REPORT

ROADMAP
Onshore Wind Energy Development in Indonesia

2024

This document is produced as part of the Southeast Asia Energy Transition Partnership's
'Wind Energy Development in Indonesia: Investment Plan' Project

ENERGY TRANSITION PARTNERSHIP

Powering Prosperity and Enabling Sustainability in South East Asia

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Foreword
Director General of New Renewable Energy and Energy Conservation

As an effort to mitigate climate change, Indonesia is committed to achieving the target of *Enhanced Nationally Determined Contribution*, namely reducing carbon gas emissions by 2030 by 32% (by its own efforts) and 43% (with international assistance). One of the ways in which this target can be achieved is through increasing the renewable energy mix target, namely 23% in 2025 and 31% in 2050. One type of renewable energy generation that plays an important role is Wind Power Plants (*Pembangkit Listrik Tenaga Bayu*/PLTB) which has the potential to significantly reduce carbon emissions in the electricity sector, strengthen national energy security, improve the quality of the environment, and encourage local economic development.

The *Roadmap for Onshore Wind Energy Development in Indonesia* document details onshore wind development efforts that have been carried out, gaps and obstacles encountered in accelerating the development of subsequent wind power plants, and steps that need to be taken by stakeholders in chronological order to address these gaps and obstacles. This Roadmap is the result of a study that aims to guide the development of the wind energy sector, offer a systematic approach that can be adopted by all stakeholders, and encourage informed decision-making in future wind power development.

The Roadmap formulation process has gone through a series of processes involving key stakeholders in the wind energy sector from the private and public sectors, as well as from national and international institutions. The existence of this Roadmap is expected to align the views and understanding of stakeholders in encouraging further PLTB development. This Roadmap is also expected to motivate all parties to actively participate in the formulation and implementation of government policies in realizing the energy transition. We can collectively realize Indonesia's commitment to reducing carbon emissions and combating global climate change.

We hope that this Roadmap will be beneficial for all stakeholders and encourage concrete steps to accelerate the energy transition in Indonesia. Let us continue to collaborate to create a better and more sustainable future for the next generation.

"We hope that this Roadmap for Onshore Wind Energy Development in Indonesia can align views, insights, visions, and steps that need to be taken to realize the acceleration of the development of the wind energy sector in Indonesia. Let us together drive the national energy transformation towards a greener and cleaner future."

Director General of New Renewable Energy and Energy Conservation,

Prof. Dr. Eng. Eniya Listiani Dewi

Foreword

By giving thanks to the presence of God Almighty, we hereby convey that the "Roadmap for Onshore Wind Energy Development in Indonesia" report has been completed. This report is one of the deliverables of the *Wind Energy Development in Indonesia: Investment Plan* project. This project aims to push for the energy transition and the development of renewable energy, especially onshore wind energy, in Indonesia. The significant potential of onshore wind energy in Indonesia needs to be properly utilized in the short term and in the long term as an effort to achieve the targeted share of renewable energy in the national energy mix. This utilization is also important to support the Government of Indonesia's commitment on achieving Net Zero Emissions (NZE) by 2060, or sooner.

This report is Report I of *Wind Energy Development in Indonesia: Investment Plan* project. This report summarizes the current conditions of onshore wind farm development in Indonesia, the related regulatory framework, gaps and challenges in wind farm development, and recommendations for chronological actions, which stakeholders can consider in order to overcome these challenges. We hope that this report can provide useful inputs for policymakers and stakeholders in determining future steps to accelerate the development of the wind energy sector in Indonesia.

In addition to this report, the deliverables under this project include the "Permitting and Regulation Assessment for Onshore Wind" (Report II), the "Wind Energy Development Booklet: Assessment of 8 onshore locations across Sumatra and Java" (Report III), and the "Investment Opportunities Guide for Indonesian Wind Projects" (Report IV).

Finally, please allow us to express our deepest gratitude for the cooperation and valuable input of all parties involved in the preparation of this report, especially the Ministry of Energy and Mineral Resources, Regional Governments and the related agencies, members of the Wind Power Technical Working Group, wind energy developers, and other parties.

Jakarta, 13 December 2023

Editorial Team

Colophon

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Author
Pondera & Indonesian Institute for Energy Economics (IIEE)

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Executive Summary

Background

Energy has a significant role in fulfilling the needs of the Indonesian population and for the future development of Indonesia. According to the Indonesia Energy Transition Outlook by IRENA (2022), the country's energy demand will increase by more than three times of what it is now because of the rising population and the economic growth in Indonesia. The publication also states that the level of electricity demand in 2050 is expected to be five times the corresponding level in 2022. To fulfil the demand, Indonesia must carefully consider the energy resources to be exploited in accordance with the push for the energy transition.

In Indonesia, wind is a significant source of RE which can be harvested. Indonesia is estimated to have wind energy potential of 155 GW, consisting of 60.6 GW of onshore wind and 94.2 GW of offshore wind (BBSP KEBTKE, 2023). However, the current utilization of wind energy is only 154.3 MW, or less than 0.1% of the potential.

Given the huge yet underutilized potential, it is essential to identify the obstacles and issues that need to be solved in order to achieve the goals stipulated in the National Energy Policy and the international commitments that have been made. This *Roadmap for Onshore Wind Energy Development in Indonesia* is created to identify these opportunities and difficulties, and is intended to serve as a guide for achieving Indonesia's wind energy development goals. Even though there have been numerous prior studies and efforts on this topic, this roadmap is aimed at compiling the results into one comprehensive report, which will serve as a specific roadmap for Indonesia's wind energy sector.

Relevance to project objectives

This roadmap (study) is part of a project titled *Wind Energy Development in Indonesia: Investment Plan*. This project is initiated by MEMR, managed by the Southeast Asia Energy Transition Partnership (ETP), and hosted by the United Nations Office for Project Services (UNOPS). ETP is a multi-donor partnership formed by governmental and philanthropic partners to accelerate sustainable energy transition in Southeast Asia in line with the Paris Agreement and Sustainable Development Goals. UNOPS is the fund manager and host of ETP Secretariat.

The purpose of this roadmap is aligned with the overall vision of MEMR as the main beneficiary of the roadmap, which is by providing technical assistance to MEMR in order to overcome challenges in proliferating renewable energy (including wind energy) development in Indonesia. During the formulation of this roadmap, engagement activities with key stakeholders from both public and private sectors, as well as national and international actors, were held through interviews, consultations, and the organization of Wind Power Technical Working Group (TWG) events, in which the preliminary results were disseminated, and the feedback was received.

This roadmap is also in alignment with the objectives of the project. In particular, the roadmap contributes to the fulfillment of two project objectives, namely: (i) gather, stocktake, and compile previous studies and work with regards to the wind sector in Indonesia; and (ii) determine a stepwise roadmap for the development of the wind sector in Indonesia. Moreover, two overarching outcomes of the project are addressed through this roadmap: (i) establish a wind sector development roadmap to guide the sectors development, highlighting gaps and impediments and offering a systematic approach that can be adopted by all stakeholders; and (ii) encourage informed decision-making on the development of wind energy in Indonesia. Furthermore, this roadmap serves as the foundation for the subsequent deliverables created in the overall project (*Wind Energy Development in Indonesia: Investment Plan)* which are Component 2: *Permitting and regulation assessment for onshore wind*; Component 3: *Wind energy potential mapping, gap analysis and site selection*; and Component 4: *Investment Opportunities Guide for Indonesian Wind Projects and Access to Finance Report*. For these three Components (to be published in the course of 2024), the findings from the roadmap are used as the context for the follow-up studies.

Approach

Based on the two project objectives, this study is expected to answer the research questions below:

1. What are the lessons learned from past studies and projects in Indonesia’s onshore wind energy sector?
2. Based on the lessons learned, what are the existing gaps/barriers that hamper the acceleration of future onshore wind project developments?
3. What are the steps to overcome these gaps/barriers, who needs to take which step, and when and how shall the steps be taken?

Results

In the table below, the challenges and lessons learned from past studies and onshore wind projects in Indonesia are identified.

Classification of challenges in wind energy development

Category	Description	Consequences	Urgency to overcome barriers
Wind data availability	• Limited availability of accurate long-term wind data • High level of uncertainty of mesoscale models as the alternative to long-term wind data • Financial burden of investments for wind measurements during tender processes by developers • Lower probability to reach financial close for a project due to uncertainties in wind data • Unpredictability of wind behavior during wind farm operation, resulting in difficulties for PLN to predict electricity production	Wind data has the highest priority in a wind farm's business case, and thus, these challenges create a high risk profile for developers and investors to step into wind energy development in Indonesia. This risk profile leads to either higher costs (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required
Availability of spatial data and standardized processes	• Absence of a clear Indonesian guideline on the analysis criteria and considerations for the technical, environmental, and social impact of a wind farm • Lack of accessible and consistent digital or high-resolution spatial (planning) data to support screening of potential locations and designing wind farm layout • Lack of standardization in the development process, including minimum prerequisite studies, feasibility study guideline, etc.	The unavailability of spatial data hampers not only the developers, but also the stakeholders in determining the optimal location for wind farm development. Without standardized processes, duration of project development can get extended, and difficulties may arise when comparing bids.	Short term solution required
Policy/Regulation and Permitting	• Uncertainty and frequent change of policies by the Government have created risks for investors and may impact the financial viability of projects • Inconsistent implementation of existing regulations • Delays in permitting process and land acquisition	For long-term investments (e.g. a pipeline of projects), developers and investors require a stable regulatory environment before entering into a country. These challenges create a high risk profile for them to enter Indonesia, and in turn, this condition leads to either higher cost (e.g. higher interest rates) or parties starting to invest somewhere else.	Medium term solution required
Research and Development	• Lack of Research and Development (R&D) activities for wind energy development and deployment to build a mature sector in Indonesia.	Without a proper knowledge base on wind energy in Indonesia, larger long-term challenges (e.g. wind data availability, grid stability, and local supply chain) cannot be solved properly or only with the support from outside of the country.	Long term solution required
Industrial Capacity	• Large investments and a pipeline of projects required for setting up a local supply chain • Lack of local knowledge on the technology • Limited skilled local workforce available	Being dependent on technology from foreign countries creates a vulnerability in terms of cost increase, quality assurance, and geo-political challenges. Furthermore, it could entail a missed opportunity for Indonesia to increase the labor welfare in this sector.	Long term solution required

Category	Description	Consequences	Urgency to overcome barriers
Infrastructure	• Sites with wind energy potential are not always near a well-developed grid; lack of transmission and distribution system infrastructure • Hard to ensure the stability and reliability of wind power given its intermittency; whereas BESS (battery energy storage system) is still relatively expensive to produce and integrate with wind power plants • Lack of supporting infrastructure such as port and road access	Absence of proper infrastructure could increase the project development costs, since the costs would have to include infrastructure improvements (which also lengthen the project duration). If these costs have to be carried by the project developers and are too significant, the feasibility of such projects could drop and hold/stop the project development.	Long term solution required
Financing & Bankability	• Suboptimal impact and support provided by existing fiscal and non-fiscal regulations to investments in wind energy • Perception of wind project investments in Indonesia as 'risky and slow', especially concerning the bankability of the unequally balanced PPAs between PLN and the developer	Before developers and investors decide to make large investment in a wind energy project in Indonesia, they require the right incentives and a well-balanced PPA to ensure a reliable business case throughout the project lifetime. If this business case cannot be guaranteed, they will perceive the project as having a high risk profile. In turn, this risk profile leads to either higher costs (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required
Procurement Mechanism	• Uncertain and unclear PLN procurement process of wind projects, bringing considerable risks for the developers	For long-term investments (e.g. a pipeline of projects), developers and investors require a stable, reasonable, and transparent procurement process before entering a country and starting to bid on projects. If this process cannot be offered, they will perceive the project as having a high risk profile. In turn, this risk profile leads to either higher costs (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required

Using the identified key challenges in the development of wind energy, steps that need to be taken to overcome these challenges are prepared in the form of a roadmap. The roadmap is laid out for the period of 2023-2030 of wind energy development in Indonesia. It includes a list of actions accompanied by the role of stakeholders, which is divided into different types of responsibility based on the RACI (Responsibility Assignment) Matrix. This identifies for each action which stakeholder should be R (Responsible), A (Accountable), C (Consulted), and I (Informed).

For each key area, the matrix specifies which roles are assigned to the stakeholders. Multiple roles can be assigned to a single task, and the specific combination of roles for each task clarifies who is doing the work, who is overseeing it, who needs to be consulted, and who should be kept informed. The table below presents the proposed stakeholders to be involved in performing the actions.

Abbreviation	Description
MEMR	Ministry of Energy and Mineral Resources
MoF	Ministry of Finance
MoI	Ministry of Industry
MoIn	Ministry of Investment
MoPW	Ministry of Public Works and Housing
BSN	*Badan Standardisasi Nasional*/National Standardization Agency
MoEF	Ministry of Environment and Forestry
KATR/BPN	Ministry of Agrarian Affairs and Spatial Planning / National Land Agency (*Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional*)
BRIN	*Badan Riset dan Inovasi Nasional* / National Research and Innovation Agency
PLN	*PT Perusahaan Listrik Negara (Persero)*, state-owned enterprise (SOE) in electricity, acting as grid operator and power off-taker
Industry/Association/Lenders	Wind association or Investors/Developers or Lenders (international and local institutions)

For each of the categories included in the action plan for the roadmap, an explanation is first given about the recommended actions to be taken.

<u>Wind data availability</u>
The variable character of wind, in combination with the complex terrain in Indonesia, makes it difficult to pinpoint the real potential of wind energy at specific locations. This is a challenge for the Government (i.e. MEMR and through the SOE PLN) in developing wind energy. For instance, RUPTL PLN contains several planned wind projects on locations with likely too little wind resource.

The current condition also poses a challenge for the developers that seek interesting locations to invest in, since the investment often comes with very high risks. Therefore, it is advised in this roadmap to use a top-down approach for future wind projects in which the Government streamlines the selection of wind project locations and takes responsibility for the first part of the project preparation. This approach consists of the following steps:

Step 1. Identification of potential wind energy locations. Conducting proper research (using more suitable modelling software for complex terrain assessment like GRASP) on areas that have sufficient potential to be included in a shortlist of potential wind farm locations.

Step 2. Identification of go-zones within potential wind energy locations. Exclusion of "no-go zones" (e.g. housing, protected forest, economic/commercial areas, etc.) from potential wind energy locations, to determine the go-zones.

Step 3. Verification of wind characteristics at the potential wind energy locations. It is recommended for the Government (PLN, PLN subsidiaries, or MEMR) to conduct these measurements and to offer them as part of the site data which will be received by the bidders during the project's tender process. In this way, a standard approach of wind data gathering can be used for all projects and prevent a proliferation of met mast being built in the same region by competing developers. In turn, the financial burden on the developers who wish to participate in the tender will be lowered significantly, creating a more sustainable and healthy wind sector.

Step 4. Develop more accurate, long-horizon forecast models. More precise and longer-term output forecasts would increase the feasibility of scheduling less rapidly deployable plants with more cost-effective fuel needs, such as coal-fired power plant and combined-cycle gas turbines, to balance the variable wind power in the system. To accomplish this, it is crucial to develop advanced forecasting models that make use of meteorological data, real-time data from operational wind plants, and remote sensing technology.

Availability of spatial data and standardized processes

This roadmap promotes the enhancement of the availability of spatial data and standardized processes through the following three key points:

Digitalization of geospatial maps

It is recommended that all geospatial maps required for the site selection process should be available digitally. To realize this, the Central Government must endorse the digitalization of this information to be prepared by each data-owning institution. Specific guidelines should be provided to align the process, namely, to ensure that the information is processed using a similar standard.

Designing a guideline for site assessment criteria

Several constraints are applicable for selecting the go-zone for a potential wind farm. Aside from a couple of standards in the SNI for wind energy, a clear guideline on the analysis criteria and considerations for the environmental and social impact of a wind farm are not yet present in Indonesia. The strong recommendation from this roadmap is to develop such a guideline, using the attached table with a selection of examples.

Subject	Criteria	Considerations
Wind characteristics	• Application of threshold values for wind speed, turbulence level, wind shear, consistency, etc.	• Wind characteristics vs. investment cost for infrastructure (e.g. in complex undeveloped terrain) • Nearby objects (e.g. large buildings) interfering with the free flow of the wind • Prevailing wind direction in relation to the terrain outlook, considering the wake effects that can occur
Logistic/access	• Maximum distance from port to the site	• Road access conditions • Required upgrades of existing infrastructure
Nearby dwellings	• Minimum distance to urban or residential and industrial areas, considering noise, shadow flickering, and external safety • Minimum distance to airports and military areas	• Potential direct offtake of nearby industrial areas • Nuisance for nearby residents during logistical operation and construction
Topography and Geotechnical	• Maximum elevation and slope for wind farm construction • Maximum level of cut and fill required for foundation and infrastructure (capital intensive)	• Soil conditions determine the type of foundation for the wind turbines • Soft soil and soil with porosity (void) or liquefaction risk to be avoided • Seismic risk (including earthquakes and landslides) • Flood risk • Lightning risk

Designing guidelines for wind development in Indonesia

In order to establish high-quality standards of wind farm development in Indonesia, it is important that project developers and investors are guided on what is expected from them during the project's development stage. A guideline, which includes not only the expectations and requirements of the Government, but also the requirements from banks for project financing to ensure a smooth due diligence process, shall thus be formulated. There are several vital aspects to ensure the effectiveness of this guideline: Consistency, Transparency, Clarity, and Responsibility.

Policy/regulation and permitting

The improvement of policy/regulation and permitting process for accelerating wind energy development can be performed by the following three key points:

Define key conditions for regulations and permitting in the wind sector

- Consistency: Developers and investors should be assured that regulations and permitting processes are always applied in a consistent and diligent manner.

- Transparency: Suggested changes to a policy or regulation should be announced in a timely manner and should preferably involve consultation with the key (private) stakeholders in the wind sector. Moreover, a clear but reasonable cut is required on how this revision applies to ongoing projects and future projects.
- Clarity: Evaluation criteria for permit applications should be reasonable, be clearly defined upfront, and refer to published standards.
- Responsibility: Overlap between requirements and studies from different authorities should be prevented. Specific studies should be evaluated by one authority for approval.

Continuous improvement on OSS system

A standardized, more transparent permitting procedure will reduce project uncertainty. Thus, continuous improvement is crucial, by monitoring and actively gathering feedback from related stakeholders, such as investors and the related government institutions. When possible, it is recommended to create a fast-track program for accelerating permitting process for wind power projects, subject to the fulfilment of pre-requisite documents and requirements for specific permits.

Smoothening land acquisition process

Governments and project developers need to engage in thorough planning, community outreach, and environmental impact assessments. It is essential to consider the social and environmental implications of land acquisition, ensuring that the transition to cleaner energy sources aligns with broader sustainability goals. It is also recommended to formulate an improved national plan of approach to smoothen the acquisition process which takes the values of the landowners and local inhabitants into account.

<u>Research and Development</u>

Specific actions are recommended through this roadmap to improve the level of R&D on wind energy in Indonesia.

Prioritization of specific R&D topics for wind energy development

Based on the three main fundamental challenges which will need further R&D and strategic studies, the following key research topics are defined to be of priority:

- Preparation of a detailed project pipeline for implementation, based on actual and more realistic figures of the targeted installed capacity of wind farms
- A cost-benefit analysis on Indonesia's industrial capacity building for the local manufacturing of wind turbine components
- Research on how transmission-related issues due to the intermittency of WPP and weak grid systems can be solved

Increased international R&D collaboration

Reaching the wind development target in Indonesia necessitates a boost in R&D funding. For this international R&D collaboration, multilateral development banks (MDBs) can serve as vital sources of funding. Financing facilities can be tailored to support various needs on a case-by-case basis. Bilateral development banks also play a crucial role in providing funding for development projects.

For instance, the German state-owned Kreditanstalt für Wiederaufbau Bank (KfW) established an agreement with the Indonesian Ministry of Finance in 2022, providing EUR 300 million promotional loan as part of the Sustainable and Inclusive Energy Programme. The financing package was expected to push for reforms in Indonesia's RE sector, which among others include improved regulations for rooftop solar PV and feed-in tariff mechanisms for renewables. Another example is the Asian Development Bank (ADB) who sets up and funds the Energy Transition Mechanism in 2021. For the accelerated early retirement of operational coal-fired power plants, ADB prepares funds to refinance existing coal-fired power plants, bring forward the plants' planned retirement, and replace these plants with cleaner and more sustainable alternatives of power generation.

Industrial Capacity

The wind industry in Indonesia is still in a very premature stage. So far, only wind turbine towers are produced in Indonesia for export. Furthermore, the two wind farms that have been established so far were largely dependent on experts from outside Indonesia. This shows that there is still a significant room to enhance the industrial capacity for the Indonesian wind sector. Such industrial capacity can be subdivided into two aspects:

Development of a local supply chain

When considering the local supply chain development, the following should be taken into account. As mentioned in the subsection on priority R&D topics, it is advisable to first conduct a proper cost-benefit analysis on Indonesia's industrial capacity building for the local manufacturing of wind turbine components. A major challenge is that such local supply chain requires large investments and a pipeline of projects to encourage manufactures (and investors) to establish factories in Indonesia. To establish such a pipeline, many actions have been identified in the other key areas of this roadmap.

Development of local know-how and expertise in wind energy development

This should consider the two underlying challenges namely, lack of local knowledge of the technology and limited availability of skilled local workforce. Specific actions can be taken to overcome these challenges, as proposed in the attached table (limited selection).

Action	Activities
Identify industry needs and standards	This entails identifying the specific skillsets and certifications required in the wind industry. This may include positions like wind turbine technicians, electricians, safety specialists, and project managers. It is also important to understand the industry's safety standards and regulatory requirement.
Engage stakeholders	Collaboration shall be formed with industry associations, local government agencies, wind project developers, and (international) educational institutions to collaborate on education and certification of skilled personnels.
Develop a curriculum	Creation of a curriculum for expertise development can cover both theoretical knowledge and practical skills relevant to the wind industry. It is essential to ensure that the curriculum is aligned with industry standards and safety regulations. The curriculum could include modules on wind turbine operation and maintenance, electrical systems, safety procedures, and environmental considerations.
Select training providers	This covers the selection of partner(s) or training providers (e.g. technical schools, community colleges, or specialized training organizations) to deliver the programs. Part of the selection process is to ensure that these providers have qualified instructors with relevant industry experience.
Funding and resources	Securing funding is important to begin training programs. Funding may come from a variety of sources, including government grants, industry sponsors, development banks, and international funding (e.g. JETP). Resources should be deployed for designing and realizing training facilities, equipment, curriculum development, and training materials.
Accessibility and inclusivity	Training programs should be accessible to a diverse group of participants to achieve gender balance and involve underrepresented or marginalized communities. One option to consider is offering scholarships or financial assistance to those who may face economic barriers to participate.

Infrastructure

Based on the identified challenges, the following recommended actions are included in the roadmap to address the challenges related to infrastructure.

Transmission system expansion, enhancement, and island-interconnections

- The planning and development of grid expansions should be synchronized with RE project planning and development (including onshore wind farms). After the identification of potential wind energy locations, action needs to be taken by PLN to prepare the potential expansion of the grid (with sufficient capacity) to the wind farm location.
- Aside from the grid expansion to wind farm locations, general reliability and stability enhancement of the grid by PLN (with sufficient capacity) is an important requirement to enable the evacuation of electricity from variable RE.
- In the long term, Indonesia will require more interisland connections to link, for example, the grid of Kalimantan with that of Java. A so-called Indonesia Supergrid will lead to optimizations of the nationwide utilization of RE sources and create a large, stable grid in which variable, dispatchable, and baseload electricity production can operate in balance.

In-depth assessment of incentives for BESS integration

An in-depth assessment of incentives for BESS integration in areas with weak grids and RE potential are vital to address energy challenges, promote sustainability, improve grid reliability, and drive economic growth. These efforts are aligned with the broader goals of transitioning to a cleaner and more resilient energy infrastructure.

Identification of potential synergies in multi-beneficiary use of road and port improvements

For an onshore wind farm, reliable road infrastructure is required to transport the very large wind turbine components to the site. This is unavoidable and will in many cases be a significant cost element in the business case of the project. What could be improved is to avoid the construction of road infrastructure only dedicated to the construction and maintenance of the wind farm alone. It would be beneficial if a synergy could be found between access to the wind farm and using the same road (likely with some expansion) to connect economic regions, connect remote villages, or decrease the pressure on existing infrastructure. The same type of synergy could also be looked for in port development. Necessary improvements of port facilities for offloading wind turbine components could also be beneficial to the port owner in the long term (e.g. heavier offloading cranes and larger storage yards).

<u>Financing & Bankability</u>

The technical feasibility of an onshore wind project is one key precondition. The second one is bankability of the project. Bankability is dependent on a predictable and transparent risk and return profile of the project for lenders and investors. Major factors for bankability are:

Incentives to overcome high "learning cost"

In an immature wind energy sector like Indonesia's, developing a wind farm is associated with a significant "learning cost". This is due to the lack of a standardized process, industrial capacity, and infrastructure. Although such a high cost is completely normal in a developing sector, with the right (financial) incentives, the learning cost could be overcome and potentially create a viable business case.

Conditions of Power Purchase Agreement (PPA) with PLN

For a period of 20-30 years, the agreement determines how the wind farm will earn back on its investment and creates a return on investment for lenders and investors. Therefore, conditions in the PPA need to be reasonable and consistent in order to result in a bankable project.

<u>Procurement Process</u>

Even though PLN's procurement process is clearly defined on paper, based on the conducted interviews, the process is still considered as the main bottleneck for a successful wind energy development due to several factors. The following challenges require strong attention to be overcome in the procurement process:

- Considering the nonrecourse project financing, the duration of financial close to be reached after PPA is awarded (PPA effective date), is expected to be more than 6 months, which is stipulated in the tender schedule. This needs to be adjusted in the procurement process.
- More than 1 month is needed to secure all required permits and studies after winning bidder announcement. Time needs to be allocated for this in the procurement process.

- A clear explanation is required if the tender is paused or cancelled (which has happened several times in the past years) to promote transparency.
- The procurement process would improve significantly (in terms reasonable risks for developers, quality assurance, and consistency) if the Government would take the responsibility in the preparation of wind farm projects (e.g. conducting wind measurement, executing pre-FS, and gathering spatial data).
- Issuance of a clear timeline (month, year) when projects will be tendered. Such a timeline should include a pipeline of projects for the coming years, which enables developers to timely prepare resources and start preparations (i.e. studies) for the upcoming tender processes. This will also create a more reasonable market behavior, preventing all developers merely focusing on the next project tendered instead of a long-term investment strategy.

