PRESENTATION

Wind Energy Development in Indonesia

COMPONENT 3

Preliminary Wind Farm Prospectus

ENERGY TRANSITION PARTNERSHIP UNOPS PONDERA

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- Introduction
- Approach
- Preconditions for each site
- Innovative wind modelling with ASPIRE
- Examples of wind farm prospectus
  (with Q&A in between the sites)
  - North Padang Lawas – South Tapanuli, North Sumatra
  - Sukabumi, West Java
  - Probolinggo – Lumajang, East Java

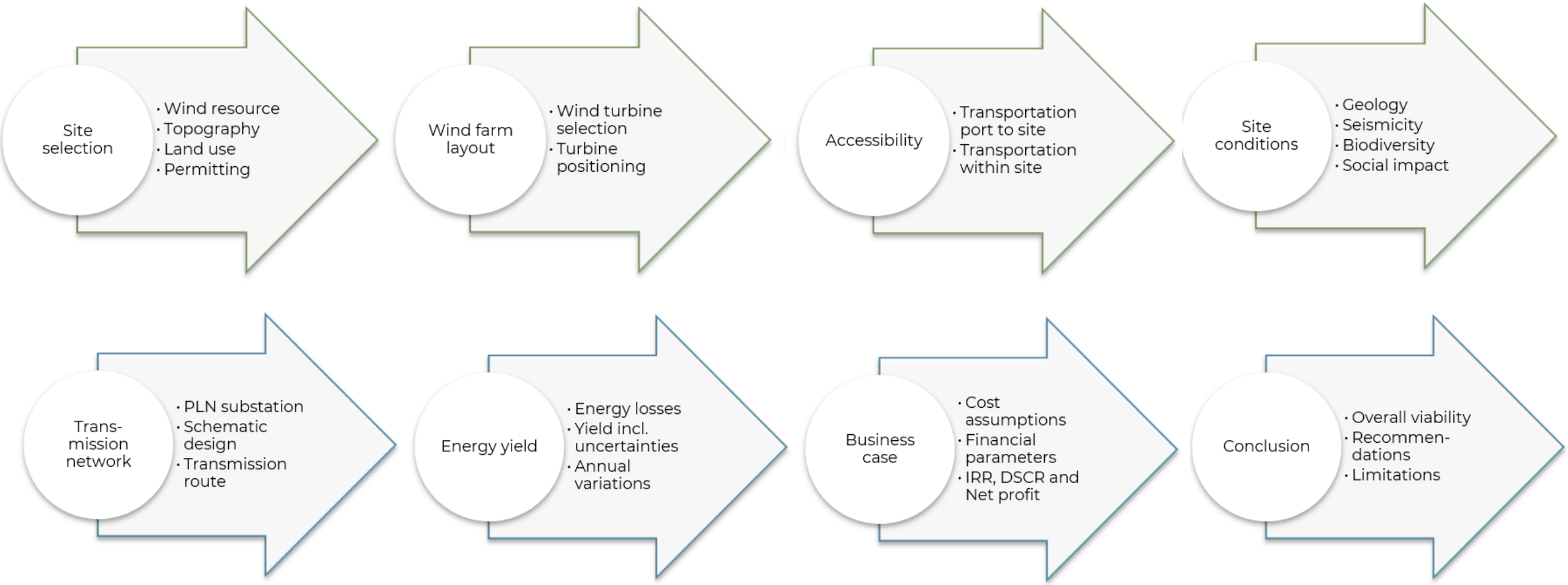
Introduction

- Component 3 of the Wind Energy Development in Indonesia: Investment Plan
- Initial assessment of 14 potential onshore wind locations
- 3 sites excluded based on lacking wind resource (2x Tuban and Samas)
- Remaining 11 locations clustered into 8 locations for further analysis
- Focus on technical and economic viability
- The goal is to **attract donor and business investment** for potential wind sites

8 Locations

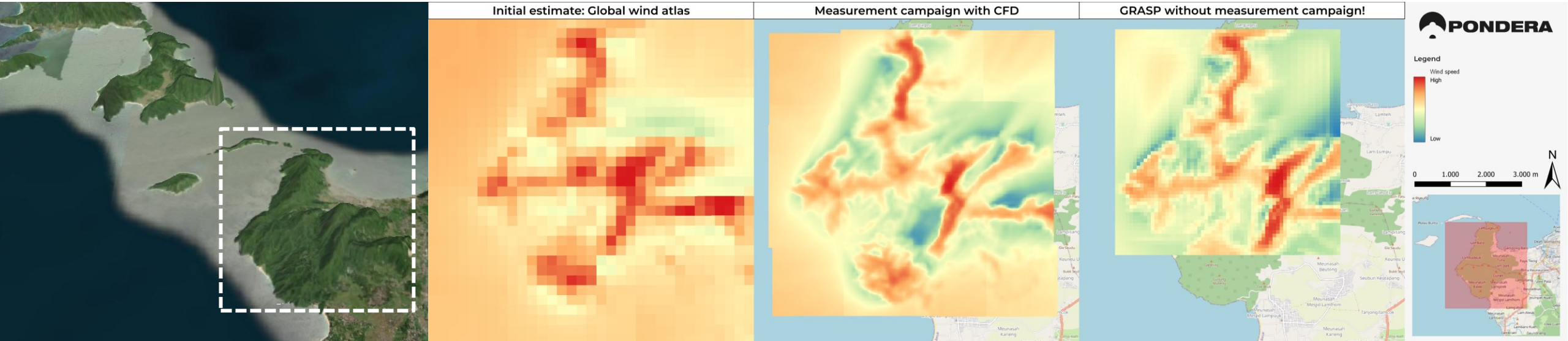
Aceh Besar	120 MW
Dairi	92 MW
North Padang Lawas	312 MW
Sukabumi	580 MW
Gunung Kidul	80 MW
Ponorogo	200 MW
Kediri	192 MW
Probolinggo	68 MW
Total potential investigated:	**1,644 MW**

Approach for all sites



Use of ASPIRE wind modelling for complex sites

- ASPIRE wind model can accurately model complex sites at an early stage of the project:
  - No measurement campaign required for early assessment
  - Similar results to combination measurement campaign and CFD
  - Current wind speed within 1% of actual met mast at location
- Annual energy production ASPIRE compared to CFD with measurements: within 3% difference
- Not a replacement of wind measurements, but an intermediate step for preliminary wind resource assessment
- Applied for assessment of Dairi, North Padang Lawas – South Tapanuli, Aceh Besar, Kediri, and Ponorogo (most complex sites)



Preconditions for each site

Average yearly wind speed: > 6 m/s
(at 100 m height)

Slope: < 15 degrees
(with a buffer of 100 m around steep ridges)

Exclusion of roads and railways
(with a buffer of 150 m)

Exclusion of other no-go zones
(protected areas, water bodies, airports, etc.; including buffer)

Reference wind turbine

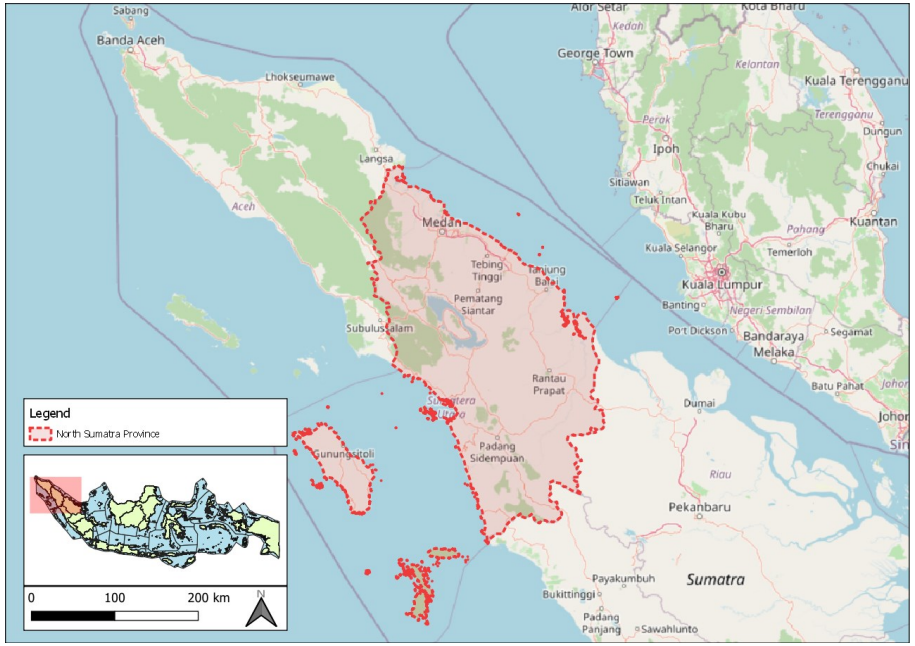
- Capacity: 4 MW
- Rotor diameter: 170 m
- Hub height: 140 m
- Inter-turbine spacing: 5x rotor diameter

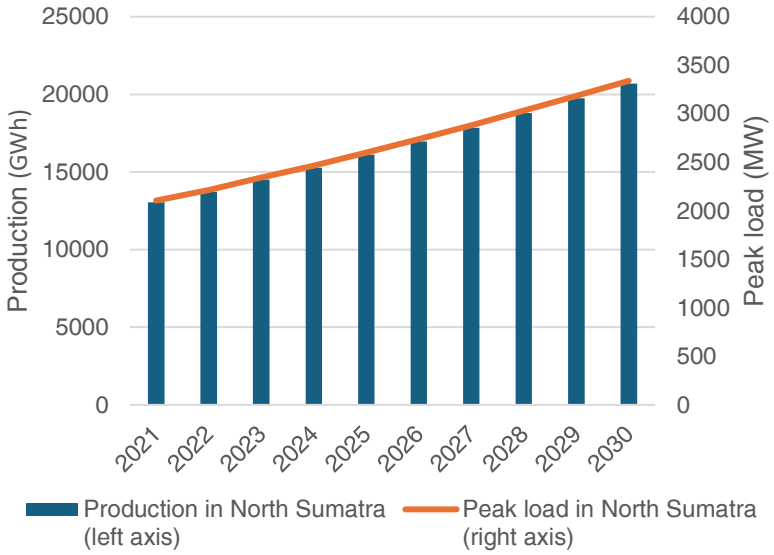
North Sumatra:
North Padang Lawas – South Tapanuli

North Sumatra:
Geographic location and demand

- The peak load of this province in 2020 was 1,883 MW
- Projected average demand growth rate 5.5% per year
- RUPTL 2021-2030 on wind energy:

Year	Capacity (MW)	Status
2024	**55**	Planned
2025	**55**	Planned
-	**88**	Potential
Total	**198**	

