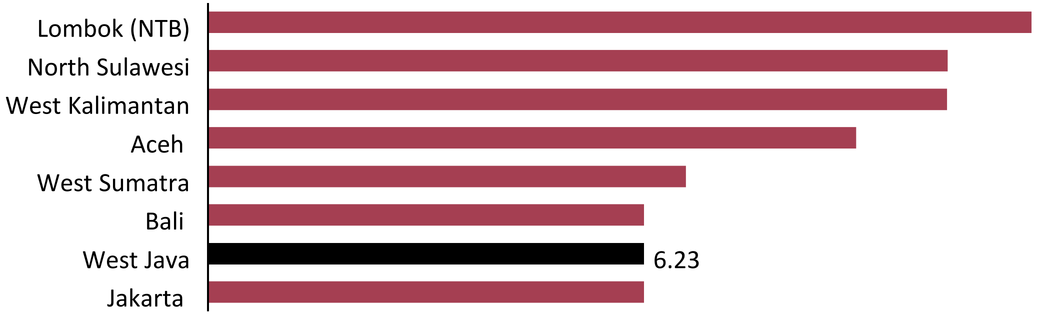
PPA price: The PPA price is a critical component of the overall business case. When submitting a tender for an onshore wind or solar project in Indonesia, the proposed PPA should be competitive however not higher than the ceiling price. Realistically the proposed PPA price should also not exceed the average generation costs (BPP).

MEMR (2021); Baker McKenzie (2021); PwC (2023);

Average cost, average tariff, and subsidies: 2012/2022 [IDR/kWh]

Year	Average cost	Average tariff	Subsidies
2012	1,374	728	103.3
2022	1,473	1,137	58.8

PLN's average generation price (BPP) for selected sub-systems: 2018/2020 [cUSD/kWh]



Calculation method for maximum PPA price according to Perpres 112/2022

Technology	Capacity	Ceiling price (cUSD/kWh)	
		1st to 10th years	11th to 30th years
PLTS (solar)	>20 MW	6.95 x F	4.17
PLTB (wind)	>20 MW	9.54 x F	5.73

The location factor (F) for West Java is 1.

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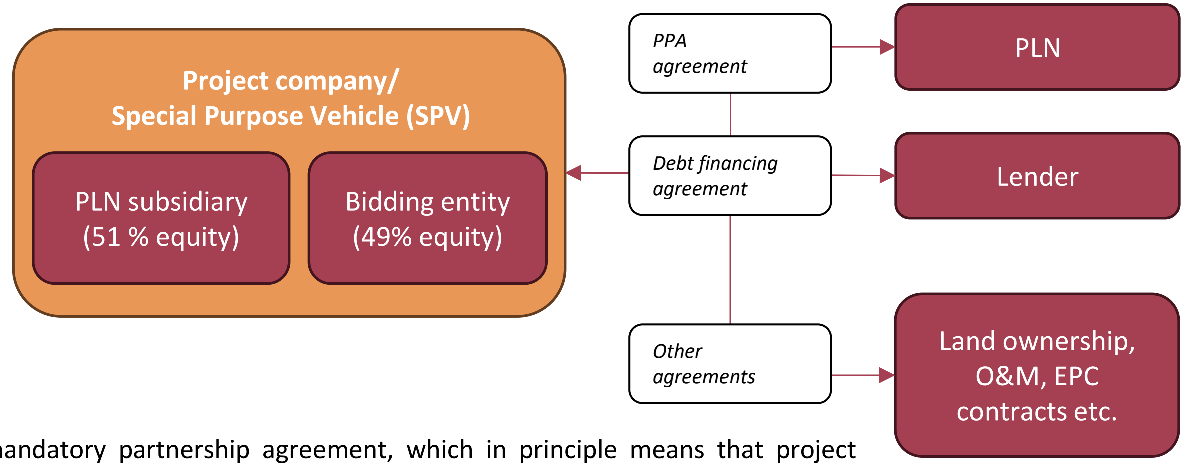
8 Risk assessment

PLN OPERATIONS AND THE MANDATORY PARTNERSHIP SCHEME

PLN: PLN controls the supply of power in Indonesia through a de facto monopoly of the transmission, distribution and supply of power. The private sector may hold a temporary license to operate grids between PLN's substation and privately owned generation plants, however, the ownership of these grids is normally transferred to PLN following construction. PLN owns its own power generation plants and procure power through independent power producers (IPP) via Power Purchase Agreements (PPA).

Project structure and finance: Large scale renewable energy projects normally follow a project finance structure, whereby a special purpose vehicle (SPV) is formed as a separate legal entity. An SPV is a created to isolate the financial risk of the shareholders. The financing of the SPV normally constitute both equity and debt in a 70/30 or 80/20 split.

Example of project structure where PLN owns 51% of ownership in a project



Mandatory partnership scheme: Since 2017, Indonesia has implemented a mandatory partnership agreement, which in principle means that project developers should pass on up to 51 pct. of the ownership of the project to PLN. However there has been different interpretations of the requirements under the mandatory partnership scheme, and it is uncertain how this will be regulated in the future.

Whether PLN acts as a minority or majority owner, potential conflicts of interest may arise in disputes over power delivery and compensation, as PLN serves both as the off-taker and a (primary) producer of power. Depending on the contractual terms, this ownership structure could introduce risks to the project. Additionally, PLN's limited cash reserves and reliance on government subsidies make it challenging to raise equity cash. If unable to secure cash equity, PLN would need to provide in-kind contributions, thereby becoming dependent on the IPP partner's financial strength through loan mechanisms.

PLN's recent joint investments in renewable projects with IPPs

Project name	Location	Entity	Status	PLN's ownership	Partner
145 MW Floating Solar plant	West Java	PT Pembangkitan Jawa Bali Masdar Jakarta	In operation since 2023	51%	Masdar or Abu Dhabi Future Energy Company
50 MW Solar PV + 14 MWh storage	East Kalimantan	PT Nusantara Sembcorp Solar Energi	In development/construction stage	51%	Semcorp Industries Ltd.
46 MWp Floating Solar PV	Riau Island	PT Nusantara Tembesi Baru Energi	PPA/financial close	51%	PT TBS Energi Utama Tbk

IEEF (2024)

REGULATIONS AND PERMITTING FOR RENEWABLE ENERGY PROJECTS

Renewable energy regulation: The legal framework for energy and renewable energy acceleration serves as a natural starting point for assessing the regulatory environment for renewable energy generation in Indonesia. Energy planning begins at the national level, guided by an overarching national energy policy. This policy is translated into a National Energy Plan (RUEN) and renewable energy targets, which are further implemented by provincial governments through Provincial Energy Plans (RUED) and provincial renewable energy targets. However, provincial targets sometimes fail to fully account for the financial capacity and capabilities of provincial governments, leading to significant variations in progress. Meanwhile, West Java is an example of a province that has already met its renewable energy target.

The Ministry of Energy and Mineral Resources oversees the energy planning process, while PPA contract negotiations are conducted directly between Independent Power Producers (IPPs) and PLN.

Table: Selected regulations on energy

Regulation	Description
Law No. 30/2017 on Energy	Establishment of the national energy council (NEC) and the national energy policy
Government Regulation (GR) No. 79/2014 on National Energy Policy	Regulates a national goal of the share of renewable energy of primary demand to 23 % in 2025 and 31 % by 2050
Presidential Regulation No. 11/2022 on the Acceleration of Renewable Energy Development for Electricity Supply	Regulates the renewable energy tariff scheme and the preparation of RUPTL (Electricity Supply Plan)
MEMR Regulation No. 10/2017 jis. MEMR Regulation No. 49/2017 and No. 10/2018 on Principles of Power Purchase Agreements	Regulates the principles of power purchase agreement between PLN as off-taker and business entities as electricity sellers
MEMR Regulation No. 20/2020 on Power System Network Rules (Grid Code)	Regulates network management, connection, planning & execution of operations, power transactions, measurements, and a summary of operational schedules

ETP & UNOPS (2024); IEEFA (2024);

Local content regulation: The primary goal of local content requirements is to ensure local participation, stimulate job creation, and support economic development. However, these requirements may increase project costs and deter foreign investment. For instance, locally produced materials are typically 35-45% more expensive than imported alternatives due to higher production costs and limited supply.

Indonesia recently introduced MEMR Regulation 11/2024, relaxing local content requirements compared to previously where companies struggled to fulfil the requirements.

According to the updated regulation, at least 20% of the total contract value must come from local content for solar PV projects, while onshore wind projects must meet a 15% local content requirement. Projects must also meet local content requirements for specific parts of the contract value. For instance, 25 pct. of the costs of solar panels must be certified local content.

Planning and permits: A variety of regulations impact project feasibility, with environmental regulations often causing delays and posing challenges to investments. The aim of these regulations is to safeguard the natural environment and ensure industrial development does not harm biodiversity or the surrounding ecosystem. Coordination with the Ministry of Forestry and Natural Resources is essential to gather information on land classification and permissible usage for the proposed project. Additionally, conducting an environmental assessment and obtaining the required permits are critical steps in the planning process.

The spatial planning office can provide crucial insights into existing zoning regulations and the feasibility of converting land into an industrial zone suitable for renewable energy development. Furthermore, development and planning agencies can offer guidance on the regional development plan and identify any other projects planned for the proposed location, ensuring alignment and minimizing potential conflicts.

[1]The 35 pct. represent a weighted average for all materials. In reality, there are specific local content requirements for each material.

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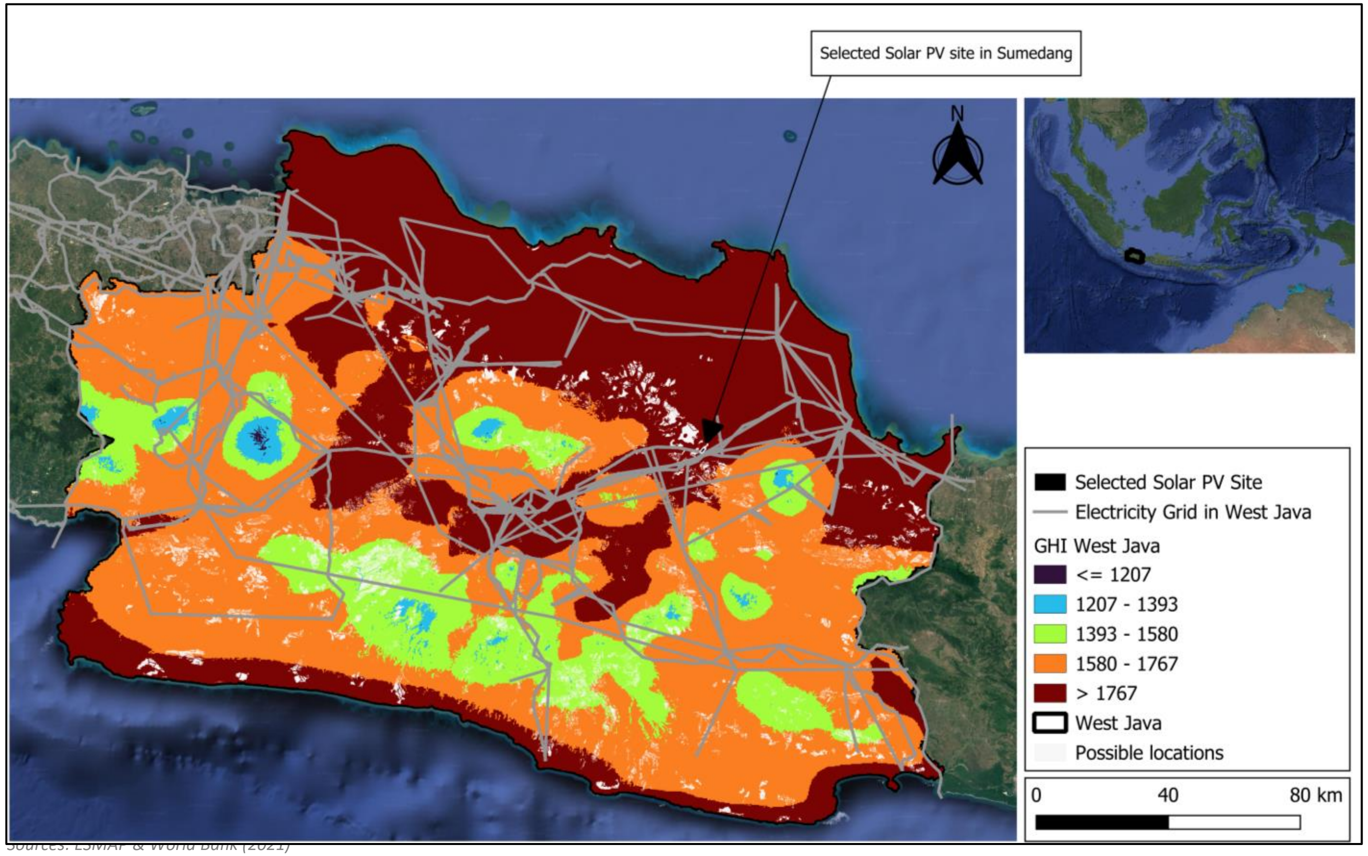
PRE-FEASIBILITY STUDY FOR UTILITY SCALE SOLAR PV

Stock photo ID:1794790762
Location: China

LARGE AREAS WITH GOOD IRRADIATION CONDITIONS IN WEST JAVA, WITH MEAN ANNUAL GHI VALUES OF 1750 KWH/M^2 IN SEVERAL AREAS

Solar irradiation distribution: The daily mean incoming global horizontal irradiation (GHI) on a flat ground level observed across the province, is roughly similar along the whole local boundaries, with the highest values experienced on the N side of the province and generally along the coast. The mean annual GHI values range between 1400 and 1900 kWh/m^2.

The map below shows the GHI across the province. The experienced Full Load Hours (FLHs), will be higher in areas with a high GHI and are distributed in the same manner.



Location selection: Observing the illustrated GHI, the depicted pattern present its lowest values in the S West Java and generally in the mountains, while increases when moving to the N of the province.

Site have been assessed for a number of criteria: Access from roads, topography of the terrain, proximity to demand centres and transmission lines. No formal cut off have been applied in the site selection, but instead an overall evaluation of the criteria for each site.

There are several good areas in West Java with great solar irradiance. The location has been selected since there is good access from roads and it is close to the transmission grid.

Observing that there are many potential areas (white areas on the map) in in the Northern part of West Java that have a good GHI and are also located close to electricity transmission lines, a location in Sumedang (-6.795330,108.140493) is chosen as the area for the development of a ground mounted solar PV plant.

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).

According to the Global Solar Atlas, the mean GHI of the selected area is 1815 kWh/m2.

The Global Solar Atlas indicates **potential production in the selected area of around 1,471 kWh/kWdc. This corresponds to 1,765 kWh/kWac, at a sizing factor of 1.2,** which is the value that will be used for the study ahead.

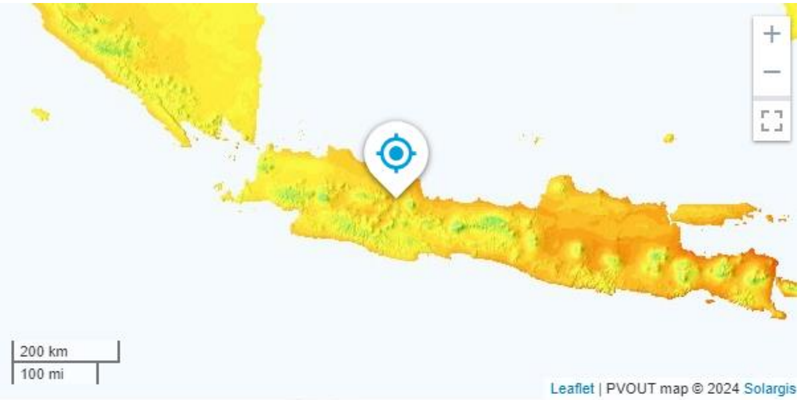
DAILY PRODUCTION IS RELATIVELY CONSTANT THROUGHOUT THE YEAR, EXPECTED TO RISE TO 1,765 AC FULL LOAD HOURS IN THE SELECTED LOCATION

Solar irradiance in West Java is high and stable throughout the year: West Java has a high and stable solar irradiance, which makes it a great location for solar PV. The main share of production is between 7 am and 5 pm.

Parameters assumed for the PV:
Tilt: **11º**
Azimuth: **0º**
Losses assumed: **7.2%**

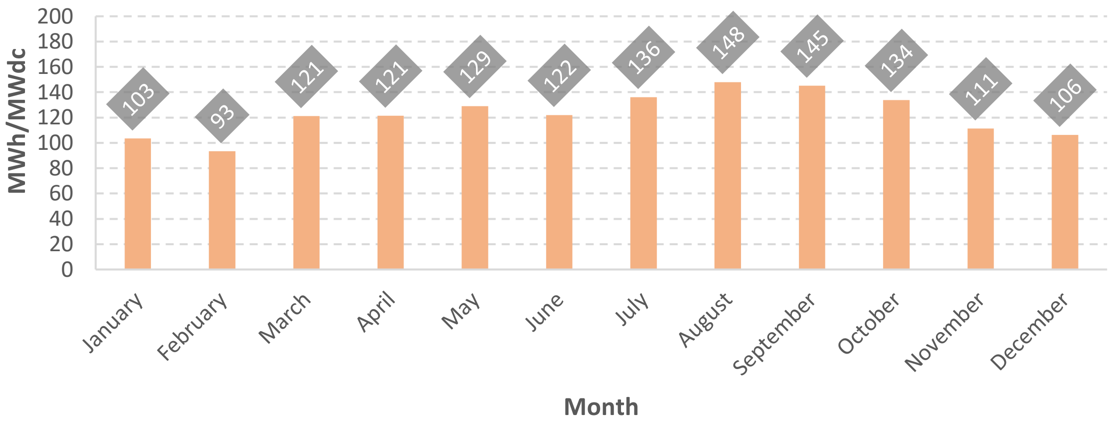
Capacity factors:

AC: **20.2%** (1,765 FLH_{AC})
DC: **16.8%** (1,471 FLH_{DC})



PVOUT: Long-term average of annual totals of PV power potential

Average Monthly Electricity Production



ESMAP % World Bank: Global Solar Atlas (2024)

Monthly production: The average potential daily unit production (MWh/MW) deviates on a monthly basis by an average of 13% in the course of a year, signalising 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 the low wind power potential within the biggest part of the region. Months between April to October reflect the highest monthly yields.

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 zero within most of the months. 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/MWdc Daily Hour	January	February	March	April	May	June	July	August	September	October	November	December
0 - 1	0	0	0	0	0	0	0	0	0	0	0	0
1 - 2	0	0	0	0	0	0	0	0	0	0	0	0
2 - 3	0	0	0	0	0	0	0	0	0	0	0	0
3 - 4	0	0	0	0	0	0	0	0	0	0	0	0
4 - 5	0	0	0	0	0	0	0	0	0	0	0	0
5 - 6	0.1	0	0	0	0	0	0	0	0.4	4	7	4
6 - 7	48	35	42	52	54	44	36	43	65	105	104	79
7 - 8	172	161	198	223	232	210	211	236	280	282	253	208
8 - 9	307	300	364	391	393	370	381	423	463	445	396	345
9 - 10	419	415	499	522	519	496	518	567	595	558	503	452
10 - 11	487	484	584	595	593	568	604	654	671	609	550	515
11 - 12	497	497	598	604	602	584	626	674	681	595	536	510
12 - 13	457	461	535	546	566	551	602	652	638	557	463	455
13 - 14	384	392	442	454	488	485	536	574	557	475	382	364
14 - 15	280	288	319	334	365	384	433	464	444	360	274	253
15 - 16	171	181	199	215	236	253	294	318	297	228	164	151
16 - 17	86	93	102	101	104	114	139	153	136	94	76	76
17 - 18	26	28	26	10	7	8	13	15	11	5	7	18
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0

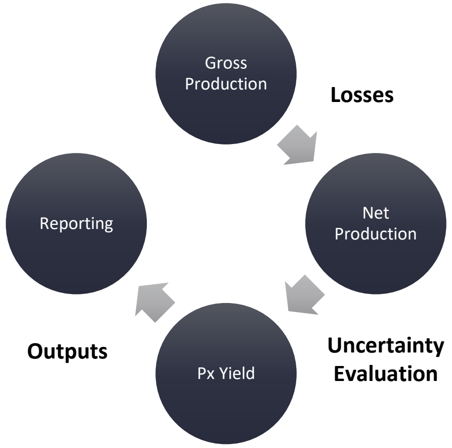
SOLAR PRODUCTION UNCERTAINTY CAN LOWER THE P90 VALUE TO 1,547 FLH_{AC}

COWI

Solar resource assessment: To perform a resource assessment, including confidence intervals, the starting point for evaluation of irradiation and losses has been ESMAP and World Bank's Global Solar Atlas, while additional uncertainty factors in relation to the utilised model and the expected 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 at an ac/dc sizing factor of 1.2
- Net production: assumption of systematic operational losses (7.2%) applied through Global Solar Atlas
- P50, P75, P90: Consideration of uncertainty factors on production and calculation of confidence level on annual energy production



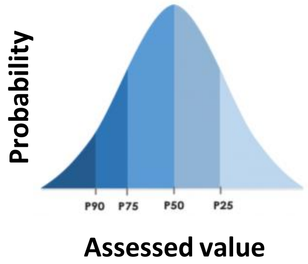
Considered Uncertainty Factors i	
Solar Radiation Model Uncertainty	8.00%
Energy Simulation Model Uncertainty	5.00%
Inter-Annual Variability of Expected Energy	2.00%

Global Solar Atlas represents 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 net P50 yield for the assessed 140 MWac utility scale solar PV park corresponds to **247.1 GWh/y** (**1,765 FLHac**), consisting the central estimate utilised in the Business Case ahead. Often at a later stage of the project, when financing needs to be secured, a P90 generation level frequently consists the preferred indicator by financial institutions since it entails a significantly higher revenue certainty. The P90 level for the present case corresponds to 216.6 GWh/y (1,547 FLHac).