Action Plan	Year								Role of Stakeholder										
	2023	2024	2025	2026	2027	2028	2029	2030	MEMR	MoF	MoPW	MoEF	KATR/BPN	BRIN	MoI	MoIn	BSN	PLN	Assoc. & Industry
Wind data availability																			
Step 1: Identification of potential wind energy locations	→	→							R/A					C				I	C
Step 2: Identification of go-zones within potential wind energy locations		→	→	→					R/A	C	C	C	C	C				I	C
Step 3: Verification of wind characteristics at the potential wind energy locations			→	→	→	→			R/A	C				C				R/A	C
Step 4: Develop more accurate, long-horizon forecast models				→	→	→	→	→	R/A	C				C				R/A	C
Availability of spatial data and standardized processes																			
Digitalization of geospatial maps	→	→	→	→					C		R/A	R/A	R/A						I
Designing a guideline for site assessment criteria	→	→	→						R		C	C	C						C
Designing guidelines for wind development in Indonesia	→	→	→						R/A							C	C	R	C
Policy/regulation and permitting																			
Define key conditions for regulations and permitting in the wind sector	→	→							R/A	C	C				C	C		C	C/I
Continuous improvement on OSS system	→	→	→	→	→	→	→	→								R/A			C/I
Smoothening the land acquisition process	→	→											C			R/A			C/I

R: Responsible **A**: Accountable **C**: Consulted **I**: Informed

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030	MEMR	MoF	MoPW	MoEF	KATR/BPN	BRIN	MoI	MoIn	BSN	PLN	Assoc. & Industry
	Year								Role of Stakeholder										
Research and Development																			
Prioritization of specific R&D topics for wind energy development	→	→	→	→	→	→	→	→	A	C				R	C	C	I	C	C/I
Increased international R&D collaboration	→	→	→	→	→	→	→	→	A					R		C	I	C	C/I
Industrial Capacity																			
Development of a local supply chain	→	→	→	→	→	→	→	→	A	C				C	R	C	C	C	C
Development of local knowhow and expertise in wind energy development	→	→	→	→	→	→	→	→	A								R	C	C
Infrastructure																			
Transmission system expansion, enhancement, and island-interconnections	→	→	→	→	→	→	→	→	A	C	I	I				C		R/A	I
In-depth assessment of incentives for BESS integration	→	→	→	→	→	→	→	→	A	C						C		R/A	C
Identification of potential synergies in multi-beneficiary use of road and port improvements	→	→	→	→	→	→	→	→	C	A	R				C	C		C	C/I

R: Responsible **A**: Accountable **C**: Consulted **I**: Informed

Action Plan	Year								Role of Stakeholder										
	2023	2024	2025	2026	2027	2028	2029	2030	MEMR	MoF	MoPW	MoEF	KATR/BPN	BRIN	MoI	MoIn	BSN	PLN	Assoc. & Industry
Financing & Bankability																			
Implementing support mechanisms that provide sufficient incentives to investors	→	→	→						C	R/A					C	C		C	C
Regulations for agreement on a bankable and balanced PPA	→	→	→						R	R						I		R/A	C/I
Procurement Process																			
Define a robust and reliable procurement process with a reasonable pipeline and timeline of projects	→	→	→						C/A							C		R/A	C

R: Responsible **A**: Accountable **C**: Consulted **I**: Informed

Conclusion and recommendations

Based on the research conducted for this roadmap, it has become clear that so far wind energy utilization is not yet fulfilling the expectations in Indonesia. It is still a question whether 60.6 GW of onshore wind (from RUEN) is a realistic potential, and whether the 8.5 GW onshore wind to be realized by 2030 (from the JETP Comprehensive Investment and Policy Plan) is a realistic target. Nevertheless, having realized only 0.13 GW of installed onshore wind farm capacity until 2023 and having only 0.14 GW in the pre-construction phase show the significant challenge to wind energy development that still lies ahead.

As introduced in Chapter 1, the objective of this research is to eventually answer the following questions:

1. What are the lessons learned from past studies and projects in Indonesia's onshore wind energy sector?
2. Based on the lessons learned, what are the existing gaps/barriers that hamper the acceleration of future onshore wind project developments?
3. What are the steps to overcome these gaps/barriers, who needs to take which step, and when and how shall the steps be taken?

The first question has been answered in Chapter 2 and 3 of this roadmap. Based on the desk research conducted, these two chapters have provided the overarching insights in the current status of wind energy development in Indonesia. The chapters have further shown the large variety of stakeholders (categorized in 20 stakeholder groups) that are involved in the development of a wind farm. This extensive list of stakeholders is a complicating factor in aligning between so many parties in developing onshore wind. Also, the regulatory framework in which wind energy development activities take place is very extensive and difficult to comprehend for the involved stakeholders. Such an extensive framework covers policies, regulations, permits, technical standards, procurement processes, land acquisition processes, and regulations on carbon credits. Although it is important to have a solid regulatory framework in place, such a framework could also intensify bureaucracy, lengthen the project duration, and increase the development process' complexity.

The second question has been answered in Chapter 4 of this roadmap. The interviews that have been conducted for the roadmap have shed some light on the many challenges/barriers perceived by the stakeholders involved in wind energy. The barriers have been categorized in 8 key areas:

- Wind data availability
- Availability of spatial data and standardized process
- Policy/regulation and permitting
- Research & Development activities
- Industrial capacity
- Infrastructure
- Financing & bankability
- Procurement mechanism

These barriers need to be overcome in order to realistically foster a thriving wind energy development in Indonesia in the coming years. Without any concrete actions being taken, it is expected that the same (or even slower) pace of wind projects will be realized, as has happened in the past 10 years. Just as worrisome, such status quo could lead to a less attractive investment climate for Indonesia for investors that wish to invest in wind energy (and possibly also other types of renewable energy).

The third question has been answered in Chapter 5. In this roadmap, a variety of recommended actions have been identified for the short, medium, and long term for each of the 8 key areas. Logically, the priority should be first on the short-term barriers and proposed solutions, while not overlooking the medium- and long-term counterparts. In the short-term, solutions need to be found to address the unavailability of wind and spatial data, the lack of attractive financing incentives, the lack of bankability of the PPAs, and the opaque PLN procurement process.

This roadmap provides a variety of solutions for these challenges with one overall conclusion: the Government of Indonesia should be the key stakeholder in initiating and implementing these solutions. The Ministry of Energy and Mineral Resources and PLN are the main authorities within the Government to take charge of the implementation, with the support from other ministries (the Ministry of Agrarian Affairs and Spatial Planning, Ministry of Public Works, Ministry of Environment and Forestry, Ministry of Industry, Ministry of Investment, and Ministry of Finance). Even implementing the solutions could be challenging because of the broad yet necessary involvement of multiple parties with possibly different interests. Therefore, it is strongly advised for the Government to include a pipeline of wind energy projects as National Strategic Projects.

To ensure a successful execution of the National Strategic Projects, a Government institution needs to be appointed and authorized to initiate, enable, and oversee the implementation of the Roadmap's action plans. This can either be done by establishing an overarching inter-ministerial committee for wind energy, or by appointing a Coordinating Ministry (e.g. the Coordinating Ministry for Maritime & Investment Affairs) to take the lead in the implementation. It could also be beneficial to continue the Wind Power Technical Working Group (TWG) setup, so that close coordination between the relevant stakeholders can be maintained. This leads to the first recommendation based on this roadmap:

> *Recommendation 1: Designate a pipeline of wind energy projects as National Strategic Projects and a Government institution as the leader in initiating, enabling, and overseeing the implementation of the Roadmap's action plans*

An often-heard discussion point is that wind energy is not progressing enough in Indonesia because there are insufficient investment funds available. Based on the research, however, it can be concluded that investment funds for actual projects are available, but it can only be deployed if the investor's conditions are fulfilled, namely, the barriers are overcome. Investments are still required but not directly to finance projects, but to finance the enabling factors of these projects. These enabling factors can be summarized in terms of Capacity Building and Technical Assistance.

An important note is that countries which have installed multiple GWs of wind energy do have more expertise in this field than Indonesia so far. Allowing and encouraging foreign experts to participate in Capacity Building and Technical Assistance programs is therefore an important prerequisite. This could for example be in the form of assisting PLN in enhancing the procurement process and assisting MEMR in conducting proper selection of wind energy locations. Another example is an assistance for OJK and local banks on establishing a greater understanding of due diligence processes for wind projects. 'Assisting' should be understood as training programs, deployment of interim staff, knowledge sharing sessions, etc. To facilitate these Technical Assistance programs, they should be integrated into the regular (annual) program of the relevant Indonesian institutions (e.g. OJK and DJEBTKE).

In this manner, Indonesia could solve the aforementioned challenges, while potentially leapfrogging over other challenges that were once faced by the experienced foreign countries. This leads to the second recommendation based on this roadmap:

> *Recommendation 2: Set-up Capacity Building and Technical Assistance programs at multiple Indonesian authorities with international support (e.g. JETP) to execute the roadmap action plans to overcome the identified barriers*

Further research

On a final note, this roadmap is part of a larger project called the *Wind Energy Development in Indonesia: Investment Plan*. Within this project, three additional deliverables will be created, namely:

- Conducting a permit requirement review for the Indonesian wind sector and for a selection of wind sites
- Mapping wind energy potential and analyzing possible gaps for 11 selected wind sites
- Establishing investment opportunities guide for the onshore wind sector

It is the intention that these deliverables can further shed some light into ways to drive Indonesia's wind energy development forward

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List of Abbreviations

ACE	Annual Contracted Energy
AEAI	*Asosiasi Energi Angin Indonesia*/Indonesian Wind Energy Association
AEP	Annual Energy Production
AMDAL	*Analisis mengenai dampak lingkungan*/Environmental impact assessment
BAPPENAS	*Badan Perencanaan Pembangunan Nasional/*National Development Planning Agency
BBSP KEBTKE	*Balai Besar Survei dan Pengujian Ketenagalistrikan, Energi Baru, Terbarukan dan Konservasi Energi/*Center for Electricity Survey and Testing, New, Renewable Energy and Energy Conservation
BESS	Battery Energy Storage Systems
BIG	*Badan Informasi Geospasial/*Geospatial Information Agency
BKPM	*Badan Koordinasi Penanaman Modal/*Investment Coordinating Board
BNPB	*Badan Nasional Penanggulangan Bencana/*National Disaster Management Agency
BPN	*Badan Pertanahan Nasional/*National Land Agency
BRIN	*Badan Riset dan Inovasi Nasional*/National Research and Innovation Agency
BSN	*Badan Standardisasi Nasional/*National Standardization Agency
CC	Carbon Credit
CCUS	Carbon Capture, Utilization and Storage
CER	Certificate of Emission Reduction
COD	Commercial Operations Date
COP	Conference of the Parties
DEN	*Dewan Energi Nasional/*National Energy Council
DPT	*Daftar Penyedia Terseleksi/*List of Selected Providers
DJEBTKE	*Direktorat Jenderal Energi Baru, Terbarukan dan Konservasi Energi*/Directorate General of New, Renewable Energy and Energy Conservation
EPC	Engineering, Procurement, and Construction
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas Emissions
GIS	Geographic Information System
GISTARU	Geographic Information System *Tata Ruang/*Spatial Layout Geographic Information System
GW	Gigawatt
Ha	Hectare
IPP	Independent Power Producer
IUPTLU	*Izin Usaha Penyediaan Tenaga Listrik untuk Umum/* Electricity Supply Business License for Public Use
JAMALI	*Jawa-Madura-Bali*/Java-Madura-Bali
KATR/BPN	*Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional* / Ministry of Agrarian Affairs and Spatial Planning/National Land Agency

KBLI	*Klasifikasi Baku Lapangan Usaha Indonesia/*Indonesian Standard Industrial Classifications
KEN	*Kebijakan Energi Nasional/*National Energy Policy (NEP)
KKPR	*Kesesuaian Kegiatan Pemanfaatan Ruang/Suitability of Space Utilization Activities*
kWh/m2	Kilowatt hours per square meter
LAPAN	*Lembaga Penerbangan dan Antariksa Nasional*/National Institute of Aeronautics and Space
LCR	Local Content Requirement
m/s	meters per second
MEAI	*Masyarakat Energi Angin Indonesia*/Indonesian Wind Energy Society
MEASNET	Measuring Network of Wind Energy Institutes
MEMR	Ministry of Energy and Mineral Resources
MERRA	Modern-Era Retrospective Analysis for Research and Applications
MoEF	Ministry of Environment and Forestry
MoF	Ministry of Finance
MoI	Ministry of Industry
MoIn	Ministry of Investment
MoPW	Ministry of Public Works and Housing
MW	Megawatt
NDC	Nationally Determined Contribution
NEP	*Kebijakan Energi Nasional (KEN)/*National Energy Policy
NIB	*Nomor Induk Berusaha*/Business Registration Number
NRE	New and Renewable Energy
NZE	Net Zero Emission
O&M	Operation and Maintenance
OJK	*Otoritas Jasa Keuangan*/Financial Services Authority
OSS	Online Single Submission
PCM	Predicted Capacity Matrix
PLN	*Perusahaan Listrik Negara*/Indonesia State Electricity Corporation
PPA	Power Purchase Agreement
PPKH	*Persetujuan Penggunaan Kawasan Hutan/*Approval for Use of Forest Area
RACI	Responsibility Assignment Matrix
RE	Renewable Energy
REC	Renewable Energy Certificate
RfP	Request for Proposal
RTRW	*Rencana Tata Ruang dan Wilayah/*Regional Spatial Planning
RUED-P	*Rencana Umum Energi Daerah Provinsi/*General Plan for Provincial Energy
RUEN	*Rencana Umum Energi Nasional/*General Plan for National Energy
RUKN	*Rencana Umum Ketenagalistrikan Nasional/*General Plan for National Electricity
RUPTL	*Rencana Umum Penyediaan Tenaga Listrik/*Electricity Supply Business Plan
SKEA	*Sistem Konservasi Energi Angin/Wind Energy Conversion Systems*

SNI	*Standar Nasional Indonesia/*Indonesian National Standards
SPPL	*Surat Pernyataan Pengelolaan Lingkungan Hidup/*Statement Letter of Environmental Management
TKDN	*Tingkat Komponen Dalam Negeri/*Local content
UKL-UPL	*Upaya Pengelolaan Lingkungan dan Upaya Pemantauan Lingkungan/*Environmental Management Efforts and Environmental Monitoring Efforts
VER	Verified Emissions Reductions
VRE	Variable Renewable Energy
W/m2	Watt per square meter
WhyPGen	Wind Hybrid Power Generation project
WPP	Wind Power Plants
WRA	Wind Resource Assessment
WTG	Wind Turbine Generators

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1 Introduction

1.1 Background

Energy has a significant role in fulfilling the needs of the Indonesian population and for the future development of Indonesia. According to the Indonesia Energy Transition Outlook by IRENA (2022), the country's energy demand will increase by more than three times of what it is now because of the rising population and the economic growth in Indonesia. The publication also states that the level of electricity demand in 2050 is expected to be five times the corresponding level in 2022. To fulfil the demand, Indonesia must carefully consider the energy resources to be exploited in accordance with the push for the energy transition.

A careful selection of energy resource utilization is especially relevant since Indonesia is committed to limit the increase in global temperature to 1.5°C and to reduce emissions according to the UN Climate Change Conference (COP21) in Paris back in 2015. Indonesia has also issued its 2060 Net Zero Emission (NZE) roadmap in 2022. The initial scenario for energy sector emissions in 2060 as presented at COP26 in Glasgow was 401 million tons of CO2e. However, discussions were then carried out again between the Ministry of Energy and Mineral Resources (MEMR) and other relevant Indonesian ministries, and it resulted in some adjustments to approach "net zero". The consolidation between these ministries results in a greenhouse gas emission target for the energy sector of 129 million tons to achieve NZE in 2060, as shown in the table below.

Table 1: Indonesia's targeted greenhouse gas emission in the Energy Sector by 2060; adapted from (DJK KESDM, 2023)

<table>
<tr><th rowspan="2">Category</th><th colspan="3">Net Zero Emission in the Energy Sector (Million Ton CO2e)</th></tr>
<tr><th>Ministry of Environment and Forestry</th><th>Initial Scenario presented at COP 26</th><th>Result of cross-ministerial consolidation</th></tr>
<tr><td>Power Plant</td><td>-66</td><td>0</td><td>0</td></tr>
<tr><td>Industry</td><td>51</td><td>231</td><td>60 (carbon capture and storage/CCS)</td></tr>
<tr><td>Transportation</td><td>62</td><td>149</td><td>52</td></tr>
<tr><td>Household</td><td rowspan="3">41</td><td rowspan="3">21</td><td>9.6</td></tr>
<tr><td>Commercial</td><td>4.4</td></tr>
<tr><td>Others</td><td>3.3</td></tr>
<tr><td>Total</td><td>87</td><td>401</td><td>129</td></tr>
</table>

The scenario of 129 million tons of CO2e above was prepared based on improved GDP assumptions, increased electrification on the demand side, the implementation of carbon capture, utilization, and storage (CCUS) in the industrial sector, and zero emissions from power plants. To achieve NZE in the energy sector, renewable energy (RE) must be utilized optimally. This idea is reflected to a certain extent in Indonesia's National Energy Policy (*Kebijakan Energi Nasional*/KEN) in 2014 which targets a RE share of 23% of the primary energy mix by 2025 and 31% by 2050.

Indonesia has a large potential for new and renewable energy sources that can meet local energy needs and help the country overcome its dependence on fossil fuels. As stated in the National Energy Policy, achieving national energy security and independence requires the development and utilization of new and renewable energy resources. It is therefore useful to understand Indonesia's RE potential. The following table shows the recent status of RE potential and utilization.

Table 2: Status of RE potential and utilization in Indonesia (Ministry of Energy and Mineral Resources, 2023a)

Energy	Potential (GW)	Utilization (GW)
Solar	3,294	0.301
Hydro	95	6.693
Bioenergy	57	3.088
Wind	155	0.154
Geothermal	23	2.365
Ocean	63	0
Total	**3,689**	**12.601**

In Indonesia, wind is a significant source of RE which can be harvested. As suggested by the table above, Indonesia is estimated to have wind energy potential of 155 GW, consisting of 60.6 GW of onshore wind and 94.2 GW of offshore wind (BBSP KEBTKE, 2023). However, the current utilization of wind energy is only 154.3 MW, or less than 0.1% of the potential.

Given the huge yet underutilized potential, it is essential to identify the obstacles and issues that need to be solved in order to achieve the goals stipulated in the National Energy Policy and the international commitments that have been made. This *Roadmap for Onshore Wind Energy Development in Indonesia* is created to identify these opportunities and difficulties, and is intended to serve as a guide for achieving Indonesia's wind energy development goals. Even though there have been numerous prior studies and efforts on this topic, this roadmap is aimed at compiling the results into one comprehensive report, which will serve as a specific roadmap for Indonesia's wind energy sector.

1.2 Objectives

There are two objectives which underlie the formulation of this roadmap, namely: (i) gathering, stocktaking, and compiling previous studies and work with regards to the wind sector in Indonesia, and (ii) determining a set of stepwise actions in a timeline to support wind energy development. This study is expected to answer the research questions below:

1. What are the lessons learned from past studies and projects in Indonesia's onshore wind energy sector?
2. Based on the lessons learned, what are the existing gaps/barriers that hamper the acceleration of future onshore wind project developments?
3. What are the steps to overcome these gaps/barriers, who needs to take which step, and when and how shall the steps be taken?

1.3 Methodology

To answer the above defined research questions, the following methodology will be applied:

- Research question 1: Desk research was conducted on openly available literature and reports to obtain the lessons learned from previous studies and projects/initiatives in the onshore wind sector. The results of this part of the research will be included in Chapter 2 and 3.
- Research question 2: Interviews were conducted with a variety of stakeholders as a means to elicit the stakeholders' views and insights on hurdles relevant to onshore wind energy development. The results of this part of the research will be included in Chapter 4.
- Research question 3: Insights that were gathered from the desk research and the interviews were expected to include or indicate a variety of suggestions to overcome these barriers. This and the expert judgement of the researchers will lead to the roadmap in Chapter 5.

In addition to the 'formal' interviews which will be conducted with several stakeholders, input to answering the research question will also be obtained via the Wind Power Technical Working Group (TWG) events. The TWG convenes important actors in the wind sector, including representatives from:

- Ministry of Energy and Mineral Resources (MEMR)
- Ministry of Finance (MoF)
- Ministry of National Development Planning (Bappenas)
- Ministry of Environment and Forestry (MoEF)
- Ministry of Agrarian Affairs and Spatial Planning (KATR/BPN)
- Ministry of Industry (MoI)
- Ministry of Investment (MoIn)
- Coordinating Ministry for Maritime and Investment Affairs
- National Research and Innovation Agency (BRIN)
- Offices for Energy and Mineral Resources from several provinces with onshore wind potential
- State-owned enterprises (PLN, PLN subsidiaries, and Pertamina NRE)
- Private enterprises (wind developers, consultants, and manufacturers)
- Associations in wind energy
- University research centers and think tank organizations
- Development agencies

TWG events serve as a platform for receiving input and feedback from these actors on (parts of) this roadmap, as well as for dissemination of preliminary and final results. Up to the time of writing, two TWG events have been conducted. Meaningful insights gathered from both events have been integrated into this roadmap.

1.4 Scope

The scope of this roadmap is explained below:

- Only onshore wind is considered; nearshore and offshore wind is out of the scope of the study.
- Wind turbine technology as mentioned in this study refers to utility-scale wind turbines (> 1 MW).
- The analyzed timeframe for the roadmap is up to 2030.

1.5 Report structure

The onshore wind energy development roadmap is structured as follows:

- Chapter 1 provides background, objectives, scope, and report structure.
- Chapter 2 presents the current conditions for wind energy development including onshore wind energy potential, installed capacity, and stakeholder analysis.
- Chapter 3 provides the current regulatory framework of wind energy development in Indonesia.
- Chapter 4 elaborates upon the challenges within wind energy development in Indonesia.
- Chapter 5 presents the pathways for wind energy development which includes the action plan and its timeline, as well as the role of each stakeholder.
- Chapter 6 concludes the roadmap with conclusions and recommendations.

2 Current conditions of wind energy development in Indonesia

2.1 Onshore wind potential

Indonesia is an archipelagic country encompassing over 17,000 islands. The country has a coastline of about 99,083 kilometers. At specific locations in Indonesia, moderate to strong winds are present which is caused by topographic circumstances (e.g. mountain ridges and compressed air flow between and around islands). An overview of wind speeds throughout Indonesia is illustrated in Figure 1. Indonesia has wind energy potential that under specific conditions (e.g. sufficient wind speed, good accessibility, etc.) can be utilized for electricity generation (EBTKE KESDM, 2017). Potential mapping is therefore very important before carrying out wind energy development, and for this reason, this section will describe the theoretical potential of wind energy in Indonesia from various sources.

The National Aeronautics and Space Institute (LAPAN) reports that several regions in Indonesia (including East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, and Southern Java) have wind speeds above 5 m/s (EBTKE KESDM, 2017). Hence, further investigations of these regions could be interesting to see if other aspects than wind speed can support the future development of wind farms. Moreover, the range of wind speeds in Indonesia is typically between 3 and 6 m/s (EBTKE KESDM, 2017). Compared to wind speeds in wind rich countries, this range indicates meager wind resource. Nonetheless, focus for wind research can still be placed on the few locations having average wind speeds above the typical range.

The Global Wind Atlas project (Technical University of Denmark, 2023) offers some information on the wind energy potential in Indonesia based on 100-m height annual average wind speeds. As can be observed in Figure 1, the map is dominated by a yellowish-green hue, which indicates that the yearly average wind speed in Indonesia is mainly 4 to 5 m/s at an altitude of 100 meters.

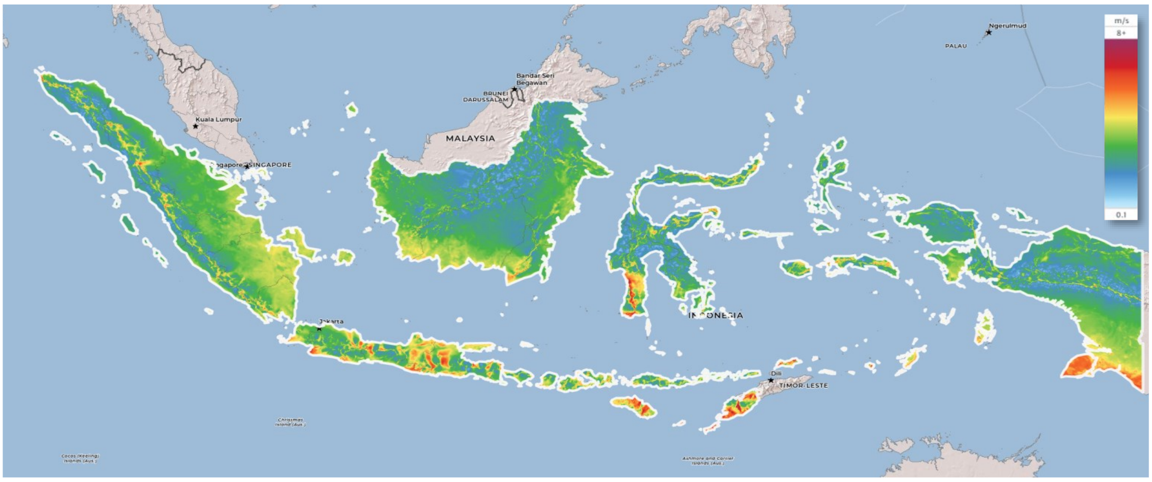

Figure 1: A graphical illustration of Indonesia's potential for wind energy at a height of 100 meters (Technical University of Denmark, 2023)

It is crucial to understand wind energy potential not only from the theoretical and technical standpoint, but also from the economic standpoint. This means that wind energy potential is also ‘measured’ using economic indicators to indicate the feasibility of exploiting the available resource. Based on a one-year measurement and analysis by the Center for Electricity Survey and Testing of New, Renewable Energy and Energy Conservation (BBSP KEBTKE) at MEMR in 2017, there are four locations which has both technical and economic wind energy potential (see Table 3).

Table 3: Areas that have the potential to develop wind energy economically and technically based on wind speeds at an altitude of 30-50 m (EBTKE KESDM, 2017)

Region	Average wind speed (m/s)
Sukabumi	7
Bantaeng	4.66
Jayapura	3.05
Sangihe Island	6.4

General Plan for National Energy (*Rencana Umum Energi Nasional*/RUEN) stipulates that Indonesia has a total onshore wind energy potential of 60.6 GW given annual average wind speeds greater than 4 m/s and at an altitude of 50 meters (see Appendix 1 in Chapter 0). Moreover, several provinces, including West Nusa Tenggara, Bengkulu, Bali, West Sulawesi, West Sumatra, East Kalimantan, and Jambi, have included wind energy potential in their respective regions within their General Plan for Provincial Energy (*Rencana Umum Energi Daerah Provinsi*/RUED-P). This indicates that the provinces already recognize wind as a potential source of RE to be capitalized upon in order to support economic development while also achieving the energy mix target. As mentioned in the previous chapter, BBSP KEBTKE (2023) augments the potential calculation of RUEN with the addition of 94.2 GW of offshore wind potential. This latest calculation is shown in Figure 2.

Figure 2: The wind energy potential map of Indonesia (BBSP KEBTKE, 2023)

2.2 Existing onshore wind farm capacity

According to the 2021–2030 Electricity Supply Business Plan (*Rencana Umum Penyediaan Tenaga Listrik*/RUPTL) of PLN (2021), the state-owned electricity company, the current contracted capacity (with PLN) of wind power plant is 130.9 MW. Such capacity is based on two provinces, namely, South Sulawesi and Bali as shown in the following Table 4. It is noteworthy that other sources register the installed capacity as 154.3 MW; this figure corresponds to the sum of rated power for all installed wind turbines in Indonesia. By comparing the installed capacity figure with the identified potential in the previous section, it can be inferred that there is still an opportunity to develop the large, 'untouched' wind energy potential.