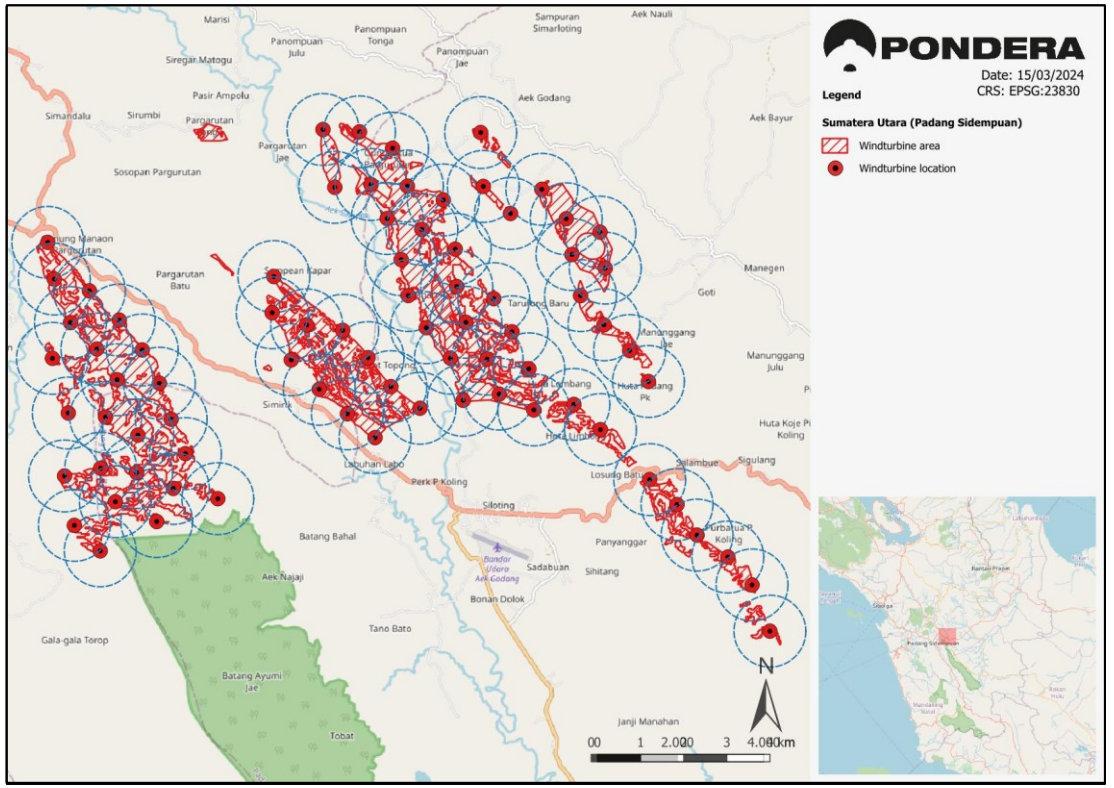


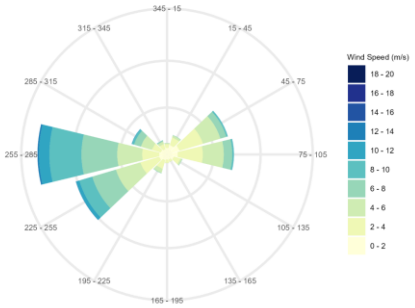


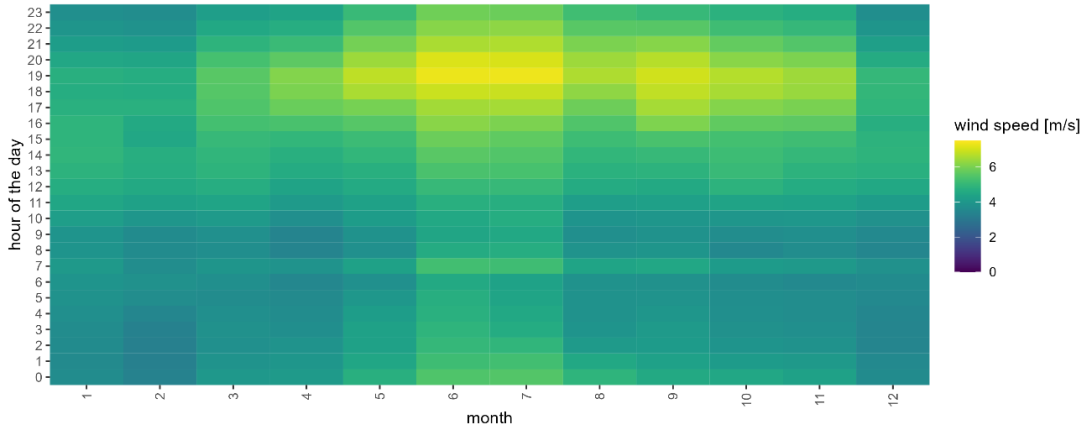
North Padang Lawas – South Tapanuli:

Site selection and pre-design

- Average yearly wind speed (> 6 m/s)
- Slopes (< 15 degrees, with buffer)
- Exclusion areas with buffers
- Analysis of location specific permit requirements
- Resulting in a final wind farm area
- Design of a preliminary layout:
  78 WTG, installed capacity of 312 MW

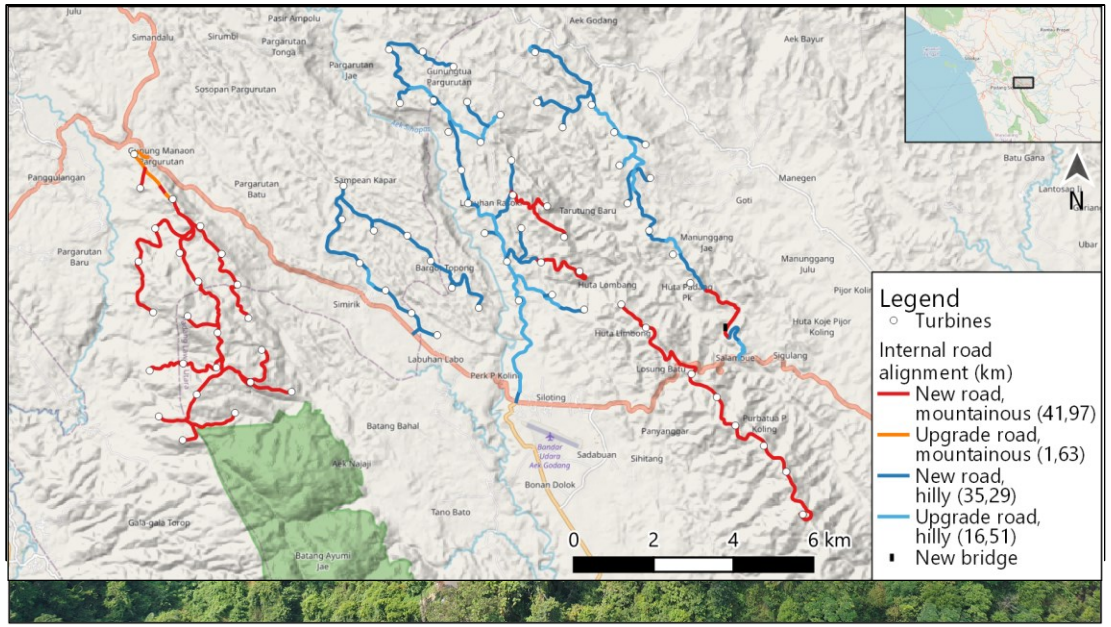






North Padang Lawas – South Tapanuli:
Wind farm accessibility

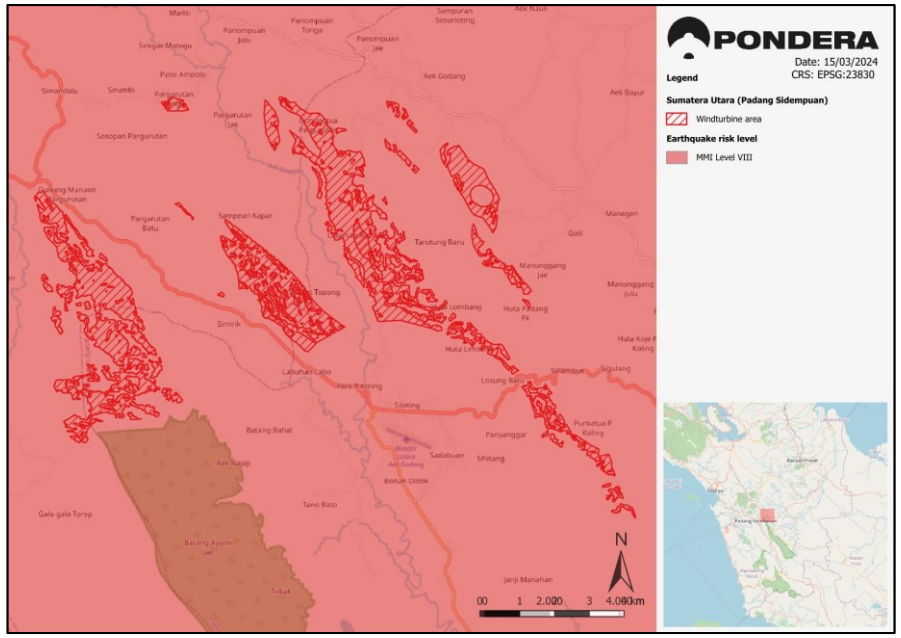
- **Port-to-site:** Port of Sibolga vs. Port of Dumai
  - Port of Sibolga route: too many bridges and other obstacles
  - Port of Dumai route: preferred, but also requires some specific road adjustments
- **Transport within the site:** new roads and upgraded roads required

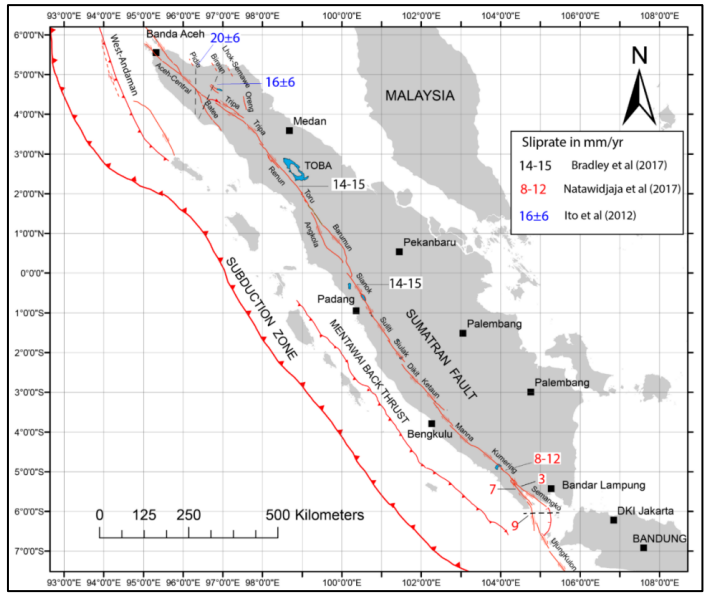


North Padang Lawas – South Tapanuli:

Site conditions: soil, land movement and seismicity

- **Soil**: Black slates, sandstone and quartzite beds
- **Land Movement Vulnerability Index:** Southwestern and eastern part of the site) more vulnerable to land movement/landslides.
- **Seismicity:** The site lies relatively close to the Great Sumatran Fault. Within the site, a larger number of smaller faults are present.
  - The site has potential to be hit by strong earthquakes with an intensity larger than VIII on the Modified Mercalli Intensity (MMI) scale.
  - The foundation design should consider the land movement vulnerability and seismic risk by adhering to the IEC 61400 standards for this.