Value Level	Description	FLH_{AC} Confidence	AEP Confidence [GWh/y]
$P50_{value}$	Value based on the already considered uncertainty within the calculated model	1,765	247
$P75_{value}$	$P50_{value} * (1 - P75_{uncertainty})$	1,650	231
$P90_{value}$	$P50_{value} * (1 – P90_{uncertainty})$	1,547	217



ESMAP & World Bank: Global Solar Atlas (2024), MEASNET (2016)

A 140 MW_{AC} PROJECT IS CONSIDERED, WITH A SIZING FACTOR OF 1.2

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 today. A **sizing factor of 1.2** is chosen for the present assessment. The Indonesian Technology Catalogue describe that a factor between 1 and 1.35 is common.

Data from existing plants: Examples from the latest large solar projects developed in Indonesia also featured a sizing factor of 1.4:

- Likupang solar plant, developed in 2018 in North Sulawesi, with a capacity of 21 MWdc and 15 MWac
- 3 PV projects in Lombok, each with a capacity of 7 MWdc and 5 MWac

Other large systems have a slightly lover DC/AC sizing factor:

- The floating PV system om the Cirata reservoir in West Java has a capacity of 192 MWdc and 125 MWac. This equals a DC/AC sizing factor of 1.3.

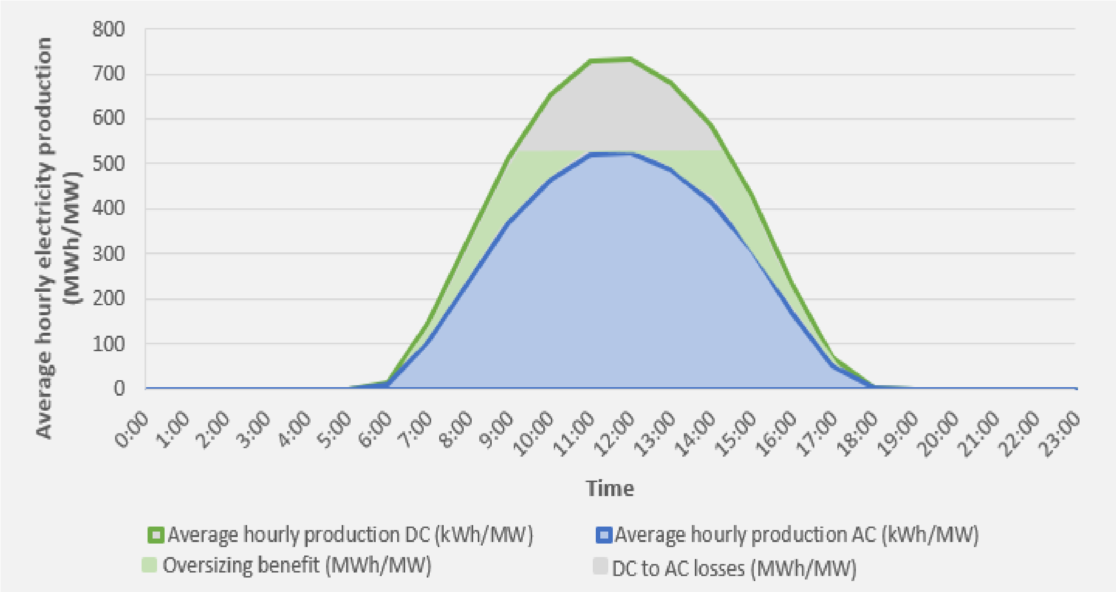


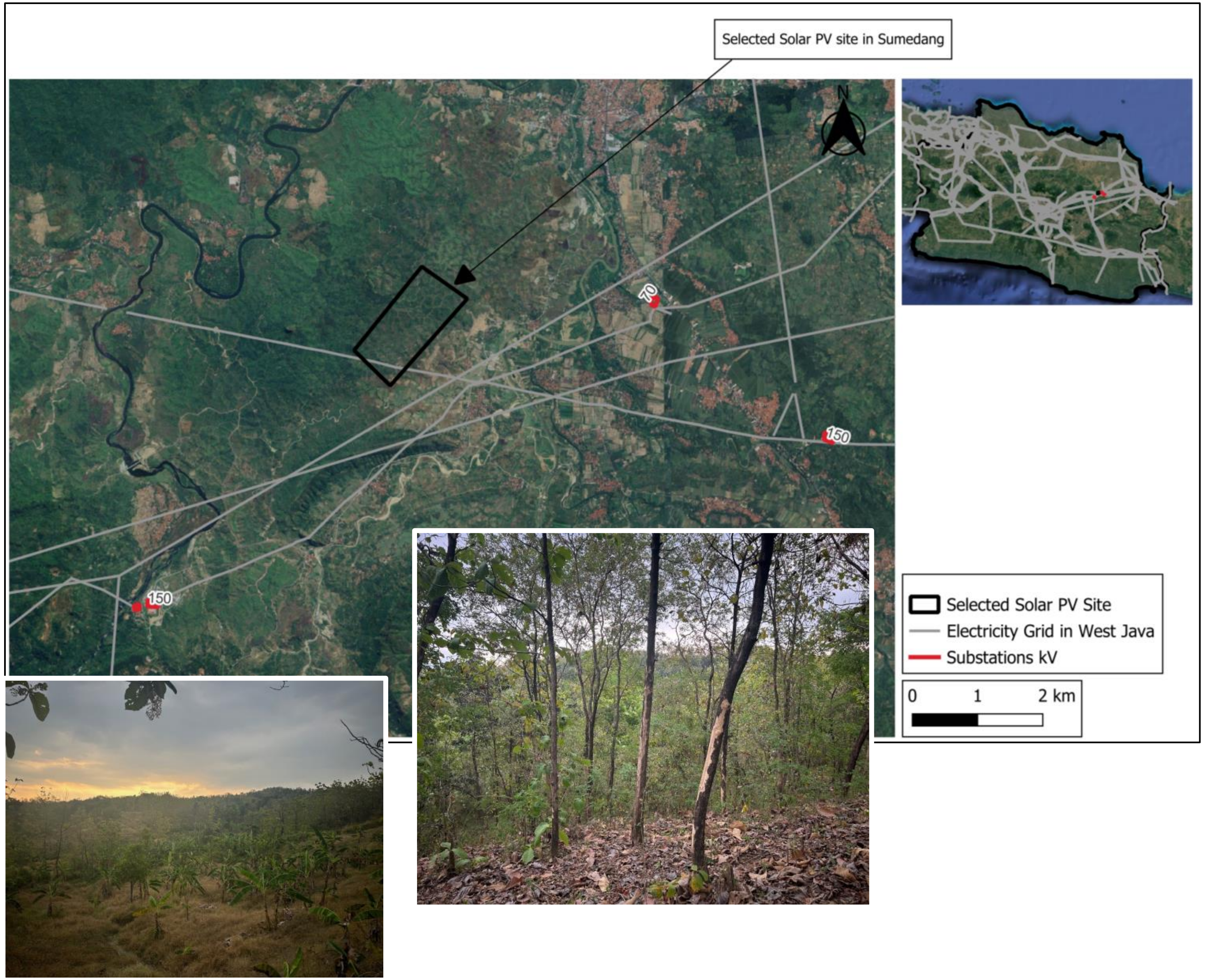
Illustration of average hourly electricity production from solar PV

Capacity selection: A **140 MWac PV plant has been chosen as the suitable reference case for the project under examination**, for several reasons:

- Larger solar PV plants generally improve the economic viability of the project
- Larger sizes of PV plants are increasingly common in other markets
- There is limited experience with very large PV plants in Indonesia. Therefore 140 MWac is a relatively large plant, yet still smaller than many projects in other markets.

Danish Energy Agency & Ea Energy Analyses (2024); VENA Energy (2021)

A POTENTIAL LOCATION IN SUMEDANG IS SELECTED



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.

The Location of the ground-mounted PV plant: The proposed site is located in the Tomo subdistrict of Sumedang regency, with the majority of the area situated in Marongga village and a smaller portion in Mekarwangi village.

Most of the land is covered with tall plants such as teak while some locations are used by the community for rice fields, gardens and animal husbandry. The land is mostly owned by Perhutani and some of the land is owned by the community.

The site is located approximately 10 km away to a 150 kV substation from PLN named Kadipaten Baru. A 70 kV substation is located within 3 km from the site, however without efficient capacity for the solar farm's connection. The land is currently production forest. Therefore, the trees in the area would need to be cleared before a project could be built. The land zoning according to the Regional Regulation of Sumedang No.04 of 2018 is production forest.

The location has normal telecommunications and internet access.

Spacing requirements: A ground-mounted PV plant of 140 MWac magnitude (168 MWdc with a sizing factor of 1.2) will require ~8,800 m^2/MWdc, according to the latest technological projections, as reported by the Danish Energy Agency in the most recent Technology Data Catalogue for the Indonesian Power Sector (2024). This translates to 1.48km^2 (151 Ha) of space considerations within the considered area.

Danish Energy Agency & Ea Energy Analyses (2024); Google Earth Satellite photos.

TECHNO-ECONOMIC DATA USED FOR THE BUSINESS CASE

Technical features	
Capacity	168 MWdc 140 MWac
Technical lifetime	28 years
Plant availability	99.5%
Space requirements	8,874 m^2/MWdc
Capacity factor	20.2 % (AC) 16.8 % (DC)
Construction time	0.5 years
DC/AC Inverter lifetime	14 years

Economic features	
CAPEX	0.64 mUSD/MWdc 0.77 mUSD/Mwac
DEVEX	3.5%
Fixed OPEX	7,595 USD/MWac-year
WACC (real)	8.23%
Expected PPA	Year 1 to 10: 6.95 cUSD/kWh Year 11 to 28: 4.17 cUSD/kWh
Corporate tax rate	22.0%
Depreciation rate	20% declining balance across lifetime
Inflation rate	2.00%

Source	CAPEX[1]	Notes
Technology catalogue for the Indonesian Power Sector	0.73 M$/MWdc 0.88 M$/Mwac	Value for whole Indonesia, based on extrapolation of PPAs and other international sources. Interpolation between 2020, 2030 and 2050. Based on sizing factor of 1.2.
EPC contractors	0.69 M$/MWdc 0.96 M$/MWac	Average value for 2021 based on elicitation of EPC prices, more specifically for North Sulawesi from 4 providers.
Data from small existing PV in Riau	0.75 M$/MWdc	Average value for construction of 2 small size PV in Riau: RAPP (1.35 MWdc) and Pertamina RU II (2 MWdc) constructed in 2021.

Figures reflect the projected 2025 data (beginning of construction) in real 2023 price levels, according to the Danish Energy Agency's Technology Catalogue for the Indonesian Power Sector (2024).

Danish Energy Agency & Ea Energy Analyses (2024)

PV module price considerations

Decreased component cost trajectories

Solar module procurement has experienced a decrease in costs during 2024 according to the Chinese Module Marker (CMM), which is a benchmark for Chinese solar panel prices. OPIS, A Dow Jones Company has assessed the recent cost of TOPCon panels from China at 0.089 USD/W Free-On-board (FOB). OPIS reports that Q4 2024 deliveries to Southeast Asia at a cost of 0.090 USD/W on a Cost Insurance and Freight (CIF) basis, with indications that prices for the first half of 2025 could be as low as 0.080 USD/W on a CIF basis. (OPIS, 2024)

Current module prices of 0.090 USD/W (CIF) could indicate lower total CAPEX costs than 0.64 M$/MWdc used in this study. The impact of lower CAPEX costs are analyzed in a sensitivity analysis.

FID and COD: The assumed final investment decision (FID) is 2025 and the commercial operation date (COD) is 2026 with construction undertaken between 2025 and 2026.

Comparison of CAPEX sources: Several sources indicate CAPEX estimations for Indonesia. Some of the projects from the table are from 2021. Since 2021 solar PV module prices have fallen, which could indicate lower total CAPEX costs.

Land cost: The ZNT land price for the area is less than 100,000 Rp/m2 (6.3 USD/m2). A general cost of land for Indonesia is included in the CAPEX of the project. A variation in the cost of land is analysed in the sensitivity analysis by changing the CAPEX.

THE UTILITY SCALE GROUND-MOUNTED PV PROJECT IS NEGATIVE WITH AN IRR OF 7.5%

Results: The business case for a 140 MWAC ground-mounted solar plant in West Java is negative based on baseline assumptions, with a Net Present Value (NPV) of -5 mUSD and a real Internal Rate of Return (IRR) of 7.5%, which is very close to the estimated Weighted Average Cost of Capital (WACC) of 8.2%.

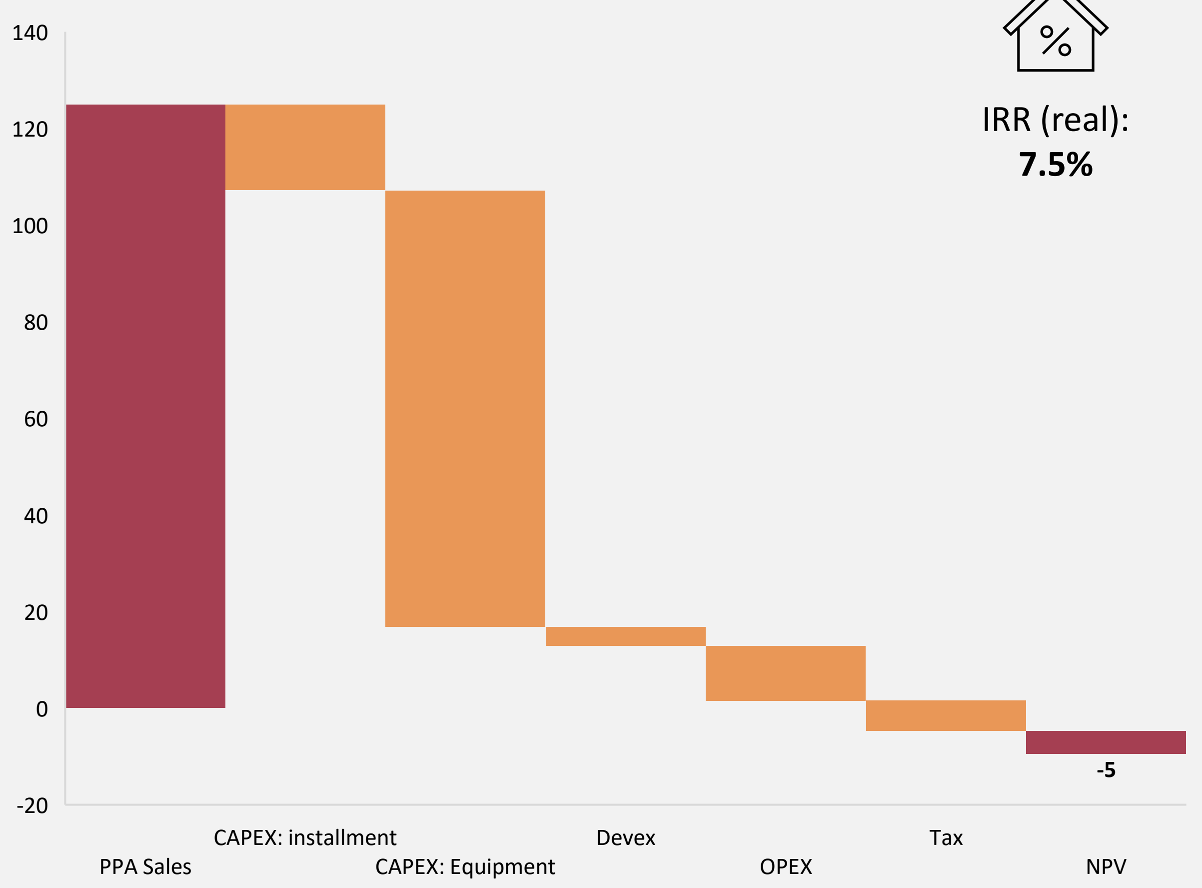
Costs: The cost of equipment constitutes the majority of project costs, meaning even small fluctuations in solar panels or inverters could significantly impact project feasibility. Additionally, stringent local content requirements reduce the available supply of equipment, potentially driving up investment costs.

Other costs include installment costs, development costs, taxes, and operating expenses, though these represent a smaller share of the project's cash flow. Development costs, however, tend to be less predictable, especially in markets with limited experience. Factors such as permitting and land clearing could significantly increase development costs, raising their overall share of total project expenditures.

Revenue: To offset project costs, a stable source of revenue must be secured. For this project, the sale of electricity is assumed to be the sole revenue source why certainty on PPA contract terms and price levels are important.

Following the ceiling price scheme, the net present value of the PPA sales accumulates to 125 mUSD assuming a 28-year contract period.

Breakdown of NPV components



Note: 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 1ST STAGE'S BREAK-EVEN PPA PRICE FOR THE SELECTED PV PROJECT IS 7.40 cUSD/KWH

1st stage PPA price: The first stage of the PPA term is the most critical determinant of project feasibility due to discounting effects. Therefore, the agreed initial PPA price plays a pivotal role in the business case evaluation.

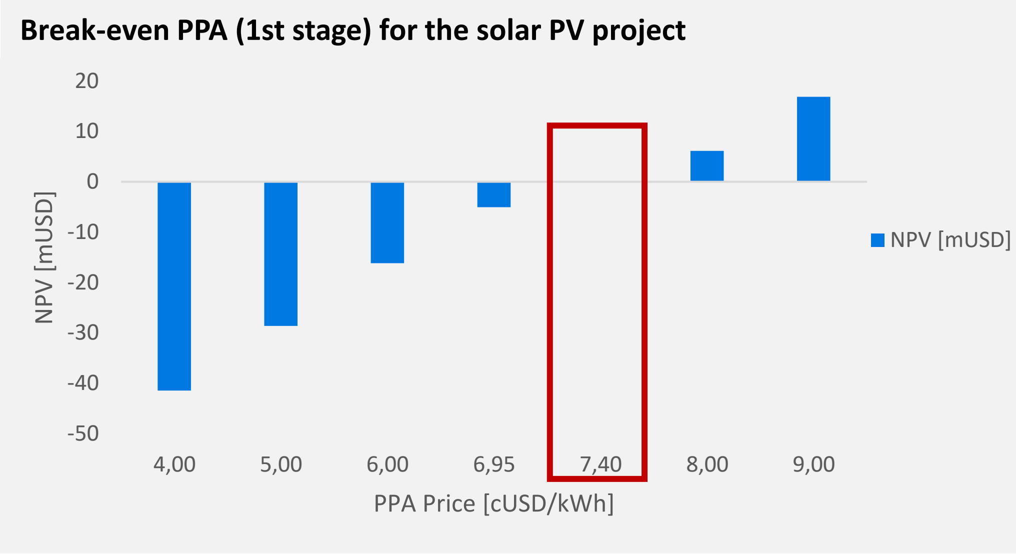
Several factors create uncertainty regarding the potential PPA level expected by investors in a solar project in West Java, including:

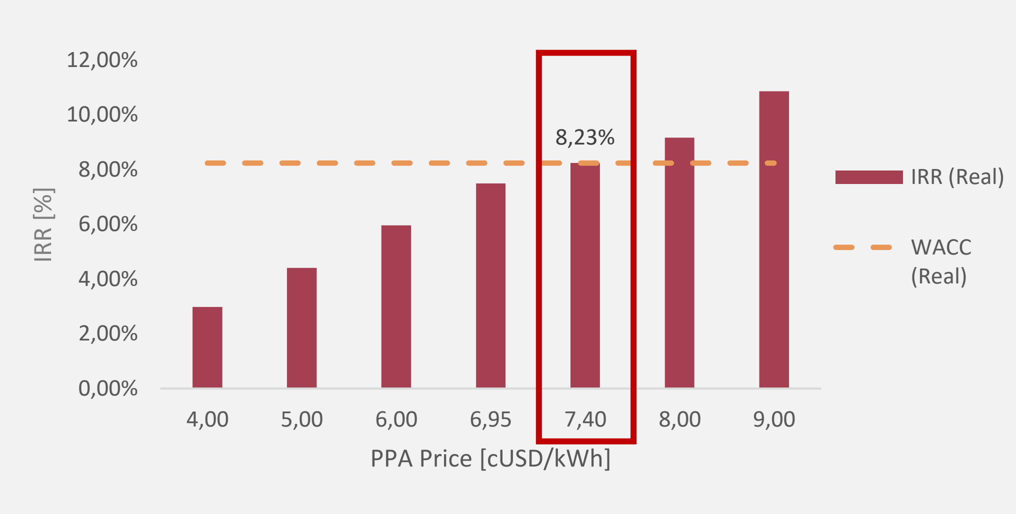
- The regional BPP and how it compares to the ceiling price set by presidential regulation.
- Competitively low bids from other investors, particularly in projects benefiting from financial advantages such as lower financing costs or reduced CAPEX.