Table 4: Existing wind energy installed capacity in Indonesia (PLN, 2021)

No.	Province	Electricity System	Units	Total Capacity (MW)	Developer	PPA terms
1	Bali	Tiga Nusa Bali	3	0.3	PLN	Unknown
2	Bali	Tiga Nusa Bali	1	0.6	IPP	Unknown
3	South Sulawesi	Sulselrabar	1	70.0	IPP (UPC Renewables)	11 ¢USD/kWh (30 years)
4	South Sulawesi	Sulselrabar	1	60.0	IPP (Vena Energy)	11 ¢USD/kWh (30 years)
	Total			**130.9**		

2.3 Analysis on the key stakeholders of onshore wind

Several key stakeholders are involved in the development of onshore wind power plants in Indonesia. These stakeholders have their respective roles and responsibilities in renewable energy development, particularly in the wind sector. Moreover, the stakeholders are interconnected (and intertwined) in an intricate network. As an illustration, Figure 3 depicts the network's intricacy through a formal chart. It is important to understand the characteristics of each stakeholder, and therefore, the following list is provided to give a concise description of the key stakeholders along with their respective roles in onshore wind energy development.

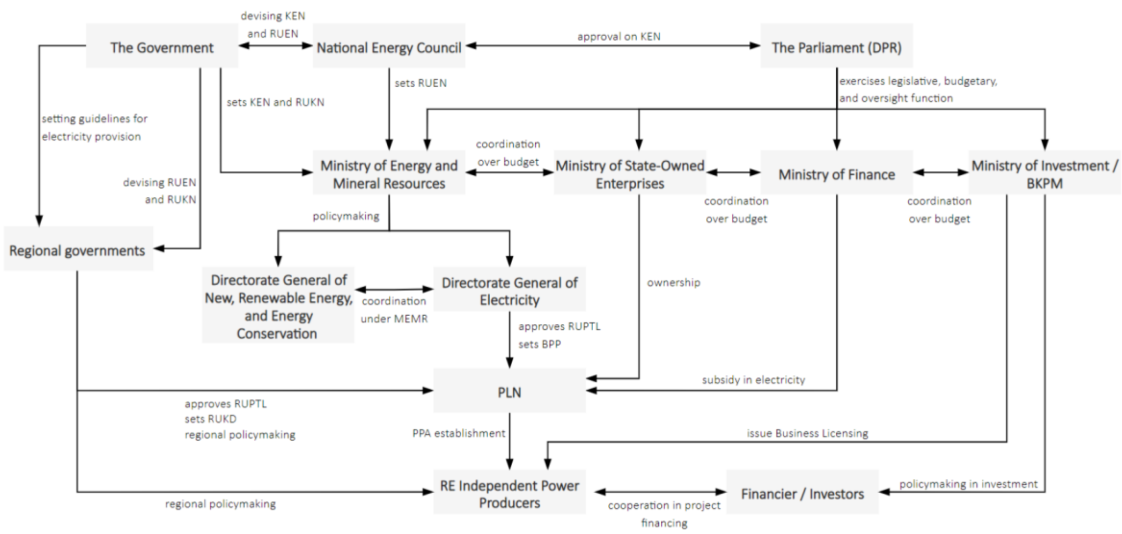

Figure 3: A formal chart displaying the intricate network of stakeholders in the renewable energy sector (Simanjuntak, 2021)

1. The Ministry of Energy and Mineral Resources (MEMR)
   This government institution formulates policies to protect and supervise the use of Indonesia's energy sources and assets. Legislation and regulations in the energy sector is designed by MEMR in such a way to ensure Indonesians have access to accessible, affordable, and reliable energy. The span of policymaking authority also extends to the electricity sector. MEMR is responsible for issuing regulations for the RE and electricity sector through the Directorate General of New, Renewable Energy and Energy Conservation (DJEBTKE) and the Directorate General of Electricity (DJK), respectively. In addition, there is also another unit within this ministry which is known as the Center for Electricity Survey and Testing, New, Renewable Energy and Energy Conservation (BBSP KEBTKE). Supervised by DJEBTKE, this institution is the technical implementing unit which carries out operational and/or supporting technical tasks in the electricity and energy conservation sector within the scope of new and renewable energy. BBSP KEBTKE actively measures wind energy potential at some sites and uses the results to draw wind energy potential maps. In addition, MEMR also conducts the development of human resources in relevant disciplines to the energy sector.

2. The Ministry of Investment/Investment Coordinating Board (MoIn; *Kementerian Investasi*/*Badan Koordinasi Penanaman Modal*/BKPM)
   The Ministry of Investment is mainly responsible for developing investment policies in Indonesia for both national and international actors. The role of this ministry is to become the focal point between the Government and all investment sectors, with the aim of inviting quality investments to Indonesia in order to boost the nation's economic growth and employment rate (Ministry of Investment, 2022). In terms of wind energy development, MoIn has the authority to issue permits and licenses for relevant businesses in this sector through the Online Single Submission (OSS) system. An example of such license is the Business Registration Number (see Table 7 in Section 3.2). Additionally, MoIn also facilitates the granting of RE incentives and debottlenecking of investment projects.

3. The Ministry of Finance (MoF)
   MoF is responsible for policymaking and administering the country's finances and wealth. Policies pertinent to MoF include, but are not limited to, state budgeting, taxes, asset management, fiscal balance, and custom and excise (Ministry of Finance, n.d.). Related to wind energy development, the MoF can formulate and implement policies which are favorable to support investment and industrial development in the wind sector. These policies can be promoted in the form of tax credits or other tax facilities. By making use of these facilities, private developers may have a more attractive business case on their wind projects.

4. The Ministry of Industry (MoI)
   MoI is authorized to formulate and implement policies in the industrial sector. Relevant policies to wind energy include, among others, minimum local content requirement and enforcement of industrial standards. Additionally, MoI also provides technical guidance and supervision in the industry (Ministry of Industry, n.d.). MoI can therefore play a major role in the establishment of Indonesia's wind industry.

5. The Ministry of Environment and Forestry (MoEF)
This ministry formulates and implements policies related to the environmental and forestry sectors. The utilization of RE for electrical purposes has an impact on the environment at every stage, including planning, pre-construction, construction, operation, and post-operation. Thus, MoEF plays an essential part in the process of wind energy development, specifically through advocation of environmentally responsible power plant development. For example, MoEF can issue regulations and permits for the use of forest areas for wind energy development.

6. The Ministry of Public Works and Housing (MoPW)
The authority of MoPW lies in formulating and implementing policies related to, among others, provision and maintenance of roads, development of infrastructures, building regulations, and supervision of construction services (Ministry of Public Works and Housing, 2023). Construction of wind farms is likely to involve the use of public infrastructures, such as transporting large wind turbine components through public roads and ports. Hence, MoPW plays an important role in the permitting, preparation, and execution stage of wind projects.

7. The Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (KATR/BPN)
This ministry formulates, enacts, and implements policies in spatial planning, agrarian/land infrastructure, agrarian/land legal relationships, agrarian/land management, land acquisition, control of space use and land, and handling of issues regarding agrarian/land and space utilization. Other fields which are within KATR/BPN's policymaking authority include land surveying, mapping, and measurement, as well as land rights determination and land registration (Ministry of Agrarian Affairs and Spatial Planning, 2021). Branch offices of KATR/BPN exist in provinces, cities, and municipalities. Given these functions, KATR/BPN has a pivotal role to play in wind energy development, particularly in supporting and administering the wind farm's land acquisition. Wind project developers need to consult with KATR/BPN to obtain information on the land's ownership status and corresponding category in the spatial plans. Moreover, part of KATR/BPN's responsibility is to issue a permit on space utilization (see Table 7 in Section 3.2).

8. National Research and Innovation Agency/*Badan Riset dan Inovasi Nasional* (BRIN)
BRIN was established in 2019 as an institution that performs research, studies, development, and application to promote national invention and innovation, following the merger of BATAN, BPPT, LAPAN and LIPI as well as research institutions within ministries and institutions. (BRIN, 2023). One of BRIN's targets is to develop science and technology, and to create industries based on strong and long-term research. Despite being a newly founded institution, BRIN is composed of experts from several public (research) institutions (e.g. LAPAN) which have had experience with wind energy research. Moreover, BRIN is supported by universities in Indonesia namely, University of Indonesia, Bandung Institute of Technology (ITB), Gadjah Mada University Sepuluh Nopember Institute of Technology, Diponegoro University, Hasanuddin university, Sebelas Maret University, Andalas University, Airlangga University, Brawijaya University, University of Sumatra Utara, and international universities exchange programme. BRIN is also tasked with monitoring, controlling, and evaluating the performance of duties and functions of Regional Research and Innovation Agencies (BRIDA) pursuant to the provisions of laws and regulations.

9. The National Energy Council/*Dewan Energi Nasional* (DEN)
DEN is led by the President of the Republic of Indonesia. As shown in Figure 4, DEN's members include several ministers and stakeholder representatives from academia, environment, technology, consumers, and industry. The main responsibility of DEN is to devise a long-term, high-level plan for the energy sector with the aim of establishing a fair, sustainable, and environmentally friendly energy management. As the product of DEN, the National Energy Policy (KEN) stipulates the country's RE integration targets. It can be inferred that DEN has a crucial role in guiding the future integration of RE, including wind energy, into the energy system. Another product of DEN is RUEN, which is the operationalization of KEN (see Section 3.1 for further information).

Figure 4: Organization structure of DEN (Simanjuntak, 2021)

10. National Standardization Agency (BSN)
This body carries out government duties in the field of national standardization and has the function of facilitating relevant stakeholders in developing and maintaining the Indonesian National Standards (*Standar Nasional Indonesia*/SNI). An SNI Formulation Technical Committee, which consists of representatives from the Government, producers, consumers, and academicians, is formed to devise the standards (Badan Standardisasi Nasional, 2020). SNI is developed as a market reference whose implementation is voluntary. Its development can involve adaptation of internationally recognized standards, such as IEC standards for wind energy. However, SNI can also be enforced compulsorily through technical regulations as stipulated by the relevant Ministry/Institution. Currently, there are already some SNI articles related to the wind energy (see Section 3.4).

11. PT PLN (Persero)
The Indonesian state-owned enterprise is in charge of the electricity sector. PLN has the priority to provide electricity for public use and is the sole off-taker and party that has the right to sell electricity to end consumers except for a few "Business Areas" (Wilayah Usaha), where private participants could sell electricity directly to the off-taker. As the nation's principal electricity supplier, PLN has control over the transmission, distribution, and provision of electricity to the general population. The most common business structure is that an IPP enters into a Power Purchase Agreement (PPA)

with PLN to develop, construct, and operate a power plant and then supply the produced electricity to the PLN. Subsequently, PLN purchases the electricity from the IPP and would further sell and distribute electricity to the public. Hence PLN becomes an off-taker of the electricity produced by Independent Power Producers (IPP).

12. Local governments
    Local governments play a crucial role in the implementation of regional programs in the energy sector, particularly the utilization of RE. At the local level, regional governments have control over several types of licenses and permits which should be obtained when developing a wind farm, especially in the examination of required documents. For example, recommendation (or support) letter from the regency or the province is often needed for wind projects (see Section 3.2 for further information). The delegation of authority to local governments to implement the new and renewable energy sector is anticipated to boost the achievement of energy mix targets by promoting a variety of regional innovations.

13. Investors
    To finance onshore wind projects, investors are required to finance early-stage development of projects (e.g. wind measurements, feasibility studies, etc.) and to provide equity financing for the realization of such wind farms. Investors could also provide debt financing (loans) if required.

14. Financial Institutions and Multilateral Development Banks
    Financial institutions (e.g. commercial banks, investment banks, and insurance) and Multilateral Development Banks (e.g. ADB and IFC) serve an essential role in the growth of the alternative and new energy sectors. National banks have already begun to support the RE industry, whereas financial institutions have even stopped funding the development of fossil fuel power plants. A key tool for achieving the national energy mix target is sustainable finance, which according to Financial Services Authority/*Otoritas Jasa Keuangan* (OJK) Regulation No.51/2017 is defined as a comprehensive support from the financial services sector to create sustainable economic growth by aligning economic, social, and environmental interests. Indonesia needs financial help from the private sector, especially the banking sector, in addition to the severely constrained state budget, to meet the 2060 NZE objectives.

15. Financial Services Authority/*Otoritas Jasa Keuangan* (OJK)
    Indonesian Financial Services Authority (OJK) is responsible for carrying out an integrated regulatory and supervisory system for all activities in the financial services sector. In the RE sector, OJK plays part in fostering green lending practices for financial services industry under OJK`s supervision, namely banking, capital market, and non-bank financial industry. OJK has worked with banks (under their authority) to promote green lending by providing technical assistance and capacity building. For instance, in 2014, OJK in collaboration with the United States Agency for International Development (USAID) created The Clean Energy Handbook. This guideline was created to assist Financial Services Institutions in assessing clean energy and RE projects such as mini hydro, biogas, biomass, solar photovoltaic, and wind power. Specifically in the wind power section, the handbook outlines the overview of wind energy sector in Indonesia, technology usage, project lifecycle, assessment process, investment and financial aspects of wind projects, and the project risk management. However, there is no further explanation of clear action steps on the investment guideline other than the basic technical parameters in estimated project costs.

16. Indonesian Wind Energy Society/*Masyarakat Energi Angin Indonesia* (MEAI)
    This community was established in 2008 and legally in 2010. The presence of this community is motivated by the absence of an organization that accommodates researchers, business practitioners, and educators who are concerned and interested in the development of wind energy in Indonesia. The members of this society are individuals, and its membership has not grown much. There are currently around 120 members. As this society is a non-profit organization, there is not much activity being organized by MEAI. However, MEAI is often invited by stakeholders such as the Indonesia Renewable Energy Society (*Masyarakat Energi Terbarukan Indonesia*/METI), MEMR and, PLN to share the research that has been done related to wind energy.

17. Indonesian Wind Energy Association/*Asosiasi Energi Angin Indonesia* (AEAI)
    AEAI was founded in 2014 with members from private developers and manufacturing companies in Indonesia's wind sector. This association was involved in developing wind-related regulations together with the Government.

18. Development Partners
    Some development partners have aided wind energy development in the country (see Appendix 2 in Chapter 0 for the complete list). Some examples include:

    a. Wind Hybrid Power Generation and Marketing Development Initiatives Indonesia (WHyPGen) project. This project was funded by Global Environment Facility (GEF) and United Nations Development Programme (UNDP). The project was started in 2012 with the objective of facilitating commercial on-grid WHyPGen systems for environmentally sustainable electricity supply. Moreover, this project was designed to remove the barriers towards larger use of wind energy for electricity generation.
    b. Mapping of Indonesia's Wind Resources. This project was an outcome of the partnership between the Government of Indonesia and Denmark. The Indonesian Wind Energy Potential Map was launched in 2017 and contains information about Indonesia's wind energy potential. This partnership is expected to help the government and business actors in determining areas that have the potential for wind energy development.
    c. European Union (EU) Delegation & EU Climate Dialogues. This institution provides a cooperation of a wide array of green projects, which include studies on offshore wind in Indonesia. To achieve the goal, EU works closely with some Indonesian government agencies related to energy sector, i.e., Bappenas and the Just Energy Transition Partnership (JETP) Secretariat. Specifically in wind energy development, the EU has ongoing activities including possible technical assistance and investment support (through the European Investment Bank).

19. Private developers
    The private sector has shown increased interest in the development and the implementation of wind energy over the years. These developers can act as IPP, who sell the electricity to PLN under a Power Purchase Agreement (PPA) scheme. Examples of these developers who are active in Indonesia are UPC Renewables, WPD, Vena Energy, Akuo Energy, Medco Power, etc.

20. Engineering companies, consultancy firms, and contractors
    For the development and realization of an onshore wind farm, many disciplines are necessarily involved (e.g. mechanical, electrical, civil, and infrastructure engineering). Hence, a variety of engineering and consultancy companies are typically involved throughout the wind project life cycle. For example, the planning and development stage involves at least consultants with expertise in construction, wind energy harvesting, grid integration, permitting, and environmental impact assessment. In the construction phase, contractors are required to deliver the wind farm components to the site, build the civil structures and foundations, and install the wind turbines as well as the supplementary electrical infrastructures. Whereas the wind industry is not mature in Indonesia, the dependency on foreign companies for all the beforementioned is now relatively high.

3 Regulatory framework of wind energy in Indonesia

The Government has issued various regulations concerning the utilization of RE which includes wind energy. The regulations are in the form of Laws, Government Regulations, Presidential Regulations, and Ministerial Regulations. The table below highlights some relevant regulations concerning wind energy development. Almost all regulations listed are applicable to all the four project stages as illustrated in Figure 5. The exceptions are regulations no. 34 and no. 35 which are limited to the construction phase only.

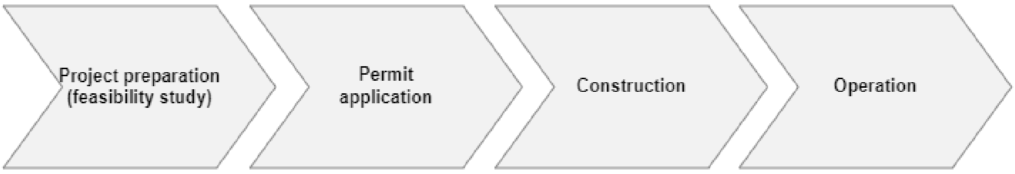

Figure 5: General project stages onshore wind farm development

Table 5: Regulations related wind energy development

No.	Regulation	Title	Description
	General		
1	Law No.30/2007	Energy	▪ This regulates energy resource management, energy reserve for energy security, authority of central and local government in regulating energy, National Energy Policy, General Plan for National Energy, and the establishment of National Energy Council. ▪ Energy accessibility in remote and underdeveloped areas use local energy sources, especially renewable sources.
2	Government Regulation No.79/2014	National Energy Policy	Target to increase the share of new and renewable energy in the primary energy mix to 23% by 2025 and 31% by 2050
3	Presidential Regulation No.22/2017	General Plan for National Energy	Description and plan for implementing the National Energy Policy which is cross-sectoral in order to achieve the National Energy Policy targets

No.	Regulation	Title	Description
	Electricity		
4	Law No.30/2009	Electricity	This law regulates the division of integrated electricity supply business areas, the application of regional tariffs which are limited to a certain business area, the use of electric power networks for telecommunications, multimedia and information technology purposes, and cross-country sale and purchase of power.
5	Government Regulation No.14/2012 *jo.* Government Regulation No.23/2014	Amendments to Government Regulation No.14/2012 on Electricity Supply Business Activities	This regulates conditions on electricity supply business.
6	Minister of Energy and Mineral Resources Regulation No.28/2012 *jo.* Minister of Energy and Mineral Resources Regulation No.7/2016	Amendments to Regulation of the Minister of Energy and Mineral Resources No.28/2012 on Application Procedures for Business Areas Providing Electricity for Public Interest	This regulates business licensing on provision of electric power for public purposes.
7	Minister of Energy and Mineral Resources Regulation No.35/2013 *jo* Minister of Energy and Mineral Resources Regulation No.12/2016	Amendments to Regulation of the Minister of Energy and Mineral Resources No.35/2013 on Business Licensing Procedures Electricity	This regulates licensing procedures for electricity companies, including business licensing provision of electric power for public purposes.
8	Minister of Energy and Mineral Resources Regulation No.24/2017	Mechanism for Electricity Generation Cost Stipulation of PT PLN	This regulates determination mechanism for electricity generation costs by PT PLN (Persero), excluding electricity transmission costs.
9	Minister of Energy and Mineral Resources Regulation No.39/2017	Implementation of Physical Activity on New and Renewable Energy and Energy Conservation	This regulates the physical activities of renewable energy utilization carried out by the relevant directorate.
10	Minister of Energy and Mineral Resources Regulation No.10/2017 *jis.* Minister of Energy and Mineral Resources Regulation No.49/2017 and Minister of Energy and Mineral Resources Regulation No.10/2018	Second Amendment to the Regulation of the Minister of Energy and Mineral Resources No. 10/2017 concerning the Principles of Electricity Purchase Agreements	This regulates Principles in the Electricity Purchase Agreement between PT PLN as off-taker and business entities as the electricity seller.

No.	Regulation	Title	Description
11	Minister of Energy and Mineral Resources Regulation No.35/2014 *jis.* Minister of Energy and Mineral Resources Regulation No.14/2017 and Minister of Energy and Mineral Resources Regulation No.30/2018	Delegation of Granting Authority to Electricity Business Licenses in the Context of Implementing One Stop Integrated Services (*Pelayanan Terpadu Satu Pintu*/PTSP) to the Head of the Agency Investment Coordination (*Badan Koordinasi Penanaman Modal*/BKPM)	This regulates the delegation of authority from the Minister of Energy and Mineral Resources to the Head of the Agency Investment Coordination (BKPM) which includes several permits.
12	Minister of Energy and Mineral Resources Regulation No.50/2017 *jis.* Minister of Energy and Mineral Resources Regulation No. 53/2018 and Minister of Energy and Mineral Resources Regulation No.4/2020	Utilization of Renewable Energy Sources for Power Provision	This regulates the purchasing process through direct appointment conditions, cooperation schemes, and assignment of electricity purchases to PT PLN for renewable energy power plant with funding coming from grants.
13	Minister of Energy and Mineral Resources Regulation No.20/2020	Power System Network Rules (Grid Code)	This regulates network management, connection, planning & execution of operations, power transactions, measurements, and a summary of operational schedules.
14	Presidential Regulation No.112/2022	Acceleration of Renewable Energy Development for Electricity Supply	This regulates the acceleration of the development of electricity generation from RE sources; the regulation includes the electricity purchase price for each RE source.
	Job creation		
15	Law No.11/2020	Job Creation	This regulation concerns job creation efforts from the Government with a goal of absorbing as much Indonesian workforce as possible amidst the increasingly competitive landscape and the demands of globalized economy.
16	Government Regulation No.5/2021	Risk-Based Business Licensing	This regulates risk-based business licensing, including electronically integrated business licensing system services (Online Single Submission/ OSS).
17	Government Regulation No.21/2021	Implementation of Spatial Planning	This regulates conditions related to spatial planning, space utilization, control of space utilization, supervision of spatial planning, guidance of spatial planning, and spatial planning institutions.

No.	Regulation	Title	Description
	Local Content		
18	Law No.3/2014	Industry	The scope of this regulation includes masterplan for national industry, national industry policy, industrial area, development of industrial infrastructures, industrial empowerment, permit, and capital investment.
	Fiscal Facilities		
19	Minister of Finance Regulation No.21/2010	Granting of Taxation and Customs Facilities for Activities Utilizing Renewable Energy Sources	Tax and customs facilities can be provided by the Government for activities of renewable energy sources utilization in the form of: a. Income tax facilities; b. Value added tax facility; c. Import duty facilities;
20	Minister of Finance Regulation No. 176/2009 *jo.* Minister of Finance Regulation No.188/2015	Exemption from Import Duty on Imports of Machinery and Goods and Materials for Industrial Construction or Development in the Context of Capital Investment	This regulates exemption from import duties on goods and services in accordance with applicable regulations.
21	Minister of Finance Regulation No.66/2015	Exemption from Import Duty on Imports of Capital Goods in the Context of Building or Expanding the Power Generation Industry for Public Interest	Exemption from import duties is granted for Capital Goods which are used for the power generation industry under certain conditions.
22	Government Regulation No.78/2019	Income Tax Facilities for Investment in Certain Business Fields and/or in Certain Regions	This pertains to the provision of income tax facilities for specific business fields. Investment in NRE is granted a one additional year of option to extend tax-loss carryforward.
23	Minister of Finance Regulation No.11/PMK.010/2020	Implementation Of Government Regulation No.78/2019 Concerning Income Tax Facilities for Capital Investment in Certain Business Fields and/or in Certain Regions	This regulation acts as the technical guideline on the tax facilities provided via Government Regulation No.78/2019, specifically on the entailed administrative requirements (to be submitted via OSS) to receive the facilities.
24	Presidential Decree No.10/2021 jo. 49/2021	Investment Business Field	The regulation provides an investment business list and prescribes that under certain conditions, power generation (>1 MW) can be open to 100% foreign investment and enjoy tax facilities.

No.	Regulation	Title	Description
25	Investment Coordinating Board (MoIn/BKPM) Regulation No.4/2021	Guidance and Procedure for Risk-Based Business Licensing Services and Investment Facilities	This regulation provides procedures and guidelines for risk-based business licensing services (based on OSS) and investment facilities (including customs facilities) which among others is applicable to the power generation sector.
26	Investment Coordinating Board (MoIn/BKPM) Regulation No.7/2020	Details of Business Fields and Types of Pioneer Industrial Production as well as Procedures for Providing Corporate Income Tax Reduction Facilities	This stipulates the new list of Indonesian Standard Industrial Classifications (*Klasifikasi Baku Lapangan Usaha Indonesia*/KBLI) which can be subjected to tax holidays; among others, the listed business field include industry that produces main component for power generating machines and NRE power plants (classified as economic infrastructure).
27	Minister of Finance Regulation No.35/2018 jo. No.130/2020	Granting of Corporate Income Tax Reduction Facilities	Under certain conditions, corporate income tax reductions can be applied to pioneering industries, industry that produces power generating machines and NRE power plants (classified as economic infrastructure).
	Environmental Management		
28	Law No.32/2009	Environmental Protection and Management	This regulates the planning, utilization, control, and management of hazardous and toxic materials as well as hazardous and toxic waste.
29	Government Regulation No.22/2021	Implementation of Environmental Protection and Management	This regulates environmental approvals, protection and management of water quality, air quality protection and management, protection and management of marine quality, control over environmental damage, hazardous and toxic chemicals waste management, and non- hazardous and toxic chemicals waste management.
30	Minister of Environment and Forestry Regulation No.4/2021	List of Businesses and/or Activities that are Required to Have Environmental Impact Analysis, Environmental Management Efforts and Environmental Monitoring Efforts or a Statement of Capability for Environmental Management and Monitoring	This regulates list of businesses and/or activities that are required to have various types of environmental permits.

No.	Regulation	Title	Description
31	Minister of Environment and Forestry Regulation No.6/2021	Procedures and Requirements for Management of Hazardous and Toxic Waste	This regulates waste management procedures of Hazardous and Toxic Waste.
32	Minister of Environment and Forestry Regulation No.7/2021	Forestry Planning, Changes in Forest Area Designation and Changes Functions of Forest Areas, as well as Use of Forest Areas	This regulates forestry planning, changes in forest area designation and function, and use of forest areas.
33	Minister of Environment and Forestry Regulation No.8/2021	Forest Management and Preparation of Forest Management Plans and Forest Utilization in Protected Forest and Production Forest	The scope of this regulation includes forest governance and preparation of forest management plans, forest utilization business licensing, forest utilization business, forest product processing, guarantee of legality of forest products, and non-tax state revenue from forest utilization.
	Transport		
34	Minister of Transportation Regulation No.48/2014	Procedures for Loading, Arranging, Transporting and Unloading Goods by Train	This regulates procedures for loading and arranging goods as well as unloading goods using train transportation. (Applicable to the construction phase only)
35	Minister of Transportation Regulation Number KM 44/2005	Implementation of Indonesian National Standards (SNI) 03-7112-2005 Regarding Aviation Operation Safety Areas as Mandatory Standards	This regulation pertains to the mandatory application of SNI on KKOP (*Kawasan Keselamatan Operasi Penerbangan*; applicable to the construction phase only)

3.1 Wind energy in the context of energy and electricity planning

The development of wind energy for electricity generation has been mentioned in the energy and electricity planning documents. Figure 6 illustrates the hierarchy of energy and electricity planning documents with respect to the regulations.