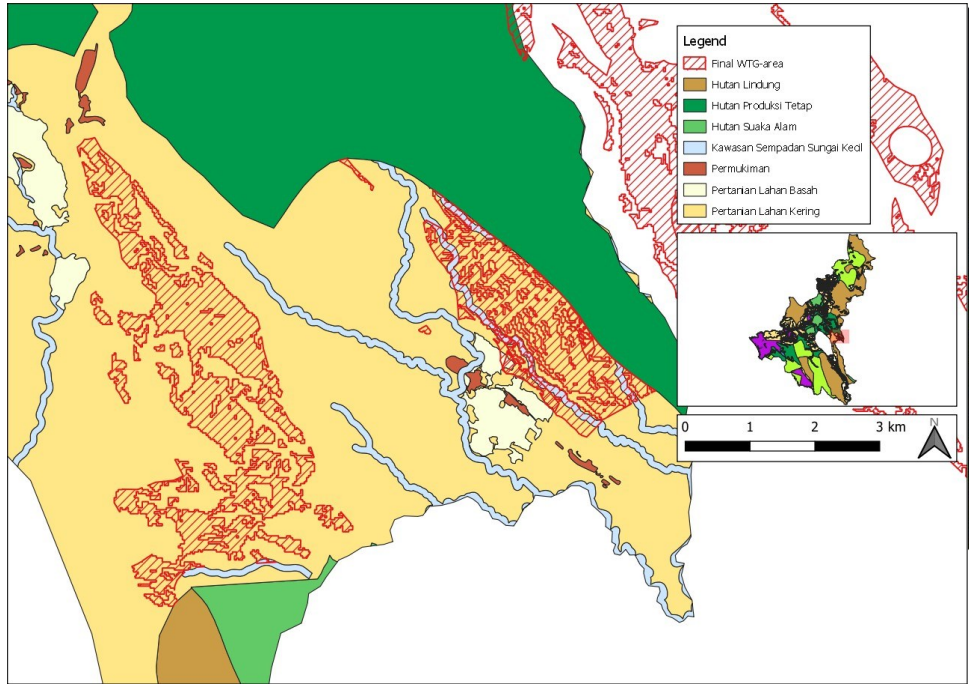


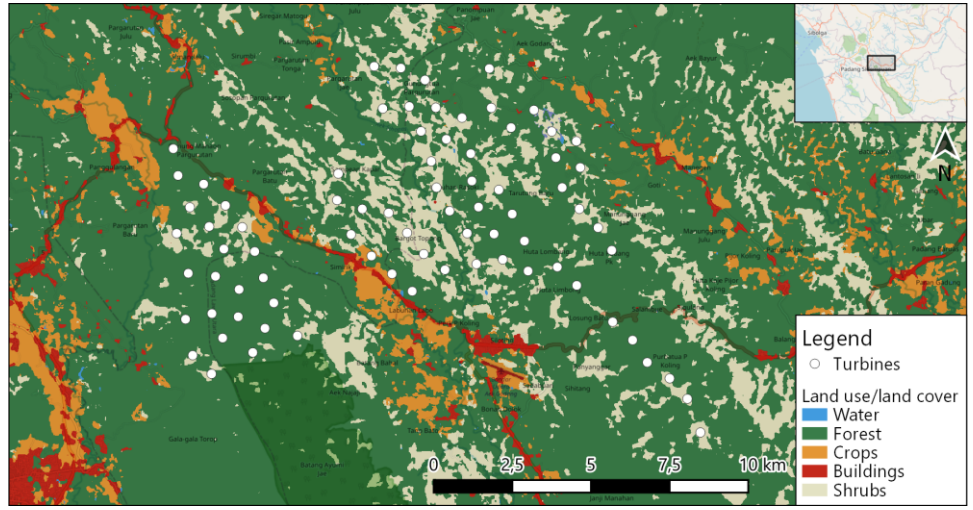


North Padang Lawas – South Tapanuli:

Site conditions: biodiversity and social impact

- **General impression:** variation between valley terrain (west), deep gorge (central) and steeper slopes (east)
- **Biodiversity:**
  - According to the online biodiversity database GBIF, no endangered animal or plant species were observed in the area in recent times that are categorized in the IUCN global red list category.
  - Still, some primary forest is still present in the southeastern part, with potential impact on the biodiversity
- **Social impact:**
  - Apart from the villages near the main road, the area is sparsely populated.
  - The social impact is mainly limited to the loss of agricultural land, reduced accessibility during road construction and transport and visual impact

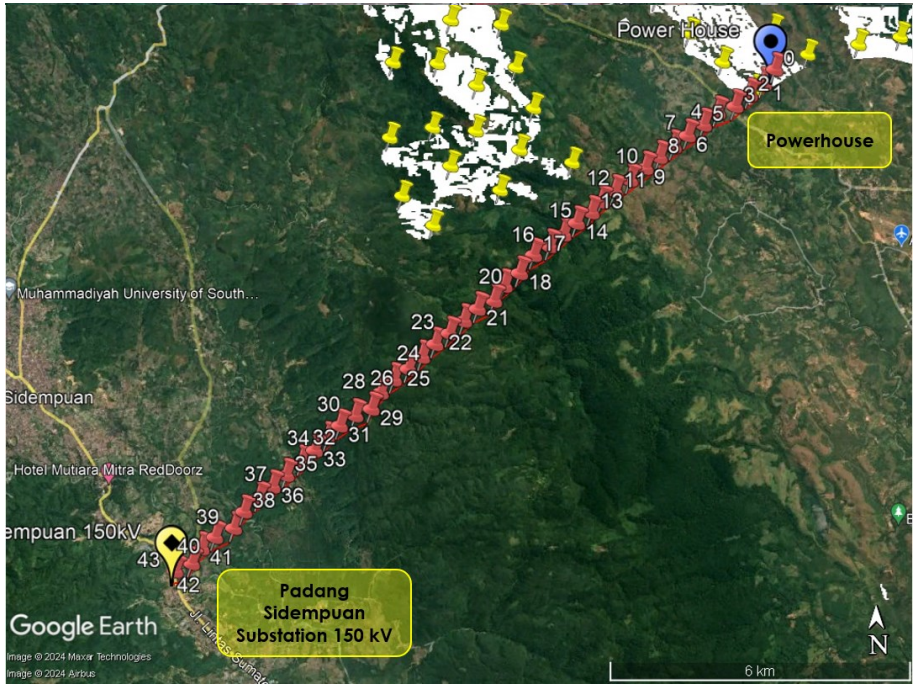


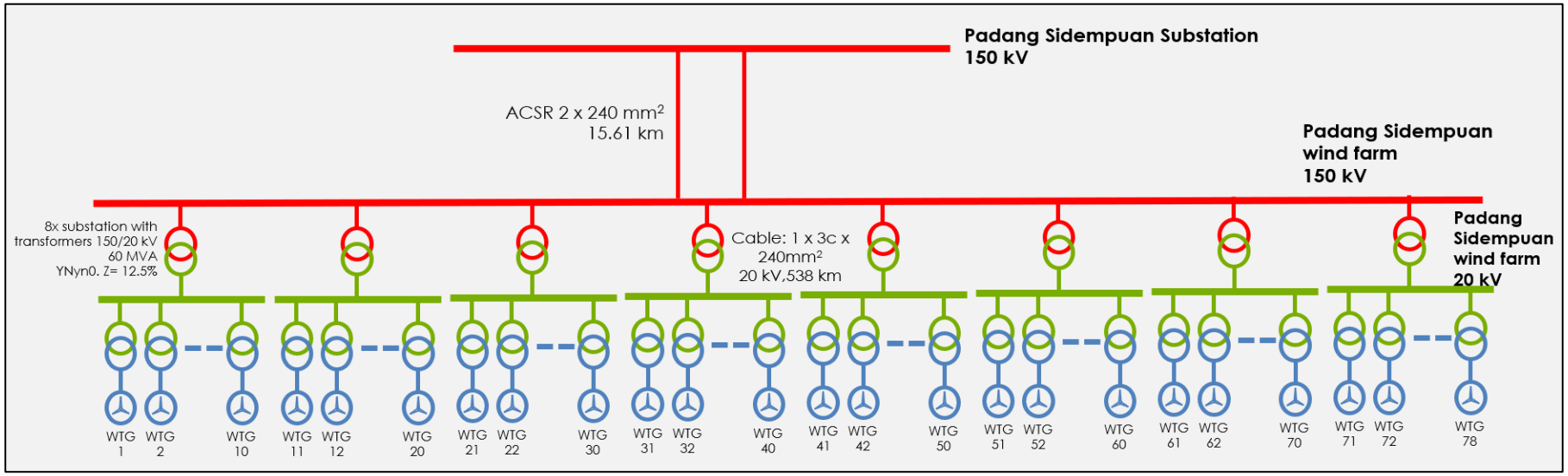


North Padang Lawas – South Tapanuli:

Transmission network

- **Point of connection:** closest point of connection to the existing PLN grid is the Padang Sidempuan 150 kV PLN substation
- **Transmission line:** 15 km transmission line with 44 towers are required
- **Schematic electrical design:**

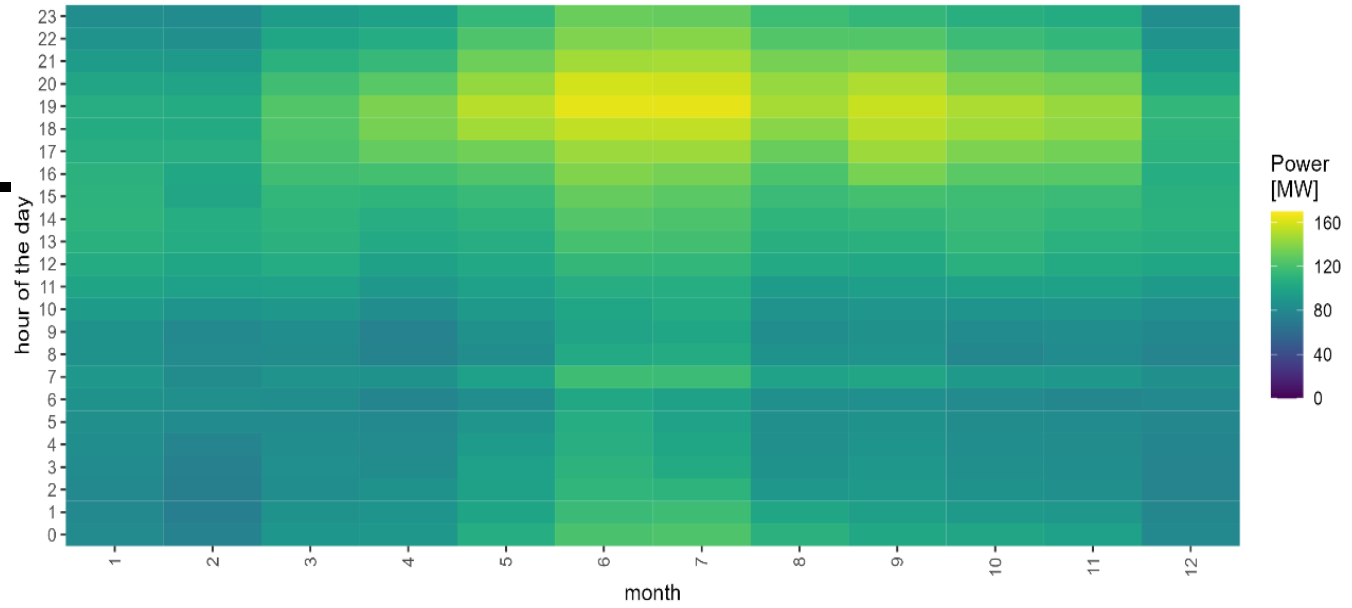




North Padang Lawas – South Tapanuli:

Energy yield

- **Wind turbine location specific analysis:** Long-term average wind speed calculated with the ASPIRE model at a height of 140 m. Subsequent iterations recommended.
- **P50 Net AEP calculation:** gross AEP minus losses (22.4%).
- **P90 AEP 25 years calculation:** P_{50} * (1 – 1.28*σ), in which σ is the uncertainty percentage (20%).
- **Monthly/hourly production variation:**



Parameter [Unit]	Amount
Number of new WTGs	78
Rated Power per WTG [MW]	4.0
Total rated Power [MW]	312.0
Rotor diameter [m]	~170
Hub height [m]	140
Air density [kg/m3]	1.129
Wind speed [m/s]	6.9
Gross result [MWh/yr]	1,183,369
Gross results including wake effects [MWh/yr]	1,055,565
P50 [MWh/yr] [12]	**918,143**
P90 (25 yr) [MWh/yr]	**682,813**
P50 [hrs/yr]	2,943
P90 (25 yr) [hrs/yr]	2,189

North Padang Lawas – South Tapanuli:

Business case

- **Cost assumptions:** lower-, baseline-, and upper-bound total investment cost
- **Financial parameters:**
  - 25 years operation
  - Gearing 70/30
  - Debt tenure 10 years
  - Interest rate 9%
  - Tariff*
    - Year 1-10: $10.49 cents / kWh
    - Year 11-25: $5.73 cents / kWh
- **Preliminary conclusion:** Initial IRR has potential but needs to increase to attract more investors. DSCR needs to increase > 1

Cost component	Baseline cost including VAT	Comment	Cost range
Preparation works	USD 6,375,000	DEVEX: Prior to Financial Close	90% - baseline -120%
Project management	USD 23,220,000	DEVEX: Until CoD	Baseline
Wind turbines	USD 217,408,000	CAPEX: Including transport and installation	90% - baseline -120%
Civil works: foundations	USD 31,255,000	CAPEX	80% - baseline -150%
Civil works: roads	USD 43,817,000	CAPEX	80% - baseline -150%
Civil works: crane hardstands	USD 10,940,000	CAPEX	80% - baseline -150%
Electrical works	USD 74,646,000	CAPEX	90% - baseline -120%
Land acquisition	USD 79,961,000	CAPEX	90% - baseline -150%
Risk contingencies	USD 37,152,000	DEVEX + CAPEX	Baseline
Lower bound total investment cost (DEVEX + CAPEX)	**USD 469,734,000**	**Investment cost per MW: USD 1,506,000**	
Baseline total investment cost (DEVEX + CAPEX)	**USD 524,776,000**	**Investment cost per MW: USD 1,682,000**	
Upper bound total investment cost (DEVEX + CAPEX)	**USD 667,449,000**	**Investment cost per MW: USD 1,901,000**	
Baseline operational expenditure (OPEX)	**USD 9,017,000 / year**	**Operational cost per MW / year: USD 29,000**	

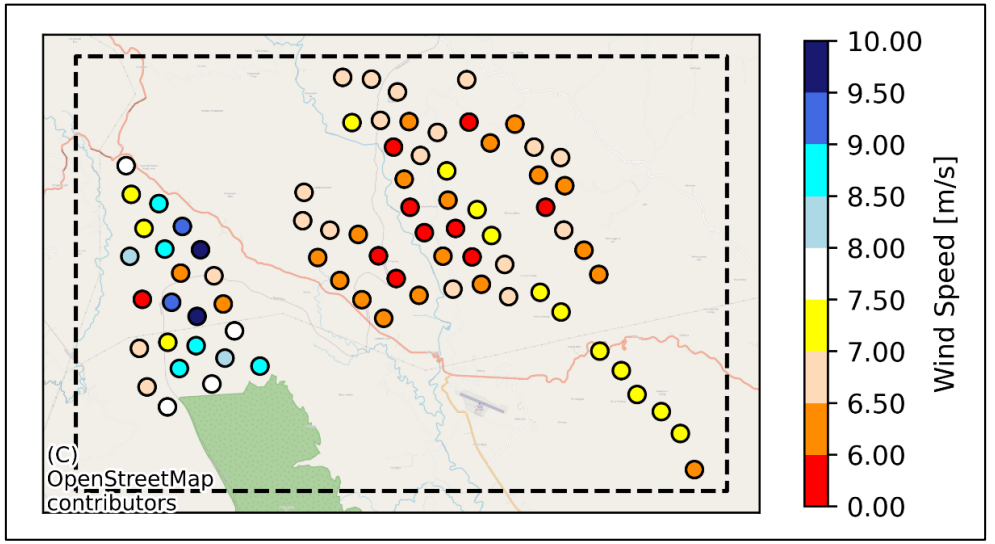
Business case outcome	Lower bound cost scenario	Baseline bound cost scenario	Upper bound cost scenario
Project (before taxes) Internal Rate of Return (IRR) at P50	12.93 %	10.80 %	6.77 %
Average Debt Service Coverage Ratio (DSCR) at P90	0.97	0.88	0.72
Net profit at P50 over 25 years	USD 417,987,000	USD 356,181,000	USD 210,654,000

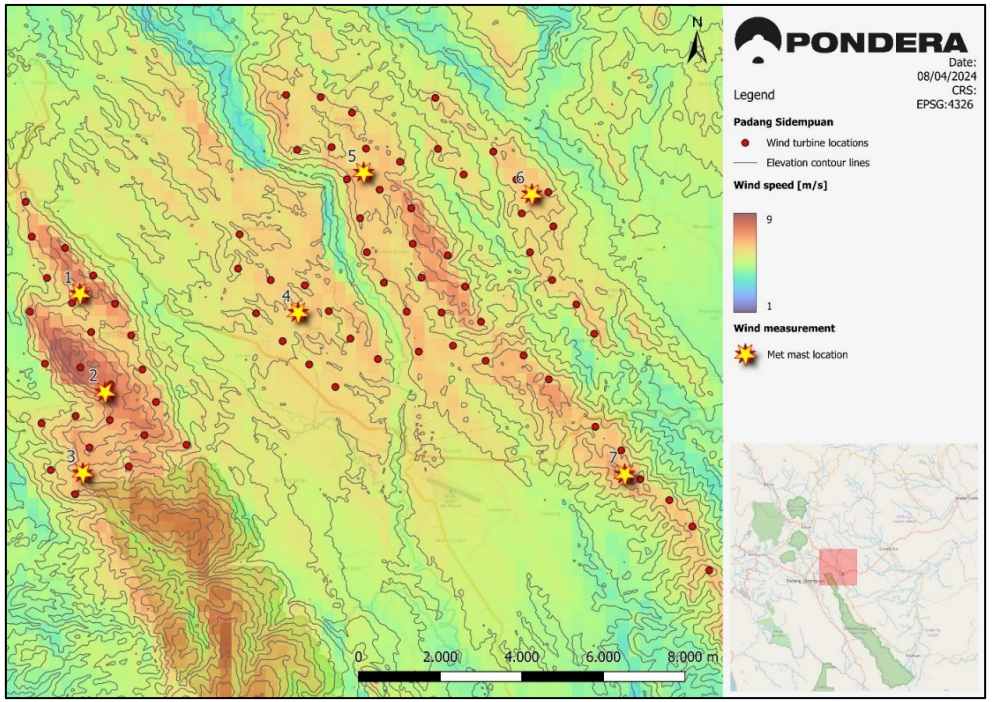
*Based on Presidential Regulation 112/2022 ceiling tariff (with location factor)

North Padang Lawas – South Tapanuli:

Conclusion & Recommendations

- **Conclusion:** The overall techno-economic viability of a wind farm near North Padang Lawas – South Tapanuli could be relatively promising but requires further optimizations to increase the IRR and DSCR to an attractive level. Reconsidering the site layout during a follow up study could improve this.
- **Recommended further analysis:**
  - Validation of wind resource by wind measurements
  - Detailed assessment of the land use / ownership
  - Assessment of offloading and storing the wind turbine components at Port of Dumai
  - Conducting geotechnical soil investigation and soil stability analysis.
  - On-site biodiversity study
  - Grid impact study and early alignment on PPA conditions





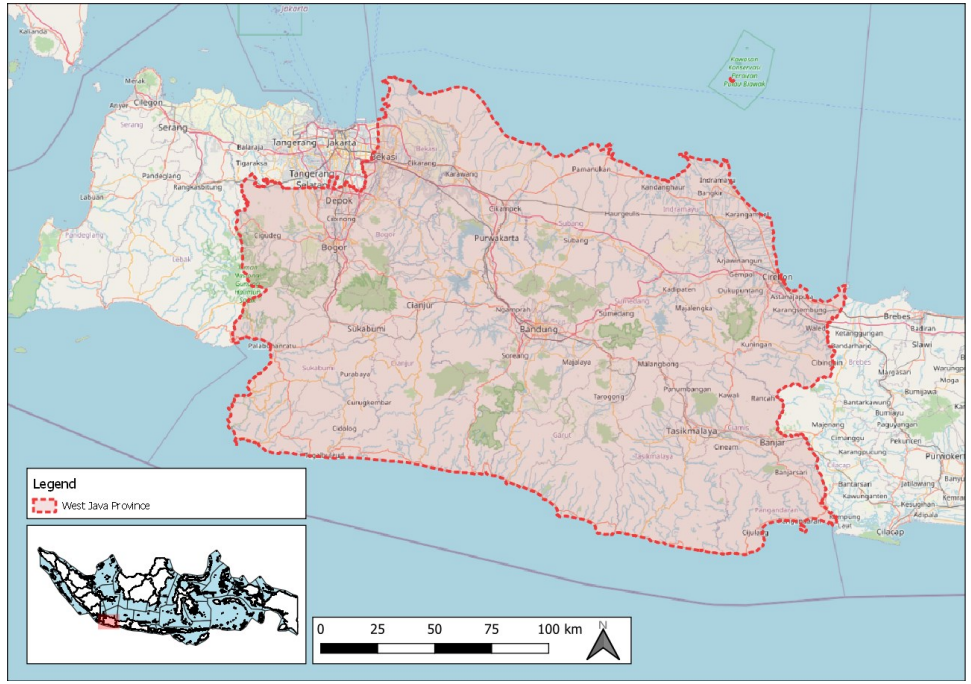
No rights can be derived from any of the presented information and results.. Verification and validation through physical surveys, measurements, design, calculations, and stakeholder consultations are required