Given these factors, it is crucial to determine the minimum first-stage PPA price that enables the project to break even, ensuring an IRR equal to the expected real WACC (8.23%) and an NPV of zero. It effectively represents the bid value an investor might propose in an auction or negotiation to develop the solar project while securing returns in line with the expected WACC.

Break-even PPA price: The break-even PPA price is the PPA price for the first 10 years, which returns an NPV of 0 and an IRR that equals the cost of capital (WACC).

The break-even price for this case in an all-things equal scenario is 7.4 cUSD/kWh, which is moderately higher than the regulated ceiling price assumed in the base case.





1st stage break-even PPA

SENSITIVITY ANALYSIS ON CAPEX, FULL LOAD HOURS, PPA PRICE AND CONTRACT PERIOD

Scenario analysis : A scenario analysis is conducted to evaluate the impact on Net Present Value (NPV) when key input assumptions deviate from the base case. The results are presented in a matrix format, illustrating the effects of different combinations of input factors on NPV. The key input factors are CAPEX, Full Load Hours and PPA price.

CAPEX: the estimation of the capital costs is based on figures from the Indonesian Technology Catalogue and developer interviews, but actual project costs could vary largely depending on market conditions, supply chain and real project conditions.

CAPEX is varied from **0.6 to 1.4 mUSD/MW$_{AC}$**. The range selected is the cost range of imported panels (IEA WEO23, average of India and China) and the upper bound of the uncertainty range indicated by the Indonesian Technology Catalogue, all projected to 2025 estimations.

Full Load Hours: Irradiance is used to estimate annual production. Since irradiance is based on modelled data, estimated full load hours and annual production levels are subject to some uncertainty. Annual production is varied between **1,650** and **1,815 Full Load Hours.**

PPA Price: The baseline PPA price follows the ceiling price scheme. Since PPA processes are competitive, the realized PPA price is likely to be lower than the baseline. Additionally, given the low uptake of renewables in Indonesia, regulatory changes could increase the ceiling price. To account for these uncertainties, a ±10% variation in the PPA price has been assumed for the first 10 years of the contract period.

Contract period: Changing the contract period to 25 or 30 years compared to the baseline of 28 years have marginal impact on the overall feasibility of the project. The payback period remains constant at 8.3 years, indicating that variations in project duration do not affect the timeline for recovering the initial investment. This suggests that early-stage cash flows drive the investment recovery, while later years primarily influence overall profitability.

Net Present Value in selected scenarios [mUSD]

Scenario	1st stage PPA (cUSD/kWh)		Capex (m$/MW)	FLHs AC		
Low				*1.650*	*1.704*	*1.815*
	62,55		*0,6*	-4	2	7
			0,8	-25	-19	-13
			1,4	-113	-106	-99
Baseline				*1.650*	*1.704*	*1.815*
	69,50		*0,6*	8	14	20
			0,8	-12	-5	1
			1,4	-98	-90	-82
High				*1.650*	*1.765*	*1.880*
	76,45		*0,6*	12	19	25
			0,8	-7	0	7
			1,4	-92	-83	-75

Contract period	NPV	IRR	Payback time
Baseline contract period (28 years)	-5.1 mUSD	7.5%	10
Shorter contract period (25 years)	-6.2 mUSD	7.29%	10
Longer contract period (30 years)	-4.5 mUSD	7.59%	10

SOCIO-ECONOMIC ANALYSIS FOR SOLAR PV

Stock photo ID: 699866378
Location: China

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3 Resource evaluation
4 Project size & restrictions
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6 Business case
7 Environmental & social aspects
8 Risk assessment

Financial assessment input to the socio-economic assessment

Financial analysis of the 140 MW Solar PV Project in Sumedang – West Java:

The Pre-Feasibility Study (PFS) in the chapters above was elaborated by a consortium consisting of Ea Energy Analyses and Viegand Maagøe, with local support from PT Innovasi, an Indonesian consultancy.

The socio-economic analysis in the following sections is based on project specific input from the PFS; see Ea Energy Analyses, Viegand Maagøe and PT Innovasi. (2024b). For easy reference, these inputs are highlighted in the table to the right. The socio-economic assessment of the project is based on the data provided in the PFS of the 140 MW Solar PV project but adjusted when appropriate; i.e., taxes paid.

Summary Conclusion of the 140 MW Solar PV Project:

Financial Viability:

- IRR (real): The internal rate of return is 7.5%, slightly below the weighted average cost of capital (WACC) of 8.23%, indicating that the project does not meet its required rate of return.
- NPV (real): The net present value is negative (-5.1 mUSD), suggesting that the project does not create value and may not be financially feasible under the given assumptions.

The project demonstrates strong energy production and relatively low operational costs. However, with a negative NPV and an IRR below the WACC, it faces financial viability challenges under current assumptions. To make the project more attractive, potential adjustments could include increasing PPA rates, optimizing Capex/Opex, or securing subsidies/incentives.

The conclusion above represents the financial evaluation of the project. This financial conclusion will be further refined and adjusted as part of the subsequent economic cost-benefit analysis.

Table – Summary findings of the 140 MW Solar PV project

Solar power, Sumedang	Input
Baseline year	2025
IRR (real)	7.49%
NPV (real)	-5.1 mUSD
Size of project in MW	140
Baseline Capex (mUSD)	108.1 mUSD
Baseline Opex (USD/y)	1,035,191
Price per MW (USD/MW)	0.77
Initial annual production (GWh/y)	245,892
PPA USD/MWh (y 1-10)	69.50
PPA USD/MWh (y 11-28)	41.70
Real WACC	8.23%
Lifetime LCOE (USD/MWh)	46.34

COWI

Summary of quantitative socio-economic assessment

Socio-economic assessment of the solar PV plant of 140 MW in Sumedang:
The data provided in the table to the right offers a financial and socio-economic snapshot of the project. Below is an analysis of the key socio-economic indicators (the last five rows) and their implications:

Economic Net Present Value (ENPV): 240 USD million
- The ENPV reflects the project's value to society, considering all socio-economic benefits and costs, discounted at a real social discount rate (SDR) of 6.23%. A positive ENPV of 240 USD million indicates that the project generates substantial net economic benefits for society, making it economically viable from a public welfare perspective.

Economic Internal Rate of Return (ERR): 25.2%
- The ERR measures the rate of return on the project’s socio-economic investment, considering all externalities. An ERR of 25.2% is significantly higher than the real SDR of 6.23%, indicating robust socio-economic viability.

Benefit-Cost Ratio (B/C-Ratio): 2.91
- The B/C-ratio represents the efficiency of the project in converting costs into benefits. A ratio of 2.91 means that for every 1 USD spent, the project generates 2.91 USD in socio-economic benefits. This ratio exceeds the standard threshold of 1.0, confirming the project's strong justification from an economic perspective.

Summary of Socio-Economic Viability
- Positive Outcomes:
  - The project delivers substantial socio-economic benefits, primarily through carbon emission reductions, energy security, and job creation.
  - The high ERR and B/C-ratio demonstrate the efficiency and strong societal value of the investment.
- Considerations:
  - The project’s financial NPV is negative (-5.1 USD million), but its socio-economic value compensates for the financial shortfall.
  - Addressing potential land-use and biodiversity impacts effectively will further enhance the project’s social acceptability and environmental sustainability.

Table – Summary conclusions of the financial and socio-economic assessment

	West Java - Solar
Baseline or evaluation year	2025
IRR (real)	7.49%
NPV (real)	-5.1 mUSD
WACC	8.23%
Size of project in MW	140
Baseline Capex	108.1 mUSD
Baseline Opex (USD/y)	1,035,191
Price per MW	0.77
Initial annual production (GWh/y)	245,892
PPA USD/MWh (y 1-10)	69.50
PPA USD/MWh (y 11-28)	41.70
Real SDR	6.23%
Lifetime LCOE (USD/MWh)	46.34
ERR	25.19%
ENPV	239.7 mUSD
ENPV of total benefits	365.4 mUSD
ENPV of total costs	-125.7 mUSD
B/C-ratio	2.91

ECONOMIC ASSESSMENT – JOB CREATION AND LOCAL ECONOMIC IMPACT

Local Economic Impact: The value of the increase in the economic activity in the main sectors of the investments can be summarized as the indirect effect to the economy. This is also known as the multiplier effect of the investment. The local share of this effect is the local economic impact. The increased economic activity occurs throughout the economy, when the investment in the main sectors obtains input from supporting sectors. For the construction, operation and maintenance of a solar PV plant, the main sectors are assumed to be manufacturing of equipment, construction and land transportation. The most important input sectors to the main sectors in West Java's economy includes production and processing of raw materials, metal and electronics work, transportation and transportation support functions. Other sectors such as financial services, real estate and government administration are relevant two, but among the top contributions to the three main sectors.

The local economic impact is summarized in table 4 to the right.

Table – Local economic impact (USD)

Local economic impact	
Construction (Million USD)	16.21
Annual effect from operation and maintenance (Million USD/year)	0.58

Job creation: A new renewable energy plant will generate jobs for the local community, both during the construction phase and the operating and maintenance phase of the process.

As mentioned earlier, during the construction phase of a utility scale solar PV, workers are needed to manufacture equipment for the panels, transport materials, and install and construct the panels. This effect constitutes the direct effect. The employment model bases the calculation of the direct effect on the CAPEX, and it thus accounts for the jobs created not only during the actual construction, but also the production and transport of the solar PV equipment. Additionally, the purchase, transport and construction of the panels will lead to jobs related to the extraction of new raw materials, manufacturing of construction tools, provision of administrative, health and other support to the workforce directly engaged in the construction. This is the indirect effect.

The sum of employment effect for a ground mounted solar PV plant of 140 MW in Sumedang is summarized in the table below and the effect over time is highlighted in the figure.

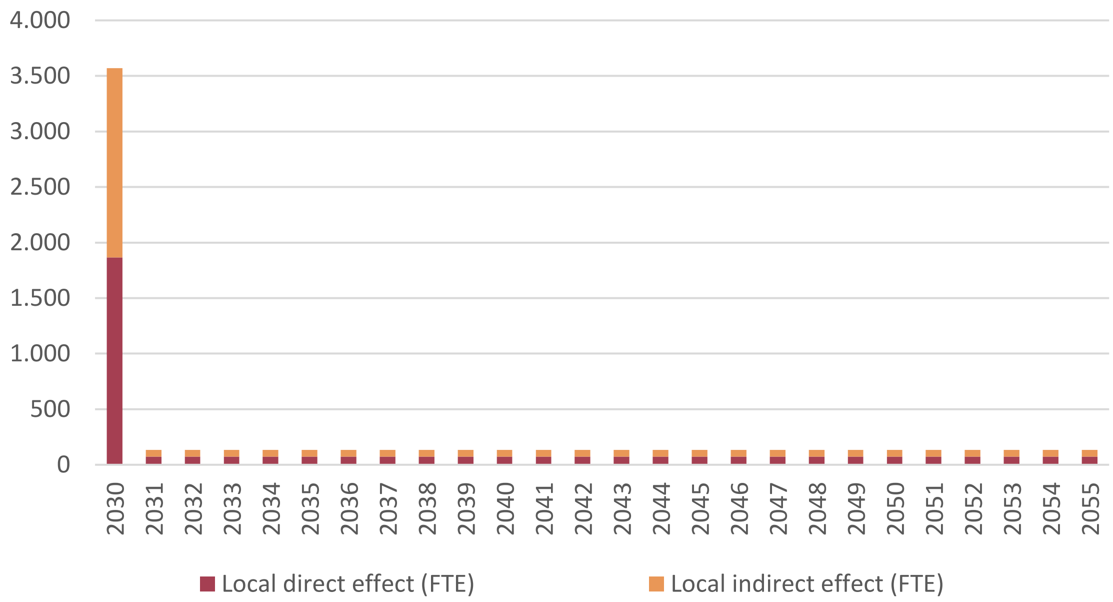

Figure – Local employment effect over time (FTE)

Table – Local direct and indirect employment effect by phase (FTE)

	Local direct effect	Local indirect effect
Construction phase (FTE)	1,870	1,700
Annual effect from operation and maintenance phase (FTE/year)	70	60

Economic Assumptions underpinning the socio-economic Assessment (1)

Assumptions:

Price of CO_2:
It is assumed that the CO_2 tax will start at 4.7 USD per tonne of CO_2 in 2025 and increase annually by 15%, reaching 151 USD per tonne of CO_2 by 2050.

Reduction in CO_2 emissions:
The calculations of CO_2 reductions are based on PLN's documentation, which specifies an emissions factor of 0.817 kg CO_2/kWh in accordance with official figures in State Electricity Company. (2019). It is assumed that each kilowatt-hour (kWh) generated by solar PV or wind directly offsets an equivalent kWh that would otherwise be produced by PLN's existing fossil fuel power plants.

In the first year of operation, the solar PV project is projected to generate 288,232 MWh of electricity. Based on PLN's estimated average CO_2 emission factor of 0.817 kg CO2 per kWh for Indonesia, the project will avoid approximately 235,485 tonnes of CO_2 emissions by replacing fossil fuel-based electricity generation. This will contribute to reducing the CO2 intensity of products manufactured in Indonesia, thereby reducing the EU CBAM CO2 tax, and making imports from Indonesia more attractive in Europe.

CO_2 Emissions from Land Clearing in Sumedang
The development of the solar PV project in Kuta Cot Glie involves land clearing, contributing to CO_2 emissions due to the removal of vegetation that serves as a natural carbon sink. The land type designated for the solar PV project is savannah, which is zoned as a plantation area under regional spatial planning regulations. Although the site is not a dense forest, the clearing of 140 hectares of vegetation is estimated to release approximately 7,000 tonnes of CO_2, calculated using an emission factor of 50 tonnes of CO_2 per hectare. However, the removal of vegetation also eliminates the annual CO_2 absorption capacity of the area, which are interpreted as a recurring loss of potential sequestration. See Viegand Maagøe and PT Innovasi. (2024b).

Value of Statistical Life (VSL):
In Indonesia, direct estimates of VSL are limited due to the scarcity of comprehensive studies. Various international studies suggest VSL values around 600,000 USD. Data from the Centre for Research on Energy and Clean Air (CREA) and the Institute for Essential Services Reform (IESR) highlight the impact of air pollution in Indonesia.

In 2022, emissions from coal-fired power plants caused 10,500 deaths nationally, with 4,315 fatalities in West Java alone. The total health cost of these emissions was estimated at USD 7.4 billion; see DataIndonesia. (2023). This implies a VSL value of approximately USD 700,000 which is used in this socio-economic assessment. This value captures also reduced hospital admissions and medical expenses related to air pollution.

Avoided death and health benefits:
The "deaths per MW" metric links energy generation to health impacts. In West Java, the population density near coal plants suggests fewer people are exposed to pollutants, warranting an adjusted rate of 0.20 deaths per MW instead of the average for Indonesia of 0.495 deaths per MW. Assuming 50% of the 140 MW capacity replaces coal, while the rest offsets cleaner sources, the calculation is:

Avoided deaths = 0.20 × 70 MW = 16.8 deaths.

Thus, a 140 MW solar PV project in Sumedang can prevent approximately 16.8 deaths through partial coal displacement.

Net additional value of increased new employees:
For skilled workers in West Java, new wages of USD 5,500/year create an additional value of USD 1,500/year compared to previous earnings of USD 4,000/year. For unskilled or semi-skilled labour, the additional value is USD 3,000/year based on previous earnings of USD 2,500/year.

On average, the net additional value of creating one job in Indonesia through renewable energy projects is USD 1,000–5,500/year. Assuming 75% skilled and 25% unskilled workers, the societal value per new employee is approximately USD 1,750/year.

Employment effects:
The 140 MW solar PV project assumes that a total of 3,570 direct and indirect jobs will be created during the construction and preparation phase. This includes direct employment on-site and indirect jobs generated in supporting sectors such as supply chain, transportation, and services. During the operational phase, it is estimated that 130 direct and indirect jobs will be sustained, which include on-site operation and maintenance roles and ongoing support activities in related industries.

ECONOMIC ASSUMPTIONS UNDERPINNING THE SOCIO-ECONOMIC ASSESSMENT (2)

Assumptions:

Real Social Discount Rate (SDR):

The Social Discount Rate (SDR) is crucial for cost-benefit analyses of public projects, reflecting society's preference for present benefits over future ones. Organisations like the Asian Development Bank and World Bank recommend real SDRs of 6%-9% for developing countries to balance societal preferences and opportunity costs. In Indonesia, the Ministry of Finance estimated a real SDR of 6.19% based on the Social Rate of Time Preference (SRTP) and 6.82% using the Social Opportunity Cost of Capital (SOC).

A midpoint real SDR of 6.23% is deemed appropriate for 2024, aligning with international standards and Indonesia's development goals. This value, 2%-point lower than the WACC used in feasibility studies, ensures public investments are evaluated fairly, prioritising long-term societal benefits.

Fiscal corrections:

Taxes and subsidies are considered transfer payments, meaning they do not represent real economic costs or benefits to society but instead serve to redistribute resources. Therefore, certain adjustments are made to the financial calculations made in the PFS. Value-added tax (VAT) is excluded from input and output prices. Direct and indirect taxes are removed from input prices, and subsidies or public entity transfers, such as tariffs, are excluded from output prices.

Evaluation criteria: ENPV, ERR, and B/C Ratio:

In economic evaluations, particularly within the context of Cost-Benefit Analysis, decision-makers rely on three primary criteria to assess the desirability and feasibility of projects: Economic Net Present Value (ENPV), Economic Rate of Return (ERR), and the Benefit/Cost Ratio (B/C Ratio). Each of these measures provides a distinct perspective on the project's value to society, guiding stakeholders in resource allocation and project prioritisation.

- **1. Economic Net Present Value (ENPV)** measures the net welfare impact of a project by discounting the difference between its total economic benefits and costs. A positive ENPV indicates that the project contributes positively to societal welfare, justifying its implementation.

- **2. Economic Rate of Return (ERR)** evaluates the efficiency of a project by identifying the discount rate at which the project's net benefits (ENPV) become zero. It highlights the project's capacity to generate value relative to its costs.

- **3. Benefit/Cost Ratio (B/C Ratio)** compares the present value of a project's benefits to its costs, offering a straightforward indicator of efficiency. This ratio assists in ranking projects when resources are limited, ensuring that investments yield maximum societal returns.

Summary of Decision Rules for Key Economic Measures:

- The **ENPV** measures the net welfare impact of a project by comparing total discounted social benefits and costs. A positive ENPV indicates societal benefits exceed costs, making the project desirable, while a negative ENPV suggests it should be rejected.

- The **ERR** represents the discount rate at which ENPV equals zero, reflecting the project's efficiency. Projects with an ERR above the social discount rate are considered acceptable.

- The **B/C ratio** compares the present value of benefits to costs. A ratio greater than one indicates economic viability, while a ratio of one or less suggests inefficiency.

Together, these measures evaluate overall welfare (ENPV), efficiency (ERR), and cost-effectiveness (B/C ratio) to assess the project's economic viability.