One of the important planning documents is RUEN, which is an energy management planning set up by DEN to fulfill the regional, inter-regional, and national energy demand. RUEN is the operationalization of the National Energy Policy (KEN). The latest RUEN was published in 2017, and its coverage extends up to 2050. In RUEN, the installed capacity of wind farm is planned to become 1.8 GW in 2025 and 28 GW in 2050 (equivalent to 46% of the total wind energy potential in Indonesia). The year-by-year installed capacity target can be seen in Figure 7. Another important document in electricity planning is RUKN (*Rencana Umum Ketenagalistrikan Nasional/*General Plan for National Electricity). This document is an indicative, high-level document for national electricity planning prepared by the Government based on KEN. This document covers electricity system planning in the generation, transmission, and distribution phases.

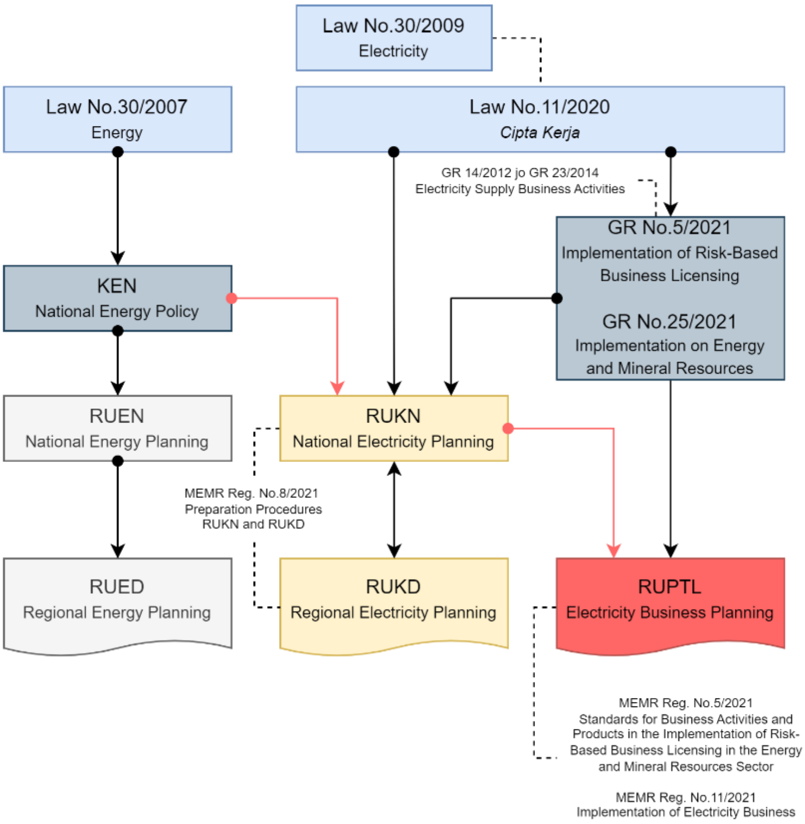

Figure 6: A depiction of Indonesia's regulatory framework for energy and electricity planning (Ministry of Energy and Mineral Resources, 2023a)

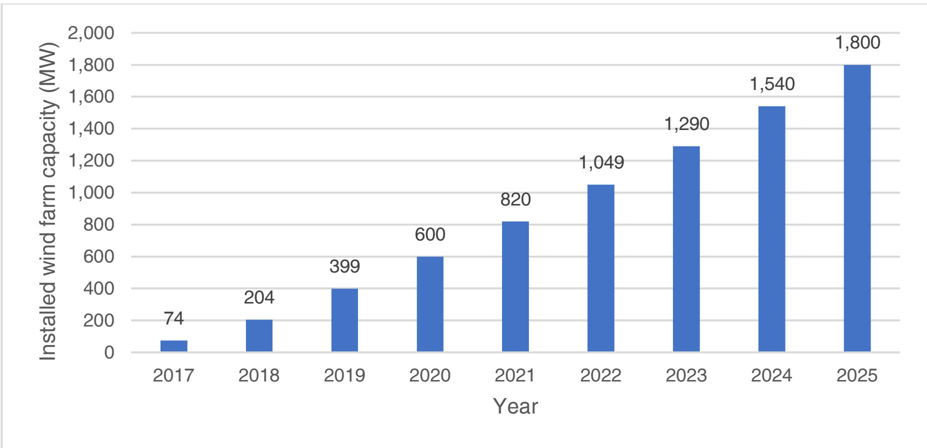

Figure 7: Planned installed wind farm capacity according to RUEN (Dewan Energi Nasional, 2017)

In addition to the Government's planning documents, a more concrete electricity planning document is represented by RUPTL. Similar to RUKN, RUPTL covers planning for electricity generation, transmission, and distribution, however, in greater detail. RUPTL is prepared by PLN and other business entities having a license to produce electricity. These license holders must formulate RUPTL using RUKN as the guideline. The RUPTL draft is then submitted to MEMR for approval. Implementation of electricity provision for public interest must be in accordance with RUKN and RUPTL. Hence, any wind farm project to be constructed shall be aligned with the goals set in RUKN and typically listed in the project procurement list of RUPTL. In this report, we only refer to PLN's RUPTL which is made publicly accessible.

RUPTL of PLN entails a 10-year development plan for the procurement of electricity generation, transmission, and distribution infrastructure. Hence, the document is an essential guide for business participants (including developers and contractors) to understand the current situation of the national electricity network as well as prospects and trends of new projects. For their execution, these new projects are allocated to either IPP or PLN.

The current so-called 'green' RUPTL is a guideline for PLN and IPPs in developing national power infrastructure and the country's transition toward RE. The latest version of the RUPTL is published for the period of 2021-2030 and issued as MEMR Decree No. 188.K/HK.02/MEM.L/2021. RUPTL 2021-2030 is based on detailed calculations of electricity demand and generation, as well as the required transmission and distribution infrastructure to meet the projected demand. Key insights from this RUPTL include:

1. RUPTL assumes an annual economic growth of 5.15 - 5.19%, with electricity demand projected to grow by an average of 4.9% per year.
2. During 2021-2030, the sector is anticipated to build a total of 40,575 MW of generation capacity, of which about 51.6% (or equivalent to 20,923 MW) is based on New and Renewable Energy (NRE) sources, and the remaining 48.4% (or equivalent to 19,652 MW) is based on fossil fuels.
3. To achieve the target of 23% of national electricity supplied from RE sources in 2025, PLN has planned infrastructure development that includes:
    a. 47,723 km circuit of transmission network with approximately 76,662 MVA of station transformers,
    b. 456,547 km circuit of distribution lines, and
    c. 31,095 MVA substation transformers.

RUPTL PLN 2021-2030 has set targets for installed wind farm capacity as presented in the Figure 8 and Table 6.

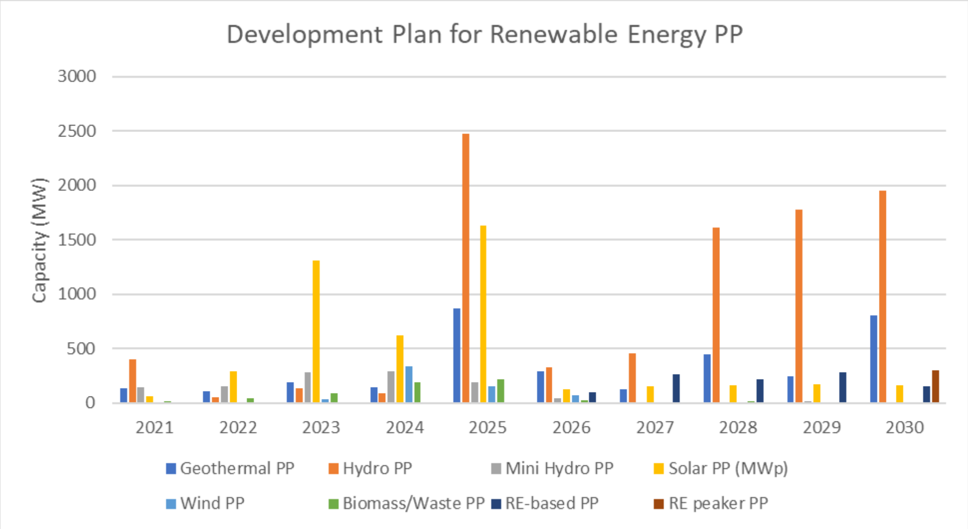

Figure 8: A graphical representation of the development plan for RE power plants as per RUPTL PLN 2021-2030 (PLN, 2021)

Table 6: Numerical description of the development plan for RE power plants as per RUPTL PLN 2021-2030 (PLN, 2021)

Type of RE power plant	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Geothermal PP	MW	136	108	190	141	870	290	123	450	240	808	**3,355**
Hydro PP	MW	400	53	132	87	2,478	327	456	1,611	1,778	1,950	**9,272**
Mini Hydro PP	MW	144	154	277	289	189	43	-	2	13	6	**1,118**
Solar PP	MWp	60	287	1,308	624	1,631	127	148	165	172	157	**4,680**
Wind PP	MW	-	2	33	337	155	70	-	-	-	-	**597**
Biomass/ Waste PP	MW	12	43	88	191	221	20	-	15	-	-	**590**
RE Baseload PP	MW	-	-	-	-	-	100	265	215	280	150	**1,010**
RE Peaker PP	MW	-	-	-	-	-	-	-	-	-	300	**300**
Total	**MW**	**752**	**648**	**2,028**	**1,670**	**5,544**	**978**	**991**	**2,458**	**2,484**	**3,370**	**20,923**

As can be seen in the table above, the plan for wind power development is targeted to reach a total of 597 MW during the period 2021-2030. However, until the moment of writing, there is 0 MW installed capacity based on RUPTL, since its release in 2021. The last wind farm installation was in 2019 (the Tolo 1 wind farm project), and since then, no additional wind farm capacity was added to the grid. At the time of writing, PLN has initiated the tender process of three wind farm development projects. These projects are Tanah Laut (70 MW, awarded but not yet under construction), Timor (20 MW, still in tender process), Aceh (55 MW, still in tender process). Assuming an ambitious commercial operation date of 2024 for all three, this would lead to 145 MW additional installed capacity, while the RUPTL above states the goal of having 372 MW additional capacity by the end of 2024. Furthermore, it is noteworthy that there is no plan for further wind farm development after 2026. It should also be noted that RUPTL serves as a guideline for electricity planning and project development, and that it is a dynamic document that can be adjusted as needed.

At the time of writing, the Government is preparing a new RUKN draft and once it is issued, a new RUPTL document will usually follow. It was also reported that PLN will readjust several assumptions in its RUPTL. Among others, the future electricity demand will be adjusted to current conditions considering that after the Covid-19 pandemic the increase in electricity demand is quite significant. This demand growth is in line with the potentially significant demand from the industry, such as the construction of processing and refining plants of mineral ore smelters, as well as the establishment of new industrial areas in some regions (Wahyudi, 2022).

3.2 Legal, licensing, and permitting aspects

Licenses and permits for wind power projects can be divided into three stages, i.e., development, construction, and operation. Each of these stages has specific types of licenses and permits which respectively have an expiry date and an issuing government body. The required licenses and permits for WPP development are summarized in Table 7.

Table 7: List of permits necessary for WPP development

No.	Permit name	Relevant authority to obtain the permit
1	Measurement Recommendation Letter	This can be processed directly through KKPR and Building Approval (PBG). The recommendation letter depends on the met-mast instrument location: if the tower is located nearby airport, it will need a permit (such as *Izin Kawasan Keselamatan Operasi Penerbangan*/KKOP) from the Office of Transportation (*Dinas Perhubungan*).
2	Research Recommendation	Depending on the research topic, an authority is responsible for issuing this recommendation. For example, if the research is performed in one village, the recommendation letter can be obtained from the Village Head. Meanwhile, if the research is conducted in multiple villages, the letter can be obtained from the Head of Sub-District (*Kecamatan*).
3	Regent Recommendation	Regent/*Bupati* office
4	Business Registration Number/*Nomor Induk Berusaha* (NIB) using OSS	NIB is issued by the Ministry of Investment (*Badan Koordinasi Penanaman Modal*/BKPM) after registering via Online Single Submission (OSS).
5	Letter of Support from regional government (e.g. Governor)	Governor office
6	Electricity Supply Business License for Public Use /*Izin Usaha Penyediaan Tenaga Listrik untuk Umum* (IUPTLU)	Directorate General of Electricity – the Ministry of Energy and Mineral Resources
7	Suitability of Space Utilization Activities/ *Kesesuaian Kegiatan Pemanfaatan Ruang* (KKPR)	Ministry of Agrarian Affairs & Spatial Planning/ National Land Agency (KATR/BPN), the process is performed via OSS, involving many government institutions and depends on the location case. For example if the location is near an airport, it will need approval from the local transportation office. If the location is near agricultural areas, it will need approval from the Ministry of Agrarian Affairs or Ministry of Agriculture. For Foreign Investment (PMA), the approval must come from the central Land Agency (BPN). But for domestically invested companies (PMDN), the approval can come from the regional Land Office (BPN) if one administrative

No.	Permit name	Relevant authority to obtain the permit
		district is involved. If the location crosses multiple districts, then the approval will be issued by the provincial Land Agency (BPN).
8	Research Permit	Depending on the research topic, an authority is responsible for issuing this permit. For example, if the research is performed in one village, the recommendation letter can be obtained from the Village Head. Meanwhile, if the research is conducted in multiple villages, the letter can be obtained from the Head of Sub-District (*Kecamatan*).
9	Environmental Feasibility License (*Surat Keputusan Kelayakan Lingkungan Hidup*) or AMDAL documents (≥ 50 MW)	Ministry of Environment and Forestry
10	Environmental Approval/*Persetujuan Lingkungan*	Ministry of Environment and Forestry
11	(If applicable) Approval for Use of Forest Area/*Persetujuan Penggunaan Kawasan Hutan* (PPKH)	Ministry of Environment and Forestry. The PPKH application process is conveyed through the OSS system. Usually, it will firstly need an MoU with the concession holder (such as PERHUTANI and INHUTANI), and then the approval for forest area use can be processed by the Ministry of Environment and Forestry.
12	Memorandum of Understanding in the Framework of Construction, Development and Operation of Wind Power Plant	This depends on the context of the MoU in which direction the cooperation is heading towards. It could be with the local government (Regent), the Provincial Government, PLN, PLN Indonesia Power, or PLN Nusantara Power.
13	Building Approval /*Persetujuan Bangunan Gedung* (PBG)	Office of Public Works and Spatial Planning Service (PUPR) and the Investment Board One-Stop Service (*Dinas Penanaman Modal Pelayanan Terpadu Satu Pintu*/DPMPTSP). The process has also been integrated with the Online Single Submission (OSS) Application.
14	Water Use Permit	Ministry/Office of Energy and Mineral Resources, Ministry/Office of Public Works. Groundwater use of more than 100 m^3 per month requires permission from the Ministry of Energy and Mineral Resources.
15	Operation Worthiness Certificate or *Sertifikat Laik Operasi* (SLO)	Ministry of Energy and Mineral Resources. This ministry has the list of accredited technical inspection agencies (*Lembaga Inspeksi Teknik*) that can issue the SLO.
16	Operation Permit /*Izin Operasi*	Ministry of Energy and Mineral Resources or Governor. An Operation License is a permit to provide electricity for one use. The Operation Permit is granted by the Minister of Energy and Mineral Resources if the installation covers cross-provinces, or the Governor if the installation covers cross-districts/cities.
17	Building Functional Worthiness Certificate or *Sertifikat Laik Fungsi* ("SLF")	Local Government – Office of Public Works and Spatial Planning Service (PUPR) and the Investment Board One-Stop Service (*Dinas Penanaman Modal Pelayanan Terpadu Satu Pintu*/DPMPTSP). The process has also been integrated with the Online Single Submission (OSS) Application.

3.3 Ceiling electricity tariffs for wind power

In 2022, the Government has introduced a new ceiling tariff for RE power plants to make RE projects in Indonesia more attractive. The wind power plant ceiling tariff as mentioned in Presidential Regulation No. 112/2022 can be seen in Table 8.

Table 8: Ceiling tariffs for wind power based on Presidential Regulation No. 112/2022 (F = location factor)

Capacity (MW)	Ceiling Price					
	≤ 5 MW		> 5 MW to 20 MW		> 20 MW	
	Staging Year 1-10	Staging Year 11-30	Staging Year 1-10	Staging Year 11-30	Staging Year 1-10	Staging Year 11-30
c$/kWh	11.22 x F	6.73	10.26 x F	6.15	9.54 x F	5.73
LCOE c$/kWh	9.41		8.60		8.00	

The table above shows that the prices are arranged according to size/capacity and staging. The first stage price was made higher in order to repay the acquired loan for the project (if applicable). The location factor (F) is determined based on the difficulty level of accessing the areas and their state of electricity development. The location factor value can be seen in Table 9.

Table 9: Value for location factor (F) based on Presidential Regulation No. 112/2022

No.	Region	F
1.	Jawa, Madura, Bali	1.00
	- Small Island	1.10
2.	Sumatra	1.10
	- Riau Island	1.20
	- Mentawai	1.20
	- Bangka Belitung	1.10
	- Small Island	1.15
3.	Kalimantan	1.10
	- Small Island	1.15
4.	Sulawesi	1.10
	- Small Island	1.15
5.	Nusa Tenggara	1.20
	- Small Island	1.25
6.	North Maluku	1.25
	- Small Island	1.30
7.	Maluku	1.25
	- Small Island	1.30
8.	West Papua	1.50
9.	Papua	1.50

3.4 Standards in wind energy technology

As reference and guidance for implementation of wind energy technology and projects, there are related standards which should be used. The list of Indonesian National Standard for wind energy are presented in Table 10.

Table 10: Indonesian National Standards for wind energy, adapted from (EBTKE KESDM, 2020)

No.	Standard Number	Title	Remarks
1	SNI 04-6612.1-2001	Wind energy conversion systems (*Sistem Konversi Energi Angin*/SKEA) - Part 1 Safety requirements for the design of SKEA structures	This standard relates to the philosophy of safety, quality assurance, and engineering integrity, and specifies the requirements for SKEA safety.
2	SNI 04-6612.2-2001	Wind energy conversion systems (SKEA) - Part 2 Safety requirements for control and protection systems, electrical systems, installation, assembly, and erection of wind turbines, commissioning, and operation	This standard relates to the philosophy of safety, quality assurance, and engineering integrity and specifies the requirements for SKEA safety.
3	SNI 04-6612.3.1-2002	Wind energy conversion systems - Part 3 Safety systems, protective and monitoring devices – Section 1 Control and safety systems	The scope of this standard is operations management and safety concepts established at the design stage within the framework of the Wind Energy Conversion System (SKEA) concept, to optimize operations and maintain installations in a safe condition in terms of equipment malfunctions.
4	SNI IEC 61400-2-2016	Wind turbines Part 2 Design requirements for small-scale wind turbines	This standard contains a philosophy of safety, quality assurance, and technical integrity, and establishes requirements for the safety of small-scale wind turbines including design, installation, and operation and maintenance under specified external conditions.
5	SNI IEC 61400-21-2016	Wind turbines Part 21 Measurement and assessment of power quality characteristics of grid-connected wind turbines	This standard includes recommendations on preparation for measurements and assessment of the power quality characteristics of grid-connected wind turbines.
6	SNI 8398-2017	Feasibility study guideline for wind power plant development	This standard is a guideline in conducting a feasibility study to determine the feasibility of on-grid and off-grid Wind power plant based on technical aspect assessments, infrastructure data studies, economic, financial, and socio-cultural aspects.

No.	Standard Number	Title	Remarks
7	SNI IEC 61400-12-1-2017	Wind energy generation systems – Part 12-1 Measurement of the performance of electrical power produced by wind turbines	This standard provides guidance for the measurement, analysis, and reporting of electrical power performance tests for wind turbines.
8	SNI 3851-1-2018	Wind Power Plant Terms Definitions Symbols and Classification Part 1 General	This standard provides terms, definitions, symbols, and classification of wind power plant systems.
9	SNI 3851-2-2018	Wind energy conversion system. Part 2 Guidelines for measuring wind speed and direction for basic calculations of power, wind energy and wind turbines	This standard contains technical guidelines and instructions for determining wind energy potential at a location.
10	SNI 6207-2018	Guideline for wind-diesel hybrid system configuration	This standard contains guidelines for the use of wind-diesel hybrid systems including basic concepts regarding system configuration and components in various usage configurations.
11	SNI IEC 61400-12-2-2018	Wind turbines – Part 12-2 Power performance of a wind turbine that produces electricity based on the installation of an anemometer in the nacelle	This standard establishes procedures for verifying the performance characteristics of single turbines that are not considered as small wind turbines.
12	SNI IEC 61400-26-1-2019	Wind power plant systems - Section 26-1 Availability for Wind Power Plant	This standard is intended to define a common basis for the exchange of information on availability indicators between owners, utilities, lenders, operators, manufacturers, consultants, regulatory bodies, certification bodies, insurance companies, and other stakeholders in the wind power generation business.
13	SNI IEC 61400-21-1:2019	Wind power plant systems - Part 21-1: Measurement and assessment of electrical characteristics–Wind Turbines ((IEC 61400-21-1:2019, IDT)	This standard outlines about measurement and assessment of electrical characteristic for wind power plant.
14	SNI IEC 61400-24:2019	Wind power plant systems - Part 24: Lightning protection (IEC 61400-24:2019, IDT)	This standard contains lighting protection for wind power plant.
15	SNI IEC 61400-25-1:2017	Wind power plant systems-Part 25-1: Communication for monitoring and Control of Wind Power Plants-Overall explanation of principles and modules	This standard contains communication for monitoring and control of wind power plants.

No.	Standard Number	Title	Remarks
16	SNI IEC 61400-25-5:2017	Wind power plant systems-Part 25-5: Communication for Monitoring and Control of Wind Power Plants - Compliance Testing	This standard pertains to communication for monitoring and control of wind power plants.
17	SNI 6612-3-1:2021	Wind Energy Conversion Systems-Part 3: Safety systems, protective devices, and monitoring-Section 1: Control and safety systems	This standard contains safety systems, protective devices, and monitoring.
18	SNI 9120:2022	Method for calculating wind energy potential	This standard provides a method for calculating wind energy in a location/region in relation to wind power plant development, especially for large scale, on-grid application.
19	SNI IEC 61400-1:2019	Wind power plant systems - Part 1: Design requirements (IEC 61400-1:2019,IDT)	This standard outlines the minimum design requirements for wind turbines to ensure the structural integrity of the wind turbine.
20	SNI IEC 61400-6:2020	Wind power generation systems: Part 6: Tower and foundation design requirements (IEC 61400-6:2020,IDT)	This standard sets out the general requirements and principles to be used in assessing the integrity of land-based wind turbine support structures (including foundations).

3.5 Policy regarding Local Content Requirements (LCR)

The Local Content Requirements (LCR) policy is applied to Engineering, Procurement, and Construction (EPC) projects that procure components, raw materials, construction materials, material handling, heavy equipment, and local assembly including services and combinations of products and services. LCR is a part of industrial policies and is aimed at protecting local industries, creating employment, boosting exports of goods, enhancing local innovation capacity, and supporting broader economic development in the country. Furthermore, LCR can be used as performance requirements for an industry. As stated in the Ministry of Industry Regulation No.48/2010, the targeted local content (*Tingkat Komponen Dalam Negeri/*TKDN) for electricity infrastructures is still limited to the following:

- Coal fired power plant
- Hydro power plant
- Geothermal power plant
- Steam gas power plant
- Solar power plant
- Electricity networks (transmission and distribution)

In addition to this, this regulation was amended to the Ministry of Industry Regulation No.54/2012 which to date, several regulations are amended to the Ministry of Industry Regulation No.23/2023 with specific percentage for Solar power plant only (not wind energy).

There is not yet a specific LCR for wind power plants. However, there are concerns among IPPs that LCR will become applicable to wind projects too. This could cause major problems because most wind turbine components such as the rotor, blades, hub, gear box as well as electrical components such as the generator and transformer can only be produced by limited or certain manufacturers which are not yet present in Indonesia. Before such manufacturing in Indonesia becomes interesting for these manufacturers, a mature wind industry first needs to be established to create sufficient demand. If LCR is hampering wind energy development, a grid lock may arise because of it.

3.6 Environmental requirements

Referring to the regulations for RE implementation, the environment surrounding the envisioned WPP must be assessed prior to the installation, during installation, as well as in the post-installation to anticipate for and avoid for possible negative impacts to the environment. The Minister of Environment and Forestry Regulation No.4/2021 mentions that WPP projects are required to have environmental documents depending on the size of the planned WPP as follows:

- Statement Letter of Environmental Management or *Surat Pernyataan Pengelolaan Lingkungan Hidup* (SPPL) for wind power plants less than 1 MW
- Environmental Management Efforts and Environmental Monitoring Efforts or *Upaya Pengelolaan Lingkungan dan Upaya Pemantauan Lingkungan* (UKL-UPL) for wind power plants between 1 MW to 50 MW
- Analysis Regarding Environmental Impact or *Analisis Mengenai Dampak Lingkungan Hidup* (AMDAL) for wind power plants greater or equal to 50 MW

3.7 Land acquisition and impact on the area

Land availability is one of the most critical points for the establishment wind farms in Indonesia. Therefore, it is crucial for the developer to investigate the following factors at the envisioned site:

- Type of land and physical conditions: land area and terrain conditions (flat, hilly, obstacles, land coverage, etc.);
- Land use and land cover;
- Land status and ownership;
- Land acquisition options: rent or long-term leasing agreement, purchasing from the owner including price of land per ha;
- Land access including available access roads, transmission lines, etc.;
- Legal aspects of the lands including policies, rules, permission, and laws;
- Regional development program, etc.;
- Nearest point of connection to the (PLN) grid.

Aside from the actual land required to build the wind farm, in the development stage, it is vital to also determine the impact of the wind farm on the area and the surrounding land. Therefore, the following factors should be thoroughly investigated for the envisioned wind farm:

- Existing airports in vicinity of the planned area to anticipate the impact of radio communication signal interferences, danger for approaching aircrafts, etc.;
- Nature conservation areas and impact on the biodiversity (e.g. bird casualties due to the wind farm);
- Social circumstances in the area (e.g. livelihood of the local people) and the possible impact due to the envisioned wind farm;
- Cultural heritage;

- Military area such as for military training, camping, etc.;
- Compatibility with the latest Regional Spatial Planning or *Rencana Tata Ruang dan Wilayah* (RTRW) in relation to forest conservation, agricultural area, settlement, and regional development.

3.8 Carbon Credits

In 2021, the Government has issued Presidential Regulation No.98/2021 on the Implementation of Carbon Economic Value for Achieving Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development. This regulation is expected to mobilize more green financing and investment which will have an impact on reducing greenhouse gas (GHG) emissions. Carbon credit (CC), carbon trading, or carbon emission credit is a mechanism designed to provide an economic incentive to reduce GHG emission, mainly carbon (CO_2) emissions, using a trading scheme as one of the main measures for achieving emission reduction targets.