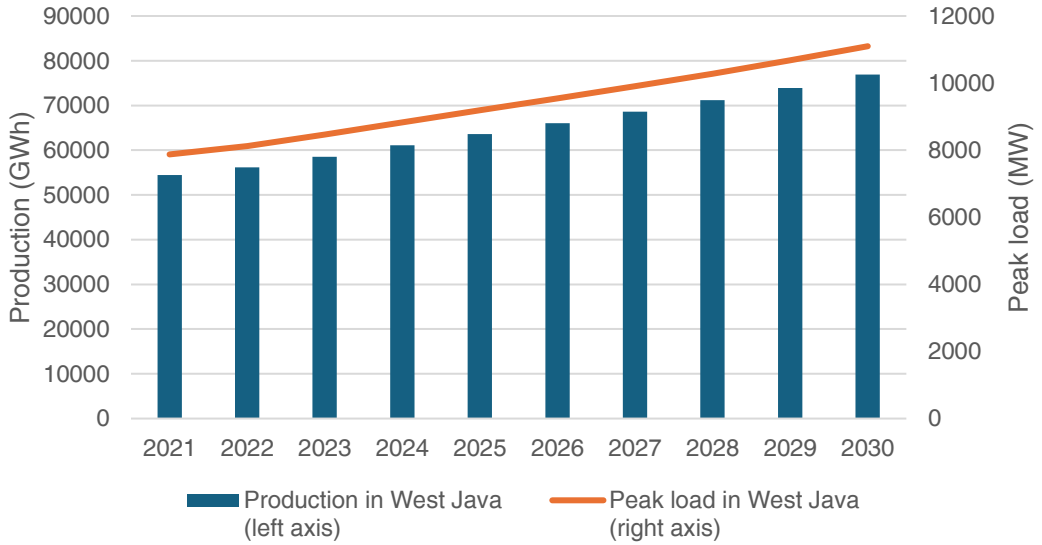
West Java: Sukabumi

West Java:
Geographic location and demand

- The peak load of this province in 2020 was 7,712 MW
- Projected average demand growth rate 3.88% per year
- RUPTL 2021-2030 on wind energy:

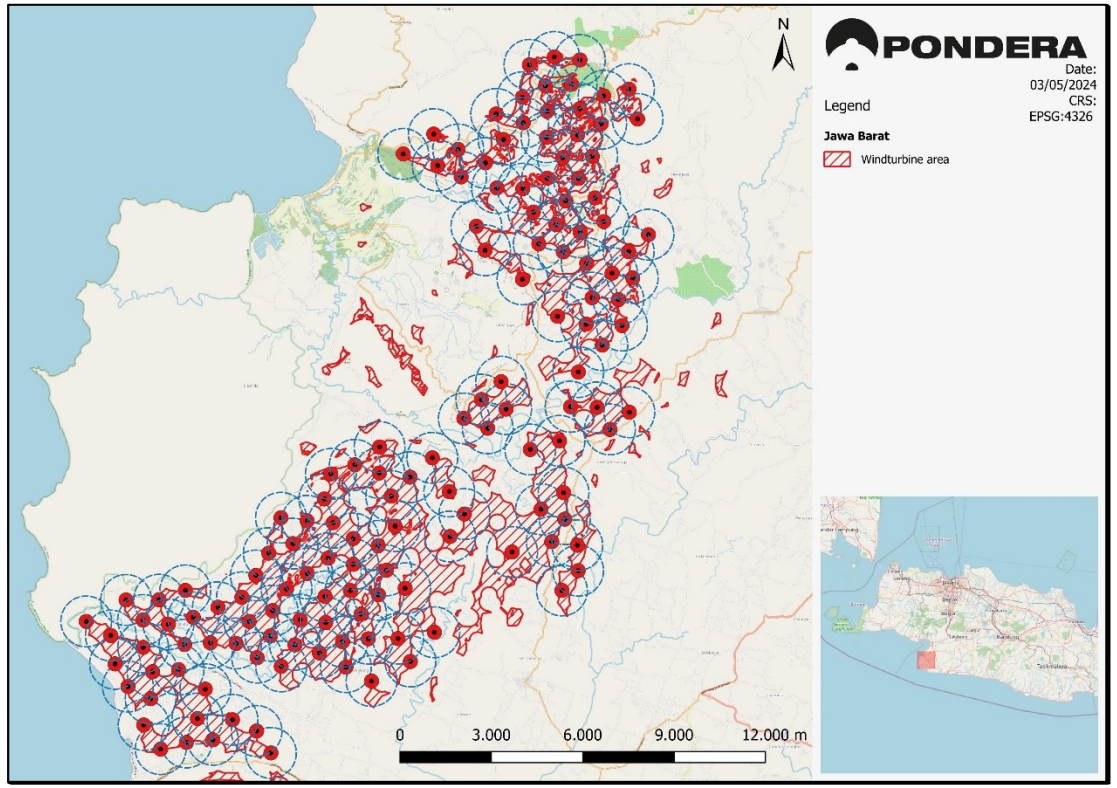
Year	Capacity (MW)	Status
2024	**60**	Planned
-	**85**	Potential, in Cirebon
-	**150**	Potential, in Garut
-	**670**	Potential, in Sukabumi
Total	**965**	

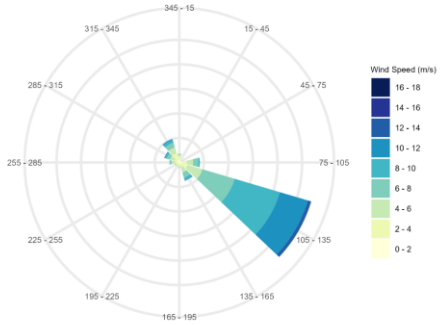


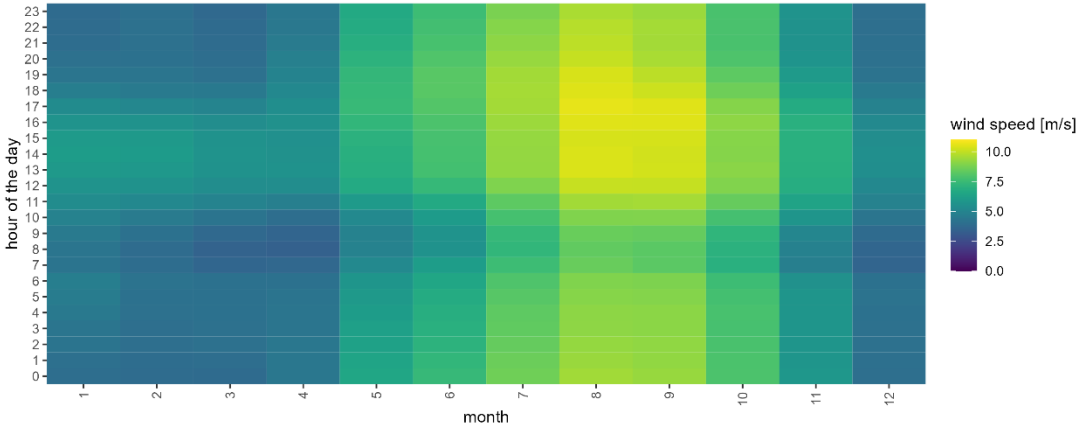


Sukabumi:
Site selection and pre-design

- Average yearly wind speed (> 6 m/s)
- Slopes (< 15 degrees, with buffer)
- Exclusion areas with buffers
- Analysis of location specific permit requirements
- Resulting in a final wind farm area
- Design of a preliminary layout:
  145 WTG, installed capacity 580 MW