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Sensitivity Analysis of socio-economic results (1) – Economic Net Present Value (ENPV)

Overview of Sensitivity Analysis:

The sensitivity analysis evaluates the impact of varying assumptions, such as CO_2 tax, Value of Statistical Life (VSL), emissions intensity, and the real Social Discount Rate (SDR), on key economic metrics. The real SDR is the rate used to evaluate the present value of future costs and benefits in cost-benefit analysis. It reflects the opportunity cost of capital in society and accounts for the preference for present consumption over future consumption. The real SDR excludes inflation.

ENPV reflects the net societal benefits, while the B/C ratio indicates the project's cost-effectiveness. The analysis helps identify how changes in assumptions influence project viability. The results of the sensitivity tests is presented in the table the right as well as in the two charts in this slide and the next. Primarily worst-case scenarios have been assessed.

Key findings of sensitivity analysis on the ENPV across Scenarios:

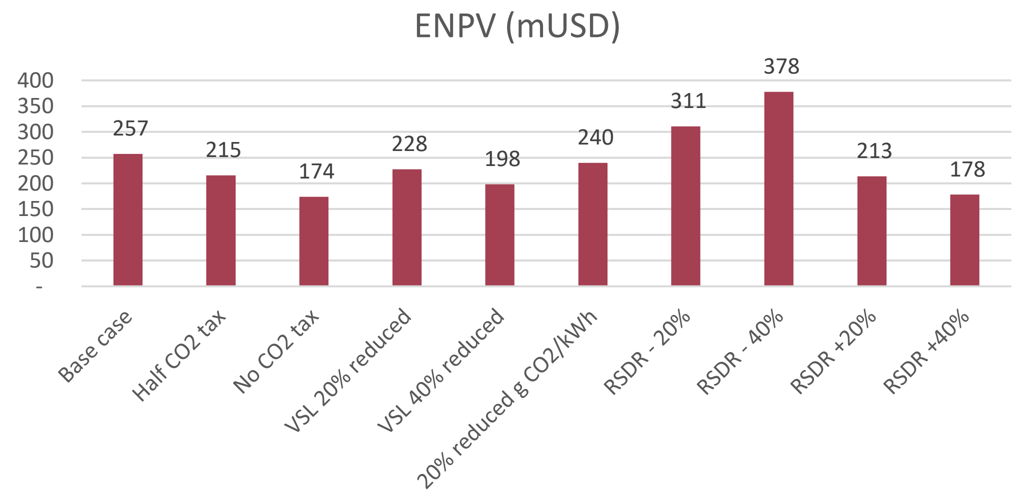


Figure – Sensitivity analysis on the ENPV across scenarios
Note: RSDR in the chart stands for Real Social Discount Rate (SDR)

Table – Summary of sensitivity analyses across scenarios

Scenario	Real SDR (%)	ENPV (million)	B/C Ratio
Base Case	6.23%	256.9	3.04
Half CO2 Tax	6.23%	215.4	2.71
No CO2 Tax	6.23%	173.9	2.38
VSL 20% Reduced	6.23%	227.6	2.81
VSL 40% Reduced	6.23%	198.2	2.58
20% Reduced g CO2/kWh	6.23%	239.7	2.91
Real SDR - 20%	4.99%	310.8	3.44
Real SDR - 40%	3.74%	378.0	3.91
Real SDR + 20%	7.48%	213.5	2.72
Real SDR + 40%	8.72%	177.9	2.45

Sensitivity Analysis of Socio-Economic Results (2) – Benefit-Cost Ratio (B/C Ratio)

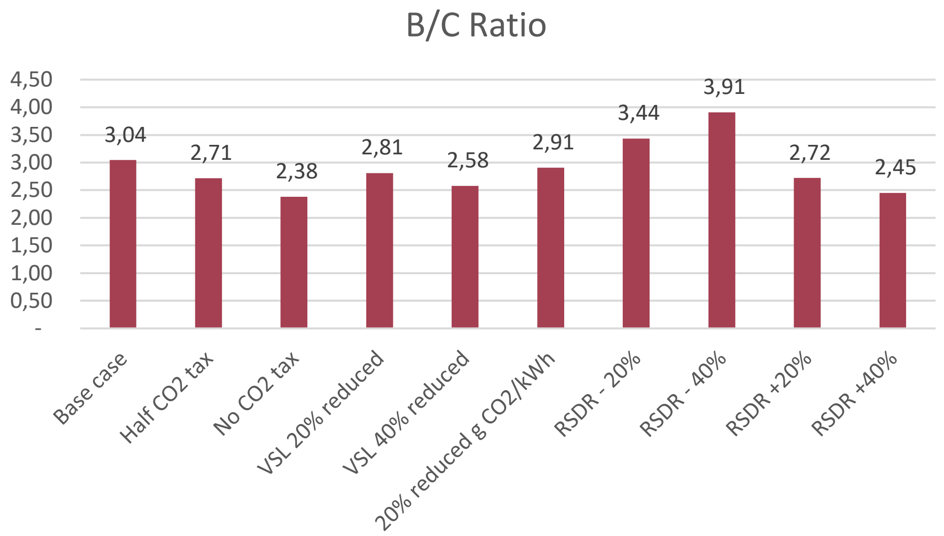
Key findings of sensitivity analysis:

- **1. CO_2 Tax Variations:** Reducing or removing the CO_2 tax significantly decreases ENPV and B/C ratios, indicating a negative impact on project viability. The same applies to changes in power production.
- **2. VSL Adjustments:** A 20–40% reduction in VSL moderately lowers ENPV and B/C ratios but retains acceptable viability.
- **3. Reduced Emissions Intensity:** A 20% reduction in g CO_2/kWh shows minimal impact, demonstrating robustness.
- **4. Real Social Discount Rate (SDR):** Lower real SDR values significantly increase ENPV and B/C ratios, while higher real SDRs reduce economic desirability.

Overall Conclusion on the Robustness of the Project
The sensitivity analysis demonstrates that the project remains robust under a wide range of assumptions. While variations in CO_2 tax, Value of Statistical Life (VSL), and real Social Discount Rate (SDR) impact the Economic Net Present Value (ENPV) and Benefit-Cost Ratio (B/C ratio), the project consistently delivers positive ENPV and a B/C ratio above 1 in most scenarios. This indicates that the project is economically viable and resilient to uncertainties in key parameters.

Lowering or removing the CO_2 tax and increasing the SDR reduces the project's desirability, but the outcomes remain within an acceptable range for decision-making. Additionally, adjustments to VSL and emission factors show minimal effect on the project's economic viability, underscoring its robustness in achieving net societal benefits. Overall, the project is well-positioned to deliver substantial value and remains a strong candidate for investment under varied economic and policy conditions.

Key findings of sensitivity analysis on the B/C ratio across scenarios:



Note: RSDR in the chart stands for Real Social Discount Rate (SDR)
Figure – Sensitivity analysis on the B/C Ratio across scenarios

Social Assessment– Land Category, Land Use and Ownership Status

Land Category and Land Use:

The potential Solar PV site is located in Marongge in the Tomo District, near Nagrak village. The analysis of land category status indicates that the Solar PV area in Sumedang includes production forest, local protection areas, agricultural land, and urban settlements.

The land designated for Solar PV development in Sumedang is predominantly open space devoid of human habitation. Most of the area surrounding the planned Solar PV location is designated as "Production Forest" (around 90%) and managed by the Ministry/Forestry Provincial Agency (Perhutani). The production forest is used for timber production, particularly teak and mahogany.

However, the community has repurposed much of this land for agriculture, predominantly for growing crops. Additionally, several communities herd buffalo in the forest area administrated by Perhutani. Use of the area should therefor both receive approval from the Ministry of Environment and Forestry and ensure compensation to communities that utilities the area to grow crops for livelihood, even though they don't officially own the land. Much likely it will need to compensate land and ensure the communities can grow their crops in a replacement area.

The relatively flat land is utilized for agricultural purposes, rice fields, livestock, and plantations. The steep elevations are home to primary forest plants that are either individually managed or under the supervision of Perhutani (stated-owned enterprise) for the production forest case.

Ownership Status:

Marongge Village owns an area (categorized as Village Treasury Land) near the Solar PV location, covering 90 hectares. The village has suggested using this land for the solar PV development instead of the Perhutani land that are currently being reviewed.

The part of the area where the Land Category is designated agriculture or urban settlement is either privately or community owned, and usage should be agreed or arranged with the stakeholders. Construction of solar PV in this area will require land clearing, which will reduce the area's carbon absorption capabilities and result in the loss of a small part of the working area for farmers and ranchers.

*Table – Land category based on applied regulations in Sumedang**

Land Category in RTRW	Actual Land Use	Regency: Sumedang	Ownership Status	Notes for RE Development
Production Forest	Forest, Community Forest	✓	State Owned, managed by Perhutani	It can be used if there is an Approval for Forest Area Use from the Ministry of Environment and Forestry in accordance with Government Regulation No. 23/2021
Urban Settlement	Settlement	✓	Community	Can be used if a sale and purchase or rental agreement is obtained
local protection area	Forest	✓	State Owned, managed by Perhutani	It can be used if there is an Approval for Forest Area Use from the Ministry of Environment and Forestry in accordance with Government Regulation No. 23/2021
Agriculture Area	Paddy fields, horticultural crops	✓	Private or community	Can be used if a sale and purchase or rental agreement is obtained

Source: PT Inovasi report

Method:

Initial land analysis was conducted by checking the land zoning status as stated in the published RTRW (Regional Spatial Planning) document for the category of land use. This was validated by checking with the Ministry of Agraria and Land Agency (ATR/BPN) available data and discussed with DBMPR (Dinas Bina Marga Penataan Ruang/Roads and Spatial Planning Agency) of West Java*. This analysis was complimented by field visits and surveying local stakeholders.

*Input from PT Inovasi

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Social Assessment – Community in the Area and Land Price Estimation

Community in the area:
Marongge Village and Tomo District is a blend of agricultural, industrial, and informal land uses. The majority of the population in these areas work as rice farmers, while others are employed in nearby factories and construction sites.

This region is positioned within the West Java government's initiative to establish Sumedang as a major industrial hub, known as BUTOM (Buahdua-Ujungjaya-Tomo). The industrial development is primarily driven by the textile and apparel sector, which generates significant energy demand for factory operations. Despite ongoing industrial growth, some newly established factories face challenges related to incomplete land permits. As a result, many local residents are employed as daily, transient laborers rather than holding permanent positions*.

Additionally, the community's proximity to a sand and stone quarry and processing plant influences local employment opportunities and land use patterns.

The population of Marongge Village is approximately 1,700 people, with half of them being of productive age. In the broader Tomo District, the population is around 24,000. Educational attainment in these communities typically ranges from junior high school to high school, though some members of the younger generation have pursued bachelor's degrees, particularly in economics and management.

Land Price Estimation*:
The land value zone (ZNT) is a standardized land valuation provided by the central government to estimate the market value of land parcels within a defined area. This information is primarily used as a reference for determining non-tax state revenue and is generally lower than the NJOP (Tax Object Sales Value). Table below compares the land prices listed in the ZNT to those obtained from firsthand interviews. It shows that while the ZNT issued by the Ministry of ATR/BPN is 100,000 Rp/m2, the interviews with local stakeholders indicate that prices could be between 200,000 and 400,000 Rp/m2.

*Table – Land price estimation**

Regency	Land Value Zone (ZNT) issued by Ministry of ATR/BPN	Interview with local stakeholders
Sumedang	< Rp 100,000/m^2	- NJOP is below Rp 500,000/m^2 - Based on an interview: between Rp 200,000 and Rp 400,000/m2. - Majority of the land is owned by State Owned, managed by PERHUTANI

Source: PT Inovasi report

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*Input from PT Inovasi

SOCIAL ASSESSMENT– COMMUNITY ENGAGEMENT AND INDIGENOUS PEOPLE TERRITORY

Community Engagement:
The community in Marongge Village, including both the village and sub-district, is not yet familiar with renewable energy, including the Solar PV project. However, they express their support for the construction of the Solar PV site.

The community in Nagrak village is not yet familiar with renewable energy, including Solar PV, and therefore lacks understanding or opinions about the Solar PV development plan, particularly regarding its potential impact. There is concern that the presence of the Solar PV may generate heat, as they assume sunlight could be reflected and affect the nearby market, potentially impacting the village. However, they are primarily hopeful that the Solar PV site will bring development and job opportunities to the area (see also the local impact of renewable energy).

The Village Head has suggested that local non-governmental organizations should play a central role in the construction project, as they have the capacity to mobilize the local community, for example the NGO Karang Taruna, who consisting mainly of young people. Additionally, there are local actors from Pemuda Pancasila who can be coordinated by the Head of Marongge Village to further engage the community in the project.

A survey of Marongge Village's solar energy potential was previously carried out by private parties from Malaysia, but no follow-up has been done yet. This has impacted the issue of trust between the developer and the communities*.

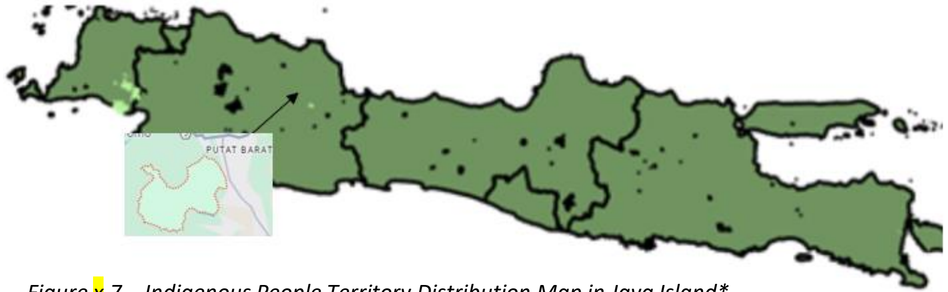


*Figure x.7 – Indigenous People Territory Distribution Map in Java Island**

Source: BRWA and PT Inovasi report

Local impact of Renewable Energy :
The community request that local residents be prioritized as workers for the project, citing a past factory construction where workers from outside areas, such as Karawang and Java, were employed. The community hopes that the construction of the Solar PV will provide significant job opportunities, including the creation of new businesses such as food stalls around the project area to cater to workers.

In addition, the community hopes that the construction of the Solar PV will encourage the development of public infrastructure, including new roads. They also requested considerations from the project developers after the construction, such as providing electricity subsidies for the community, offering free electricity for public facilities, and installing streetlights. Currently, the main road to Marongge Village, which is heavily used by people and sand factory trucks, lacks street lighting, and the community believes that the addition of lights would improve safety and convenience.

Culture and practices:
In Marongge Village, when construction takes place, a thanks-giving event is required. There is a sacred tomb in Marongge Village that is often visited by people from outside the village, though it is located quite far from the Solar PV location.

Indigenous People Territory*: According to the findings of desk study into the existence of indigenous communities registered with the Customary Area Registration Agency (BRWA), West Java has three registered indigenous community areas. They don't seem to overlap with the potential Solar PV site. Once the project planning is more mature, it is recommended that an Environmental and Social Impact Assessment (ESIA) is conducted, to ensure that the project risks are managed in alignment with international environmental and social safeguards, such as the IFC Performance Standards for Environmental and Social Sustainability.

*Input from PT Inovasi

ENVIRONMENTAL ASSESSMENT – WILDLIFE, BIODIVERSITY AND NATURAL DISASTER RISK

Wildlife and Biodiversity:

From the global mapping data on Protected Areas developed by the Key Biodiversities Area Partnership, there are no threatened key biodiversity included in the potential solar PV site in Sumedang*. Additionally, from the site visit and survey, no protected flora or fauna have been identified in the area as shown in the map.

The Solar PV site is located within the Perhutani Production Forest, an area primarily planted with teak and mahogany trees for timber production. Licensing for the project must be coordinated with Perhutani authorities due to the site's protected status and ongoing timber harvesting activities.

The region is characterized by a steep mountainous region in the south with a height of more than 1.500 m above sea level, the area of gently sloping hillside in the middle with a height of 100-1.500 meter above sea level, in the northern region of vast plains with a height of 0-10 m above sea level, and region River flow. According to the Central Bureau of Statistics (BPS), Jawa Barat covers a land area of 37.040,04 km2.

The development of renewable energy projects should ensure that biodiversity is protected, conserved, and that sustainable management and use of natural resources are implemented wherever possible throughout the project lifecycle.

Natural Disaster Risk

West Java, including the Sumedang region, is in general prone to various natural disasters such as earthquakes. The region is located near several active fault lines, including the Baribis Fault, the Lembang Fault, and the Cileunyi-Tanjungsari Fault. These faults have the potential to generate earthquakes of magnitudes up to 7.0, presenting a significant seismic risk for the area.

The Sumedang area in general is at risk of landslide and flooding. However, according to interviews with local stakeholders, the area of the potential Solar PV site are hilly in shape, and there have been no instances of landslides or floods.

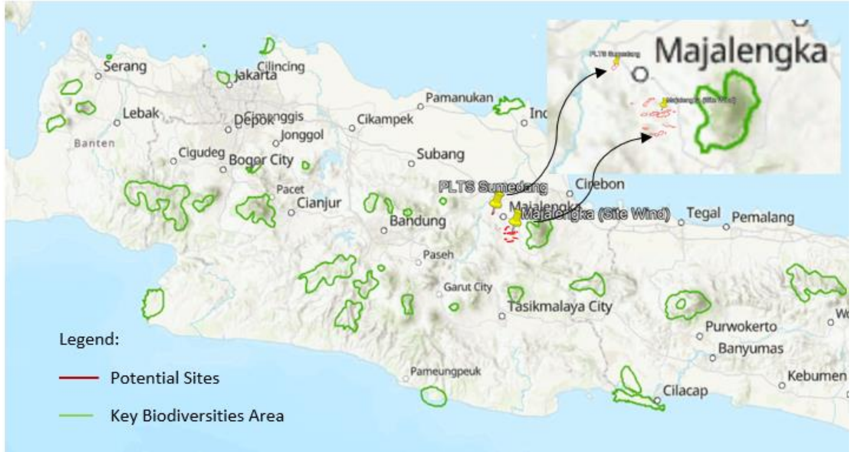


Figure – Key Biodiversity Areas Map in Java Island

*Source: https://www.keybiodiversityareas.org**

Figure – Identified active fault lines in West Java

Source: https://www.researchgate.net/figure/Map-of-identified-active-faults-in-Java-Island-3-Blue-ellipse-represents-NE-SW-faults_fig1_352814821

*Input from PT Inovasi

Environmental Assessment- Emissions Avoided

Emissions avoided:

Reduction in CO_2 Emissions and Land Clearing Impacts

The reduction in CO_2 emissions is calculated using PLN's emissions factor of 0.817 kg CO_2/kWh. Each kWh generated by solar PV offsets the equivalent from fossil fuel power plants. In the first year, the project is expected to generate 245,892 MWh, avoiding approximately 200,894 tonnes of CO_2 emissions.

However, as shown in the figure, power production gradually decreases over time, reducing annual emissions avoided due to the natural degradation of solar PV systems.

The project in Sumedang involves clearing 140 hectares of savannah, releasing an estimated 7,000 tonnes of CO_2, based on an emission factor of 50 tonnes per hectare. While these initial emissions partially offset the reductions, the project's long-term environmental benefits remain significant despite the degradation in power production.

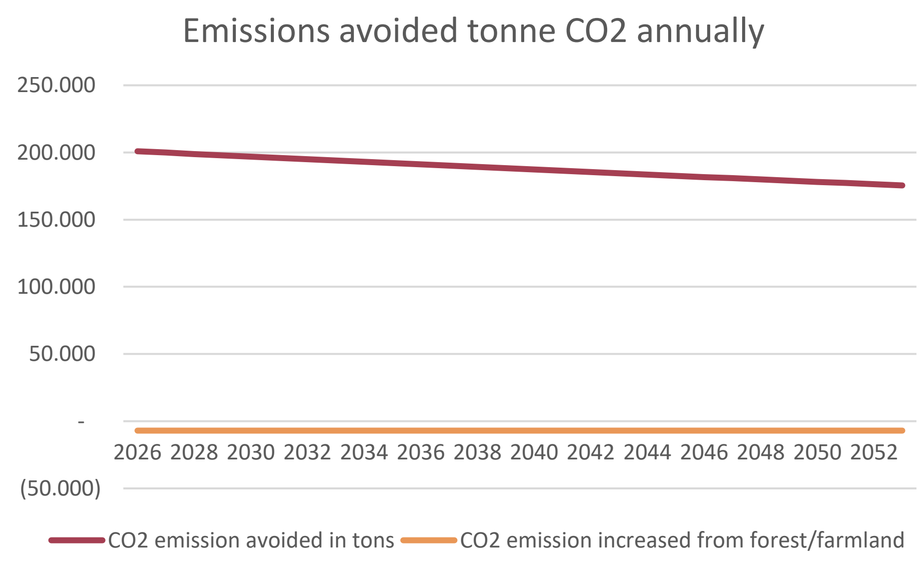


Figure – Emissions avoided tonne CO2 annually

Emissions avoided	Simple sum	NPV
CO2 emission avoided in tonnes	5,261,295	2,506,945
CO2 emission increased from forest/farmland	(196,000)	(91,654)
Annual savings in tonnes CO_2 (annuity)		184,465

Table – Sum and NPV of emissions avoided

The table above presents a comparison of CO_2 emissions avoided, emissions increased, and annual savings, using both a simple sum and Net Present Value (NPV) approach:

CO_2 Emission Avoided:

The total emissions avoided over the project lifetime amount to 5,261,295 tonnes in the simple sum calculation, but the NPV reduces this figure to 2,506,945 tonnes. The NPV accounts for the time value of reductions, indicating that avoided emissions in later years have less impact in present-value terms.