CC, also known as carbon offsets or Verified Emissions Reductions (VERs), are tradable instruments certifying that one ton of carbon dioxide (CO_2) equivalent (CO_2e) has been avoided or removed from the atmosphere; one ton of CO_2 is equivalent to one credit. Therefore, CC is the result of emission reduction due to project implementations in industry, cleaner transportation, and emission-reducing energy projects including RE. The credit produced by a project could be sold and used by the buyer. The incentive for such a buyer to buy CC is to offset its own carbon emissions to be compliant with the organization's sustainability targets or to prevent carbon taxing. As agreed in the Paris Agreement, the target of 31.9% unconditional emission reduction (as Business-as-Usual scenario) and 43.3% by international support in 2030 is the commitment of the Government as Nationally Determined Contribution (NDC) toward NZE in 2060.

CC is issued by certifying institutions with scientifically sound methodologies. This credit offers a reliable way to offset, document, and report voluntary compensation for residual GHG emissions, and thus, substituting GHG emissions produced from (for example) fossil fuel power plants. The emission reductions would be represented by a Certificate of Emission Reduction (CER) whose value depends on the size of a power plant. Named as 'IDXCarbon', the Indonesian marketplace for CC was established in September 2023.

There are several types of carbon offsetting projects, all of which either aim to avoid GHG emissions or remove them directly from the atmosphere, and in RE infrastructure, these projects aim to install RE power plants in suitable locations, and thus improving the local prevalence of clean power.

The benefits of carbon credits are:
- To support the purpose of public policy for reducing of carbon emission in any sector including the energy sector;
- To improve the air quality, such as reducing air pollution from coal fired power plants;
- To motivate for low carbon technology;
- In the energy sector (for PLN), to substitute for carbon emission produced by conventional power plants by implementing the green or RE based power plants by the scheme of carbon credit (RE certification).

For wind power plants, the size of the wind farm and its characteristics (load characteristics or capacity factor) will affect the emission reduction (in tons) to prevent the carbon emission produced (ECP) by conventional power plant such as coal fired power plants. Calculating ECP values from PLN coal power plants is used as avoided cost for reduction of GHG emissions and will be the benefit of PLN. However, there are ongoing discussions with developers whether it should be PLN or the owner of the RE plant (i.e. wind farm) that can either sell the carbon credits from the plant or use it for its own carbon offset. In the current regulations it is decided that it is PLN that owns the carbon credits. While, in other countries (like the Netherlands), it is the plant owner who is eligible to do this, not the grid operator.

4 Challenges in wind energy development

There are various challenges that prevent Indonesia's wind energy potential from being developed to its fullest. These challenges are determined and summarized based on the feedback provided from multiple stakeholders, such as investors/developers, as well as a literature review from past studies. These challenges can be classified into several categories as shown in Table 11.

Table 11: Classification of challenges in wind energy development

Category	Description	Consequences	Urgency to overcome barriers
Wind data availability	• Limited availability of accurate long-term wind data • High level of uncertainty of mesoscale models as the alternative to long-term wind data • Financial burden of investments for wind measurements during tender processes by developers • Lower probability to reach financial close for a project due to uncertainties in wind data • Unpredictability of wind behavior during wind farm operation, resulting in difficulties for PLN to predict electricity production	Wind data has the highest priority in a wind farm's business case, and thus, these challenges create a high risk profile for developers and investors to step into wind energy development in Indonesia. This risk profile leads to either higher costs (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required
Availability of spatial data and standardized processes	• Absence of a clear Indonesian guideline on the analysis criteria and considerations for the technical, environmental, and social impact of a wind farm • Lack of accessible and consistent digital or high-resolution spatial (planning) data to support screening of potential locations and designing wind farm layout • Lack of standardization in the development process, including minimum prerequisite studies, feasibility study guideline, etc.	The unavailability of spatial data hampers not only the developers, but also the stakeholders in determining the optimal location for wind farm development. Without standardized processes, duration of project development can get extended, and difficulties may arise when comparing bids.	Short term solution required
Policy/Regulation and Permitting	• Uncertainty and frequent change of policies by the Government have created risks for investors and may impact the financial viability of projects • Inconsistent implementation of existing regulations • Delays in permitting process and land acquisition	For long-term investments (e.g. a pipeline of projects), developers and investors require a stable regulatory environment before entering into a country. These challenges create a high risk profile for them to enter Indonesia, and in turn, this condition leads to either higher cost (e.g. higher interest rates) or parties starting to invest somewhere else.	Medium term solution required
Research and Development	• Lack of Research and Development (R&D) activities for wind energy development and deployment to build a mature sector in Indonesia.	Without a proper knowledge base on wind energy in Indonesia, larger long-term challenges (e.g. wind data availability, grid stability, and local supply chain) cannot be solved properly or only with the support from outside of the country.	Long term solution required
Industrial Capacity	• Large investments and a pipeline of projects required for setting up a local supply chain • Lack of local knowledge on the technology • Limited skilled local workforce available	Being dependent on technology from foreign countries creates a vulnerability in terms of cost increase, quality assurance, and geo-political challenges. Furthermore, it could entail a missed opportunity for Indonesia to increase the labor welfare in this sector.	Long term solution required

Category	Description	Consequences	Urgency to overcome barriers
Infrastructure	• Sites with wind energy potential are not always near a well-developed grid; lack of transmission and distribution system infrastructure • Hard to ensure the stability and reliability of wind power given its intermittency; whereas BESS (battery energy storage system) is still relatively expensive to produce and integrate with wind power plants • Lack of supporting infrastructure such as port and road access	Absence of proper infrastructure could increase the project development costs, since the costs would have to include infrastructure improvements (which also lengthen the project duration). If these costs have to be carried by the project developers and are too significant, the feasibility of such projects could drop and hold/stop the project development.	Long term solution required
Financing & Bankability	• Suboptimal impact and support provided by existing fiscal and non-fiscal regulations to investments in wind energy • Perception of wind project investments in Indonesia as 'risky and slow', especially concerning the bankability of the unequally balanced PPAs between PLN and the developer	Before developers and investors decide to make large investment in a wind energy project in Indonesia, they require the right incentives and a well-balanced PPA to ensure a reliable business case throughout the project lifetime. If this business case cannot be guaranteed, they will perceive the project as having a high risk profile. In turn, this risk profile leads to either higher cost (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required
Procurement Mechanism	• Uncertain and unclear PLN procurement process of wind projects, bringing considerable risks for the developers	For long-term investments (e.g. a pipeline of projects), developers and investors require a stable, reasonable, and transparent procurement process before entering a country and starting to bid on projects. If this process cannot be offered, they will perceive the project as having a high risk profile. In turn, this risk profile leads to either higher cost (e.g. higher interest rates) or parties starting to invest somewhere else.	Short term solution required

4.1 Wind data availability

The limited availability of accurate long-term wind data is challenge for wind energy development in Indonesia. In other countries, such data may be available from local weather stations. Nonetheless, the data is not openly available in Indonesia. This limitation makes it difficult to identify potential locations with suitable wind speeds. To overcome the limitation, the Government and developers use wind speed maps to look for the best wind sites. A commonly used wind map is Global Wind Atlas, which is owned and operated by the Technical University of Denmark. These maps provide information on wind characteristics in various regions across the globe. The characteristics are exemplified by average, maximum, and minimum wind speed. In turn, they can be converted into power density maps (W/m^2) and annual energy production maps (kWh/m^2). These maps can be useful as the basis for site selection. However, the accuracy of these maps is much lower than actual wind measurements at specific sites, due to the mesoscale modeling being used. Global Wind Atlas explains this as follows in their FAQ: "Mesoscale modeling is modeling the atmosphere's complex flows and weather features so that weather systems and weather fronts are well described and modeled. However, mesoscale models are too coarse to accurately describe the flow over hills and ridges. Typically, mesoscale models have a grid spacing ranging from 1 to 10 km . This means that terrain is often oversimplified by the grid spacing in mesoscale models" (Technical University of Denmark, 2023).

A region can be selected for wind energy development based on promising wind speeds as illustrated in the map. However, the actual wind resource on each envisioned wind turbine location can deviate significantly from the average wind speed shown in the map (in both positive and negative sense). This deviation often occur in Indonesia in which hills and ridges (as mentioned before) are very common in areas with higher wind speeds. A good example for this is illustrated in Figure 9, namely, the area of Tanah Laut wind project (ongoing procurement by PLN). Based on the wind map (left image), the area looks very promising. Nonetheless, based on this map alone, it is very difficult to predict real wind behavior at this location because of the rugged terrain (right image). The hills and ridges make it difficult to predict the wind behavior using mesoscale modeling. In other words, the pinpointed location on the map with 8.12 m/s average wind speed entails very high uncertainty. To decrease this significant uncertainty, on-site wind measurements for a certain period are always necessary in Indonesia (and obligatory for PLN tenders).

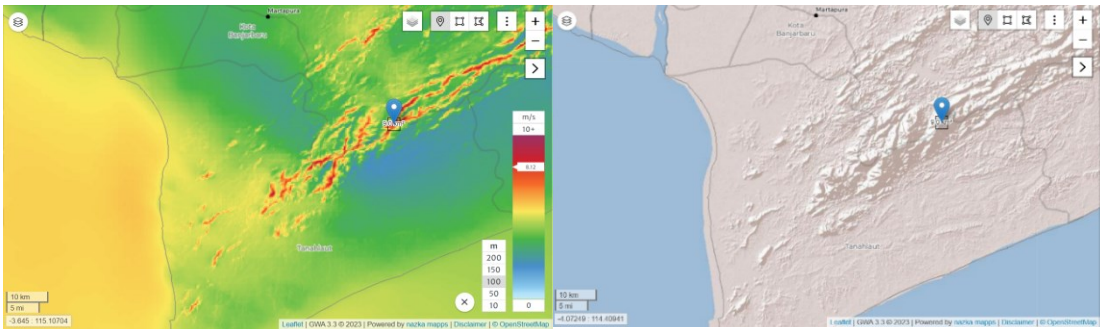

Figure 9: Wind- and terrain map Tanah Laut South Kalimantan (Technical University of Denmark, 2023)

In Indonesia, these on-site measurements are generally initiated and conducted by wind farm developers. However, there are other parties that also perform the measurements, such as:

- Center for Electricity Survey and Testing, New, Renewable Energy and Energy Conservation (BBSP KEBTKE) is a government institution under MEMR that has performed calculation of wind energy potential and created wind energy potential map of Indonesia. The map can be accessed through MEMR geoportal, for which the third edition was launched in 2021. The agency has installed meteorological masts (met mast) at more than 30 locations, ranging from 30 to 100 meters in height, in several provinces across Indonesia. These masts were erected for data collection over several years and have been dismantled afterwards. This collected wind data is not openly accessible, but it can only be accessed in a processed form via the wind map of MEMR.
- Other government institutions and development partners have executed wind measurements at various heights to expedite the utilization of wind energy at more than 200 locations throughout Indonesia. Examples of these institutions include LAPAN, BPPT, P3TKEBTKE-ESDM, WIND GUARD, SOLUZIONA, NIPSA, and WHyPGen. Some of this wind measurement data are openly accessible, whereas the majority are used as input for further research and studies.

Although these wind measurements activities help the wind sector in general, dedicated wind measurements are still required for specific projects. This is because wind measurements need to comply with international standards for the results to be used in PLN tenders and for project financing purposes. For example, the measurement shall be done at a suitable height (preferably at hub height of the envisioned wind turbine) and for a certain duration. Such project specific measurements are conducted frequently throughout Indonesia by IPP developers (e.g. UPC Renewables, Akuo Energy, and Egeres) who aim to participate in PLN tenders. Because of the investments required for these wind measurements, IPP developers regard the resulting data as confidential and do not allow its sharing with third parties.

To understand the necessity for obtaining wind data with good quality, the subsection explains how wind resource assessments are conducted. The measurement is regarded as a vital step in every wind farm development.

4.1.1 Conducting Wind Resource Assessment

For utility-scale projects, there are normally 3 steps of Wind Resource Assessment (WRA) conducted during development stage. The first step is to define the most appropriate location to develop the wind farm. Mesoscale modelling is usually used for this purpose. The model is derived from openly available global meteorological reanalysis data, such as Modern-Era Retrospective Analysis for Research & Applications (MERRA) and ERA5. Based on this data, further modelling runs are conducted to obtain higher levels of resolution and include climate effects. The final modelling run will usually cover a minimum of 10 years of historical wind data for each grid cell in the country, at multiple heights, down to a frequency of 10 minutes. As explained above, mesoscale modelling has significant limitations and therefore, the second step is vital.

As the second step, developers must validate the mesoscale model by acquiring wind data at the location itself. This wind data can be gathered using a met mast, SODAR, or LiDAR installed at one or multiple locations (depending on the consistency of the terrain) within the envisioned project location. If developers wish to participate in tenders, the wind data recorded should cover a minimum of one year of continuous measurement. When installing these met-mast instruments, developers must adhere to a set of regulations as defined by IEC 61400 and Measuring Network of Wind Energy Institutes (MEASNET) guideline. MEASNET is an international organization consisting of several companies engaged in the field of wind energy. The members established MEASNET to perform mutual and periodical quality assessment for harmonizing and preparing uniform interpretation of measurements standard and evaluation. Normally, the wind potential data collected by developers is proprietary and not for public use. This is because wind measurements entail a significant development cost, which can range from 1.5 to 2 billion Indonesian Rupiah per met mast tower according to various sources. The rental of LiDAR or SODAR for wind measurements also has a similar range of development cost.

As the last step, once the data from the met mast is gathered, long-term wind data is needed to correct and predict long-term wind data variation. This long-term data is usually acquired from meteorological weather stations. Mostly for Indonesian market, due to the absence of local long term-wind data which can fulfil the requirements from IEC 61400 and MEASNET guideline, secondary data are then used from various sources, such as Vortex LES (Large Eddy Simulation), ERA-5 (European Centre for Medium-Range Weather Forecasts Reanalysis v5), and MERRA-2 (Modern-Era Retrospective Analysis for Research & Applications). However, usage of secondary data entails uncertainty for calculating the annual energy production (AEP), when correlating short-term to long-term data. This uncertainty needs to be transparently included in the WRA and the subsequent yield calculation. This last step should be conducted by an independent consultant to ensure bankability of the result, especially when the project is pursuing non-recourse project financing from international lenders.

4.1.2 Challenges in wind data availability

Based on the numerous interviews conducted in this research, the following challenges on wind data availability were identified:

- The identification of potential wind sites in Indonesia is challenging for project initiators, researchers, and the Government because of the limited availability of accurate long-term wind data.
- Using mesoscale models as alternative for long-term wind data brings high level of uncertainty because of the limited ability to model complex terrain, which is often the case in Indonesia.
- The competitive tendering system requires each developer to conduct “the same” wind measurements at the project locations. For each project tender that a developer considers participating in, a significant investment is required for conducting wind measurements and WRA. The investment is even higher at projects with complex terrains, where developers must install and operate more than one wind measurement campaign. It is noteworthy that wind measurements are conducted in the early stage of the project which is associated with high levels of uncertainty on whether the project will materialize or not. Aspects that contribute to such uncertainty include: will and when the project be tendered, how much competition is there, and what are the tender requirements? For the developers that do not win the tender process for a particular wind project, these measurement costs must be written-off (in addition to all other costs for preparing the bid). In the long-term, this could lead to a significant financial burden for developers and unwanted behavior in projects (e.g. cost claims discussions to compensate for past losses).

- In general, the uncertainty of AEP for wind projects in Indonesia is quite high due to a lack of long-term data that can be used for correlating and validating wind data. This and other uncertainties lower the P50 and P90 values of the AEP, which lowers the probability of achieving financial close for the project.
- The unpredictability of the wind behavior at complex terrains in Indonesia is not only challenging in the development stage, but also in the operation stage. For PLN, it is important to determine how much electricity production can be expected from the wind farm for the coming hours and days so they can take the appropriate measures to keep the grid stable (electricity from the wind farm is intermittent). Without sophisticated, high-certainty prediction models, achieving grid stability remains a challenge for PLN, and consequently, this condition makes them likely to act conservatively by, for example, performing preventive curtailing of the wind farm's power output.

4.2 Availability of spatial data and standardized processes

4.2.1 Guidelines on wind farm impact

For the development of a wind farm, the impact of the wind farm on the surroundings needs to be considered. Although wind power plants produce zero carbon emission, they are likely to produce other impacts on the environment and society, mainly due to its visual nuisance (including shadow flickering), noise, and safety concerns for the local community. Currently, there is not yet a clear and specific guideline applicable in Indonesia on how all these impacts should be analyzed and considered in wind farm development. For example, the minimum distance from a wind turbine to residential areas is not yet defined. Such guidelines are necessary to prepare the wind farm layout. Below are several reasons why the preparation of a proper wind farm layout is essential:

- A proper layout preparation removes any constraints that may hinder the project from being funded by international lenders, particularly those related to the project's environmental and social factors.
- The preparation can optimize cost, time, and effort spent by the developers/investors during development stage. For permitting process (KKPR), wind farm layout is one of the requirements for getting the approval. In the case of an improper layout, the overall process will need to be revised, and this adds unnecessary time and cost.
- The preparation avoids potential conflicts between developers and industry owners. There are often cases where more than two companies apply for permitting for the same area, or where a mining area reserved for future development is identified within a wind power plant area. These possible overlaps might raise conflict between investors and industry owners.

4.2.2 Spatial data

Several types of geospatial maps are required during the development stage to properly define the wind farm layout. Examples of these maps include wind speed maps, land use maps, forest area maps, topographical maps, and natural hazard maps. All these maps must be obtained from reputable secondary sources. In Table 12, an overview is given of the required spatial planning maps to design wind farm layouts, and the maps' limitations in terms of availability. When acquired, the data is then processed and overlaid in GIS software to determine the available area for wind farm development. Exclusion criteria are determined in accordance with the minimal requirements and international standards (in the absence of Indonesian standards) for establishing wind power plants.

However, some information/maps are not digitally available, complicating the process of designing the layout and identifying the area for wind power development. Furthermore, obtaining these maps needs to be done through a variety of local and national governments, each with its own procedures.

Table 12: List of spatial planning maps required for wind turbine layout

Category	Exclusion area or evaluation criterion	Indicative Responsible Institution	Status
Environmental	National Park	MoEF	Data is available at MoEF website such as sigap.menlhk.go.id or SIMONTANA KLHK; however, the data cannot be downloaded.
	Nature Conservation Area		
	National wildlife protection area		Not digitally available
	World heritage site		Not available
	Birds and bats conservation area		Not digitally available
Environmental	Bird migratory path (indicative)		Not digitally available
Infrastructure	Roads	Ministry of Public Works and Housing or *Badan Informasi Geospasial* (BIG)	Data can be accessed via BIG portal; however, high resolution data are not available especially for areas outside of Java Island.
	Highway		
	Railway		
	Airport		
	Port		
	Industrial area	Ministry of Public Works and Housing or Office of Land-use Planning (regency)	Not digitally available
	Future highway	Ministry of Public Works and Housing or BIG	Not digitally available
Nature	River	Ministry of Public Works and Housing or BIG	Currently available
	Lake	BIG	Currently available
	Ocean (Shoreline)	BIG	Currently available
	Mountain	BIG	Currently available
	Volcano	BIG	Not available
Land-Use	Protected Forest	MoEF	Data is available at MoEF website such as sigap.menlhk.go.id or SIMONTANA KLHK; however, the data cannot be downloaded.
	Production Forest	MoEF	
	Farmland	Office of Land-use Planning (regency level)	Regional maps on Land-use Planning are available in the website of the Ministry of Agrarian Affairs and Spatial Planning (atrbpn.go.id)
	Settlement Area		Not digitally available
	Tourism Place		Not digitally available
	Mining		Not digitally available
	Local Cultural Heritage		Not digitally available
Grid	150 kV Substation	PLN	Not digitally available

Category	Exclusion area or evaluation criterion	Indicative Responsible Institution	Status
	150 kV Transmission Lines		
	Distance to the grid (transmission lines < 30 km)		
Disaster	Tsunami risk	National Disaster Management Authority (*Badan Nasional Penanggulangan Bencana*/BNPB)	Currently available
	Soil Movement risk		
	Earthquake risk		
	Flood risk		
Other	Slope Terrain	BIG	Data can be accessed via BIG portal; however, high resolution data are not available especially for areas outside of Java Island.
	Wind speed map	MEMR	Due to the higher accuracy, external data (e.g. ERA-5 and Vortex LES data are currently used) is preferred over EMD Danida (produced in collaboration with MEMR)

Based on the discussions with wind farm developers, the absence of qualified digital map/data makes it difficult to map the locations of dwellings. Moreover, it is also difficult to precisely determine the migration routes of birds. Without such data, uncertainties remain present in the projects while it is preferred to mitigate the uncertainties early on. Not mitigating these uncertainties could have a substantial impact on the project. For example, if at the later stage of a project, it becomes clear that a wind turbine is too close to a dwelling area, the lender may request to remove the turbine or reduce the operational hours of the turbine. Hence, wind farm yield will be curtailed, and in turn, this creates a negative impact on the project's profitability and bankability.

In some cases, when digital maps are available, the resolution might not be sufficient. This could reduce the accuracy of results of the spatial data analysis. One example is the Digital Elevation Model from the National Geospatial Information Agency (*Badan Informasi Geospasial*/BIG) which shows the slope and complexity of a terrain. The open-source map available from BIG has 1:50,000 resolution, which is workable for flat terrain. However, in locations where the terrain is quite hilly and complex (e.g. elongated ridges), a higher resolution map is needed. In most cases, an additional topographical survey is still required to verify the resulting wind farm layout.

The challenges above highlight the importance of having high quality, digital spatial data to create a proper wind farm layout, which can fulfill the mandatory requirements for permitting processes (KKPR or PPKH) and the requirements from investors/lenders.

4.2.3 Standardized development process

In addition to the need for proper guidelines for analyzing the environmental and social impacts of wind farms in Indonesia, several interviewed parties mentioned the need for a standardized wind farm development procedure. In the absence of such standards, each initiator or developer uses its own methodology to conduct a feasibility study, set up a business case, select the most suitable suppliers and manufacturers, etc. before the wind project tender is conducted by PLN. When the tender is eventually commenced, all executed studies and collected data are mandated to fulfill the requirements as stipulated in the tender documents. Consequently, there is a considerable risk of mismatch between the executed development methodology and the required methodology. This condition makes wind farm development unnecessarily complex and risky. Additionally, the missing standards might also lead to the lack of quality of results from the development activities. A standardized development process is thus needed to uphold quality and reduce risk of wind project development.

4.3 Policy/regulation and permitting

Currently, some regulatory frameworks are already in effect (see Chapter 3). However, according to some wind project developers, the main challenge encountered in the investment and development of RE projects is the frequently changing regulations. This adds uncertainty to the developers since regulations might change during the execution of project, which could affect the appetite of the investors and the financial feasibility of the project. An example of the changing regulations is on the RE tariff, for which the chronological order of changes over the past 8 years is described below:

- Under MEMR Regulation 50/2017, the offered RE tariffs were determined based on the electricity production cost (*Biaya Pokok Penyediaan*/BPP) for each region. According to investors, this regulation introduced uncertainty as the BPP is updated annually and could potentially waive the real and true costs of generation - via the subsidies afforded to coal and diesel fuel. (Percentage of) the BPP is set as the maximum allowable PPA tariff.
- In several wind project Request for Proposal (RfP) documents issued after 2017, PLN indicated an owner-estimated tariff that was lower than the tariff stipulated in MEMR Regulation No. 50/2017. IPPs are obligated to bid lower or equal to the owner-estimated tariff.
- In 2022, Presidential Regulation No. 112/2022 regarding the Acceleration of Renewable Energy Development for Electricity Generation was issued. According to this regulation, the electricity purchase price is based on staged ceiling tariffs, which will be evaluated annually by the MEMR.

A specific challenge within both the old and existing regulations is that they allow a negotiation process to take place between PLN and the developers about the electricity purchase tariff. But because PLN is the monopolist in the grid sector, the developers have a weak position at the negotiation table. The developers could feel pressured to bid tariffs as low as possible in tenders to acquire a wind project (without having the sight on when the next projects will be tendered). Consequently, this could lead to a business case which is no longer bankable or affects the financial stability of the project. Moreover, the agreed electricity tariff sets the benchmark for future similar projects tendered by PLN, i.e. PLN expects the same tariff (or even lower) for the next projects although the project specifications and conditions can vary significantly.

From the permitting side, the Government has implemented permit simplification through the Online Single Submission system (OSS). This system was introduced to streamline the permitting process for various business activities including RE power plants. However, the specific requirements and processes may vary depending on the location and the scale of the project. Some permits require lengthy processing time and involve many government institutions or officials. It is essential to work closely with the local stakeholders, diligently adhere to all applicable regulations, and maintain open communication throughout the project's lifespan.

One of the permits that has become challenging for developers is the issuance of KKPR, which gives permission for the developer/investor to conduct land acquisition for areas more than 1 ha. Obtaining land permits for a WPP project in Indonesia can be a complex and challenging process due to a variety of factors, including legal, environmental, social, and regulatory considerations. After OSS was introduced, all processes for KKPR issuance are managed by the Central Government, including the Ministry of Agrarian Affairs and Spatial Planning (*Kementerian Agraria dan Tata Ruang*/*Badan Pertanahan Nasional* or KATR/BPN), who mainly deals with land acquisition and certification process. Due to many requests from investors in different sectors, there is a long queue in the KKPR process to be managed centrally by KATR/BPN in its Jakarta office. The approval duration for this process is also longer than specified in the regulation. The reason for having a very long queue of documents on their desks seems to have become the excuse for this lengthy process.

The lengthy process is also sometimes coupled with overlapping land rights. Based on interviews with the developers, it is found that in Indonesia, ownership of specific land can be claimed by multiple parties. Furthermore, a piece of land is often allocated for various purposes, such as agriculture, forestry, or traditional community use. This situation can result in extended project timelines and escalated costs. Therefore, it is important for developers to work closely and deal with the different stakeholders and ensure compliance with central and local regulations to secure the land permit (KKPR) for the wind farm.

Finally, it is noteworthy that the subsequent deliverable under the project of which this roadmap is part (Wind Energy Development in Indonesia: Investment Plan), will include a more thoroughly assessment on the permitting procedure for onshore wind including barriers and recommendations.

4.4 Research and Development (R&D) activities

Globally, R&D activities have proven to be effective in bringing the renewables costs down, increasing technological capabilities of local RE technology manufacturers, and enhancing the competitiveness of RE technologies in global and local markets. Unfortunately, R&D activities in Indonesia are still very limited. For instance, the listed wind energy potential in RUEN (60.6 GW) has not considered any restrictions for WPP development. One of the important yet neglected restrictions is the Strategic Environmental Assessment (*Kajian Lingkungan Hidup Strategis*), which is mandated by the Ministry of Home Affairs in regional development planning. Apart from that, there is also a lack of studies conducted by local institutions, while long-term, fundamental research is usually the role of the public sector and primary focus of public R&D initiatives.

There are three main fundamental challenges which will need further R&D and strategic studies to reach a successful implementation for wind development in Indonesia:

1. Solving the high level of uncertainty of mesoscale models as the starting point for selection of wind energy locations;
2. Formulating a clear and efficient strategy on building Indonesia's industrial capacity in the wind sector (e.g. what are the benefits of having wind turbine components manufactured in Indonesia?);
3. Developing a plan to ensure grid stability and reliability with the integration of intermittent wind power.

4.5 Industrial capacity

Utility-scale wind turbine technology and its domestic market has not yet developed in Indonesia. Therefore, the country still relies on foreign technology for wind energy, especially for wind turbines. The main components of a wind turbine can be seen in the figure below.