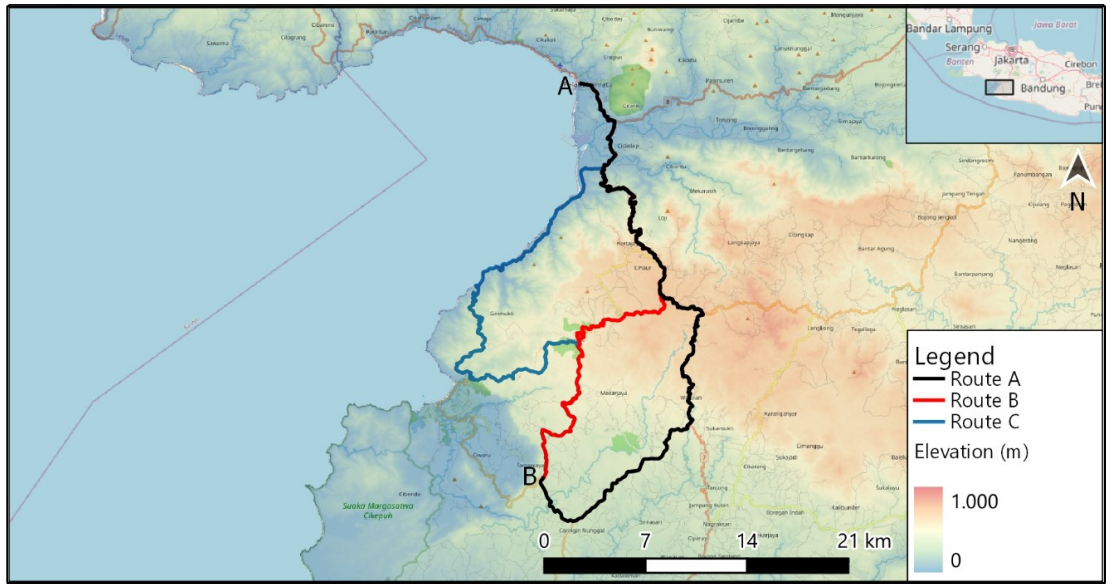


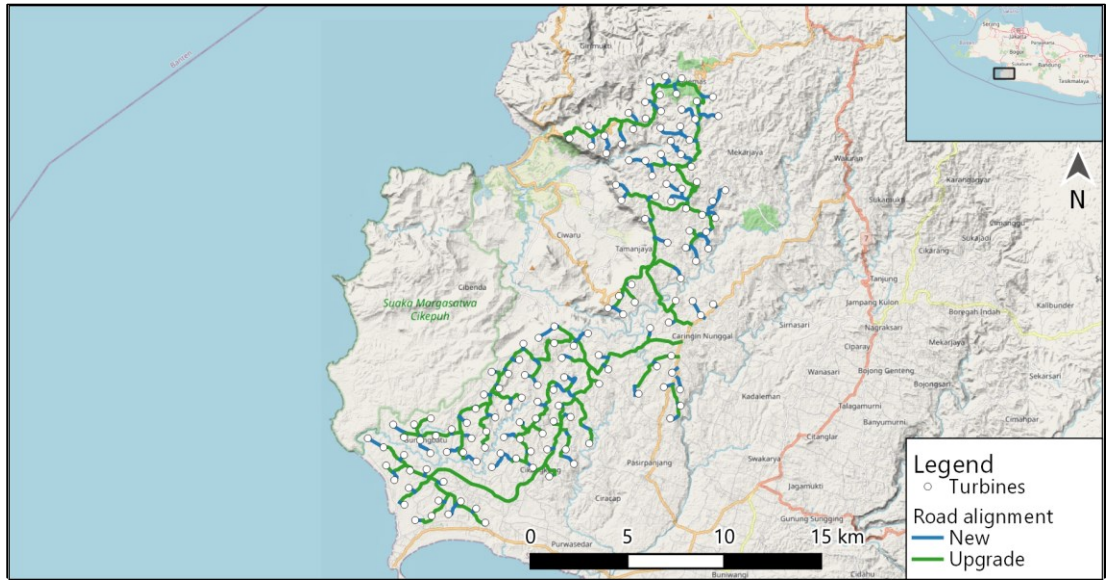




Sukabumi:
Wind farm accessibility

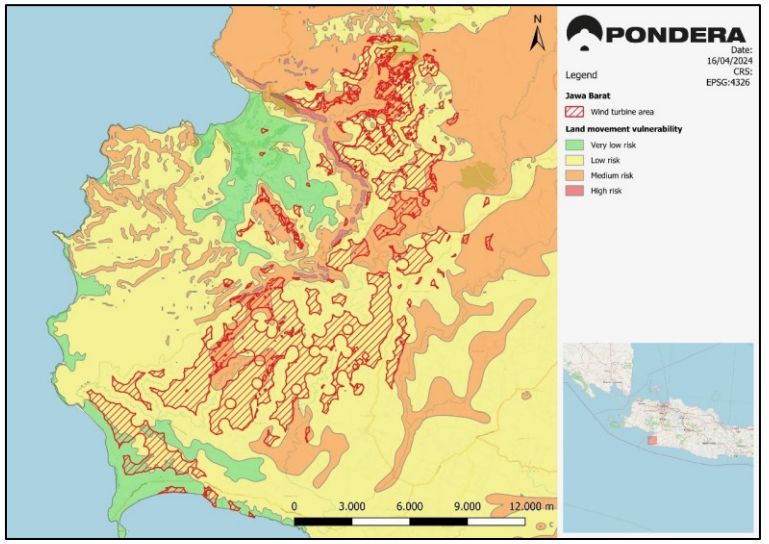
- **Port-to-site options:**
  - Non-commercial port of PT Cemindo Gemilang
  - Port of PT Cemindo Gemilang Bayah
  - New temporary jetty near the site
  - Pelabuhan Ratu fishing port (preferred starting point)
  - Three route options: Route A is preferred, least road adjustments required
- **Transport within the site:** new roads and upgraded roads required

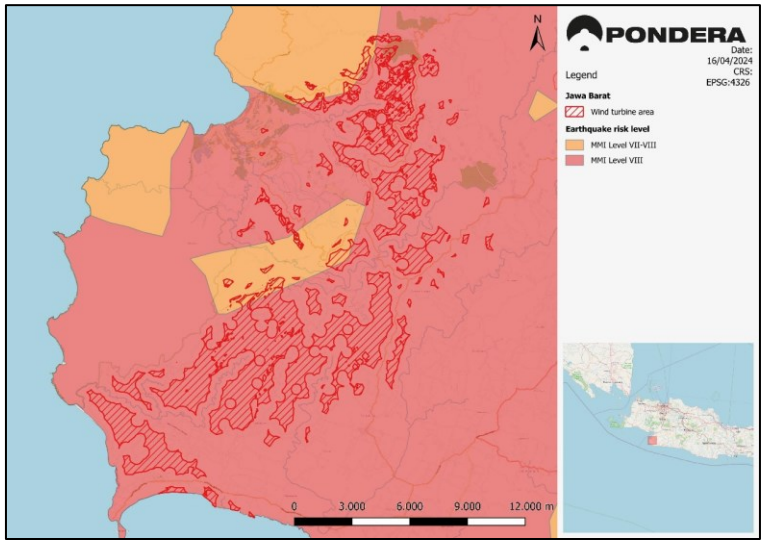




Sukabumi:
Site conditions: soil, land movement and seismicity

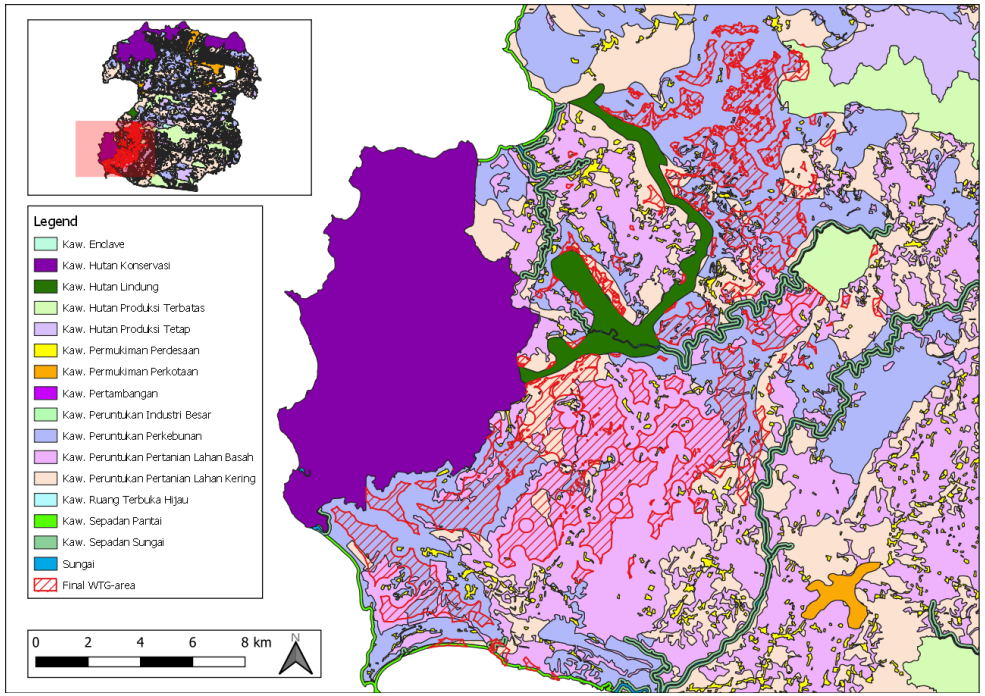
- **Soil**: Turbedite deposits in the base with sandstone and conglomerate on top
- **Land Movement Vulnerability Index:** In general, low risk, with some medium risk areas
- **Seismicity:**
  - The site has potential to be hit by strong earthquakes with an intensity larger than VIII on the Modified Mercalli Intensity (MMI) scale
  - The foundation design should consider the land movement vulnerability and seismic risk by adhering to the IEC 61400 standards for this.

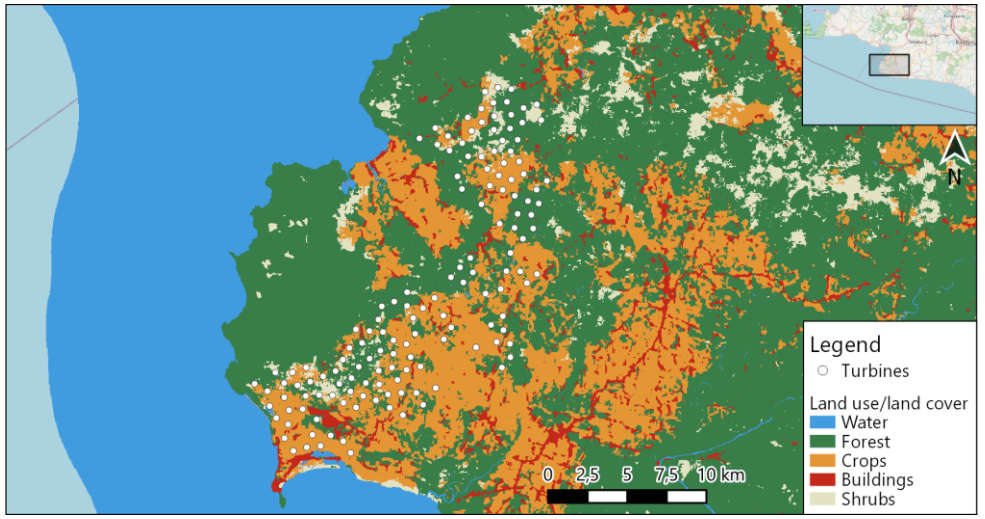




Sukabumi:
Site conditions: biodiversity and social impact

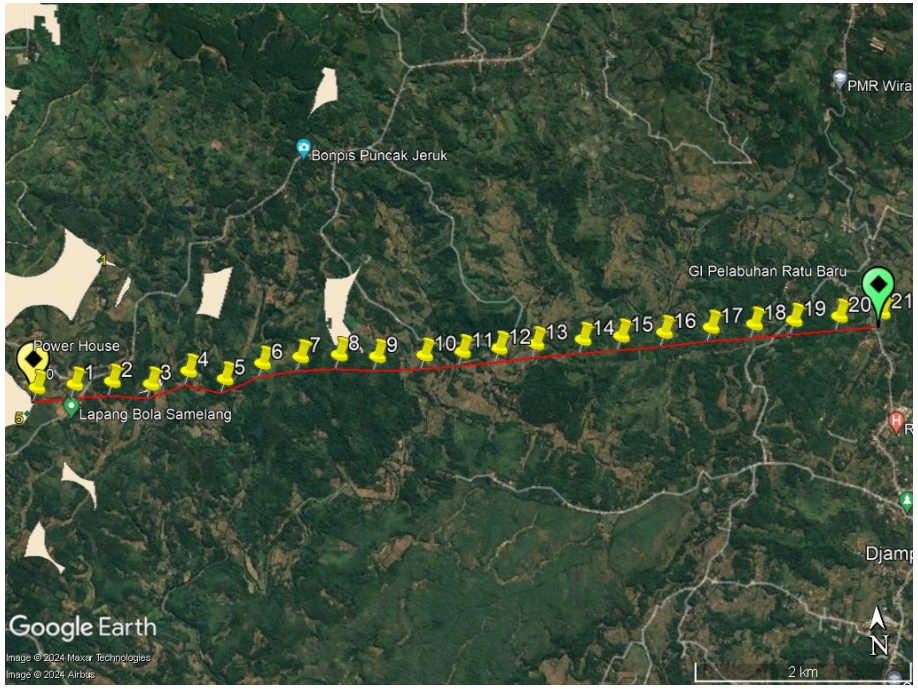
- **General impression:** A variation between a stretched ridge, hills and flatter areas mainly used for larger plantations
- **Biodiversity:**
  - Several animal and plant species were observed in the area that are categorized in the IUCN global red list category.
  - Some primary forest is still present, located on the ridge.
- **Social impact:**
  - In large parts of the region villages and scattered houses are present, to be affected by the wind turbines
  - The social impact could be loss of agricultural land, reduced accessibility during road construction and transport and visual impact
  - Special geological features makes that the area is branded as a tourist destination. The area is recognized as a Geopark by UNESCO.