CO_2 Emission Increased from Land Clearing:

Land clearing contributes to an increase in emissions by 196,000 tonnes (simple sum) or 91,654 tonnes (NPV).

Annual Savings in CO_2 Emissions:

The annual savings in CO_2 emissions are calculated at 184,465 tonnes. This figure highlights the consistent yearly contribution of the project to emissions reduction despite the degradation over time.

Conclusion:

The NPV approach provides a more nuanced view, factoring in the time value of emissions savings, and still demonstrates the project's substantial net environmental benefit.

Summary Conclusions and Recommendations – 140 MW Solar project in Sumedang

Summary Conclusions:

1. The 140 MW Solar PV project in Sumedang demonstrates strong economic viability, delivering significant positive societal and environmental benefits. The project consistently achieves a positive ENPV and B/C ratio above 1, even under varied sensitivity assumptions.

2. The project is robust, showing resilience to changes in key economic parameters such as CO_2 tax, Value of Statistical Life (VSL), emissions intensity, and the Social Discount Rate (SDR). It offers substantial avoided CO_2 emissions of 200,894 tonnes annually in the first year, making it a critical contributor to Indonesia's renewable energy and climate goals.

3. The project demonstrates strong alignment with Indonesia's long-term energy and climate goals, contributing to the transition away from fossil fuels.

4. Job creation during the construction and operation phases provides direct economic benefits to the local community, fostering regional development:
   - Construction Phase:
     - Local Direct Effect: 1,870 Full-Time Equivalent (FTE) jobs.
     - Local Indirect Effect: 1,700 FTE jobs.
   - Operation and Maintenance Phase (Annual):
     - Local Direct Effect: 70 FTE jobs per year.
     - Local Indirect Effect: 60 FTE jobs per year.

5. 90% of the area is designated as "Production Forest“. However, the community has repurposed much of this land for informal use of agriculture, predominantly for growing crops and herding buffalos. Impacts on livelihood and sufficient compensation are therefore not known and need to be explored further.
6. Marongge Village owns an area (categorized as Village Treasury Land) near the Solar PV location, covering 90 hectares. The village has suggested using this land for the solar PV development instead of the Perhutani land that are currently being reviewed.

7. The community in Marongge Village, including both the village and sub-district, is not yet familiar with renewable energy. However, they initially express their support for the construction of the Solar PV site if it is done in alignment with conscious development and ensure livelihoods.

8. The avoided emissions and environmental benefits significantly outweigh the minor CO_2 emissions from initial land clearing, ensuring net positive impacts.

Summary Recommendations:

1. Proceed to detailed feasibility studies to confirm technical and financial assumptions.

2. Once the project is planning to move forward an Environmental and Social Impact Assessment (ESIA) should be conducted to ensure compliance with international environmental and social standards. This is also necessary to secure international funding, which requires justified land acquisition prior to development.

3. Engage with local stakeholders to address land-use considerations, develop a Livelihood Restoration Plan and optimize project implementation.

4. Prioritize the project within West Java's renewable energy development strategy, given its strong socio-economic impact.

5. Ensure that land clearing and development adhere to environmental best practices to minimize ecological disruption.

6. Develop a robust stakeholder engagement plan to address local concerns and secure community support and involve local non-governmental organizations.

7. Conduct a comprehensive risk analysis to address uncertainties, particularly around policy changes and CO_2 pricing.

8. Evaluate potential for scaling similar solar projects in other areas of West Java to maximize renewable energy impact.

9. Prioritize local residents as workers for the project. The community hopes that the construction of the Solar PV will provide significant job opportunities, including the creation of new businesses such as food stalls around the project area to cater to workers.

Site photos

Drone pictures of potential Solar PV site in Sumedang*:

Northeast point of view

South point of view

South point of view

Northeast point of view

Northeast point of view

South point of view

*Input from PT Inovasi

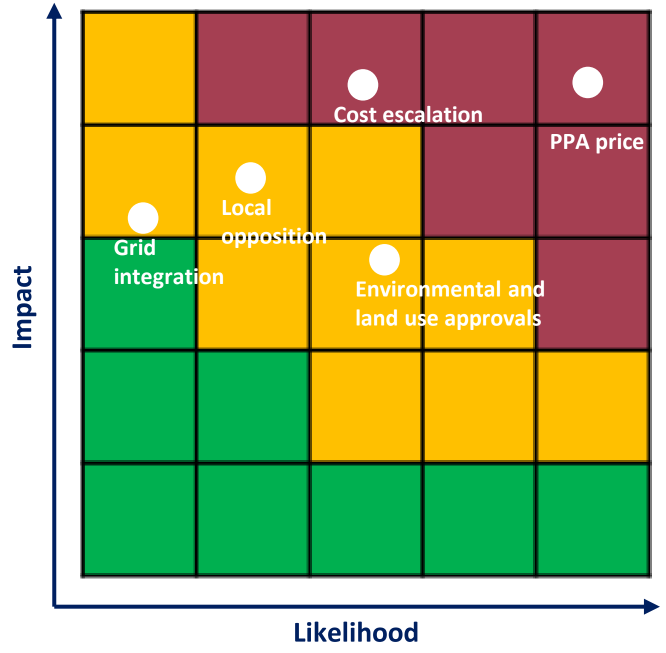
KEY PROJECT RISKS ARE PPA UNCERTAINTY AND COST ESCALATION

Risk log and actions

Risk indicator	Description	Impact	Action
PPA price	Obtaining a PPA price that provides satisfactory returns is subject to high uncertainty, because there is no guaranteed price mechanism as a FiT scheme, why the final PPA price is a result of negotiations with PLN, and PLN is the only offtaker of utility scale PV. Considering previous experience, it is highly unlikely that PLN will accept a price close to the break even PPA price, particularly considering the low average generation price (BPP) in WJ.	PPA price uncertainty have substantial impact on the feasibility of the project, especially since the sale of electricity is the only revenue source of the project.	• Conduct thorough price sensitivity analyses to evaluate the financial impact meeting PLN's acceptable PPA price • Engage in early dialogue with PLN to obtain price indications • Postpone project development until there is more certainty on PPA price settlements. • Abandon the project
Grid integration	Since there are three possible substations near the project site, it is less likely that this risk becomes material for project feasibility.	Grid integration challenges can result in curtailment and disrupted production, and ultimately it can result in PLN not accepting grid connection at the nearest substation, which could delay or significantly inflate costs.	• Engage with PLN in the early development phase to gain indications of grid availability • Conduct grid impact study • Explore options for adding storage technology
Environmental and land use approvals	The proposed site is classified as production forests, which require forest area approval permits to conduct survey activities. A land use approval and reclassification is also required	There is a risk that approvals for converting production forest land are delayed or cannot be granted for e.g., environmental reasons.	• Engage in early dialogue with the Ministry of Forestry and Environmental planning. • Perform an environmental impact study • Consider alternative locations with good irradiation potentials
Local opposition	Local population might be against the project for reasons related to visual impact, environmental concerns or influence on local economy.	Delayed project development or problems during construction.	• Engage early with the local community • Source local labor in the construction phase • Allocate a share of the budget for local investments in e.g., schools
Costs escalation	Developing renewable energy projects in countries with limited prior experience is subject to costs escalation because there are many unknown factors. For this particular case, there is high uncertainty on the cost of land and the cost of upgrading infrastructure related to land clearing and road infrastructure upgrades. Total project costs could also be amplified in case local content requirements are enforced.	Costs escalation, particularly if it relates to major budget posts, such as infrastructure upgrades (e.g., strengthening the road network), have a direct impact on the financial feasibility of the project.	• Sign options to lease with landowners to fix land acquisitions costs in the early development phase • Engage with the local officials to obtain information on development activities to explore synergies that could lower the costs of upgrading infrastructure • Engage with local suppliers to obtain prices for key services, such as clearing of land etc. • Abandon the project

Risk evaluation: The main risk for this project centers on revenue uncertainty, which affects the business case, especially given past challenges in negotiating an acceptable PPA price with PLN. With numerous unknown factors, the likelihood of cost escalations is high. Conducting a thorough cost analysis is essential to developing a realistic PPA proposal and ensuring a financially viable business case.

Risk matrix



Stock photo ID: 699866378
Location: China

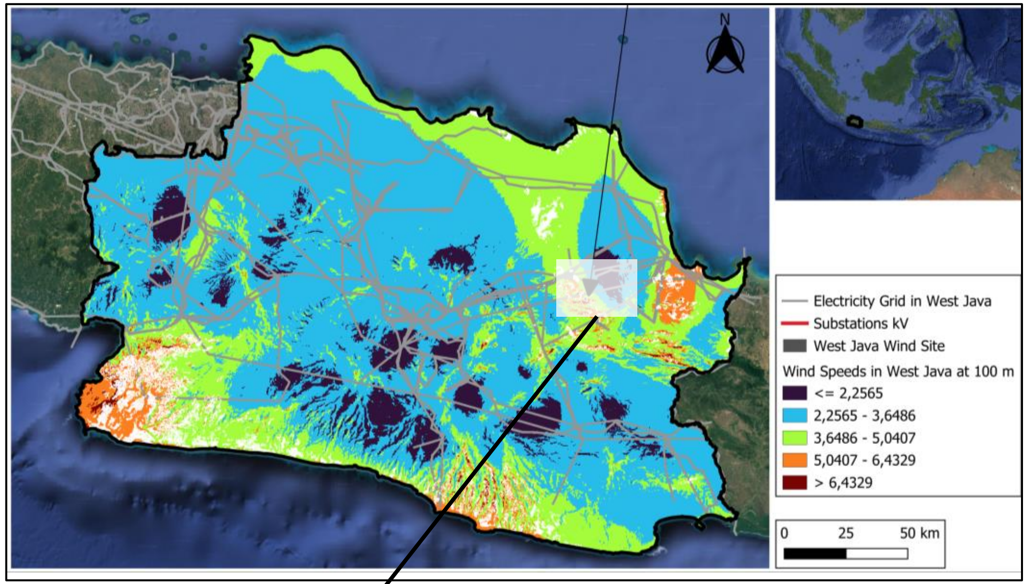
Mean annual wind speeds in the province are between 2 and 6.5 m/s

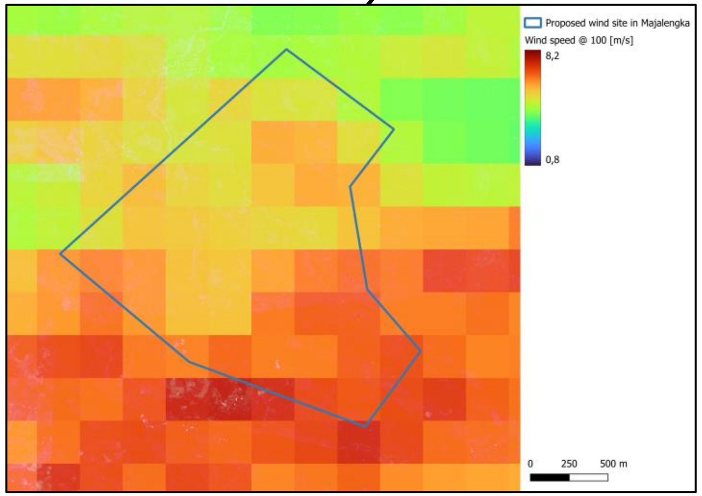
Wind resource: Most of the province experiences relatively low mean wind speeds, generally below or well below 5 m/s. In the central part of West Java, wind speeds are especially low, often below 3.5 m/s, rendering onshore wind development unfeasible. However, in the southwestern, southern, and northwestern regions, wind speeds can reach or exceed 6 m/s. The analysis also indicates that land availability exists in these areas, further supporting the potential for wind power development.

Location selection: Known as the 'City of Wind', Majalengka is among the most attractive locations for wind power development in West Jawa. Meanwhile, the windiest sites are located on hilltops at relatively high elevations. As part of the pre-screening of sites, a few concrete sites were visited in the vicinity of Majalengka. The selected site has attractive wind speeds and is close to electricity transmission infrastructure and with good road conditions nearby. Other parts of West Jawa are more suitable for onshore wind power generation, particularly Sukabumi (SW) and Garut (SE). However, as developers are already investigating these areas, they have not been chosen for pre-feasibility studies.

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 reflects a rotor diameter of 163 m, with a hub height of 150m and a nameplate capacity of 4.5 MW (specific power of 216 W/m²).

Yield calculations: Using the hourly wind speeds available from Global Wind Atlas and the power curve of the turbine, the calculation of power production results in a FLH value of 2,675 h for the selected area.



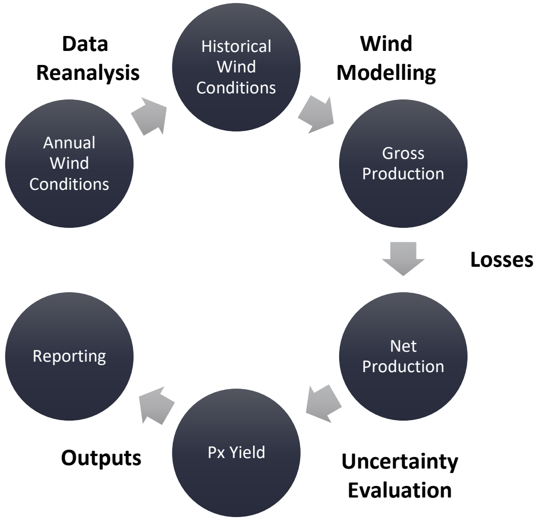


The proposed location has average mean wind speeds ranging between 5 and 6.5 m/s, which offers a favorable potential for onshore wind development

ESMAP & World Bank: Global Wind Atlas (2024)

WIND PRODUCTION IS LOW & UNCERTAIN IN THE AREA: THE P90 VALUE IS RISING TO 2,260 FLH

Wind resource assessment: Starting from the hourly wind data and the power curve of the turbine deployed (163m rotor diameter, 123m height, 4.5MW), a resource assessment including uncertainty evaluation is carried out to calculate the P50, P75 and P90 values. The assessment is representative for an average weather year in the vicinity of the chosen area, and is based on wind resource mapping undertaken by the Technical University of Denmark (DTU) under the umbrella of the Global Wind Atlas.



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 turbine, based on its power curve, using mesoscale data;
- **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.

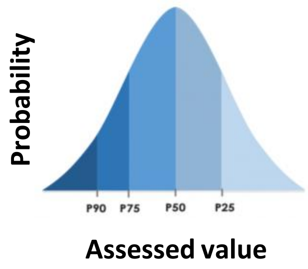
Considered Uncertainty Factors i (On AEP)			
On Wind Speed → On AEP*		On AEP	
Wind uncertainty (2-5%)	3.50 → 4.55%	Power Curve (5-10%)	7.50%
Long Term Adjustment (1-3%)	2.00 → 2.60%	Metering (0-5%)	2.50%
Vertical Extrapolation (0-5%)	2.50 → 3.25%	Wake Effects (0-5%)	2.50%
Horizontal Extrapolation (0-5%)	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%	$\sqrt{\sum_i (1.282 * Uncertainty_i)^2}$

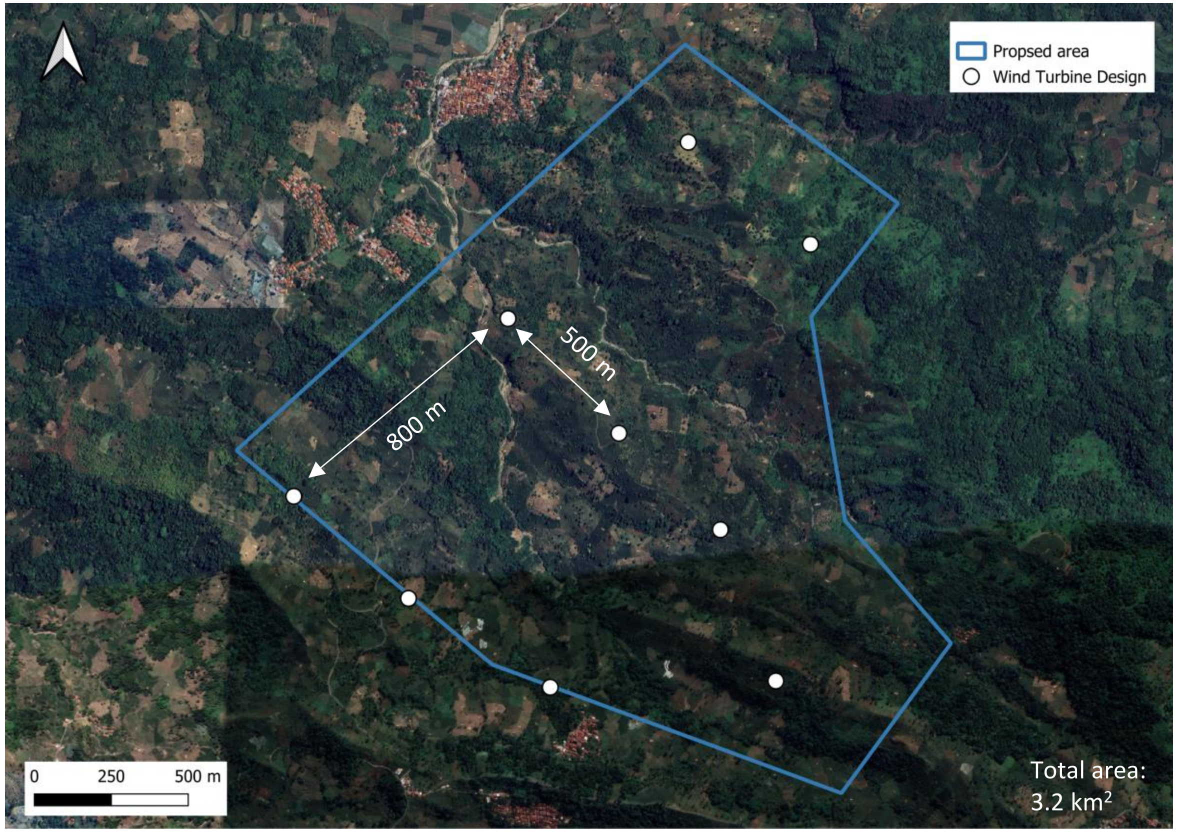
Resulting values: The final net P50 yield for the assessed 40.5 MW wind farm corresponds to **108.3 GWh/y** (**2,675 FLH**), consisting the central estimate utilised in the Business Case ahead. At a later stage of the project, when financing needs to be secured, a P90 generation level frequently consists the preferred indicator by financial institutions since it entails a significantly higher revenue certainty. The P90 level for the present case corresponds to 91.5 GWh/y (2,260 FLH).