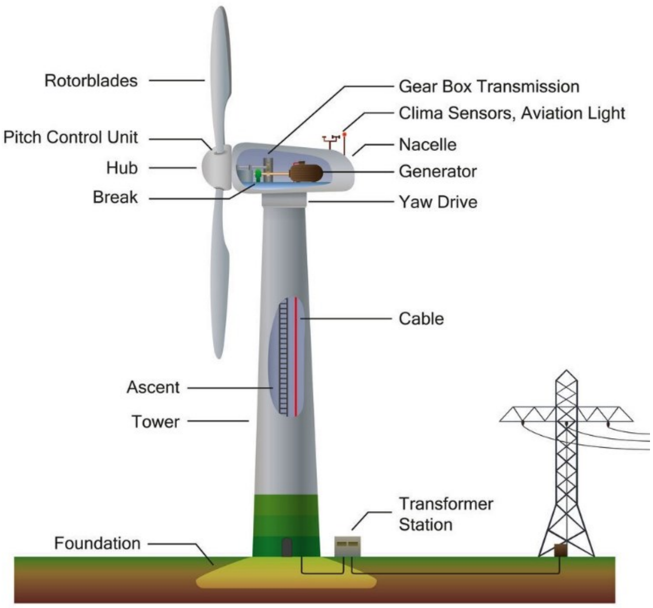

Figure 10: Main components of a wind turbine (Bilderzwerg - stock.adobe.com, 2022)

According to one of the interviewed developers, Indonesia has historically implemented local content requirements to promote domestic manufacturing and job creation. At some point, wind energy projects may need to adhere to these requirements. A premature application of these requirements can negatively impact the availability and supply of equipment and materials for WPP development because the local manufacturing capabilities are not yet up to speed.

There are three points to be taken into account when establishing the local wind power supply chain development in Indonesia:

- If locally produced goods should be of the same level of quality as those which are imported, then one can expect a higher cost (and price) for the former type of goods. This is mainly caused by the high upfront investments required in preparing skilled workforce and building new production facilities to speed-track Indonesia's wind industry. Since the higher costs will reduce the wind project's profitability, the Government needs to offer incentives that promote the utilization of local goods over imported products that have been proven worldwide.
- Local content requirements often require the use of domestically produced parts, which are likely not of the same quality as imported parts. This can lead to reduced cost efficiency due to the increase of maintenance costs during WPP operations. Furthermore, the absence or the shorter period of guarantees and warranties on these parts as requested by lenders in their risk mitigation strategy is likely to reduce the project's bankability.
- Aside from local supply chains, it is critical that Indonesia has qualified manpower for the development, construction, and operation of wind farms. Given that wind power generation is a relatively new technology in Indonesia, where approximately 'only' 154 MW of wind farm capacity is installed, it is reasonable to assume that the current workforce is still lacking the competencies needed to support a large-scale rollout of wind farms. Therefore, it is essential for the Government to prepare capacity building and knowledge transfer programs to equip local labor with the needed knowledge and expertise.

4.6 Infrastructure

Wind farm construction entails more than just installing the wind turbines. A large network of infrastructure is required to complete the construction until the wind farm is ready to be operated. In Indonesia, the locations with good wind potential are generally spread across remote locations with limited existing infrastructure. This means the infrastructure might need to be established or improved before the construction can take place. Nonetheless, realizing the infrastructure (both road and transmission infrastructure) comes with challenges. Examples of such challenges as derived from the conducted interviews are as follows:

4.6.1 Transmission infrastructure

The existing transmission infrastructure could vary greatly between locations in Indonesia, in terms of capacity, reliability and availability. Some locations may have more stable and reliable grid networks, whilst others may have restrictions or require upgrades to enable wind energy integration. The Jawa-Sumatra-Bali (Jamali) network is the most established network in Indonesia which makes it the most suitable for wind farm interconnection to the network. However, it does not mean that every location on Java, Sumatra or Bali has an available transmission line nearby. And if so, the load capacity of such transmission line needs to be analyzed. For example, if a transmission line is near the location for the envisioned wind farm, it could be fully "occupied" for the delivery of electricity to a nearby village. Therefore, transmission line upgrade is still required. In Figure 11, an example is illustrated for the Sukabumi region, in which a wind farm is envisioned. The nearest 70 kV transmission line with a transmission station is located in Pelabuhan Ratu. If a wind farm is established in this region, a sub-transmission line (likely > 20 km) will need to be realized from the wind farm's substation to that transmission station. Another condition is that this transmission station must have the required feeder available for cable/line connection.

Moreover, to connect all wind turbines within the wind farm to the substation, a wind farm transmission system needs to be realized as well. All these parts of the transmission network require expensive transmission cables (at a variety of voltage levels) and transformers (to raise the voltage at the substation), a pathway through often complex terrains (requiring specific permits), protective measures to prevent damage to the transmission line (e.g. due to falling trees) which could hamper power production, etc.

Besides improving the transmission lines, building advanced control centers or modernizing the existing ones is key to dealing with the intermittency of wind power (see Subsection 4.6.2), as well as other variable renewable energy. Upgrading the control center could increase power system reliability and allow for flexible grid operation. This means that the control center can manage the transmission and distribution of power from multiple sources (power plants) to the demand centers in a more flexible manner. In turn, power demand-supply balance can be achieved at all times with high levels of wind (and renewable) energy integration into the grid. An example of such an advanced control center is the currently constructed Main SCADA/EMS Control Center and Disaster Recovery Control Center for the Java-Madura-Bali system. This facility is developed within the cooperation between ETP and PLN. Given its anticipated operation in early 2025, the facility has the potential to improve the integration of variable renewable energy sources such as wind across the power system. Similarly, the advanced control center also needs to be built for other power systems in Indonesia, including wind rich areas such as Sulawesi, to support wind energy development.

To conclude, wind farm development entails more than just the cost and permitting requirements for the wind turbines themselves. Establishing the transmission infrastructure can be a major challenge which adds pressure on the business case and procedure time for permits, etc.

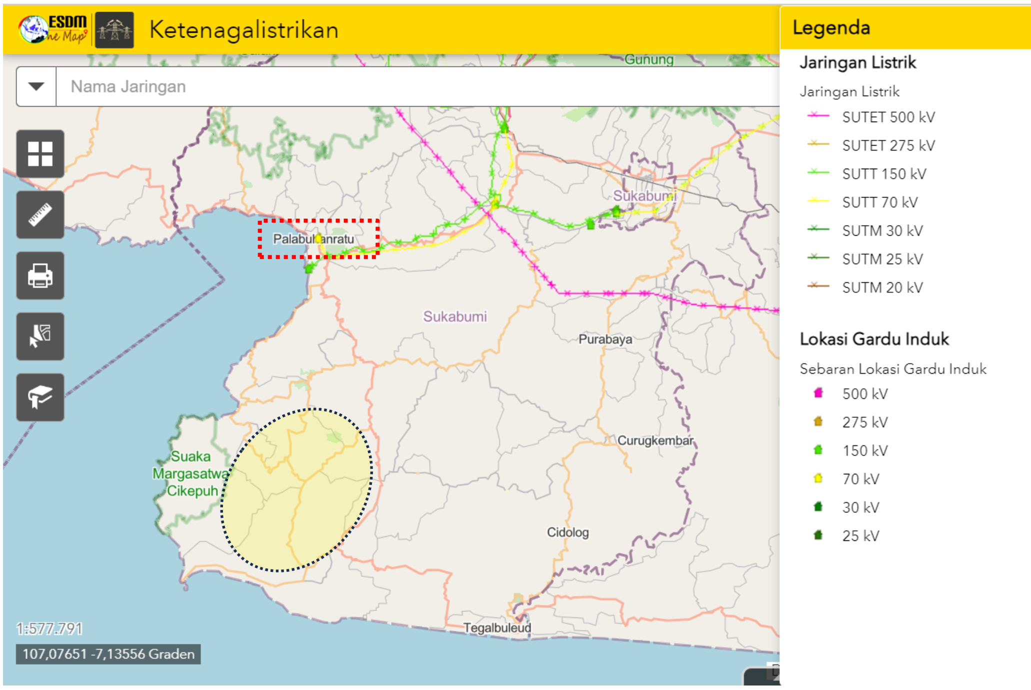

Figure 11: Current transmission network in the Sukabumi region; Pelabuhan Ratu area is marked with a red rectangular dash, whereas the indicative location of the envisioned wind farm is shown within the yellow oval area (Ministry of Energy and Mineral Resources, 2023b)

4.6.2 Intermittent nature of wind power plants

Unlike conventional power plants, wind power plants cannot always consistently produce energy at all hours of the day. This is what is called “intermittency”. For WPP, the source of energy depends on the availability of the wind, for which the resources normally fluctuate, per minute, hour, day, and cannot be stored for later use.

The general principle of optimum generation is to ensure the balance between load and the supply, and therefore, it is expected that during peak load, the energy produced could match the demand required. On the other hand, during off-peak, the energy produced is expected to be reduced following the load profile. However, for intermittent energy such as wind, it is challenging to meet the demand profile most of the time. There will always be a case where the supply outweighs the demand, and vice versa. Therefore, intermittent RE will have to be accompanied by baseload generator, such as coal-fired, natural gas, geothermal and hydro power plant. Another alternative is to integrate the intermittent RE with Battery Energy Storage System (BESS), which can store unused energy and dispatch the energy later when required.

In a more stable and reliable grid such as the Jamali system, this intermittency issue is less problematic because PLN can turn on other generators in standby mode, to quickly react when there is sudden loss of power produced by the wind farm. Nevertheless, there is still a question as to who (PLN or the wind farm IPP) bears the cost of this standby generator. The same goes for curtailing (limiting the wind power production) as ordered by PLN when too much electricity is being produced by the wind farm.

In other systems where the grid size is quite small, balancing supply and demand of power may become more complicated, especially when there is no standby generator available. PLN normally requests developers to install a BESS. However, investment cost will increase because of the BESS integration and need to be compensated by PLN with an additional tariff (on top of the production tariff).

When integrating an intermittent power plant or what is called Variable Renewable Energy (VRE), it is important to have a good forecasting tool, which could accurately predict the energy that can be generated within 5-15 minutes time range. Hence, the grid operator can manage the replacement of generator in time when there is sudden drop from the produced wind power. So far, such prediction tools are not yet available for wind farms in Indonesia.

4.6.3 Logistical access

In Indonesia, road access can vary significantly depending on the remoteness of an area. This is because the country has diverse geography, including mountains, dense forests, and islands. Existing road infrastructure in some regions may be suitable for carrying wind turbine components and construction equipment, whilst in others, modifications or enhancements may be required to enable transportation of equipment. As many prospective wind energy sites are in less developed areas with insufficient road infrastructure, road improvements to access these places are required. Improving the roads needs engineering solutions and sometimes complex execution (e.g. through dense forest), which translates to increased project costs, more stringent permitting regulations to be complied with, and prolonged construction periods. This could lead to a significant part (15-30%) of the investment cost required to ensure the availability of sufficient logistical access. In the case of Sidrap WPP, the selected wind turbine has a tower height of 80 meters and blades with a length of 57 meters (weighing 15 tons each).

For the transport of one wind turbine blade from the port to the designated turbine location, 10 hours of transportation time was required. As a reference, the following table shows the typical dimension of wind turbines' main component which need to be transported over road infrastructure.

Table 13: Typical dimensions of wind turbines' main component (anonymized internal document)

Constraints	Wind turbine parts	Minimum requirements
Weight	Nacelle	150-200 tons
Dimension (height and width clearance)	Tower	5-6 meters
Dimension (length)	Blade	70-80 meters

Moreover, port infrastructure is another significant challenge for the development of wind energy in Indonesia. During the development of Sidrap WPP, there were several modifications applied to the port due to its insufficient offloading and storing capabilities. Specialized port facilities, including heavy-lift cranes, storage yards, and assembly areas are needed to handle these oversized components safely and efficiently.

4.7 Financing and bankability

4.7.1 Financing

In order to attract lenders and investors to finance a project, its risk and return profiles need to be predictable and transparent. Minimizing project risks makes the project more attractive and increases the lender's confidence, which could lead to the provision of financing at a cheaper rate. Therefore, a strong understanding of the overall risks posed by wind power projects is necessary. Risk types can include wind resource uncertainty, technology risk (including unforeseen O&M costs and downtime), longevity of government incentives and supportive policies, instability of carbon price, and uncertainty and bankability issues of the PPA. Due to the high-risk circumstances for investors in the development, construction, and operation of wind farms in Indonesia, wind projects are viewed as a risky investment, resulting in investors' expectations of significant profits in return.

Fiscal and non-fiscal regulations could promote wind farm investments. To attract investment interest in the development of renewable power generation, the Government has issued a range of fiscal and non-fiscal incentives. Based on Presidential Regulation No. 112/2022 concerning the acceleration of RE development, fiscal incentives applicable to wind energy development can include:

- Income tax facilities
- Import facilities, such as import duty exemptions
- Land and building tax facilities
- Support for financing facilities and/or guarantees through state-owned enterprises

These incentives are provided through the OSS system, subject to commitment fulfilment (verification) through the Ministry of Finance. Additional incentives such as grants, subsidies, low-interest rates, or other financing schemes may also help to reduce the project cost and make the projects more economically viable. However, these fiscal and non-fiscal incentives have so far not yet led to more bankable wind projects in Indonesia. This could be the result of lack of awareness of these incentives, or the incentives are not yet tailored to the needs of the developers and the investors.

Another reason is the problems faced when implementing the incentives. For example, a developer mentioned that some income tax facilities were revoked midway through the project because of an asset transfer to PLN which was mandated in the Power Purchase Agreement (PPA; signed before income tax facilities were granted). Another constraint for the development of WPP is the absence of VAT output, whereas PLN could not collect VAT from the customers. As a result, all VAT must be paid by the developer (with some tax incentives), adding 11% of additional cost to the project.

Finally, it is noteworthy that the subsequent deliverable under the project of which this roadmap is a part of (*Wind Energy Development in Indonesia: Investment Plan*) will include a more thorough assessment on potential sources of finance and methodologies on how to access such sources.

4.7.2 PPA bankability

PPA is one of the main documents to guarantee the revenue of wind power plant project. Ensuring PPA bankability from the lenders' as well as investors' perspective is important. Current PPAs in Indonesia rely on MEMR Regulation No. 10/2017 and MEMR Regulation No. 10/2018 which govern conventional and RE projects. The dual application potentially leads to improper PPA schemes for RE projects because of the significant differences with respect to conventional energy production.

Recognizing the pitfalls of the above regulations, MEMR prepared a draft to overcome the issue. In practice, however, the PPA draft published by PLN during RfP stage still follows the prevailing scheme regulated by PLN. As reference, the table below summarizes some bankability issues stemming from the PPA and Shareholder Agreement draft issued by PLN from Tanah Laut wind farm tender (July 2022).

Table 14: Examples of PPA bankability issues according to investors and lenders

Issues in PPA	Description
Annual Contracted Energy (ACE)	A thorough study and explanation should be informed during tender process regarding the basis of ACE, and whether it can be revised during the PPA term.
Predicted Capacity Matrix (PCM) which shows the forecasted power production by the WPP	Based on practical experience, updates/changes to the PCM can be made upon PLN request and must be implemented by a PPA amendment.
PLN's preemptive right to buy the project at any given time	Current PPAs allow agreement termination by IPPs and selling of the plant to PLN with a price equal to at least the senior debt. This is unfavorable for IPPs as they need security on the expected return from the project.
Project milestone and Performance Security requirements	Unmatched timeline between PPAs and financing activities, e.g. Financial Close or COD after PPA Effective Date during the due diligence by lenders may result in additional sunk cost borne by investors especially if there is no guarantee for the investors to win the tender process.
Risk allocation during Force Majeure and Government Force Majeure	Based on the current PPA, PLN is obliged to buy the project if a force majeure situation still occurs, but in the Tanah Laut WPP PPA (Article 14), both PLN and IPP will bear the risk of force majeure, without further explicit details.
Restriction on transfer of shareholders	The limitation on the transfer of ownership as set out in the current PPA draft or sponsor agreement may reduce the profitability of the project.
Financial benefit	Currently, the proceeds of renewable market-based instruments (MBI; i.e., carbon credit, REC, green tag, and/or tradable rights) go to PLN. Having mutual/shared benefit on the MBI proceeds will increase the attractiveness of RE projects market.

Issues in PPA	Description
Dispute settlement	Having neutral location of seat arbitration (conducted by SIAC, in Singapore instead of Jakarta) will support neutrality of the arbitration process, and thus, contributes to the bankability.
Local content requirement	Domestic component level regulations demand the use of locally made components, and infractions will result in a fine equal to the difference in value between utilization of the local component with the existing one.
Mandatory partner	An unbalanced share of overrun and development cost between the developer and the mandatory partner (as obligated by PLN as a consequence of the tender regulations) via the Special Purpose Company.

4.8 Procurement mechanism

There are currently two utility-scale wind farms in operation in South Sulawesi. Wind farm development frequently involves multinational developers working with local partners, as was also the case for the two existing wind farms. It is noteworthy that these two wind farms were proposed before 2017 by respective developers and procured by PLN without any competitive bidding process. Currently, the procurement mechanism for utility-scale wind projects involves a competitive bidding process called the Direct Selection process. Projects that will be procured by PLN shall firstly be listed on RUPTL PLN. The IPP procurement flowchart is illustrated in Figure 12.

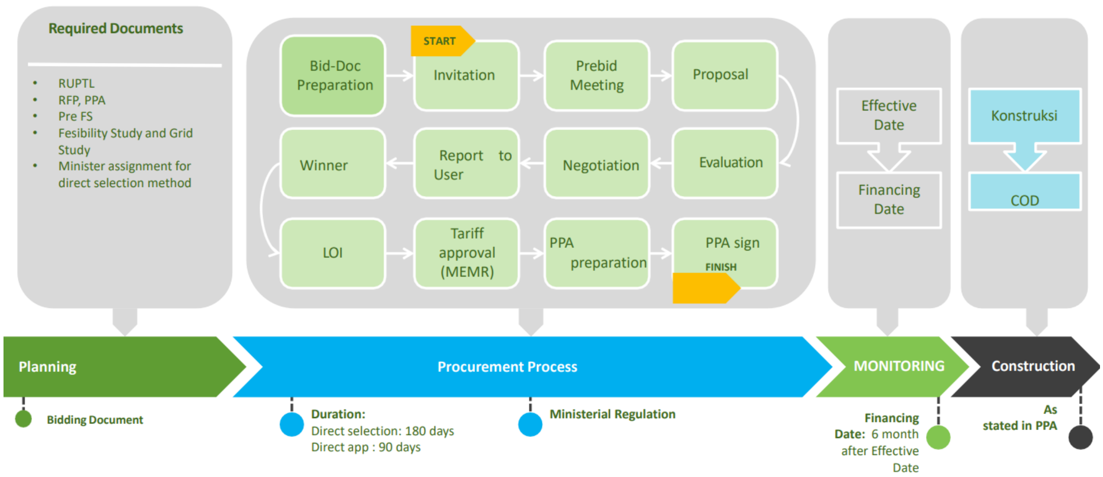

Figure 12: PLN's procurement process for wind energy projects established by an IPP (PLN, 2022)

PLN holds tenders to select IPPs for cooperation via long-term PPAs. To participate in the tender, IPPs must be registered in the List of Selected Providers (*Daftar Penyedia Terseleksi*/DPT). Hence, the procurement process starts with the pre-selection of IPPs through DPT. DPT is a pre-qualification stage carried out by PLN to ensure that IPPs who wish to collaborate have adequate competence, both from a technical and non-technical perspective, including financial stability. Among others, IPPs are required to submit their legal documents and project portfolio. IPPs who passed the DPT pre-selection process will then be able to participate in PLN's tender process.

PLN has implemented the procurement of 1.2 GW RE power plants until March 2023 and will continue to execute further procurement of these plants, including wind farms (Rahayu, 2023). However, a fixed timeline of publication of new tenders for wind projects is currently not available for the public. Furthermore, the Commercial Operations Date (COD) listed in RUPTL merely serves as an indication (which is not always fulfilled) for IPPs, meaning it is difficult to predict when tenders will be conducted and when IPPs have to start preparing. Consequently, IPPs are often not well prepared to comply with the requirements of ongoing and upcoming tenders. Such preparation is necessary because the tender normally prescribes the submission of one-year wind data along with the bid.

5 Roadmap for onshore wind energy

Development of wind energy is lagging compared to other RE sources in Indonesia, both in realization and in planned capacity in RUPTL PLN. From a total of 81.2 GW of generating capacity in Indonesia, wind energy only contributes 154 MW-worth of capacity (or only 0.05%). In the current RUPTL, only 597 MW of wind projects have been planned until 2030. This amount is very small when compared to the identified wind energy potential: 60.6 GW onshore and 94.2 GW offshore. Even if only 10% of this total onshore potential is realistic, a 6 GW-worth of wind project development still needs to take place in the coming decades. For this future vision, a roadmap for onshore wind energy has been created in this study as the pathway to reach more significant numbers than the realized 154 MW and the planned 597 MW wind farm capacity.

Below are the key considerations and assumptions which are vital for the roadmap's establishment:

- This roadmap targets a 1.8 GW of installed wind capacity (as targeted in RUEN for 2025) by 2030. This amount of wind generating capacity will annually avoid the emission of up to 5.04 Mt CO_2 (compared to unabated coal-fired power plant) (IEA, 2020). To achieve this, there are still fundamental barriers which need immediate mitigation actions.
- Assuming an investment of at least USD 2 million per MW, achieving the roadmap target (1.8 GW) would thus require an estimated minimum investment of USD 3.6 billion in the period of 2023-2030. The installation of 1.8 GW wind farm capacity will likely need to be spread out over the next 7 years. Local and international investors are encouraged to participate in funding the wind projects, in order to achieve the targeted capacity by 2030.
- Onshore wind technology is already a proven technology, even though it has not been widely developed in Indonesia. Wind power can be competitive in areas with strong wind resources and with the support of financial incentives, e.g., tax reliefs and carbon credits that can be owned and sold by the developers.
- Improvements to the existing regulatory framework for the procurement process and pricing of wind projects are needed to reduce unnecessary risks for the investors.
- To reliably achieve high penetrations of wind power, the flexibility of transmission systems must be enhanced. Flexibility is a function of access to flexible generation, storage, and demand response, and is greatly enhanced by larger and faster power markets, smart grid technology, and the use of output forecasting in system scheduling.
- Road and port infrastructures and equipment availability play a significant role to reach the targeted capacity, especially in underdeveloped regions in Indonesia. Having synergized regional development (e.g. building infrastructures that connect multiple economic regions) could increase the benefits of wind energy development for a region.

This 2023 – 2030 Wind Energy Development Roadmap includes the following: (1) role of the stakeholders for the roadmap's implementation, and (2) roadmap of key areas for wind energy development. In the following two sections, both aspects are elaborated respectively.

5.1 Role of stakeholders in implementing the roadmap

In the roadmap (see Section 5.2), roles are defined for the relevant stakeholders by means of the Responsibility Assignment Matrix (RACI) matrix. A RACI matrix is a project management tool used to define and clarify the roles and responsibilities of individuals or teams within a project or organizational process. The acronym "RACI" stands for the four main roles that can be assigned:

- Responsible (R): The person or team responsible for completing a specific task or activity. This individual or group is held accountable for the work and ensures its successful completion.
- Accountable (A): The person who is ultimately answerable for the task or project's success or failure. There can be only one "Accountable" person for each task, and they have the authority to make final decisions and sign off on the work.
- Consulted (C): Individuals or teams who provide input and expertise on a task but do not have the final responsibility for its completion. They are stakeholders or subject-matter experts whose insights are valuable.
- Informed (I): People or groups who need to be kept informed about the progress of a task or project but are not directly involved in its execution. They receive updates and information as needed.

For each key area, the matrix specifies which roles are assigned to the stakeholders. Multiple roles can be assigned to a single task, and the specific combination of roles for each task clarifies who is doing the work, who is overseeing it, who needs to be consulted, and who should be kept informed. Table 15 presents the proposed stakeholders to be involved in performing the actions.

Table 15: List of the proposed stakeholders to be involved in the roadmap

Abbreviation	Description
MEMR	Ministry of Energy and Mineral Resources
MoF	Ministry of Finance
MoI	Ministry of Industry
MoIn	Ministry of Investment
MoPW	Ministry of Public Works and Housing
BSN	*Badan Standardisasi Nasional*/National Standardization Agency
MoEF	Ministry of Environment and Forestry
KATR/BPN	Ministry of Agrarian Affairs and Spatial Planning / National Land Agency (*Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional*)
BRIN	*Badan Riset dan Inovasi Nasional* / National Research and Innovation Agency
PLN	*PT Perusahaan Listrik Negara (Persero)*, state-owned enterprise (SOE) in electricity, acting as grid operator and power off-taker
Industry/Association/Lenders	Wind association or Investors/Developers or Lenders (international and local institutions)

5.2 Roadmap of key areas for wind energy development

This section details the roadmap and is organized in subsections according to the respective challenges identified in Chapter 4.

5.2.1 Roadmap actions for Wind data availability

As previously explained, the variable character of wind, in combination with the complex terrain in Indonesia, makes it difficult to pinpoint the real potential of wind energy at specific locations. This is a challenge for the Government (i.e. MEMR and through the SOE PLN) in developing wind energy. For instance, RUPTL PLN contains several planned wind projects on locations with likely too little wind resource. The current condition also poses a challenge for the developers that seek interesting locations to invest in, since the investment often comes with very high risks. Therefore, it is advised in this roadmap to use a top-down approach for future wind projects in which the Government streamlines the selection of wind project locations and takes responsibility for the first part of the project preparation. This approach consists of the following steps:

Step 1: Identification of potential wind energy locations

There is room for improving the Government's analysis of Indonesia's onshore wind potential (i.e. 60.6 GW according to RUEN) due to the entailed shortcomings. Examples of these shortcomings include the limited number of factors taken into consideration (e.g. no assessment of land use), the use of low wind speed threshold value (starting at 4 m/s) which is likely not bankable, and the adoption of highly uncertain mesoscale modeling input. To determine the actual potential locations for wind energy development, more detailed analyses are required on the wind behavior at each location. The mesoscale modeling output (like Global Wind Atlas) is still a good starting point for a coarse selection of potential areas. Nevertheless, it does not take the terrain complexity into account. On-site wind measurements, in combination with CFD (Computational Fluid Dynamics) modeling, can provide a better picture of the complex wind behavior at each location. This combined method gives a much more accurate outcome than a wind resource assessment based on mesoscale modeling output. However, it is too costly and inefficient to execute wind measurements at all potential sites in Indonesia, since many of them might be excluded in the end due to insufficient wind resource measured.

There is an alternative approach available which is called GRASP modelling. This model does not require actual wind data to simulate wind behavior in complex terrains. In Figure 13, results of an executed onshore wind study in Indonesia are illustrated. The image shows a comparison between (1) the model results of the traditional mesoscale modeling (Global Wind Atlas) without wind measurements, (2) model results of wind measurements including CFD modeling, and (3) results of GRASP modelling. A wind farm yield calculation based on the GRASP model (3) differed only 2% from the yield calculation based on the model of wind measurement including CFD modeling (2). This specific example shows that it could be feasible to determine the wind potential and wind farm yield at a high level of accuracy, without having to execute wind measurements across Indonesia as the first step in the site selection. Eventually, wind measurements are necessary for a bankable feasibility study. However, the measurement can then only be done for the projects that have passed the initial analysis of their potential. This minimizes the risk in investing in the measurements.