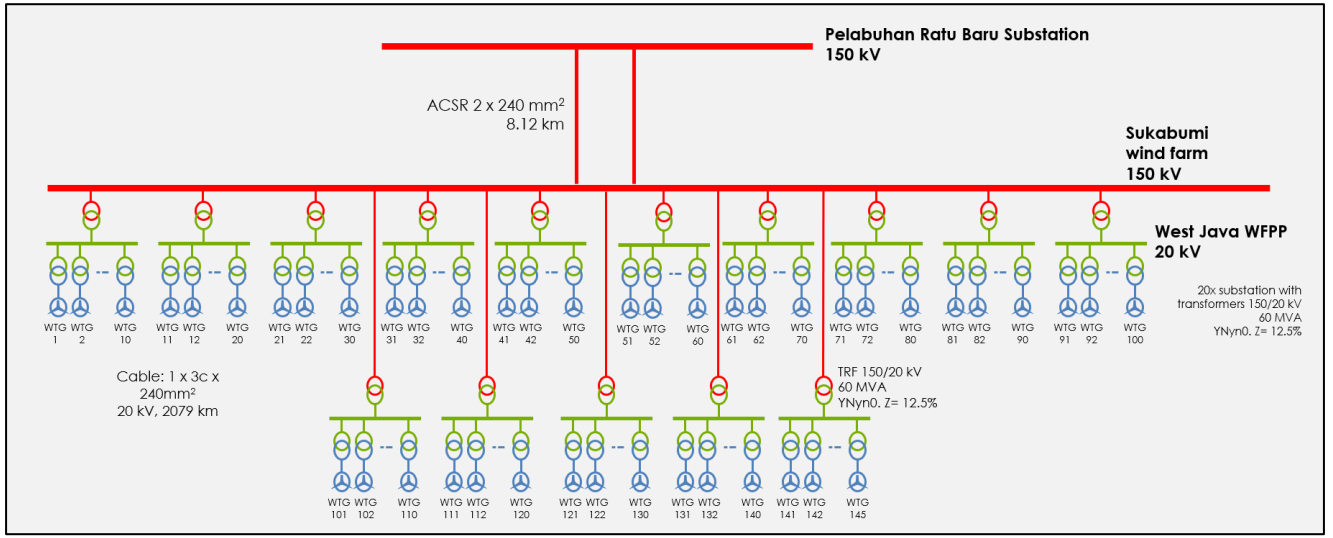




Sukabumi:
Transmission network

- **Point of connection:** closest point of connection to the existing PLN grid is the Pelabuhan Ratu Baru 150 kV substation
- **Transmission line:** 8 km transmission line with 22 towers are required
- **Schematic electrical design:**

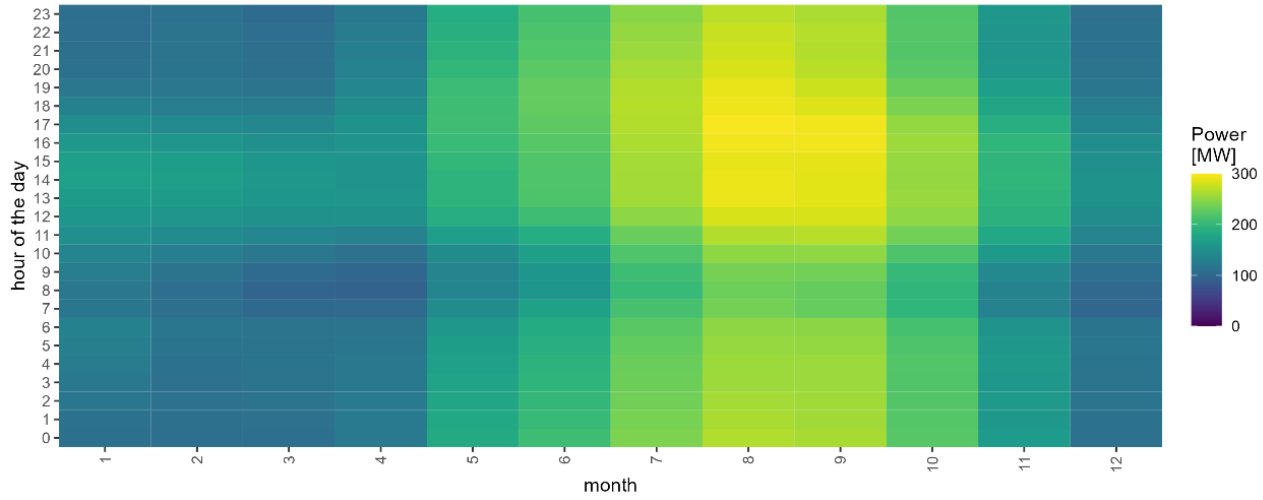




Sukabumi:
Energy yield

- **Wind turbine location specific analysis:** Long-term average wind speed calculated at a height of 140 m. Subsequent iterations recommended.
- **P50 Net AEP calculation:** gross AEP minus losses (22.5%).
- **P90 AEP 25 years calculation:** P_{50} * (1 – 1.28*σ), in which σ is the uncertainty percentage (20%).
- **Monthly/hourly production variation:**

Parameter [Unit]	Amount
Number of new WTGs	145
Rated Power per WTG [MW]	4.0
Total rated Power [MW]	92.0
Rotor diameter [m]	~170
Hub height [m]	140
Air density [kg/m3]	0.986
Wind speed [m/s]	6.2
Gross result [MWh/yr]	2,057,739
Gross results including wake effects [MWh/yr]	1,833,274
P50 [MWh/yr] [11]	**1,594,415**
P90 (25 yr) [MWh/yr]	**1,379,332**
P50 [hrs/yr]	**2,749**
P90 (25 yr) [hrs/yr]	**2,378**



Sukabumi:
Business case

- **Cost assumptions:** lower-, baseline-, and upper bound total investment cost
- **Financial parameters:**
  - 25 years operation
  - Gearing 70/30
  - Debt tenure 10 years
  - Interest rate 9%
  - Tariff*
    - Year 1-10: $9.54 cents / kWh
    - Year 11-25: $5.73 cents / kWh
- **Preliminary conclusion:** Initial IRR not yet attractive (below 10%). DSCR needs to increase > 1

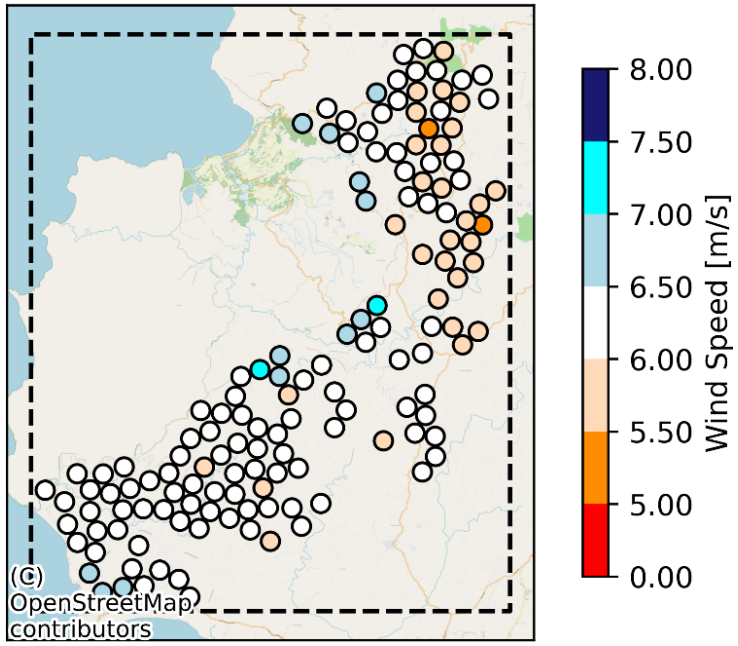
Cost component	Baseline cost $ including VAT	Comment	Cost range
Preparation works	USD 10,420,000	DEVEX: Prior to Financial Close	90% - baseline -120%
Project management	USD 42,531,000	DEVEX: Until CoD	Baseline
Wind turbines	USD 404,156,000	CAPEX: Including transport and installation	90% - baseline -120%
Civil works: foundations	USD 58,103,000	CAPEX	80% - baseline -150%
Civil works: roads	USD 31,817,000	CAPEX	80% - baseline -150%
Civil works: crane hardstands	USD 13,025,000	CAPEX	80% - baseline -150%
Electrical works	USD 199,907,000	CAPEX	90% - baseline -120%
Land acquisition	USD 133,196,000	CAPEX	90% - baseline -150%
Risk contingencies	USD 68,050,000	DEVEX + CAPEX	Baseline
Lower bound total investment cost (DEVEX + CAPEX)	**USD 865,849,000**	**Investment cost per MW: USD 1,493,000**	
Baseline total investment cost (DEVEX + CAPEX)	**USD 961,206,000**	**Investment cost per MW: USD 1,657,000**	
Upper bound total investment cost (DEVEX + CAPEX)	**USD 1,202,173,000**	**Investment cost per MW: USD 2,073,000**	
Baseline operational expenditure (OPEX)	**USD 16,659,000 / year**	**Operational cost per MW / year: USD 29,000**	

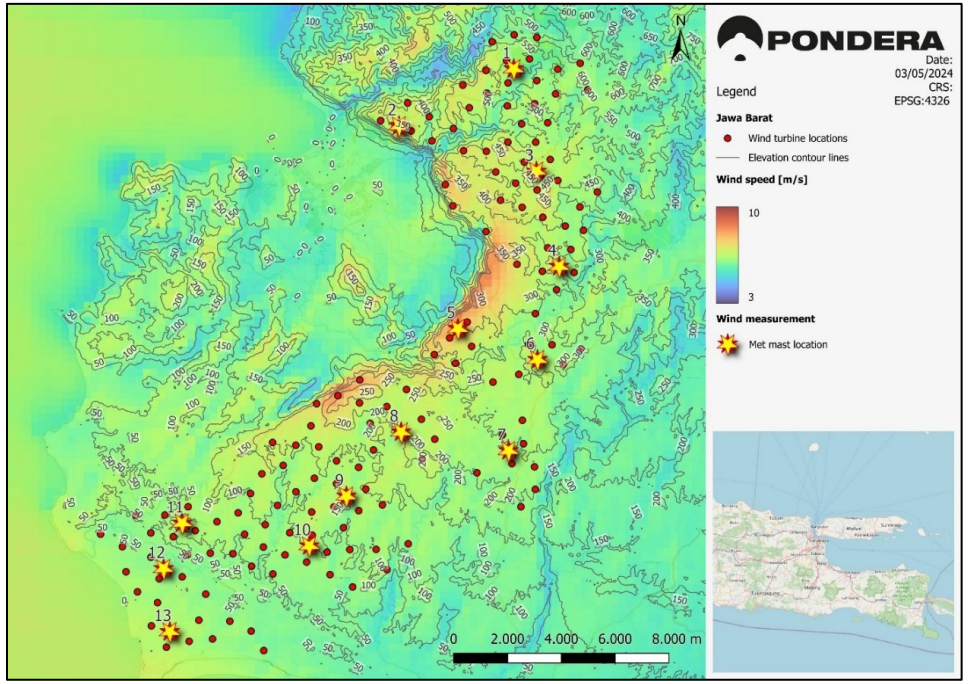
Business case outcome	Lower bound cost scenario	Baseline bound cost scenario	Upper bound cost scenario
Project (before taxes) Internal Rate of Return (IRR) at P50	9.74%	8.00%	4.70%
Average Debt Service Coverage Ratio (DSCR) at P90	0.96	0.88	0.73
Net profit at P50 over 25 years	USD 514,786,000	USD 414,539,000	USD 178,021,000