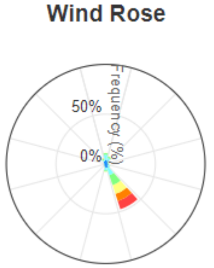
Value Level	Description	FLH Confidence	AEP Confidence [GWh/y]
$P50_{value}$	Value based on the already considered uncertainty within the calculated model	2,675	108
$P75_{value}$	$P50_{value} * (1 - P75_{uncertainty})$	2,456	99
$P90_{value}$	$P50_{value} * (1 – P90_{uncertainty})$	2,260	92

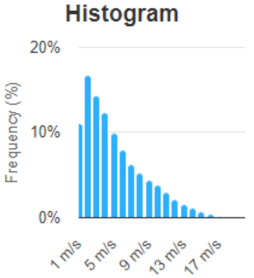


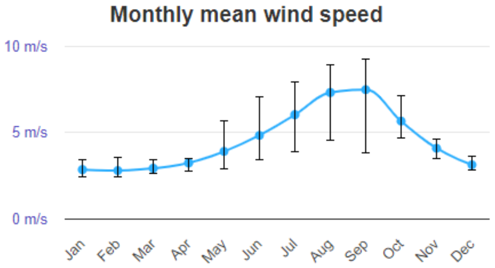
ESMAP & World Bank: Global Wind Atlas (2024); MEASNET (2016)

A POTENTIAL LOCATION IN MAJALENGKA IS SELECTED









ESMAP & World Bank: Global Wind Atlas (2024),

Siting considerations: Wind resource is a key criterion when selecting sites for onshore wind development, as it forms the foundation of the project's feasibility. Other important considerations include infrastructure conditions, as well as the availability and proximity of grid networks capable of absorbing additional power generation. Lastly, zoning and land ownership can significantly impact permitting processes and project economics

Location details : The proposed site is located in Cibodas county in the regency of Majalengka. Majalengka is one of the windiest areas in West Java. The nearest 150 kV sub-station (Kadipaten Baru) is located 9.5 km from the site. Most of the site is located on hill tops and the slope of the site is between 6-30 degrees. The highest point is 500 meters above ground level.

Land zoning and costs: The site is classified as dryland agriculture, and according to the Regional Regulation of Majalengka No.11 of 2011, it is designated for agricultural use and as a protection area for subordinate regions, which are part of protected forest land. Currently, the regional regulation regarding spatial planning in Majalengka is under revision. However, this area is not part of the KP2B (Sustainable Food Agriculture Area). If the site were included in the KP2B, any land used would require replacement land that is three times larger to maintain the KP2B designation.

To estimate the initial land price, we can refer to the ZNT (Land Value Zone) data. ZNT is a standardized land valuation provided by the central government to estimate the market value of land parcels within a specific area. For this site, the ZNT ranges from Rp 200,000 to Rp 500,000 per square meter. This data serves as a useful reference for determining the market value of the land.

Spacing requirements: The spacing requirement depends on the turbine design, defined as the number of turbines, hub height and rotor diameter. In this study it is assumed that the distance between the wind turbines is 5 times the rotor diameter in the dominant wind direction and 3 times the rotor diameter in the non-dominant wind direction. This enable us to locate 9 wind turbines within the proposed area. With a nameplate capacity of 4.5 MW, the total capacity of the site is 40.5 MW.

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

TECHNO-ECONOMIC DATA USED FOR THE BUSINESS CASE

COWI

Technical features

Capacity	40.5 MWe
Technical lifetime	28 years
Plant availability	99.7%
Space requirements	14,000 m^2/MWe
Capacity factor	31% (2,675 FLH)
Construction time	1.5 years

Economic features

CAPEX	1.74 M$/MWe
Fixed OPEX	40,427 $/MWe-year
DEVEX	5%
WACC (real)	8.23%
Expected PPA	Year 1 to 10: 9.54 cUSD/kWh Year 11 to 28: 5.73 cUSD/kWh
Corporate tax rate	22.0%
Depreciation rate	20% declining balance across lifetime
Inflation rate (USD)	2.00%

FID and COD: The assumed final investment decision (FID) is 2025 and the commercial operation date (COD) is 2026 with construction undertaken between 2025 and 2026.

Land cost: The ZNT land price for the area is less than 200,000-500,000 Rp/m2 (13 to 32 USD/m2). A general cost of land for Indonesia is included in the CAPEX of the project. A variation in the cost of land is analysed in the sensitivity analysis by changing the CAPEX.

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**.

Figures reflect the projected 2025 data (beginning of construction) in real 2023 price levels, according to the Danish Energy Agency's Technology Catalogue for the Indonesian Power Sector (2024).

BASED ON THE BASELINE ESTIMATIONS, THE SELECTED ONSHORE WIND PROJECT IS NOT PROFITABLE, WITH AN IRR OF 4.06%

Results: The business case for a 40.5 MW onshore wind plant in West Java is not profitable based on baseline assumptions, with a Net Present Value (NPV) of -19 mUSD and a real Internal Rate of Return (IRR) of 4.06%.

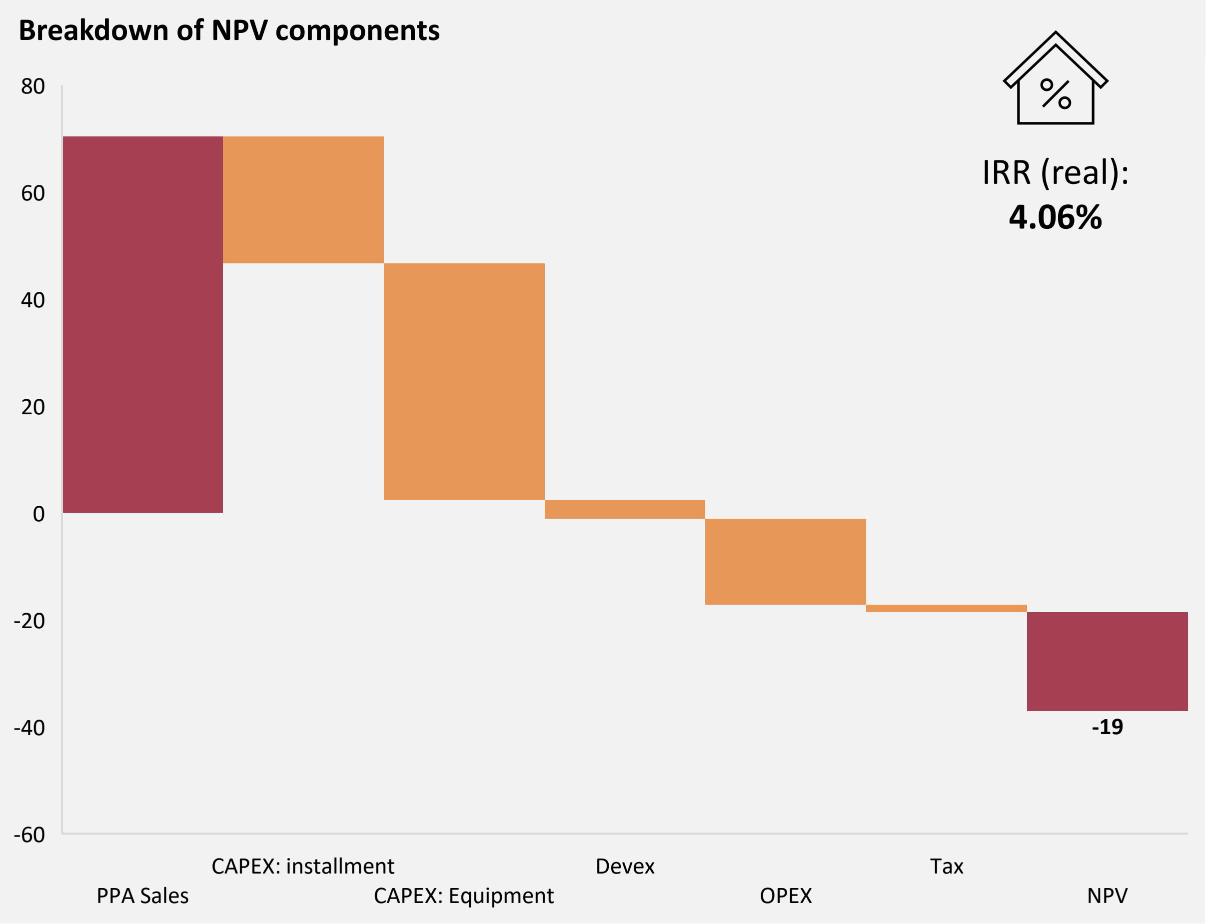
Costs: The cost of equipment and installation constitutes the majority of project costs. Changes in market conditions such as increased local content requirements or supply chain disruptions could drive up project costs and worsen overall project feasibility.

Other costs include development costs, taxes, and operating expenses, though these represent a smaller share of the project's cash flow. Development costs, however, tend to be less predictable, especially in markets with limited experience. Factors such as permitting and land clearing could significantly increase development costs, raising their overall share of total project expenditures.

Revenue: To offset project costs, a stable source of revenue must be secured. For this project, the sale of electricity is assumed to be the sole revenue source why certainty on PPA contract terms, price levels and production volumes are important.

Following the ceiling price scheme, the net present value of the PPA sales accumulates to 70 mUSD assuming a 28-year contract period.

Due to the low wind speed at this location, increasing production volumes and improving revenue for this onshore wind project is highly challenging.



Note: 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 1ST STAGE'S BREAK-EVEN PPA PRICE FOR THE WIND PROJECT IS 13.7 CUSD/KWH

1st stage PPA price: The first stage of the PPA term is the most critical determinant of project feasibility due to discounting effects. Therefore, the agreed initial PPA price plays a pivotal role in the business case evaluation.

Several factors create uncertainty regarding the potential PPA level expected by investors in an onshore wind project in West Java, including:

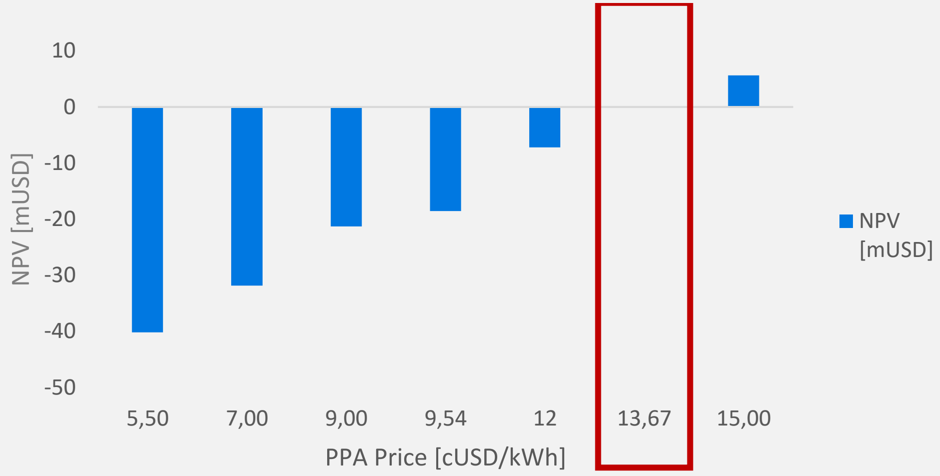
- The regional BPP and how it compares to the ceiling price set by presidential regulation.
- Competitively low bids from other investors, particularly in projects benefiting from financial advantages such as lower financing costs or reduced CAPEX.

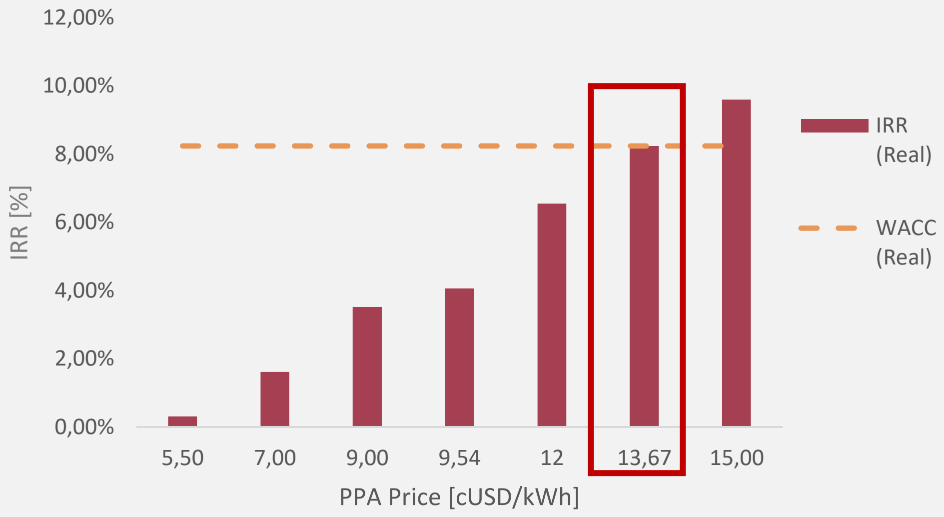
Given these factors, it is crucial to determine the minimum first-stage PPA price that enables the project to break even, ensuring an IRR equal to the expected real WACC (8.23%) and an NPV of zero. It effectively represents the bid value an investor might propose in an auction or negotiation to develop the solar project while securing returns in line with the expected WACC.

Break-even PPA price: The break-even PPA price is the PPA price for the first 10 years, which returns an NPV of 0 and an IRR that equals the cost of capital (WACC).

The break-even price for this case in an all-things equal scenario is 13.67 cUSD/kWh, which is much higher than the regulated ceiling PPA price assumed in the base case.

Break-even PPA (1st stage) for the wind project





1st stage break-even PPA

SENSITIVITY ANALYSIS ON CAPEX, FULL LOAD HOURS, PPA PRICE AND CONTRACT PERIOD

Scenario analysis : A scenario analysis is conducted to evaluate the impact on Net Present Value (NPV) when key input assumptions deviate from the base case. The results are presented in a matrix format, illustrating the effects of different combinations of input factors on NPV. The key input factors are CAPEX, Full Load Hours and PPA price.

CAPEX: the estimation of the capital costs is based on figures from the Indonesian Technology Catalogue and developer interviews, but actual project costs could vary largely depending on market conditions, supply chain and real project conditions.

CAPEX is varied from 1.1 **to 2.2 mUSD/MW,** corresponding to a range of -31% to +37% of the reference assumption.

Full Load Hours: Irradiance is used to estimate annual production. Since irradiance is based on modelled data, estimated full load hours and annual production levels are subject to some uncertainty. Annual production is varied between **2,456** and **2,893 Full Load Hours.**

PPA Price: The baseline PPA price follows the ceiling price scheme. Since PPA processes are competitive, the realized PPA price is likely to be lower than the baseline. Additionally, given the low uptake of renewables in Indonesia, regulatory changes could increase the ceiling price. To account for these uncertainties, a ±10% variation in the PPA price has been assumed for the first 10 years of the contract period.

Contract period: Changing the contract period to 25 or 30 years compared to the baseline of 28 years have marginal impact on the overall feasibility of the project. The payback period remains constant at 12 years, indicating that variations in project duration do not affect the timeline for recovering the initial investment. This suggests that early-stage cash flows drive the investment recovery, while later years primarily influence overall profitability.

Net Present Value in selected scenarios [mUSD]

Scenario	1st stage PPA (cUSD/kWh)	Capex (m$/MW)	FLHs AC 2.456	FLHs AC 2.675	FLHs AC 2.893
Low	85,86	1,1	-18	-15	-11
		1,6	-43	-40	-36
		2,2	-63	-59	-55
Baseline	95,40	1,1	-1	4	8
		1,6	-24	-19	-14
		2,2	-42	-37	-31
High	104,94	1,1	3	8	12
		1,6	-19	-14	-9
		2,2	-37	-31	-26

Contract period	NPV	IRR	Payback time
Baseline contract period (28 years)	-18.6 mUSD	4.06%	12
Shorter contract period (25 years)	-19.03 mUSD	3.81%	12
Longer contract period (30 years)	-18.34 mUSD	4.19%	12

SOCIO-ECONOMIC STUDY FOR ONSHORE WIND

Stock photo ID: 699866378
Location: China

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Financial assessment of the socio-economic assessment

Financial analysis of the 40.5 MW onshore wind project in Majalengka – West Java:
The PFS in the previous chapters were elaborated by a consortium consisting of Ea Energy Analyses and Viegand Maagøe, with local support from PT Innovasi, an Indonesian consultancy.

The socio-economic analysis in the following sections is based on project specific input from the PFS. For easy reference, these inputs are highlighted in the table to the right. The socio-economic assessment of the project is based on the data provided in the PFS of the 40.5 MW onshore wind project but adjusted when appropriate; i.e., taxes paid.

Summary Financial Viability Conclusion of the 40.5 MW onshore wind project:

- IRR (real): The internal rate of return is 4.1%, very much below the weighted average cost of capital (WACC) of 8.23%, indicating that the project does not meet its required rate of return.

- NPV (real): The net present value is negative (-18.6 mUSD), suggesting that the project does not create value and may not be financially feasible under the given assumptions.

The project demonstrates strong energy production and relatively low operational costs. However, with a negative NPV and IRR below WACC, it faces financial viability challenges under current assumptions. To make the project more attractive, potential adjustments could include increasing PPA rates, optimizing CAPEX/OPEX, or securing subsidies/incentives.

Table – Summary findings of the 40.5 MW onshore wind project

Wind power, Majalengka	Input
Baseline year	2025
IRR (real)	4.06%
NPV (real)	-18.6 mUSD
Size of project in MW	40.5
Baseline Capex (USD)	70.6 mUSD
Baseline Opex (USD/y)	1.6 mUSD
Price per MW (USD/MW)	1.74
Initial annual production (GWh/y)	108,329
PPA USD/MWh (y 1-10)	95.40
PPA USD/MWh (y 11-28)	57.30
Real WACC	8.23%
Lifetime LCOE (USD/MWh)	74.69

SUMMARY OF QUANTITATIVE SOCIO-ECONOMIC ASSESSMENT

Socio-economic assessment of the 40.5 MW onshore wind project in Majalengka:
The data provided in the table to the right offers a financial and socio-economic snapshot of the project. Below is an analysis of the key socio-economic indicators (the last five rows) and their implications:

Economic Net Present Value (ENPV): 65.3 USD million
- The ENPV reflects the project's value to society, considering all socio-economic benefits and costs, discounted at a real social discount rate (SDR) of 6.23%. A positive ENPV of 63.3 USD million indicates that the project generates substantial net economic benefits for society, making it economically viable from a public welfare perspective.

Economic Internal Rate of Return (ERR): 14.3%
- The ERR measures the rate of return on the project's socio-economic investment, considering all externalities. An ERR of 14.3% is higher than the real SDR of 6.23%, indicating robust socio-economic viability.

Benefit-Cost Ratio (B/C-Ratio): 1.61
- The B/C-ratio represents the efficiency of the project in converting costs into benefits. A ratio of 1.71 means that for every 1 USD spent, the project generates 1.71 USD in socio-economic benefits. This ratio exceeds the standard threshold of 1.0, confirming the project's strong justification from an economic perspective.

Summary of Socio-Economic Viability
- Positive Outcomes:
  - The project delivers substantial socio-economic benefits, primarily through carbon emission reductions, energy security, and job creation.
  - The high ERR and B/C-ratio demonstrate the efficiency and strong societal value of the investment.
- Considerations:
  - The project's financial NPV is negative (-18.6 USD million), but its socio-economic value compensates for the financial shortfall.
  - Addressing potential land-use and biodiversity impacts effectively will further enhance the project's social acceptability and environmental sustainability.

Table – Summary conclusions of the financial and socio-economic assessment

	West Java - Wind
Baseline or evaluation year	2025
IRR (real)	4.06%
NPV (real)	-18.6 mUSD
WACC	8.23%
Size of project in MW	40.5
Baseline Capex	70.6 mUSD
Baseline Opex (USD/y)	1,605,189
Price per MW	1.74
Initial annual production (GWh/y)	108,329
PPA USD/MWh (y 1-10)	95.40
PPA USD/MWh (y 11-28)	57.30
Real SDR	6.23%
Lifetime LCOE (USD/MWh)	74.69
ERR	14.32%
ENPV	65.3 mUSD
ENPV of total benefits	156.9 mUSD
ENPV of total costs	-91.6 mUSD
B/C-ratio	1.71

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ECONOMIC ASSESSMENT – JOB CREATION AND LOCAL ECONOMIC IMPACT

Local Eonomic Impact: The value of the increase in the economic activity in the main sectors of the investments can be summarized as the indirect effect to the economy. This is also known as the multiplier effect of the investment. The local share of this effect is the local economic impact. The increased economic activity occurs throughout the economy, when the investments in the main sectors obtain input from supporting sectors. For the construction, operation and maintenance of an onshore wind farm, the main sectors are assumed to be manufacturing of equipment, construction and land transportation. The most important input sectors to the main sectors in West Java's economy includes production and processing of raw materials, metal and electronics work, transportation and transportation support functions. Other sectors such as financial services, real estate and government administration are relevant two, but among the top contributions to the three main sectors.

The local economic impact is summarized in the table below

Table – Local economic impact (USD)

Local economic impact	
Construction (Million USD)	7.14
Annual effect from operation and maintenance (Million USD/year)	0.87

Job creation: A new renewable energy plant will generate jobs to the local community and both during the construction phase and the operating and maintenance phase of the process.