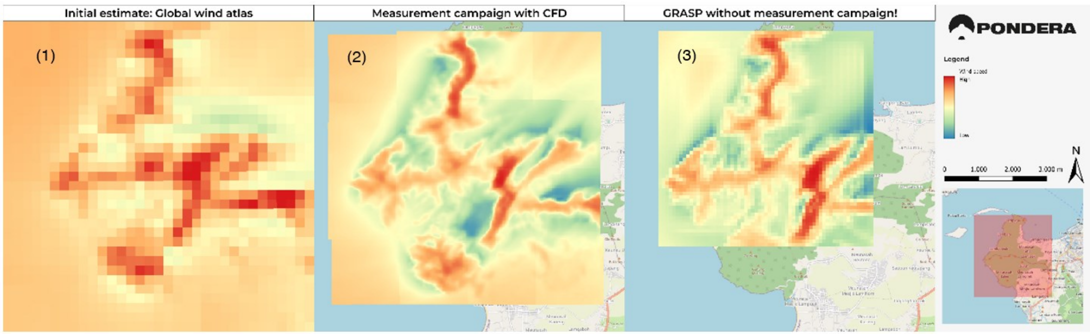

Figure 13: Model comparison for a potential onshore wind farm (Pondera, 2023)

Aside whether GRASP or another method is used to create more reliable insights in the wind behavior, it is important that in Step 1, the Government conducts proper research on areas that have sufficient potential to be included in a shortlist of potential wind farm locations. It is noteworthy that a subsequent part of this overall project (the *Wind Energy Development in Indonesia: Investment Plan)* is to conduct such research on potential wind farm locations. Component 3 of the project (titled *Wind energy potential mapping, gap analysis and site selection*) analyzes 14 wind sites in Java and Sumatra. Several of these sites are located in mountainous terrain, and therefore, considered complex terrain to model. For these sites, GRASP will be used to enhance the wind resources assessment to determine potential and feasibility of these sites. If such a method is adopted for future wind studies, the identification of potential wind energy locations will be improved, and in turn, this lowers the uncertainty for developers and investors.

Step 2: Identification of go-zones within potential wind energy locations
After the most promising potential wind energy locations have been identified in Step 1 based on reliable wind energy information, it is important to consider the spatial conditions at each location. Even if the wind speed is favorable at a specific location, it does not automatically mean that a wind farm can be established there. There could be many so-called “no-go zones” present. Examples of such zones include housing, protected forest, economic/commercial areas, etc. Therefore, Step 2 entails the identification of the “go-zones” within each location for which the no-go zones are dismissed from further analysis. These go-zones could still entail requirements to be fulfilled by the developer when a wind farm is realized, e.g. replanting of trees which are cut for constructing roads. An important requirement for this identification of go-zones is the obtainment of accurate and high-resolution spatial data of the locations to determine the correct no-go zones. This is further elaborated in Subsection 5.2.2 of the roadmap. The determination of go-zones is also included in the previously mentioned Component 3 (*Wind energy potential mapping, gap analysis and site selection*) in which 14 wind sites in Java and Sumatra are analyzed.

Step 3: Verification of wind characteristics at the potential wind energy locations
Although Step 1 has already determined the wind characteristics for each potential wind energy location, verification of these characteristics is still required though on-site measurements (by for example a wind met mast or a LiDAR). A correlation will be drawn between the short-term wind data (based on on-site measurements) and the long-term wind data. The measurements would also be useful to collect the wind data that investors require before financing wind projects. i.e. investors require at least 1 year wind measurements following IEC standards including a correct translation of the wind data into the P90 wind farm yield. Additional requirements from investors are gathered in the Component 4 (*Investment Opportunities Guide for Indonesian Wind Projects and Access to Finance Report*) under this project.

This roadmap advises the Government (through PLN, PLN subsidiaries, or MEMR) to conduct these measurements themselves and offers the results as part of the site data which will be received by the bidders during the project's tender process. In this way, a standard approach of wind data gathering can be used for all projects and prevent a proliferation of met mast being built in the same region by competing developers. In turn, the financial burden on the developers who wish to participate in the tender will be lowered significantly, creating a more sustainable and healthy wind sector. Moreover, the investment for these wind measurements conducted by the Government will be 'compensated' by likely lower tariff offers/bids, because of lower development costs for the bidders. It is important that these wind measurements must be conducted in accordance with international standards and can result in de-risking the project for the developers, i.e. measurements at such a (or multiple) location(s) that lowers the uncertainty of the wind characteristics.

Step 4: Develop more accurate, long-horizon forecast models

Enhancing the predictability of wind resources has the potential to improve the economic viability of electricity generated from wind sources in the power market, aiding developers in fulfilling their delivery commitments to PLN. When there's a disparity between the amount of electricity scheduled for meeting customers' demand and the actual delivered quantity, an imbalanced supply-demand of electricity will occur. This necessitates the use of flexible power plants and additional resources, sometimes incurring penalties for the developer/supplier. The most agile and quickly deployable plants, like gas turbines, normally come with costly fuel requirements.

More precise and longer-term output forecasts would increase the feasibility of scheduling less rapidly deployable plants with more cost-effective fuel needs, such as coal-fired power plant and combined-cycle gas turbines, to balance the variable wind power in the system. To accomplish this, it is crucial to develop advanced forecasting models that make use of meteorological data, real-time data from operational wind plants, and remote sensing technology. Once these models have been validated, it is imperative that power system operators put the models into practice.

Advanced forecasting models and techniques are employed to predict wind energy production. These forecasts consider factors such as wind speed, wind direction, atmospheric conditions, and the performance characteristics of wind turbines. They are typically divided into short-term and long-term forecasts:

- **Short-term forecasts**: These forecasts cover periods ranging from minutes to a few hours ahead. Short-term forecasts are essential for managing the grid in real-time and ensuring a stable electricity supply. They use data from various sources, including weather models, wind turbine data, and real-time observations.
- **Long-term forecasts**: These forecasts cover periods ranging from hours to days ahead. These forecasts help grid operators plan for future energy needs and optimize grid resources. They rely on advanced weather prediction models and historical wind data.

Strong collaboration between several stakeholders is essential for creating accurate forecasts, as applied in other countries. These stakeholders (e.g. meteorological agencies, wind power operators, and grid management organizations) collaborate to share data and information. High-quality meteorological data, including wind speed and direction, is integrated into forecasting models to improve their accuracy. The forecasting models incorporate details about the wind turbines, their locations, and how they interact with the local wind conditions.

Hence, the model can predict how changes in wind patterns will affect power output. For this purpose, the importance of the Government taking charge in conducting wind measurements themselves to acquire the data in a standardized manner (Step 3) must be emphasized. Acquiring wind data through the developers would not be preferred, because their data is not freely shared and therefore cannot be used to develop such forecasting models.

In addition, real-time data to reflect changing weather conditions is needed. Advanced sensors, like LiDAR, wind met masts, and wind profiling radars are used to provide continuous data, which can be incorporated into forecasts as it becomes available. Continuous verification and feedback loops ensure that forecast models are accurate and reliable. This information helps to improve forecasting models over time.

Key area action plan

Table 16: Action plan for key area 'wind data availability'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Step 1: Identification of potential wind energy locations	→	→						
Step 2: Identification of go-zones within potential wind energy locations		→	→	→				
Step 3: Verification of wind characteristics at the potential wind energy locations			→	→	→	→		
Step 4: Develop more accurate, long-horizon forecast models				→	→	→	→	→

Stakeholder involvement

Table 17: Stakeholder roles for key area 'wind data availability'

Action Plan	MEMR	Bappenas	MoPW	MoEF	KATR/ BPN	BRIN	PLN	Assoc./ Industry
Step 1: Identification of potential wind energy locations	R/A					C	I	C
Step 2: Identification of go-zones within potential wind energy locations	R/A	C	C	C	C	C	I	C
Step 3: Verification of wind characteristics at the potential wind energy locations	R/A	C				C	R/A	C
Step 4: Develop more accurate, long-horizon forecast models	R/A	C				C	R/A	C

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.2 Roadmap actions for Availability of spatial data and standardized processes

This roadmap promotes the enhancement of the availability of spatial data and standardized processes through the following three key points, which are further elaborated in this subsection:

- Digitalization of geospatial maps
- Designing a guideline for site assessment criteria
- Designing guidelines for wind development in Indonesia

Digitalization of geospatial maps

As mentioned in Step 2 of the previous key area (wind data availability), it is necessary to define various (spatial) constraints to be excluded (no-go zones) from the potential wind energy locations before any project can be further developed (go-zones). To do so, a set of geospatial maps are required. When these maps are gathered, the constraints can easily be filtered out, resulting in the remaining area available for wind farm development. Based on this study, however, it is concluded that just a few of these geospatial maps are available digitally, while most of them are either not available entirely, or available only in hardcopy or image form (not in processable GIS data).

When the map is not available at all, normally the developer must conduct a site visit together with the Local Government, perform physical measurements, and then add the results manually to the GIS system to integrate it with the other digital maps. This process entails significant cost and time, especially when a large area is considered for the envisioned wind farm. When the information is not available digitally, the developer must then add the information manually to the GIS software. This manual input should be avoided, if possible, because it is a time-consuming and costly process with an increased risk of inaccuracies of the processed information (e.g. spatial reference coordinate system).

Therefore, it is recommended that all geospatial maps required for site selection process should be available digitally. To realize this, the Central Government must endorse the digitalization of this information to be prepared by each data-owning institution. Specific guidelines should be provided to align the process, namely, to ensure that the information is processed using a similar standard. One of the successful examples is the interactive map from Land Spatial Use Planning that can be accessed via GISTARU website (atrbpn.go.id; illustrated in Figure 14).

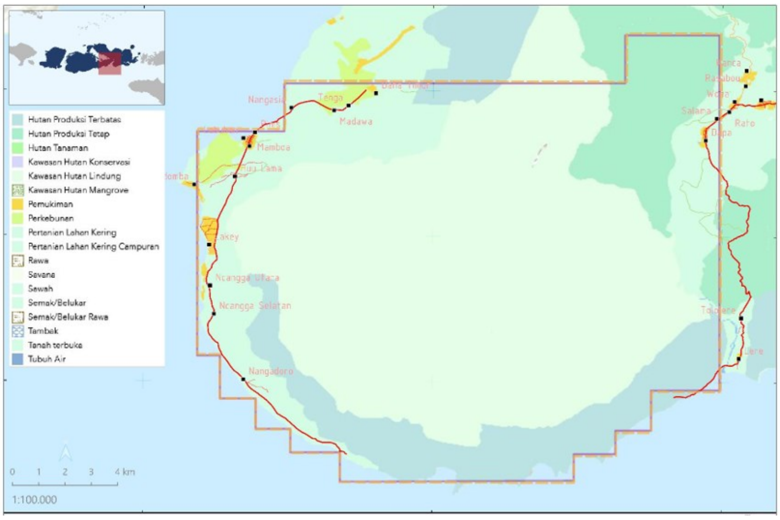

Figure 14: Example of interactive land use planning map (Ministry of Agrarian Affairs and Spatial Planning, n.d.)

Designing a guideline for site assessment criteria

As mentioned in Step 2 of previous key area (wind data availability), several constraints are applicable for selecting the go-zone for a potential wind farm. In some countries with many years of experience in onshore wind development, these constraints are formalized in regulations. Aside from a couple of standards in the SNI for wind energy, a clear guideline on the analysis criteria and considerations for the environmental and social impact of a wind farm are not yet present in Indonesia. The strong recommendation from this roadmap is to develop such a guideline. In the table below, an indicative list of criteria and considerations are written down as a starting point. There are many lessons that can be learned from other countries that already have such proven guidelines.

Table 18: Indicative list of criteria and considerations for site assessment guideline

Subject	Criteria	Considerations
Wind characteristics	• Application of threshold values for wind speed, turbulence level, wind shear, consistency, etc.	• Wind characteristics vs. investment cost for infrastructure (e.g. in complex undeveloped terrain) • Nearby objects (e.g. large buildings) interfering with the free flow of the wind • Prevailing wind direction in relation to the terrain outlook, considering the wake effects that can occur
Logistic/access	• Maximum distance from port to the site	• Road access conditions • Required upgrades of existing infrastructure
Nearby dwellings	• Minimum distance to urban or residential and industrial areas, considering noise, shadow flickering, and external safety • Minimum distance to airports and military areas	• Potential direct offtake of nearby industrial areas • Nuisance for nearby residents during logistical operation and construction
Topography and Geotechnical	• Maximum elevation and slope for wind farm construction • Maximum level of cut and fill required for foundation and infrastructure (capital intensive)	• Soil conditions determine the type of foundation for the wind turbines • Soft soil and soil with porosity (void) or liquefaction risk to be avoided • Seismic risk (including earthquakes and landslides) • Flood risk • Lightning risk
Height restriction	• Maximum wind turbine height in case the wind farm area is within the proximity of the approaching zone of a nearby airfield.	• Visual effects on the environment because of the wind farm • Wind power output • Migration routes of birds and bats

Subject	Criteria	Considerations
Land use planning	• Avoid (nature) conservation areas • Avoid national parks or other areas officially protected from development • Avoid commercial, industrial, and essential farming areas	• Minimize the use of productive farming areas (in case there is a strict regulation on changing land utilization from productive farming area to industrial/power plant area) • Possibility of co-location of wind farms and farming areas • Land price (especially near industrial areas) • Clarity on land ownership
Environmental & social impact	• Avoid overlaps with migration routes of bird species • Avoid areas with high concentration of rare or endangered animals • Avoid culturally sensitive areas (e.g., religious, historic, or archaeological sites) • Avoid negative impact on the social and economic circumstance of the nearby inhabitants	• Dense forest, requiring significant tree cutting. • Although not endangered, specific flora and fauna are in the area • Opportunities for local employment, enhancing gender equality, and youth education as part of the wind farm development
Existing transmission network	• Capacity available on the nearest grid connection (feeder and cable capacity)	• Distance to the nearest grid connection point • Voltage level of the nearest transmission line (transformer requirement) • Terrain layout for the wind farm transmission line trajectory
Electricity demand	• The envisioned wind farm capacity should not surpass the (future) power demand	• Insight in future demand centers based on special economic zones or other future industrial development.

Designing guidelines for wind development in Indonesia

In order to establish high-quality standards of wind farm development in Indonesia, it is important that project developers and investors are guided on what is expected from them during the project's development stage. A guideline, which includes not only the expectations and requirements of the Government, but also the requirements from banks for project financing to ensure a smooth due diligence process, shall thus be formulated. Specifically for the Government, this guideline can be subdivided into:

- PLN's requirements and standards concerning feasibility studies, grid impact studies, wind data gathering, etc.
- National/regional governments' requirements for environmental studies.
- National/regional governments' requirements for permits to be obtained and underlying studies required, with clear process steps, duration, and responsible authorities (see also Subsection 5.2.3).

There are several vital aspects to ensure the effectiveness of this guideline:

- Consistency:
  Although it is a 'guideline', it is important that the relevant authorities are dependable in applying/enforcing the guideline for each project in the same manner;

- Transparency:
  The guidelines could be revised over time, based on the lessons learned during the application. However, regularly changing regulations pose a challenge for the developers. Consequently, a revised guideline should be announced timely and preferably involves consultation with the key (private) stakeholders in the wind sector. Furthermore, a clear but reasonable cut is required on how the revision applies to ongoing projects and future projects (i.e. for which projects the revised guideline apply, and for which projects the previous guideline apply).

- Clarity:
  Evaluation criteria for studies to be executed and permits to apply for should be reasonable, be clearly defined upfront, and refer to widely known standards.

- Responsibility:
  Overlap between requirements and studies from different authorities should be prevented. Specific studies should be evaluated by one authority for approval. Other authorities could request for the approved study (for example for a permit application), but they should not redo the evaluation process.

Key area action plan

Table 19: Action plan for key area 'availability of spatial data and standardized processes'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Digitalization of geospatial maps	→	→	→	→				
Designing a guideline for site assessment criteria	→	→						
Designing guidelines for wind development in Indonesia	→	→						

Stakeholder involvement

Table 20: Stakeholder roles for key area 'availability of spatial data and standardized processes'

Action Plan	MEMR	KATR/ BPN	MoIn	MoPW	MoEF	BSN	PLN	Assoc./ Industry
Digitalization of geospatial maps	C	R/A		R/A	R/A			I
Designing a guideline for site assessment criteria	R	C		C	C			C
Designing guidelines for wind development in Indonesia	R/A		C			C	R	C

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.3 Roadmap actions for Policy/regulation and permitting

The improvement of policy/regulation and permitting process for accelerating wind energy development can be performed by (i) defining key conditions for regulations and permitting, (ii) continuous improvement of the OSS system, and (iii) smoothening the land acquisition process. All three aspects are elaborated in the following paragraphs.

Define key conditions for regulations and permitting in the wind sector
In the previous subsection, preconditions to a guideline for the wind development process were elaborated. These preconditions are summarized in the following key terms: Consistency, Transparency, Clarity, and Responsibility. These key conditions are, in the same manner, applicable to the formal policies, regulations, and permitting processes required for the wind energy sector:

- Consistency:
  Developers and investors should be assured that regulations and permitting processes are always applied in a consistent and diligent manner. This means that it does not matter if a project is developed in Aceh, Bali, or in other regions. It also means that regulations 'trickle down' in an unchanged manner from the initiating authority to the implementing authority.

- Transparency:
  Regulations and permitting processes could be revised over time, based on lessons learned from wind development over the years. However, frequently changing policies and regulations are not desired by the developers. Thus, any suggested changes to a policy or regulation should be announced in a timely manner and should preferably involve consultation with the key (private) stakeholders in the wind sector. Moreover, a clear but reasonable cut is required on how this revision applies to ongoing projects and future projects.

- Clarity:
  Evaluation criteria for permit applications should be reasonable, be clearly defined upfront, and refer to published standards.

- Responsibility:
  Overlap between requirements and studies from different authorities should be prevented. Specific studies should be evaluated by one authority for approval. Other authorities could request for the approved study (for example for a permit application), but they should not redo the evaluation process. For the wind energy regulations and permit processes, allocation of responsibilities to the relevant authorities is vital. In this definition of responsibility, an important aspect is alignment and coordination between key stakeholders, especially between policymakers and PLN. It is important to ensure that all parties have the same targets and act in the same manner in fulfilling these targets.

Continuous improvement on OSS system
Currently, the Central Government has developed a One Single Submission system which simplifies the application process for acquiring permits. However, according to the feedback from the developers, delays from the Government side are still experienced when processing the application, mainly due to transitioning to the new system. Especially for KKPR, processing of all applications centrally adds a longer queue with uncertain duration from submission until feedback is received from the Government. A standardized, more transparent permitting procedure will reduce project uncertainty.

Thus, continuous improvement is crucial, by monitoring and actively gathering feedback from related stakeholders, such as investors and the related government institutions. When possible, it is recommended to create a fast-track program for accelerating permitting process for wind power projects, subject to the fulfilment of pre-requisite documents and requirements for specific permits.

Smoothening land acquisition process
Land acquisition remains a significant issue in wind farm development for several reasons:

- Land availability:
  WPPs may require large amounts of land. Finding suitable, available land meeting all requirements and considerations (as listed in Subsection 5.2.2) can be a challenge. In some cases, the land might be used or allocated for other purposes, such as agriculture or conservation, leading to conflicts over land use.

- Local opposition:
  (Local) communities sometimes resist energy projects (Not In My Back Yard or NIMBY problem), especially if they believe that the projects will have negative impacts on their local environment, economic development, or property values. This opposition can lead to delays or even project cancellations.

- Environmental concerns:
  Projects may require land with specific environmental characteristics that overlap with protected areas. This can raise concerns about impacts on local ecosystems, habitats, and wildlife

- Cultural and indigenous concerns:
  In some cases, energy projects may infringe on lands with cultural or historical significance to indigenous communities. This raises issues of land rights and cultural preservation.

- Economic factors:
  Land acquisition costs can have a significant portion of a project's overall budget. Higher land acquisition costs can impact the financial feasibility of wind projects, potentially making them less attractive to investors.

To address these challenges, governments and project developers need to engage in thorough planning, community outreach, and environmental impact assessments. It is essential to consider the social and environmental implications of land acquisition, ensuring that the transition to cleaner energy sources aligns with broader sustainability goals. It is also recommended to formulate an improved national plan of approach to smoothen the acquisition process which takes the values of the landowners and local inhabitants into account. An important element of this plan should be local stakeholder participation in the early project development stage.

Furthermore, there are a couple of elements that could be considered to include in the national plan:

- A financial benefit system for the local population (e.g. discount on electricity for nearby residents, and acquisition by referring opportunity costs instead of indemnity value) can be considered.
- Finalized studies on environmental and social impact can be set as a precondition to start the land acquisition process. However, to avoid unnecessary delays, the duration of the land acquisition should be shortened.
- The possibility of allocating the responsibility for land acquisition to the Government shall be explored. This way a top-down approach is used to align all government processes. Furthermore, it could be more favorable if the Government becomes landowner instead of (foreign) developers/investors and subsequently leases the land to the wind farm owner. In this way, after the design lifetime of the wind farm (20-30 years), the land ownership can remain with the Government.

Key area action plan

Table 21: Action plan for key area 'policy/regulation and permitting'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Define key conditions for regulations and permitting in the wind sector	→	→						
Continuous improvement on OSS system	→	→	→	→	→	→	→	→
Smoothening the land acquisition process	→	→						

Stakeholder involvement

Table 22: Stakeholder roles for key area 'policy/regulation and permitting'

Action Plan	MEMR	MoF	MoI	MoIn	MoPW	KATR/ BPN	PLN	Assoc./ Industry
Define key conditions for regulations and permitting in the wind sector	R/A	C	C	C	C		C	C/I
Continuous improvement on OSS system				R/A				C/I
Smoothening the land acquisition process				R/A		C		C/I

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.4 Roadmap actions for Research and Development (R&D) activities

The potential of wind energy in Indonesia has been measured since the 1970's with East Nusa Tenggara set as the first location. In the 1980's, the research of wind energy was conducted by MEMR R&D department and LAPAN. The scrutinized areas include Java, East Nusa Tenggara, West Nusa Tenggara, and North Sulawesi. Since those organizations were disbanded, research on wind energy had been limited and lacked focus from a formal R&D authority. Therefore, specific actions are recommended through this roadmap to improve the level of R&D on wind energy in Indonesia.

Prioritization of specific R&D topics for wind energy development

Private enterprises often lean toward shorter-term R&D endeavors when they expect more predictable returns on their investments. In contrast, the public sector typically plays a primary role in long-term, fundamental research, and this should be the central focus of public R&D initiatives. Further advantages can be gained through enhanced coordination among R&D and demonstration endeavors between the public and private side. One way to improve the coordination is by identifying a set of R&D topics that will expedite the achievement of wind development targets and milestones.

Based on the three main fundamental challenges which will need further R&D and strategic studies (as identified in Section 4.4), the following key research topics are defined to be of priority:

- Preparation of a detailed project pipeline for implementation, based on actual and more realistic figures of the targeted installed capacity of wind farms (as explained in Subsection 5.2.1)
- A cost-benefit analysis on Indonesia's industrial capacity building for the local manufacturing of wind turbine components; the analysis should at least include:
    - Preconditions of companies to establish manufacturing in Indonesia;
    - Effects on local employment;
    - Requirements for education of staff and establishment of training centers to ensure compliance with international standards;
    - Sourcing of raw materials;
    - Demand projections (both local and international);
    - Macro-economic effects; and
    - Financial effects from locally manufactured components on the CAPEX of a project.
- Research on how transmission-related issues due to the intermittency of WPP and weak grid systems can be solved

Increased international R&D collaboration

Wind energy is only partially a country-specific technology. The majority of what is known about wind behavior and wind turbine technology is applicable in every country. Therefore, a cross-country R&D collaboration on wind is essential for Indonesia. The collaboration can be fostered especially with countries that have a long-lasting track record in wind energy development, like Germany, Denmark, and the Netherlands. Having the collaboration could leverage existing international R&D initiatives and draw significant lessons from these countries for Indonesia. Moreover, establishing a long-term alignment of wind energy research agendas is also critical to kickstart the collaboration. Countries like Indonesia are very interesting subjects of R&D for fundamental research on wind behavior in complex terrain, tropical circumstances, and archipelagic nature.

Reaching the wind development target in Indonesia necessitates a boost in R&D funding. For this international R&D collaboration, multilateral development banks (MDBs) can serve as vital sources of funding. Financing facilities can be tailored to support various needs on a case-by-case basis. Bilateral development banks also play a crucial role in providing funding for development projects. For instance, the German state-owned Kreditanstalt für Wiederaufbau Bank (KfW) established an agreement with the Indonesian Ministry of Finance in 2022, providing EUR 300 million promotional loan as part of the Sustainable and Inclusive Energy Programme. The financing package was expected to push for reforms in Indonesia's RE sector, which among others include improved regulations for rooftop solar PV and feed-in tariff mechanisms for renewables.

Another example is the Asian Development Bank (ADB) who sets up and funds the Energy Transition Mechanism in 2021. For the accelerated early retirement of operational coal-fired power plants, ADB prepares funds to refinance existing coal-fired power plants, bring forward the plants' planned retirement, and replace these plants with cleaner and more sustainable alternatives of power generation.

Key area action plan

Table 23: Action plan for key area 'Research and Development activities'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Prioritization of specific R&D topics for wind energy development	→	→	→	→	→	→	→	→
Increased international R&D collaboration	→	→	→	→	→	→	→	→

Stakeholder Involvement

Table 24: Stakeholder roles for key area 'Research and Development activities'

Action Plan	MEMR	MoF	MoI	MoIn	BRIN	BSN	PLN	Assoc./ Industry/ Lenders
Prioritization of specific R&D topics for wind energy development	A	C	C	C	R	I	C	C/I
Increased international R&D collaboration	A			C	R	I	C	C/I

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.5 Roadmap actions for Industrial capacity

The wind industry in Indonesia is still in a very premature stage. So far, only wind turbine towers are produced in Indonesia for export by PT Kenertec Power System in Cilegon, Banten (2,500 towers since 2006). Furthermore, the two wind farms that have been established so far were largely dependent on experts from outside Indonesia. This shows that there is still a significant room to enhance the industrial capacity for the Indonesian wind sector. Such industrial capacity can be subdivided into two aspects, i.e. development of a local supply chain and development of local know-how and expertise in wind energy development.

When considering the local supply chain development, the following should be taken into account. As mentioned in the previous subsection on priority R&D topics, it is advisable to first conduct a proper cost-benefit analysis on Indonesia's industrial capacity building for the local manufacturing of wind turbine components. A major challenge, as already identified in Section 4.5, is that such local supply chain requires large investments and a pipeline of projects to encourage manufacturers (and investors) to establish factories in Indonesia. To establish such a pipeline, many actions have been identified in the other key areas of this roadmap.

Meanwhile, the development of local knowhow and expertise in wind energy development should consider the two underlying challenges as identified in Section 4.5, namely, lack of local knowledge on the technology and limited availability of skilled local workforce. Specific actions can be taken to overcome these challenges, as proposed in Table 25.

Table 25: Proposed actions for the development of local knowhow and expertise in wind energy development

Action	Activities
Identify industry needs and standards	This entails identifying the specific skillsets and certifications required in the wind industry. This may include positions like wind turbine technicians, electricians, safety specialists, and project managers. It is also important to understand the industry's safety standards and regulatory requirement.
Engage stakeholders	Collaboration shall be formed with industry associations, local government agencies, wind project developers, and (international) educational institutions to collaborate on education and certification of skilled personnels.
Develop a curriculum	Creation of a curriculum for expertise development can cover both theoretical knowledge and practical skills relevant to the wind industry. It is essential to ensure that the curriculum is aligned with industry standards and safety regulations. The curriculum could include modules on wind turbine operation and maintenance, electrical systems, safety procedures, and environmental considerations.
Select training providers	This covers the selection of partner(s) or training providers (e.g. technical schools, community colleges, or specialized training organizations) to deliver the programs. Part of the selection process is to ensure that these providers have qualified instructors with relevant industry experience.
Funding and resources	Securing funding is important to begin training programs. Funding may come from a variety of sources, including government grants, industry sponsors, development banks, and international funding (e.g. JETP). Resources should be deployed for designing and realizing training facilities, equipment, curriculum development, and training materials.
Accessibility and inclusivity	Training programs should be accessible to a diverse group of participants to achieve gender balance and involve underrepresented or marginalized communities. One option to consider is offering scholarships or financial assistance to those who may face economic barriers to participate.
Certification process	A clear set of criteria for certification, including the number of training hours required, specific skills to be mastered, and any written or practical examinations should be established. Furthermore, this might entail setting up a certification body (or work with existing ones) to issue internationally recognized industrial certificates.
Safety training	Safety is a paramount concern in the wind industry during the construction and maintenance stages. Therefore, priority should be placed on safety training, including emergency response procedures and compliance with industry safety standards.
Internships and hands-on experience	This encompasses offering opportunities for on-the-job training or internships at existing (or under construction) wind projects to provide hands-on experience.
Monitoring and evaluation	Regular monitoring of the effectiveness of training programs is key to developing local expertise in wind energy. This can be done by collecting feedback from participants and in turn making necessary improvements. Evaluation of the programs' success can be done by tracking the employment rates and the career advancement of program graduates.
Continuous improvement	This entails keeping the program updated with recent industry developments, technology advancements, and changing standards.

Key area action plan

Table 26: Action Plan for key area 'industrial capacity'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Development of a local supply chain								
Development of local knowhow and expertise in wind energy development								

Stakeholder involvement

Table 27: Stakeholder roles for key area 'industrial capacity'

Action Plan	MEMR	MoF	MoI	MoIn	BRIN	BSN	PLN	Assoc./ Industry
Development of a local supply chain	A	C	R	C	C	C	C	C
Development of local knowhow and expertise in wind energy development	A					R	C	C

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.6 Roadmap actions for Infrastructure

Based on the challenges identified in Section 4.6, the following recommended actions are included in the roadmap to address the challenges related to infrastructure.

Transmission system expansion, enhancement, and island-interconnections

Although good wind resources may be available in Indonesia, most areas with the best wind resource areas are located at considerable distances from demand centers and existing transmission systems. Addressing this challenge and acting towards a solution as prescribed in this roadmap are of strong significance for the future of the wind sector.

The Government and PLN are encouraged to take immediate action to expedite the development of a transmission network that is suitable to support the energy transition. An important note is that wind energy is not the only RE source that is dependent on available and reliable grid infrastructure. Other sources (both variable and dispatchable) like solar PV, hydro power, and geothermal plants also require a connection to the grid. The difficulty with harvesting RE is that the envisioned locations cannot always be chosen near an existing grid in comparison to, for example, choosing the location for a gas turbine. RE plants' location are dependent on where the natural resources are available (and many other factors). Therefore, for many RE projects, an expansion of the grid (including building additional transmission lines, distribution lines, and advanced control centers) is required to allow generated electricity to be transferred to the main grid. This grid needs to be ready before the RE plant becomes operational.

On the other hand, it is difficult for PLN to start grid expansions way ahead of the construction of future RE plants to be connected. Grid expansions would cause a significant financial burden and risk on PLN. Therefore, the planning and development of grid expansions should be synchronized with RE project planning and development (including onshore wind farms). As elaborated in Subsection 5.2.1, after Step 1 (identification of potential wind energy locations), action needs to be taken by PLN to prepare the potential expansion of the grid (with sufficient capacity) to the wind farm location. The more certain that the wind farm will be realized, the more concrete PLN's actions need to be for the grid expansion.

Aside from the grid expansion to wind farm locations, general reliability and stability of the grid is an important requirement to enable the evacuation of electricity from variable RE. Sumatra and Jawa-Madura-Bali transmission systems are already at a level in which it is unlikely that grid reliability and stability will cause many challenges, especially when the new Jawa-Madura-Bali control center becomes operational. But on other islands, the transmission systems are not yet at this level. This means a challenging task for the Government (especially PLN) to enhance the reliability and stability of these systems too.

In the meantime, integration of Battery Energy Storage Systems (BESS) can mitigate the intermittency of wind energy (see the next action point). Therefore, providing a robust support for R&D initiatives related to new transmission technologies becomes a critical driver for the successful execution of wind projects (see also the prioritization of specific R&D topic in Subsection 5.2.4).

Finally, in the long term, Indonesia will require more interisland connections to link, for example, the grid of Kalimantan with that of Java. A so-called Indonesia Supergrid will lead to optimizations of the nationwide utilization of RE sources and create a large, stable grid in which variable, dispatchable, and baseload electricity production can operate in balance.

In-depth assessment of incentives for BESS integration

An in-depth assessment and incentives for BESS integration in areas with weak grids and RE sources are very crucial factors for creating a more reliable grid infrastructure. Weak grids are prone to voltage fluctuations and blackouts due to the intermittent nature of RE sources. BESS can provide grid stability and reliability by storing excess energy during periods of abundance and discharging it during high-demand or low-production periods, maintaining the supply-demand balance. Integrating BESS allows for better utilization of RE resources as excess RE-based power can be stored when production exceeds demand, reducing curtailment and maximizing the use of clean energy. BESS can also enhance energy resilience in areas with weak grids, making them less vulnerable to power disruptions caused by natural disasters or equipment failures. In the event of a grid failure, BESS can provide backup power, reducing downtime and economic losses

Despite the benefits of BESS, the technology requires a high investment cost for procuring, installing, and maintaining the system. Incentives for BESS integration can encourage investment in energy storage, leading to potential revenue streams. For example, BESS can participate in demand-response programs, grid balancing, and ancillary services, so that income for grid support can be earned by the BESS owner/operator. Establishing incentives and conducting policy and regulation assessments help to develop a clear and supportive institutional framework for BESS integration. In turn, this fosters investor confidence and streamlines wind project implementation.

As a summary, an in-depth assessment of incentives for BESS integration in areas with weak grids and RE potential are vital to address energy challenges, promote sustainability, improve grid reliability, and drive economic growth. These efforts are aligned with the broader goals of transitioning to a cleaner and more resilient energy infrastructure.

Identification of potential synergies in multi-beneficiary use of road and port improvements

It is a fact that for the construction of an onshore wind farm reliable road infrastructure is required to transport the very large wind turbine components to the site. This is unavoidable and will in many cases be a significant cost element in the business case of the project. What could be improved is to avoid the construction of road infrastructure only dedicated to the construction and maintenance of the wind farm alone. It would be beneficial if a synergy could be found between access to the wind farm and using the same road (likely with some expansion) to connect economic regions, connect remote villages, or decrease the pressure on existing infrastructure. Furthermore, it would make it even more beneficial if this cost can be shared between the developer and the beneficiary of the road infrastructure (e.g. regional government, MoPW, and owners of plantations that can use a quick route to their distribution facilities). A Public-Private Partnership (PPP) structure could make this feasible. To find such synergy, involvement of potential beneficiaries in the early stage of the project is required. Easing of regulations (e.g. avoidance of double tendering for the road construction for the Ministry of Public Works) is a precondition to making this work.

The same type of synergy could also be looked for in port development. Necessary improvements of port facilities for offloading wind turbine components could also be beneficial to the port owner in the long term (e.g. heavier offloading cranes and larger storage yards). Moreover, if there exists a pipeline of wind farm projects in a specific region or island, it is vital that the improvement of port facilities is not only applied for a single project. Consultations with the subsequent wind farm developers about their port requirements is recommendable. This could also entail a division of the cost for such port improvements between the developers.

Key area action plan

Table 28: Action plan for key area 'infrastructure'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Transmission system expansion, enhancement, and island-interconnections	→	→	→	→	→	→	→	→
In-depth assessment of incentives for BESS integration	→	→	→	→	→	→	→	→
Identification of potential synergies in multi-beneficiary use of road and port improvements	→	→	→	→	→	→	→	→

Stakeholder involvement

Table 29: Stakeholder roles for key area 'infrastructure'

Action Plan	MEMR	MoF	MoI	MoIn	MoPW	MoEF	PLN	Assoc./ Industry/ Lenders
Transmission system expansion, enhancement, and island-interconnections	A	C		C	I	I	R/A	I
In-depth assessment of incentives for BESS integration	A	C		C			R/A	C
Identification of potential synergies in multi-beneficiary use of road and port improvements	C	A	C	C	R		C	C/I

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.7 Roadmap actions for Financing & bankability

Technical feasibility of an onshore wind project is one key precondition. The second one is bankability of the project. Bankability is dependent on a predictable and transparent risk and return profile of the project for lenders and investors. Major factors for bankability are:

- Incentives to overcome high "learning cost":
  In an immature wind energy sector like Indonesia's, developing a wind farm is associated with a significant "learning cost". This is due to the lack of a standardized process (see Subsection 5.2.2), industrial capacity (see Subsection 5.2.5), and infrastructure (see Subsection 5.2.6). Although such a high cost is completely normal in a developing sector, with the right (financial) incentives, the learning cost could be overcome and potentially create a viable business case.

- Conditions of Power Purchase Agreement (PPA) with PLN:
  For a period of 20-30 years, the agreement determines how the wind farm will earn back on its investment and creates a return on investment for lenders and investors. Therefore, conditions in the PPA need to be reasonable and consistent in order to result in a bankable project.

To overcome the challenges identified in Section 4.7, this Roadmap provides the following recommendations on both elements.

Implementing support mechanisms that provide sufficient incentives to investors

The Government has issued a range of fiscal and non-fiscal incentives. So far, however, these incentives have not proven to be successful in terms of acceleration of wind energy development for reasons mentioned in Section 4.7. Consequently, a consistent implementation of Presidential Regulation No. 112/2022 is necessary. The implementation can be coupled with additional public dissemination activities to increase awareness on the regulation and gauge feedback from the key stakeholders on how the regulation can be improved.

The incentives should be part of a coherent framework and be consistent with measures that target the removal of administrative barriers (e.g., unnecessarily long permitting processes), as well as with other initiatives (e.g. to support R&D). International, national, and regional mechanisms should be complementary to the extent that investors are encouraged to invest in techno-economical feasible projects, rather than simply being attracted by the highest level of government support. To encourage a successful implementation, KPI's can be determined to measure how likely the application for incentives is being successfully implemented, and to identify the root cause of unsuccessful applications. When required, such procedures might need to be adjusted to simplify the process and improve the applications.

Agreement on a bankable and balanced PPA
As described in Section 4.7, there are still bankability issues with the current PPA issued by PLN for RE-based power plants. PLN as the off-taker has maintained a strong credit rating. However, the private sector will require PPA terms that are considered bankable for wind projects, which have substantially higher capital costs and risks compared with other means of power generation. These bankable PPA terms are essential to attract the large international investors and lenders needed to provide sufficient volumes of financing and low cost of capital, which cannot be offered by local banks alone. Before banks decide to finance a project, they will conduct a so-called due diligence. In this process, the complete project is critically scrutinized, including a thorough examination of the PPA terms. If unbankable PPA terms are identified during the due diligence process, these terms can be considered red flags which could cause reluctance of banks to finance the project.

It is important to maintain active discussion and communication between lenders, investors, PLN, and policymakers, to agree on a bankable PPA that reduces the associated risks for the project. There are at least two ways to achieve such an agreement. Firstly, benchmarking the PPA to other countries who have been successfully implementing wind projects is strongly recommended. The second way pertains to strengthening the understanding of OJK, as well as other relevant financial institutions, on the due diligence practices/methods for RE (including wind energy) projects. This is important because OJK sets the guidelines and reference for local banks to conduct due diligence of such projects. Similarly, knowledge transfer and capacity building programs between OJK and Financial Services Authority of countries who are more advanced in wind energy development, as well as between local banks and foreign banks originating from these countries, could be beneficial to reaching this objective.

Furthermore, this roadmap provides suggestions on possible improvements of specific PPA conditions in Table 30.

Table 30: Suggestion on overcoming PPA bankability issues

Aspect	Case and suggestion
Project milestone and performance security requirements	Case: Unmatched timeline between PPA and financing activities, e.g. the Financial Close or COD after PPA Effective Date during the due diligence by lenders may result in additional sunk cost borne by investors especially if there is no guarantee for the investors to win the tender process. *Suggestion: Provide a synchronized timeline based on input from different stakeholders and benchmarking with other countries which adopt similar procurement process*
Risk allocation during Force Majeure and Government Force Majeure	Case: Based on the current PPA, PLN is obliged to buy the project if a force majeure situation still occurs, but in the Tanah Laut WPP PPA (Article 14), both PLN and IPP will bear the risk of force majeure, without further explicit details. *Suggestion: Risk allocation between each party is expected to be split in greater detail.*
Restriction on transfer of shareholders	Case: The limitation on the transfer of ownership as set out in the current PPA draft or sponsor agreement, may reduce the profitability of the project. *Suggestion: Gain input on the main issues interpreted by the investors related to the transfer. If the issue is on the transfer pricing, fair price shall be ensured when exercising pre-emptive right, by engaging with an independent appraisal.*
Financial benefit	Case: Currently, the proceeds of renewable market-based instruments (MBI; i.e., carbon credit, REC, green tag, and/or tradable rights) go to PLN. Having mutual/shared benefit on the MBI proceeds will increase the attractiveness of RE projects market. *Suggestion: Propose a new scheme which splits the renewable MBI proceeds by at least 50/50 between PLN and project company/developer*
Dispute settlement	Case: Having neutral location of seat arbitration (conducted by SIAC, in Singapore instead of Jakarta) will support neutrality of the arbitration process, and thus, contributes to the bankability. *Suggestion: Consult with lenders on the favorable dispute settlement mechanism*
Local content requirement	Case: Domestic component level regulations demand the use of locally made components, and infractions will result in a fine equal to the difference in value between utilization of the local component with the existing one. *Suggestion: Continuous harmonization between prevailing regulation and local industry capabilities plays a significant role in successfully applying the regulation. In case the price is still expensive, or production is less, incentive might be required to promote local content. Discussion and alignment between policy makers and strategic stakeholders is required.*
Mandatory partner	Case: An unbalanced share of overrun and development cost between the developer and the mandatory partner (as obligated by PLN) via the Special Purpose Company *Suggestion: Ensure that the risks taken between the developer and Mandatory Partner is balanced*

Key area action plan

Table 31: Action plan for key area ‘financing and bankability’

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Implementing support mechanisms that provide sufficient incentives to investors	→	→	→					
Agreement on a bankable and balanced PPA	→	→						

Stakeholder involvement

Table 32: Stakeholder roles for key area ‘financing and bankability’

Action Plan	MEMR	MoF	MoI	MoIn	PLN	Assoc./ Industry/ Lenders
Implementing support mechanisms that provide sufficient incentives to investors	C	R/A	C	C	C	C
Regulations for agreement on a bankable and balanced PPA	R	R		I	R/A	C/I

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

5.2.8 Roadmap actions for Procurement process

Even though PLN’s procurement process is clearly defined on paper, based on the conducted interviews, the process is still considered as the main bottleneck for a successful wind energy development due to several factors. The following challenges require strong attention to be overcome in the procurement process:

- Considering the nonrecourse project financing, the duration of financial close to be reached after PPA is awarded (PPA effective date), is expected to be more than 6 months, which is stipulated in the tender schedule. The longer duration is due to the lengthy due diligence process conducted by the lender. This needs to be adjusted in the procurement process.
- More than 1 month is needed to secure all required permits and studies after winning bidder announcement. Moreover, additional measures are needed to ensure that the obtained permits and completed studies are under the right company (Special Purpose Vehicle or SPV). Time needs to be allocated for this in the procurement process.
- A clear explanation is required if the tender is paused or cancelled (which has happened several times in the past years) to promote transparency.
- On-site measurements (using a met mast or LiDAR) by the bidder will require a considerable amount of investment, which may not be ‘proportional' to the high level of uncertainties during the tender process. As suggested in Subsection 5.2.1, the procurement process would improve significantly (in terms reasonable risks for developers, quality assurance, and consistency) if the Government would take the responsibility in the preparation of wind farm projects (e.g. conducting wind measurement, executing pre-FS, and gathering spatial data).

- The most heard feedback regarding the procurement process is the high level of unpredictability. There is no clear timeline (month, year) when projects will be tendered. COD dates in the RUPTL do not provide any guidance on the procurement timeline either. Such a timeline should include a pipeline of projects for the coming years, which enables developers to timely prepare resources and start preparations (i.e. studies) for the upcoming tender processes. This will also create a more reasonable market behavior, preventing all developers merely focusing on the next project tendered instead of a long-term investment strategy.

Key area action plan

Table 33: Action plan for key area 'procurement process'

Action Plan	2023	2024	2025	2026	2027	2028	2029	2030
Define a robust and reliable procurement process with a reasonable pipeline and timeline of projects	→	→	→					

Stakeholder involvement

Table 34: Stakeholder roles for key area 'procurement process'

Action Plan	MEMR	MoIn	PLN	Assoc./ Industry/ Lenders
Define a robust and reliable procurement process with a reasonable pipeline and timeline of projects	C/A	C	R/A	C

R: Responsible **A:** Accountable **C:** Consulted **I:** Informed

6 Conclusion and recommendations

Based on the research conducted for this roadmap, it has become clear that so far wind energy utilization is not yet fulfilling the expectations in Indonesia. Despite that it is still a question whether 60.6 GW of onshore wind (from RUEN) is a realistic potential, and whether the 8.5 GW onshore wind to be realized by 2030 (from the JETP Comprehensive Investment and Policy Plan) is a realistic target, the potential of wind energy in Indonesia is definitely there. However, having realized only 0.13 GW of installed onshore wind farm capacity until 2023 and having only 0.14 GW in the pre-construction phase show the significant challenge to wind energy development that still lies ahead.

As introduced in Chapter 1, the objective of this research is to eventually answer the following questions:

1. What are the lessons learned from past studies and projects in Indonesia's onshore wind energy sector?
2. Based on the lessons learned, what are the existing gaps/barriers that hamper the acceleration of future onshore wind project developments?
3. What are the steps to overcome these gaps/barriers, who needs to take which step, and when and how shall the steps be taken?

The first question has been answered in Chapter 2 and 3 of this roadmap. Based on the desk research conducted, these two chapters have provided the overarching insights in the current status of wind energy development in Indonesia. The chapters have further shown the large variety of stakeholders (categorized in 20 stakeholder groups) that are involved in the development of a wind farm. This extensive list of stakeholders is a complicating factor in aligning between so many parties in developing onshore wind. Also, the regulatory framework in which wind energy development activities take place is very extensive and difficult to comprehend for the involved stakeholders. Such an extensive framework covers policies, regulations, permits, technical standards, procurement processes, land acquisition processes, and regulations on carbon credits. Although it is important to have a solid regulatory framework in place, such a framework could also intensify bureaucracy, lengthen the project duration, and increase the development process' complexity.

The second question has been answered in Chapter 4 of this roadmap. The interviews that have been conducted for the roadmap have shed some light on the many challenges/barriers perceived by the stakeholders involved in wind energy. The barriers have been categorized in 8 key areas:

- Wind data availability
- Availability of spatial data and standardized process
- Policy/regulation and permitting
- Research & Development activities
- Industrial capacity
- Infrastructure
- Financing & bankability
- Procurement mechanism

These barriers need to be overcome in order to realistically foster a thriving wind energy development in Indonesia in the coming years. Without any concrete actions being taken, it is expected that the same (or even slower) pace of wind projects will be realized, as has happened in the past 10 years.
Just as worrisome, such status quo could lead to a less attractive investment climate for Indonesia for investors that wish to invest in wind energy (and possibly also other types of renewable energy).

The third question has been answered in Chapter 5. In this roadmap, a variety of recommended actions have been identified for the short, medium, and long term for each of the 8 key areas. Logically, the priority should be first on the short-term barriers and proposed solutions, while not overlooking the medium- and long-term counterparts. In the short-term, solutions need to be found to address the unavailability of wind and spatial data, the lack of attractive financing incentives, the lack of bankability of the PPAs, and the challenging PLN procurement process for IPPs.

This roadmap provides a variety of solutions for these challenges with one overall conclusion: it is advised that the Government of Indonesia will be the key stakeholder in initiating and implementing these solutions. The Ministry of Energy and Mineral Resources and PLN are the obvious and most experienced authorities within the Government to take charge of the implementation, with necessary the support from other ministries (the Ministry of Agrarian Affairs and Spatial Planning, Ministry of Public Works, Ministry of Environment and Forestry, Ministry of Industry, Ministry of Investment, and Ministry of Finance). Even implementing the solutions could be challenging because of the broad yet necessary involvement of multiple parties with possibly different interests. Therefore, it is strongly advised for the Government to include a pipeline of wind energy projects as National Strategic Projects.

To ensure a successful execution of the National Strategic Projects, a Government institution needs to be appointed and authorized to initiate, enable, and oversee the implementation of the Roadmap's action plans. This can either be done by establishing an overarching inter-ministerial committee for wind energy, or by appointing a Coordinating Ministry (e.g. the Coordinating Ministry for Maritime & Investment Affairs) to take the lead in the implementation. It could also be beneficial to continue the Wind Power Technical Working Group (TWG) setup, so that close coordination between the relevant stakeholders can be maintained. This leads to the first recommendation based on this roadmap:

> Recommendation 1: Designate a pipeline of wind energy projects as National Strategic Projects and a Government institution as the leader in initiating, enabling, and overseeing the implementation of the Roadmap's action plans

An often-heard discussion point is that wind energy is not progressing enough in Indonesia because there are insufficient investment funds available. Based on the research, however, it can be concluded that investment funds for actual projects are available, but it can only be deployed if the investor's conditions are fulfilled, namely, the barriers are overcome. Investments are still required but not directly to finance projects, but to finance the enabling factors of these projects. These enabling factors can be summarized in terms of Capacity Building and Technical Assistance.

An important note is that countries which have installed multiple GWs of wind energy do have more expertise in this field than Indonesia so far. Allowing and encouraging foreign experts to participate in Capacity Building and Technical Assistance programs is therefore an important prerequisite. This could for example be in the form of assisting PLN in enhancing the procurement process and assisting MEMR in conducting proper selection of wind energy locations. Another example is an assistance for OJK and local banks on establishing a greater understanding of due diligence processes for wind projects. 'Assisting' should be understood as training programs, deployment of interim staff, knowledge sharing sessions, etc. To facilitate these Technical Assistance programs, they should be integrated into the regular (annual) program of the relevant Indonesian institutions (e.g. OJK and DJEBTKE).

In this manner, Indonesia could solve the aforementioned challenges, while potentially leapfrogging over other challenges that were once faced by the experienced foreign countries. This leads to the second recommendation based on this roadmap:

> Recommendation 2: Set-up Capacity Building and Technical Assistance programs at multiple Indonesian authorities with international support (e.g. JETP) to execute the roadmap action plans to overcome the identified barriers

On a final note, this roadmap is part of a larger project called the *Wind Energy Development in Indonesia: Investment Plan*. Within this project, three additional deliverables will be created, namely:

- Conducting a permit requirement review for the Indonesian wind sector and for a selection of wind sites
- Mapping wind energy potential and analyzing possible gaps for 8 selected wind sites
- Establishing investment opportunities guide for the onshore wind sector

It is the intention that these deliverables can further shed some light into ways to drive Indonesia's wind energy development forward.

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Appendix 1: Wind energy potential

Data on wind energy potential in 34 provinces in Indonesia at an annual average speed greater than 4 m/s at a height of 50 m based on RUEN.

No	Province	Potential (MW)
		RUEN
1	East Nusa Tenggara	10,188
2	East Java	7,907
3	West Java	7,036
4	Central Java	5,213
5	South Sulawesi	4,193
6	Maluku	3,188
7	West Nusa Tenggara	2,605
8	Bangka Belitung	1,787
9	Banten	1,753
10	Bengkulu	1,513
11	Southeast Sulawesi	1,414
12	Papua	1,411
13	North Sulawesi	1,214
14	Lampung	1,137
15	Yogyakarta	1,079
16	Bali	1,019
17	South Kalimantan	1,006

No	Province	Potential (MW)
		RUEN
18	Riau Islands	922
19	Central Sulawesi	908
20	Aceh	894
21	Central Kalimantan	681
22	West Kalimantan	554
23	West Sulawesi	514
24	North Maluku	504
25	West Papua	437
26	West Sumatra	428
27	North Sumatra	356
28	South Sumatra	301
29	East Kalimantan	212
30	Gorontalo	137
31	North Kalimantan	73
32	Jambi	37
33	Riau	22
34	Jakarta	4
	Total	**60,647**

Appendix 2: Development partners mapping

No.	Name of organization	Topic and detailed activity
1	EU Delegation to Indonesia & EUCD	The EU Organization provides a cooperation of a wide array of green issues, this includes the feasibility study for offshore wind in Indonesia. In achieving the goal, EU works closely with some of Indonesia's government agencies related to energy sector i.e., Bappenas and JETP Secretariat. Specifically in wind energy development, EU has ongoing supports, some of them are the possible technical assistance and investment support (through European Investment Bank).
2	UK-MENTARI	MENTARI (*Menuju Transisi Energi Rendah Karbon Indonesia*) is a partnership between the governments of Indonesia and the United Kingdom set up to promote the uptake of low-carbon energy, supporting Indonesia's just energy transition. Related to the energy sector, MENTARI works closely with the Ministry of Energy and Mineral Resources and other ministries such as Bappenas, Ministry of Investment, etc. The types of support that are currently provided include supporting policy, demonstration projects, and capacity building. In the wind energy sector, MENTARI has delivered a small-scale, off-grid energy project in eastern Indonesia to showcase a replicable, economically feasible business model that generates inclusive economic growth for rural communities.
3	GIZ	Generally, GIZ provides support to the Government of Indonesia in energy sector especially for the energy transition and renewable energy issues. The role and programs from GIZ include supporting government in implementing energy transition through technical assistance for Ministry of Energy and Mineral Resources. Other types of support are technical assistance in the form of studies to support the preparation of regulations/policies or evaluation of existing regulations, capacity development, etc. However, currently GIZ does not have any on-going activities/technical assistance/project implementation related to the development of wind energy.
4	GGGI RE-Act	RE-Act Project (Renewable Energy – Accelerated Transition) is a program from NZ, focusing on policy, capacity building, and de-risking. This program provides support to the Government of Indonesia, i.e., Bappenas and Ministry of Energy and Mineral Resources as well as other private sectors and stakeholders. Related to the energy sector, GGGI works with the Directorate of Various New and Renewable Energy, Directorate General of New Renewable Energy and Energy Conservation, Directorate General of Electricity, and Bappenas. However, currently GGGI RE-Act does not have any on-going activities/technical assistance/project implementation related to the development of wind energy.

ROADMAP
Onshore Wind Energy Development in Indonesia

2024

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