As mentioned earlier, the construction phase of an onshore wind site, workers are needed to manufacture equipment for the turbines and foundation, transport materials, and install and construct the wind farm. This effect constitutes the direct effect. The employment model bases the calculation of the direct effect on the CAPEX, and it thus accounts for the jobs created not only during the actual construction, but also the production and transport of the wind farm equipment. Additionally, the production transport and construction of the plants will lead to jobs related to the extraction of new raw materials, manufacturing of construction tools, provision of administrative, health and other support to the workforce directly engaged in the construction. This is the indirect effect

The following figure highlights the employment effects for an onshore wind power site of 40,5 MW in Majalengka over time and the sum of employment effect is summarized in the table.

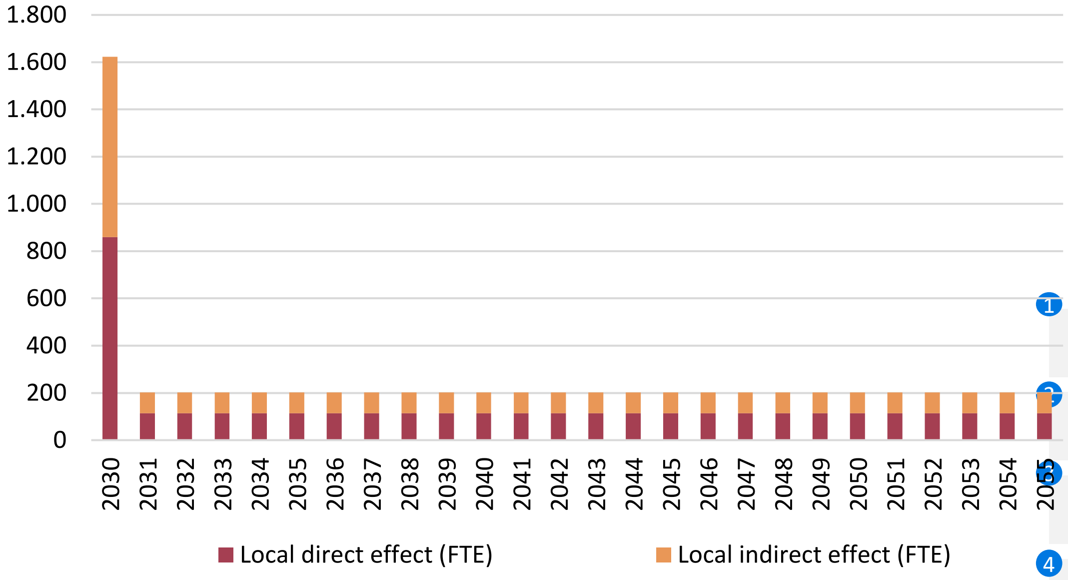

Figure – Local employment effect over time (FTE)

Table – Local direct and indirect employment effect by phase (FTE)

	Local direct effect	Local indirect effect
Construction phase (FTE)	860	760
Annual effect from operation and maintenance phase (FTE/year)	110	90

ECONOMIC ASSUMPTIONS UNDERPINNING THE SOCIO-ECONOMIC ASSESSMENT (1)

Assumptions:

Price of CO_2:
It is assumed that the CO_2 tax will start at 4.7 USD per tonne of CO_2 in 2025 and increase annually by 15%, reaching 151 USD per tonne of CO_2 by 2050.

Reduction in CO_2 emissions:
The calculations of CO_2 reductions are based on PLN's documentation, which specifies an emissions factor of 0.817 kg CO_2/kWh. It is assumed that each kilowatt-hour (kWh) generated by solar PV or wind directly offsets an equivalent kWh that would otherwise be produced by PLN's existing fossil fuel power plants.

In the first year of operation, the wind project is projected to generate 108,329 MWh of electricity. Based on PLN's estimated CO_2 emission factor of 0.817 kg CO_2 per kWh for Indonesia, the project will avoid approximately 88,505 tonnes of CO_2 emissions by replacing fossil fuel-based electricity generation.

CO_2 Emissions from Land Clearing in Lhoknga
The development of the onshore wind project in Majalengka involves land clearing within a protected forest area, contributing to CO_2 emissions due to the removal of vegetation that acts as a natural carbon sink. The site is classified as a protected forest under regional spatial planning regulations, which, although permitted for renewable energy development, poses significant environmental challenges.

The clearing of approximately 675 hectares of forest vegetation for the wind farm is estimated to release approximately 33,750 tonnes of CO_2, calculated using an emission factor of 50 tonnes of CO_2 per hectare. These emissions represent a necessary trade-off for the project's renewable energy benefits, but their environmental impact underscores the need for stringent mitigation and reforestation efforts to offset the carbon loss and preserve biodiversity in the area. However, the removal of vegetation also eliminates the annual CO_2 absorption capacity of the area, which are interpreted as a recurring loss of potential sequestration.

Assumptions:

Value of Statistical Life (VSL):
In Indonesia, direct estimates of VSL are limited due to the scarcity of comprehensive studies. Various international studies suggest VSL values around 600,000 USD. Data from the Centre for Research on Energy and Clean Air (CREA) and the Institute for Essential Services Reform (IESR) highlight the impact of air pollution in Indonesia. In 2022, emissions from coal-fired power plants caused 10,500 deaths nationally, with 4,315 fatalities in West Java alone. The total health cost of these emissions was estimated at USD 7.4 billion. This implies a VSL value of approximately USD 700,000 which is used in this socio-economic assessment. This value captures also reduced hospital admissions and medical expenses related to air pollution.

Avoided death and health benefits:
The "deaths per MW" metric links energy generation to health impacts. In West Java, lower population density near coal plants suggests fewer people are exposed to pollutants, warranting an adjusted rate of 0.20 deaths per MW instead of the average for Indonesia of 0.495 deaths per MW. Assuming 60% of the MW capacity replaces coal, while the rest offsets cleaner sources, the calculation is:

Avoided deaths = 0.20 × 24 MW = 4.9 deaths.

Thus, a 40.5 MW onshore wind project in Majalengka can prevent approximately 4.9 deaths through partial coal displacement.

Net additional value of increased new employees:
For skilled workers in West Java, new wages of USD 5,500/year create an additional value of USD 1,500/year compared to previous earnings of USD 4,000/year. For unskilled or semi-skilled labour, the additional value is USD 3,000/year based on previous earnings of USD 2,500/year.

On average, the net additional value of creating one job in Indonesia through renewable energy projects is USD 1,000–5,500/year. Assuming 75% skilled and 25% unskilled workers, the societal value per new employee is approximately USD 1,750/year.

Economic assumptions underpinning the socio-economic assessment (2)

Assumptions:

Employment effects:

The 40.5 MW onshore wind project assumes that a total of 1,620 direct and indirect jobs will be created during the construction and preparation phase. This includes direct employment on-site and indirect jobs generated in supporting sectors such as supply chain, transportation, and services. During the operational phase, it is estimated that 200 direct and indirect jobs will be sustained, which include on-site operation and maintenance roles and ongoing support activities in related industries.

Real Social Discount Rate (SDR):

The Social Discount Rate (SDR) is crucial for cost-benefit analyses of public projects, reflecting society's preference for present benefits over future ones. Organisations like the Asian Development Bank and World Bank recommend real SDRs of 6%-9% for developing countries to balance societal preferences and opportunity costs. In Indonesia, the Ministry of Finance estimated a real SDR of 6.19% based on the Social Rate of Time Preference (SRTP) and 6.82% using the Social Opportunity Cost of Capital (SOC).

A midpoint real SDR of 6.23% is deemed appropriate for 2024, aligning with international standards and Indonesia's development goals. This value, 2%-point lower than the WACC used in feasibility studies, ensures public investments are evaluated fairly, prioritising long-term societal benefits.

Fiscal corrections

Taxes and subsidies are considered transfer payments, meaning they do not represent real economic costs or benefits to society but instead serve to redistribute resources. Therefore, certain adjustments are made to the financial calculations made in the PFS. Value-added tax (VAT) is excluded from input and output prices. Direct and indirect taxes are removed from input prices, and subsidies or public entity transfers, such as tariffs, are excluded from output prices.

The proposed solar PV and wind projects can be seen as pilots for the sector development in Indonesia and their implementation will bring important capacity building and skills development, both for construction and operation phases.

Assumptions:

Evaluation criteria: ENPV, ERR, and B/C Ratio:

In economic evaluations, particularly within the context of Cost-Benefit Analysis, decision-makers rely on three primary criteria to assess the desirability and feasibility of projects: Economic Net Present Value (ENPV), Economic Rate of Return (ERR), and the Benefit/Cost Ratio (B/C Ratio). Each of these measures provides a distinct perspective on the project's value to society, guiding stakeholders in resource allocation and project prioritisation.

- **1. Economic Net Present Value (ENPV)** measures the net welfare impact of a project by discounting the difference between its total economic benefits and costs. A positive ENPV indicates that the project contributes positively to societal welfare, justifying its implementation.
- **2. Economic Rate of Return (ERR)** evaluates the efficiency of a project by identifying the discount rate at which the project's net benefits (ENPV) become zero. It highlights the project's capacity to generate value relative to its costs.
- **3. Benefit/Cost Ratio (B/C Ratio)** compares the present value of a project's benefits to its costs, offering a straightforward indicator of efficiency. This ratio assists in ranking projects when resources are limited, ensuring that investments yield maximum societal returns.

Summary of Decision Rules for Key Economic Measures

- The **ENPV** measures the net welfare impact of a project by comparing total discounted social benefits and costs. A positive ENPV indicates societal benefits exceed costs, making the project desirable, while a negative ENPV suggests it should be rejected.
- The **ERR** represents the discount rate at which ENPV equals zero, reflecting the project's efficiency. Projects with an ERR above the social discount rate are considered acceptable.
- The **B/C ratio** compares the present value of benefits to costs. A ratio greater than one indicates economic viability, while a ratio of one or less suggests inefficiency.

Together, these measures evaluate overall welfare (ENPV), efficiency (ERR), and cost-effectiveness (B/C ratio) to assess the project's economic viability.

Sensitivity analysis of socio-economic results (2) - Economic Net Present Value (ENPV)

Overview of Sensitivity Analysis of the 40.5 MW onshore wind project in Majalengka:
The sensitivity analysis evaluates the impact of varying assumptions, such as CO_2 tax, Value of Statistical Life (VSL), emissions intensity, and the real Social Discount Rate (SDR), on key economic metrics. The real SDR is the rate used to evaluate the present value of future costs and benefits in cost-benefit analysis. It reflects the opportunity cost of capital in society and accounts for the preference for present consumption over future consumption. The real SDR excludes inflation.

ENPV reflects the net societal benefits, while the B/C ratio indicates the project's cost-effectiveness. The analysis helps identify how changes in assumptions influence project viability. The results of the sensitivity tests is presented in the table to the right as well as in the two charts in this slide and the next. Primarily worst-case scenarios have been assessed.

Key findings of sensitivity analysis on the ENPV across Scenarios:

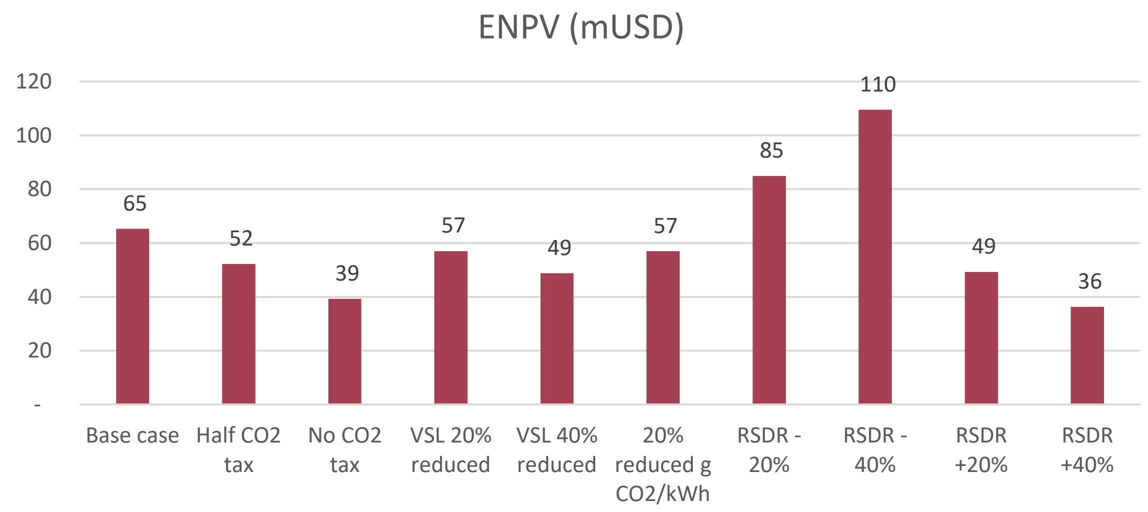

Figure – Sensitivity analysis on the ENPV across scenarios
Note: RSDR in the chart stands for Real Social Discount Rate (SDR)

Table – Summary of sensitivity analyses across scenarios

Scenario	Real SDR (%)	ENPV (million USD)	B/C Ratio
Base Case	6.23%	65.3	1.71
Half CO2 Tax	6.23%	52.2	1.57
No CO2 Tax	6.23%	39.2	1.43
VSL 20% Reduced	6.23%	57.0	1.62
VSL 40% Reduced	6.23%	48.7	1.53
20% Reduced g CO2/kWh	6.23%	56.9	1.62
Real SDR - 20%	4.99%	85.0	1.89
Real SDR - 40%	3.74%	109.6	2.11
Real SDR + 20%	7.48%	49.3	1.55
Real SDR + 40%	8.72%	36.2	1.42

Sensitivity analysis of socio-economic results (2) – Benefit-Cost Ratio (B/C Ratio)

Key findings of sensitivity analysis:

- **1. CO_2 Tax Variations:** Reducing or removing the CO_2 tax significantly decreases ENPV and B/C ratios, indicating a negative impact on project viability.
- **2. VSL Adjustments:** A 20–40% reduction in VSL moderately lowers ENPV and B/C ratios but retains acceptable viability.
- **3. Reduced Emissions Intensity:** A 20% reduction in g CO_2/kWh shows minimal impact, demonstrating robustness.
- **4. Social Discount Rate (SDR):**
  - Lower SDR values significantly increase ENPV and B/C ratios, enhancing economic viability
  - Higher SDR values reduce economic desirability but maintain viability.

Overall Conclusion on the Robustness of the Project
The sensitivity analysis demonstrates that the project remains robust under a wide range of assumptions. While variations in CO_2 tax, the VSL, and the SDR impact the ENPV and the B/C ratio, the project consistently delivers positive ENPV and a B/C ratio above 1 in most scenarios. This indicates that the project is economically viable and resilient to uncertainties in key parameters.

Lowering or removing the CO_2 tax and increasing the SDR reduces the project's desirability, but the outcomes remain within an acceptable range for decision-making. Additionally, adjustments to VSL and emission factors show minimal effect on the project's economic viability, underscoring its robustness in achieving net societal benefits.

Key findings of sensitivity analysis on the B/C ratio across scenarios:

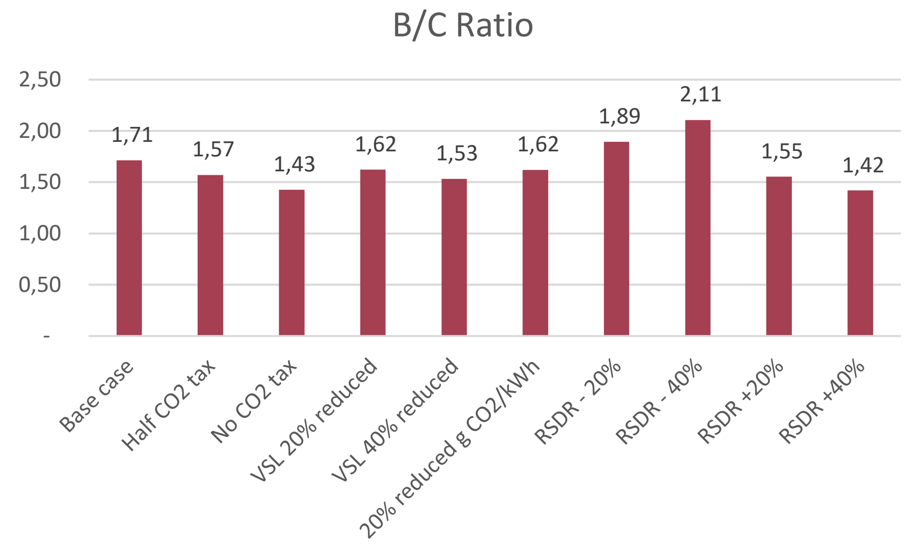

Figure – Sensitivity analysis on the B/C Ratio across scenarios
Note: RSDR in the chart stands for Real Social Discount Rate (SDR)

SOCIAL ASSESSMENT– LAND CATEGORY, LAND USE AND OWNERSHIP STATUS

Land Category and Land Use:

The potential Wind Power site is inside the boundaries of the Maja-sub district in Cibodas Village in Majalenka District, and a two smaller villages, the Citayam Kaler village and Cinangka village, is located near to the site

The analysis of land category status shows that the land at the Wind Power site in Majalenka is officially categorized as protected forest, local protection area, agriculture designation area and sustainable food agriculture area. Majority of the land, around 77%, is categorized "local protection area" and around 22% of the areas is categorized "agriculture area". The influence of the two other areas, protected forest and sustainable food agriculture area, is therefore minimal*. Additionally, there are small residential communities and kiosks scattered throughout the potential Wind Power development area.

Despite being officially characterized as "local protection area", local communities have repurposed most of this land for corn farming. According to interviews in the community, the community pay a minimal annual fee to the forestry office to use this land for plantations. The community prefers renting land over acquiring it. The corn farming, serves as a primary source of livelihood for the community. The farming cycle typically lasts 3-4 months, and most corn is used for animal feed.* As local livelihoods are depending on corn farming in this area, acquiring this land could have significant impacts on local livelihoods and it is important to ensure adequate compensation. This would possibly include land for land compensation, or training into new livelihood or employment.

Ownership Status:

The "local protection area" is state owned, managed by Perhutani, that has been tasked and holds authority to manage state forest resources. Official approval for use of the area can be obtained from the Ministry of Environment and Forestry. The agriculture area is either private or community owned, and usage of the area need to be agreed with local stakeholders as well as ensure compensation. The community holds land certificates in the form of cultivation rights, and some areas have SPPT (Land Tax Assessment Forms). In mid-December 2024, the Land Object Reform Agrarian (TORA) program will be implemented in the area. This initiative will issue forestry land certificates to the community for areas currently used as settlements and plantations, reclassifying them as residential land. This program is exclusive to Maja District.

*Input from PT Inovasi

*Table – Land category based on applied regulations in Majalenka**

Land Category in RTRW	Actual Land Use	Regency: Majalenka	Ownership Status	Notes for RE Development
Protected Forest	Forest	✓	State Owned, managed by Perhutani	It can be used if there is an Approval for Forest Area Use from the Ministry of Environment and Forestry in accordance with Government Regulation No. 23/2021
Agriculture Designation Area	Paddy fields, horticultural crops	✓	Private or community	Can be used if a sale and purchase or rental agreement is obtained
Local Protection Area	Forest	✓	State Owned, managed by Perhutani	It can be used if there is an Approval for Forest Area Use from the Ministry of Environment and Forestry in accordance with Government Regulation No. 23/2021
Sustainable Food Agriculture Area (KP2B)	Rice fields or horticultural crops	✓	Private or community	Can't be used

Source: PT Inovasi report

Method:

Initial land analysis was conducted by checking the land zoning status as stated in the published RTRW (Regional Spatial Planning) document for the category of land use. This was validated by checking with the Ministry of Agraria and Land Agency (ATR/BPN) available data and discussed with DBMPR (Dinas Bina Marga Penataan Ruang/Roads and Spatial Planning Agency) of West Java*. This analysis was complimented by field visits and surveying local stakeholders.

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

Social Assessment – Community in the Area and Land Price Estimation

Community in the area:
Cibodas Village, where the Onshore Wind site is planned close to, has approximately 3,000 residents, with 2,400 in the productive age group. Citayam, also part of Cibodas Village, has a smaller population of 216, of which 30% are elderly. Cinangka village has a population of around 500, with 350 individuals of productive age.

The majority of residents in these areas are engaged in corn farming for animal feed. Corn farming is primarily carried out by older residents, as many younger people migrate to urban areas like Cikarang for factory jobs. The farming cycle spans 3-4 months, and monthly incomes are inconsistent, averaging less than 2 million rupiah per month. The UMR (Minimum Wage) in Majalengka sub-district is 2.5 million rupiah per month.

In Cinangka village and Cibodas Village, education levels typically range from junior high school to high school. In Citayam Kaler village, the average educational attainment is elementary to junior high school, as children often choose not to continue their education beyond this level.

Infrastructure and Challenges
Road access to the potential Onshore Wind location in Cibodas Village is limited to narrow footpaths made of soil and rocks. Water access is a significant challenge for the communities across these areas, due to the dry conditions and local sources being distant and containing lime. Residents must create their own water channels to access water, and a reliable supply remains a critical need.

Land Price Estimation*:
The land value zone (ZNT) is a standardized land valuation provided by the central government to estimate the market value of land parcels within a defined area. This information is primarily used as a reference for determining non-tax state revenue and is generally lower than the Tax Object Sales Value (NJOP). Table below compares the land prices listed in the ZNT to those obtained from firsthand interviews. It shows that while the ZNT issued by the Ministry of ATR/BPN is estimated to be less than 100,000 Rp/m2, the interviews with local stakeholders indicate that prices could be between 200,000 and 300,000 Rp/m2.

*Table – Land price estimation**

Regency	Land Value Zone (ZNT) issued by Ministry of ATR/BPN	Interview with local stakeholders
Majalenka	< Rp 100,000/m^2	- NJOP is around Rp 103,000/m^2 - From interview: could be Rp 200,000 - 300,000/m^2 - Majority of the land is owned by State Owned, managed by PERHUTANI

Source: PT Inovasi report

*Input from PT Inovasi

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SOCIAL ASSESSMENT– COMMUNITY ENGAGEMENT AND INDIGENOUS PEOPLE TERRITORY

Local impacts of Renewable Energy :

The community is generally supportive of development, as long as it addresses any future impacts responsibly. For instance, after the construction of an internet tower in the area, it led to increased lightning strikes that damaged electronics, and the responsible party provided compensation. Additionally, they would appreciate if the development addresses potential impacts on agricultural land and livelihoods, by offering fair compensation if agricultural land is affected. Noise from the Wind site is a potential concern, as it might disturb the community.

The community understands that development projects require specific qualifications and does not expect involvement if they do not meet the necessary criteria. However, they are open to participating in the project. Providing education and training to the community would enable them to participate in development projects, equipping them with new skills for future employment opportunities.

They hope that development projects like renewable energy will provide job opportunities and infrastructure improvements (such as roads) and boosting tourism. Tourism related to the Wind Power site could also support local trade, such as food stalls near the site. The community's water source is generally sufficient, but residents need to create their own water channels using pipes to access water from the nearest spring. A water reservoir or drilled well would be highly beneficial to the community.

Figure – Indigenous People Territory Distribution Map in Java Island*

Source: BRWA and PT Inovasi report

Community Engagement:

The community and local authorities are unfamiliar with renewable energy and have no preconceived notions about the positive or negative impacts of the Onshore Wind project. In interviews village heads and sub-district chiefs express that socialization and education are necessary to inform them of the potential impacts and benefits. The Cibodas Village close to the Wind site often aims for community consensus for decision-making processes, and community involvement in the development of renewable energy in the region is crucial.

Culture and practices:

According to available information, no cultural aspects of the community are expected to be significantly affected by the project. According to the village head and community, the Cibodas Village close to the Wind site site does not adhere to strong traditional customs.

The Cinangka village, situated near the Wind site location, has cultural practices such as annual "year-end" events and "Thanksgiving" ceremonies typically held during construction activities. The community in Citayam Kaler village maintains several traditional cultural practices, such as "Buka Tanah" and "Tutup Tanah," as well as thanksgiving activities held before and after the planting season. A number of elders in the community typically lead traditional events. Additionally, the planned Wind site is close to several sacred tombs, where construction is strictly prohibited, but doesn't seem to be an issue with the current plan.

Indigenous People Territory*:

According to the findings of desk study into the existence of indigenous communities registered with the Customary Area Registration Agency (BRWA), West Java has three registered indigenous community areas. One of them is the Majalengka area's indigenous community area known as "Kesepuhan Nunuk," which may overlap with the area designated for wind farm development, as seen in the figure. The registered area of this customary is 2,048.16 hectares. However, the interviews with village heads and communities does not indicate there should be an issue developing in this area. However, we recommend a throughout analysis of affected communities and livelihoods through an Environmental and Social Impact Assessment (ESIA).

*Input from PT Inovasi

Environmental Assessment – Wildlife, Biodiversity and Natural Disaster Risk

Wildlife and Biodiversity:

From the global mapping data on Protected Areas developed by the Key Biodiversities Area Partnership, there are no threatened key biodiversity included in the potential Wind Power site in Majalenka*. Additionally, from the site visit and survey, no protected flora or fauna have been identified in the area. The land, though designated as protected forest, has been largely converted into agricultural fields, reducing its biodiversity significance. The land is generally dry, especially during the dry season.

The region is characterized by a steep mountainous region in the south with a height of more than 1.500 m above sea level, the area of gently sloping hillside in the middle with a height of 100-1.500 meter above sea level, in the northern region of vast plains with a height of 0-10 m above sea level, and region River flow. Jawa Barat is in the intermediate position 5o50’-7o50’ south latitude and 104o48’-108o48’ east longitude. According to the BPS (Central Bureau of Statistic), Jawa Barat covers a land area of 37.040,04 km2.

The development of renewable energy projects should ensure that biodiversity is protected, conserved, and that sustainable management and use of natural resources are implemented wherever possible throughout the project lifecycle.

Natural Disaster Risk

West Java, including the Majalenka region, is in general prone to natural disasters such as earthquakes. The region is located near several active fault lines, including the Baribis Fault, the Lembang Fault, and the Cileunyi-Tanjungsari Fault. These faults have the potential to generate earthquakes of magnitudes up to 7.0, presenting a significant seismic risk for the area.

The Majalenka area in general are at risk of landslide and flooding, especially during the rainy season. Addressing land stability are critical needs for the community. According to interviews with local stakeholder, the area is prone to landslides.

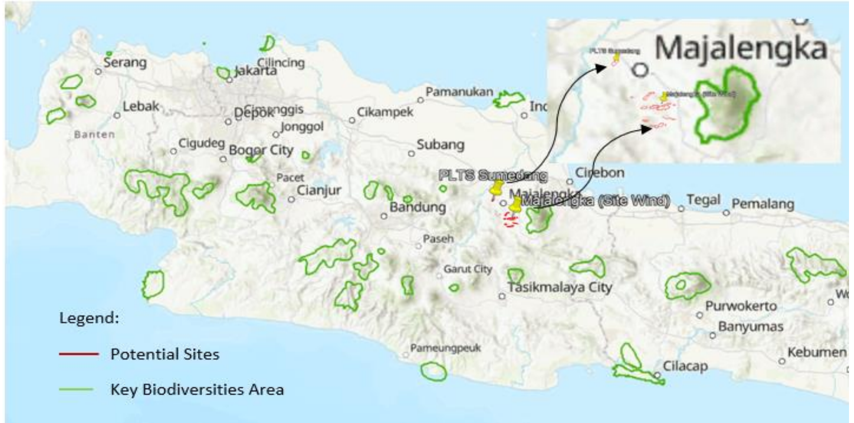


Figure – Key Biodiversity Areas Map in Java Island

*Source: https://www.keybiodiversityareas.org**

Figure – Identified active fault lines in West Java

Source: https://www.researchgate.net/figure/Map-of-identified-active-faults-in-Java-Island-3-Blue-ellipse-represents-NE-SW-faults_fig1_352814821

*Input from PT Inovasi

Environmental Assessment- Emissions Avoided

Emissions avoided:

Reduction in CO_2 Emissions and Land Clearing Impacts

The reduction in CO_2 emissions is calculated using PLN's emissions factor of 0.817 kg CO_2/kWh. Each kWh generated by the wind project offsets the equivalent from fossil fuel power plants. In the first year, the project is expected to generate 247,990 MWh, avoiding approximately 202,608 tonnes of CO_2 emissions.

The project in Majalengka involves clearing approximately 675 hectares of dryland agriculture, releasing an estimated 33,750 tonnes of CO_2, based on an emission factor of 50 tonnes per hectare. While these initial emissions partially offset the reductions, the project’s long-term environmental benefits remain significant despite the degradation in power production.

The wind project is expected to produce 108,329 MWh every year.

	Simple sum	NPV
CO2 emission avoided in tonne	2,415,742	1,088,952
CO2 emission increased from forest/farmland	(911,250)	(435,695)
Annual savings in tonne CO_2 (annuity)		49,240

Table – Sum and NPV of emissions avoided

Table above presents a comparison of CO_2 emissions avoided, emissions increased, and annual savings, using both a simple sum and Net Present Value (NPV) approach:

CO_2 Emission Avoided:

The total emissions avoided over the project lifetime amount to 2,415,742 tonnes in the simple sum calculation, but the NPV reduces this figure to 1,088,952 tonnes. The NPV accounts for the time value of reductions, indicating that avoided emissions in later years have less impact in present-value terms.

CO_2 Emission Increased from Land Clearing:

Land clearing contributes to an increase in emissions by 911,250 tonnes (simple sum) or 435,695 tonnes (NPV).

Annual Savings in CO_2 Emissions:

The annual savings in CO_2 emissions are calculated at 49,240 tonnes. This figure highlights the consistent yearly contribution of the project to emissions reduction despite the degradation over time.

Conclusion:

The NPV approach provides a more nuanced view, factoring in the time value of emissions savings, and still demonstrates the project's substantial net environmental benefit.

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

Summary Conclusions and Recommendations – 40.5 MW wind project in Majalengka

Summary Conclusions:

1. The West Java Wind Project demonstrates moderate economic viability with an ENPV of 65.3 million USD and a B/C ratio of 1.71 under base case assumptions.

2. Sensitivity analysis shows the project is vulnerable to reduced CO_2 tax and increased discount rates, requiring strong policy backing and risk management.

3. Despite financial constraints, the project aligns with Indonesia's renewable energy and climate targets, providing positive contributions to emissions reduction and energy diversification.

4. Socio-economic benefits include substantial local job creation and infrastructure improvements, directly fostering regional economic development.

5. Environmental considerations are essential, with potential impacts on biodiversity and land use requiring proactive assessment and mitigation measures.

6. Job creation is a key benefit, with:
- Construction Phase: 860 direct FTE jobs and 760 indirect FTE jobs.
- Operation Phase (Annual): 110 direct FTE jobs and 90 indirect FTE jobs.

7. Around 77% of the land is officially registered as “local protection area” and 22% is registered as agriculture area. However, despite being characterized as “local protection area”, local communities have repurposed most of this land for corn farming and are dependent on the land.

8. The community and local authorities are unfamiliar with renewable energy and has no preconceived notions about the positive or negative impacts of the Onshore Wind project. However, the community is generally supportive of development, as long as it addresses any future impacts responsibly.

9. The community recognize that development projects require specific qualifications. However, they are open to participating in the project, especially if education and training is provided to equip them with the necessary skills.

Summary Recommendations:

1. Optimize project design to enhance cost efficiency and operational effectiveness, leveraging advanced wind turbine technologies.
2. As local livelihoods are dependent on corn farming in this area, acquiring the land could have significant impacts on local livelihoods and it is important to ensure adequate compensation. This would possibly include land for land compensation, or training into new livelihood or employment.
3. Once the project is planning to move forward, an Environmental and Social Impact Assessment (ESIA) should be conducted to ensure compliance with international environmental and social standards. This is also necessary to secure international funding, which requires justified land acquisition prior to development.
4. Strengthen collaboration with policymakers to secure subsidies, tax incentives, and favourable financing mechanisms.
5. Develop risk mitigation strategies focusing on financial vulnerabilities, including CO_2 tax changes and market fluctuations.
6. Conduct detailed environmental and social assessments to minimize biodiversity impacts, identify positive social impacts, reduce any potential livelihood impacts, and ensure compliance with regulatory standards.
7. Explore technological solutions for intermittency, such as energy storage systems or grid integration mechanisms.
8. Strengthen local infrastructure, such as supplying wells and increased access to water, which is a critical matter in the community to increase positive impact.
9. Evaluate potential for scaling similar solar projects in other areas of West Java to maximize renewable energy impact.
10. Prioritize local residents as workers for the project. The community hopes that the construction of the wind will provide significant job opportunities, including the creation of new businesses such as food stalls around the project area to cater to workers.

SITE PHOTOS

Drone pictures of potential Solar PV site in Majalenka*:

Northeast point of view

South point of view

Northeast point of view

South point of view

*Input from PT Inovasi

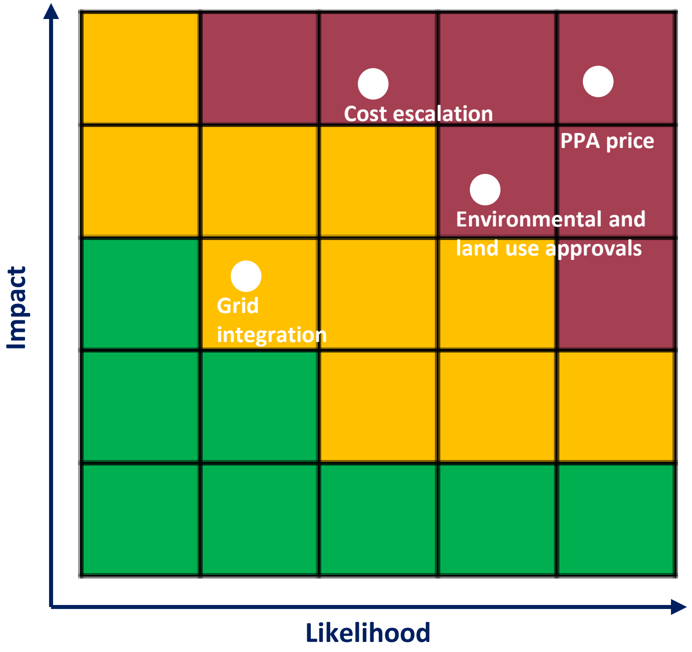
KEY PROJECT RISKS ARE PPA UNCERTAINTY, COST ESCALATION AND ENVIRONMENTAL AND LAND APPROVALS

Risk log and actions

Risk indicator	Description	Impact	Action
PPA price	Obtaining a PPA price that provides satisfactory returns is subject to high uncertainty, because there is no guaranteed price mechanism as a FiT scheme, why the final PPA price is a result of negotiations with PLN, and PLN is the only offtaker of grid connected onshore wind. Considering previous experience, it is highly unlikely that PLN will accept a price close to the break even PPA price, particularly considering the low average generation price (BPP) in WJ.	PPA price uncertainty have substantial impact on the feasibility of the project, especially since the sale of electricity is the only revenue source of the project.	• Conduct thorough price sensitivity analyses to evaluate the financial impact meeting PLN's acceptable PPA price • Engage in early dialogue with PLN to obtain price indications • Postpone project development until there is more certainty on PPA price settlements. • Abandon the project
Environmental and land use approvals	The proposed site is classified as dryland agriculture and designated for agricultural use and protection area. The regional regulation for spatial planning, which might affect land zoning.	There is a risk that approvals for converting protected forest land are delayed or cannot be granted for e.g., environmental reasons.	• Engage in early dialogue with the Ministry of Forestry and Environmental planning. • Perform an environmental impact study • Consider alternative locations with good irradiation potentials • Abandon the project
Costs escalation	Developing renewable energy projects in countries with limited prior experience often faces cost escalation due to numerous unknown factors. In this case, uncertainties exist regarding land costs and the expenses associated with infrastructure upgrades, as the existing road network leading to the site is narrow and uneven	Costs escalation, particularly if it relates to major budget posts, such as infrastructure upgrades (e.g., strengthening the road network), have a direct impact on the financial feasibility of the project.	• Sign options to lease with landowners to fix land acquisitions costs in the early development phase • Engage with the local officials to obtain information on development activities to explore synergies that could lower the costs of upgrading infrastructure • Engage with local suppliers to obtain prices for key services, such as clearing of land etc. • Abandon the project
Grid integration	The nearest 150 kV substation is located 9.5 km from the site, but its grid capacity is unknown, creating uncertainty around grid integration. This risk is further compounded by the fact that PLN in West Java has no prior experience with integrating wind energy. Meanwhile, the delivery or pay mechanism ensures a stable cash flow for the IPP, which lowers the risk.	Grid integration challenges can result in curtailment and disrupted production, and ultimately it can result in PLN not accepting grid connection at the nearest substation, which could delay or significantly inflate costs.	• Engage with PLN in the early development phase to gain indications of grid availability • Conduct grid impact study • Explore options for adding storage technology

Risk evaluation: The main risk for this project centers on revenue uncertainty, especially given past challenges in negotiating an acceptable PPA price with PLN. Additionally, West Java has relatively low average generation costs (BPP), decreasing the likelihood of securing a PPA price above the calculated break-even level. Other significant risks relate to environmental and land-use approvals, as well as potential cost escalation, which can be substantial considering the challenging road infrastructure of this area.

Risk matrix



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LIST OF ACRONYMS

Bappeda	Regional Development Planning Agency
BPP	Average cost of generation
BPS	Central Bureau of Statistics
BRWA	Customary Area Registration Agency
CAPEX	Capital Expenditures
CBA	Cost-Benefit Analysis
CREA	Centre for Research on Energy and Clean Air
COD	Commercial operation date
DEA	Danish Energy Agency
DEVEX	Development expenditures
DCF	Discounted Cash Flow Analysis
DINAS ESDM	Energy and Mineral Resources Agency of West Java
ENPV	Economic Net Present Value
ERR	Economic Rate of Return
ESIA	Environmental and Social Impact Assessment
FID	Final Investment Decision
FTE	Full Time Equivalent
GHI	Global Horizontal Irradiation
GIS	Geographical Information System
GWh	Gigawatt-hours
IESR	Institute for Essential Services Reform
IFI	International Financing Institution

INDODEPP	Indonesian-Danish Energy Partnership Programme
IRR	Internal Rate of Return
kWh	Kilowatt-hours
LCOE	Levelized Cost of Electricity
MWac	Megawatt Alternating Current
O&M	Operating and Maintenance
OPEX	Operational Expenditures
PLN	Perusahaan Listrik Negara (national electricity company in Indonesia)
PFS	Pre-feasibility Study
PPA	Power Purchase Agreement
PV	Photovoltaics
RECs	Renewable Energy Certificates
RUED	Rencana Umum Keternagalistrikan Provinsi (Regional General Plan for Electricity)
RUPTL	Electricity supply plan
SDR	Social Discount Rate
SOC	Social Opportunity Cost of Capital
SPI	Sustainable Province Initiative
SRTP	Social Rate of Time Preference
USD	United States Dollars
VSL	Value of Statistical Life
WACC	Weighted Average Cost of Capital
ZNT	Land Value Zone

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 project'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).*	$\boldsymbol{FLH}\ [h] = \frac{Annual\ generation\ [MWh]}{Rated\ power\ [MW]}$ $\boldsymbol{CF}[\%] = \frac{FLH}{8760}$

APPENDIX 1 – OVERVIEW OF INTERVIEWS

Name of interviewee	Position of interviewee	Relevant for which site-location	Date of interview	Interview conducted by
Sardino	Secretary sub-district, Tomo	Solar PV Site (Sumedang)	N/A	PT Inovasi
Aini	Secretary of Village, Tomo	Solar PV Site (Sumedang)	N/A	PT Inovasi
Edi	Village, Tomo	Solar PV Site (Sumedang)	N/A	PT Inovasi
M. Elon Dahlan	Secretary of Village, Tomo	Solar PV Site (Sumedang)	N/A	PT Inovasi
N/A	Head of Marongge Village	Solar PV Site (Sumedang)	Week 48	Sandra / DEA
N/A	Secretary of Marongge Village	Solar PV Site (Sumedang)	Week 48	Sandra / DEA
N/A	Head of Nagrak village	Solar PV Site (Sumedang)	Week 48	Sandra / DEA
Cuhro	Head of Village, Majalenka	Wind Power Site (Majalenka)	N/A	PT Inovasi
Hepi Purwanto	Head of village, Majalenka	Wind Power Site (Majalenka)	N/A	PT Inovasi
Abudin	Head of village, Majalenka	Wind Power Site (Majalenka)	N/A	PT Inovasi
Partiningsih	Head of sub-district, Majalenka	Wind Power Site (Majalenka)	N/A	PT Inovasi
N/A	Camat Maja	Wind Site	Week 48	Sandra / DEA
N/A	Village Head and Community of Cibodas Village	Wind Site	Week 48	Sandra / DEA
N/A	Head of Majalenka District	Wind Site	Week 48	Sandra / DEA
N/A	Head of Citavem Kaler village	Wind Site	Week 48	Sandra / DEA

Danish Energy Agency

Viegand Maagøe

Ea Energy Analyses

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COWI