*Based on Presidential Regulation 112/2022 ceiling tariff (with location factor)

Sukabumi:
Conclusion & Recommendations

- **Conclusion:** The overall techno-economic viability of a wind farm near Sukabumi is relatively poor based on the IRR and DSCR. Reconsidering the site layout during a follow up study could improve this.
- **Recommended further analysis:**
  - Validation of wind resource by wind measurements
  - Detailed assessment of the land use / ownership
  - Analysis on the possibility of building a temporary jetty
  - Conducting geotechnical soil investigation and soil stability analysis.
  - On-site biodiversity study
  - Grid impact study and early alignment on PPA conditions





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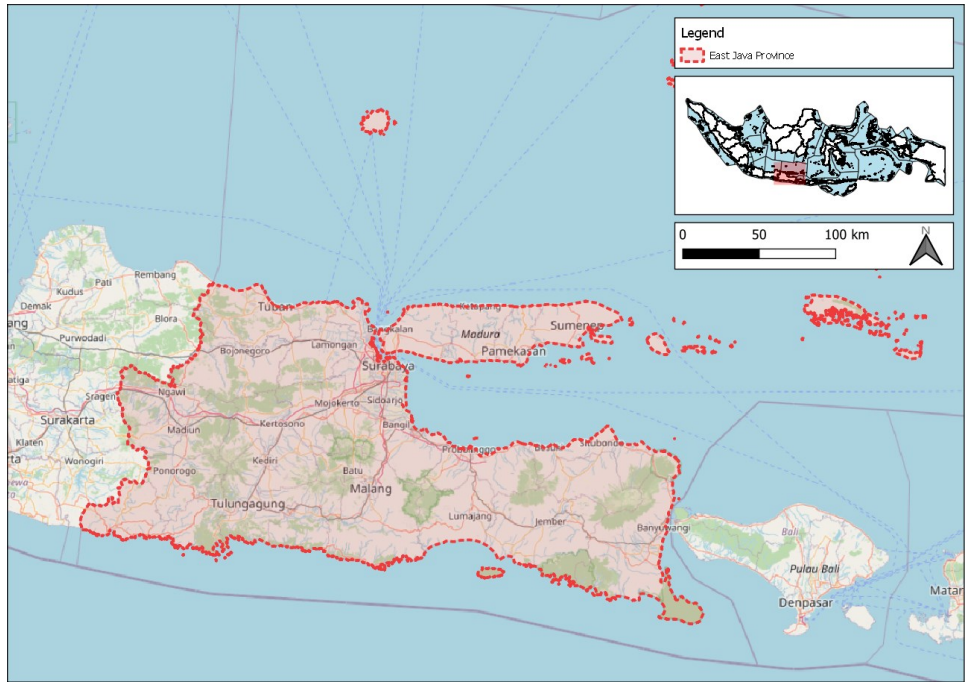
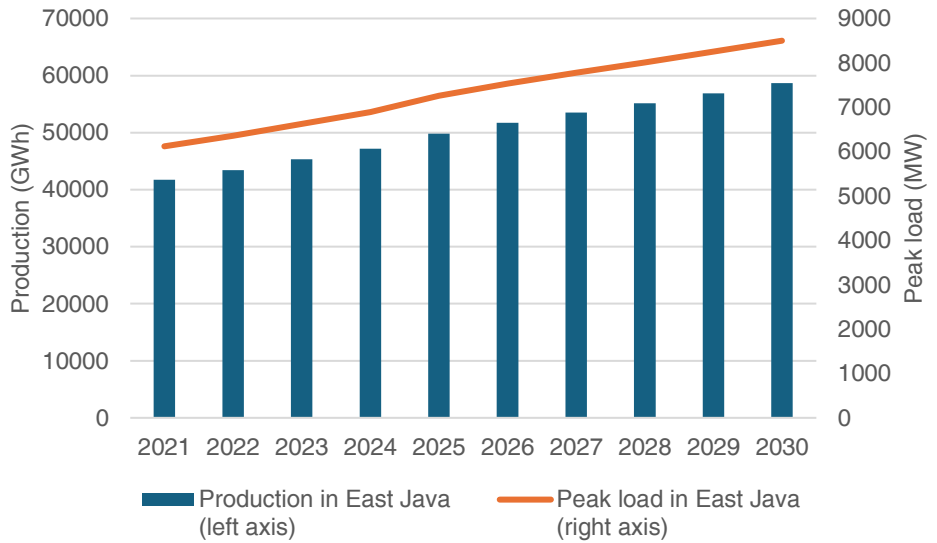
East Java: Probolinggo – Lumajang

East Java:
Geographic location and demand

- The peak load of this province in 2020 was 5,935 MW
- Projected average demand growth rate 3.7% per year
- RUPTL 2021-2030 on wind energy:

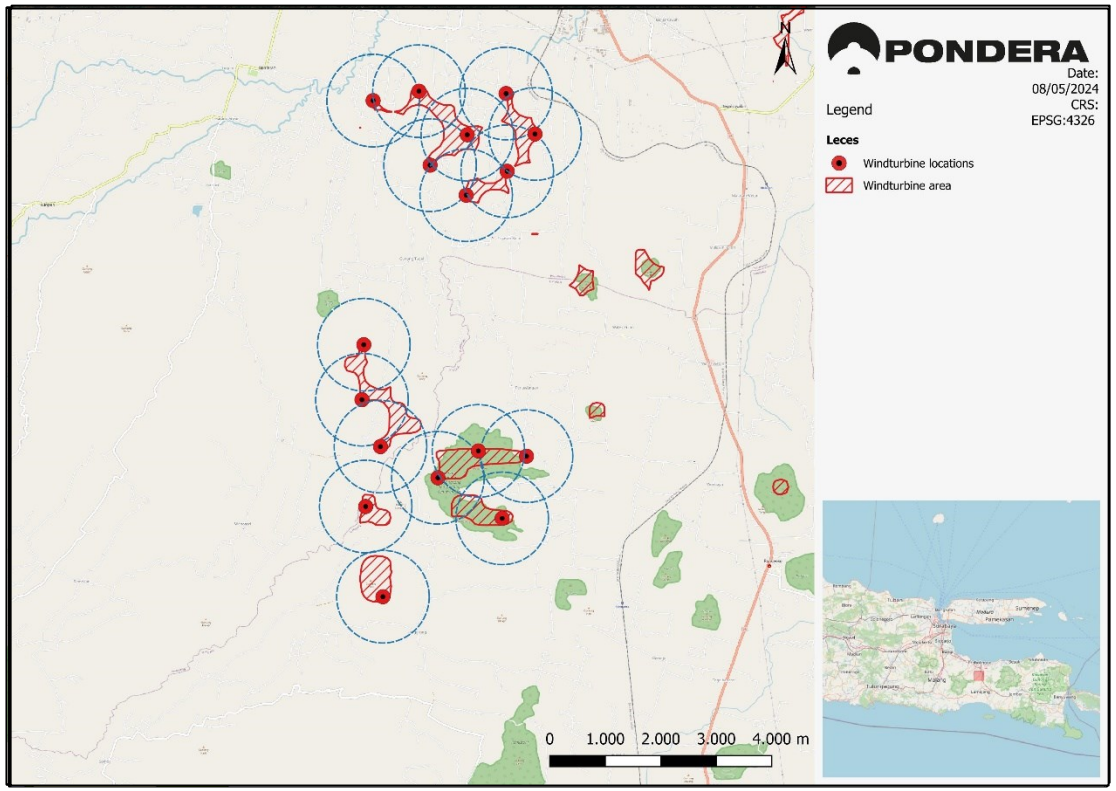
Year	Capacity (MW)	Status
-	**75**	Potential, in Banyuwangi
-	**50**	Potential, in Probolinggo
-	**66**	Potential, in Tuban
-	**140**	Potential, in Tuban (solar and wind)
Total	**331**	

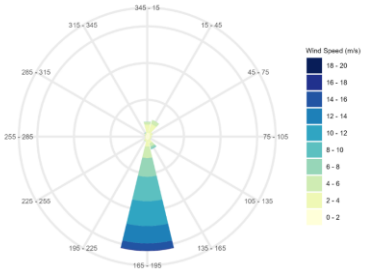


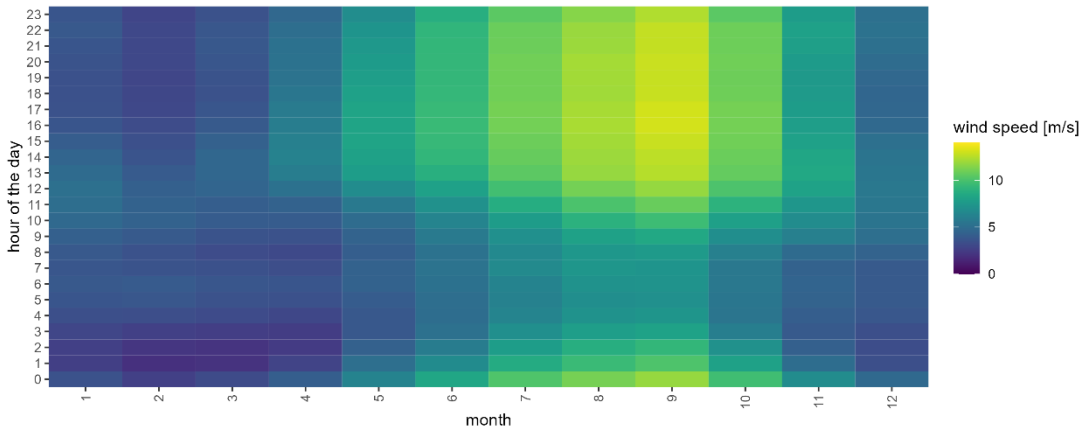


Probolinggo – Lumajang:
Site selection and pre-design

- Average yearly wind speed (> 6 m/s)
- Slopes (< 15 degrees, with buffer)
- Exclusion areas with buffers
- Analysis of location specific permit requirements
- Resulting in a final wind farm area
- Design of a preliminary layout:
  17 WTG, installed capacity 68 MW



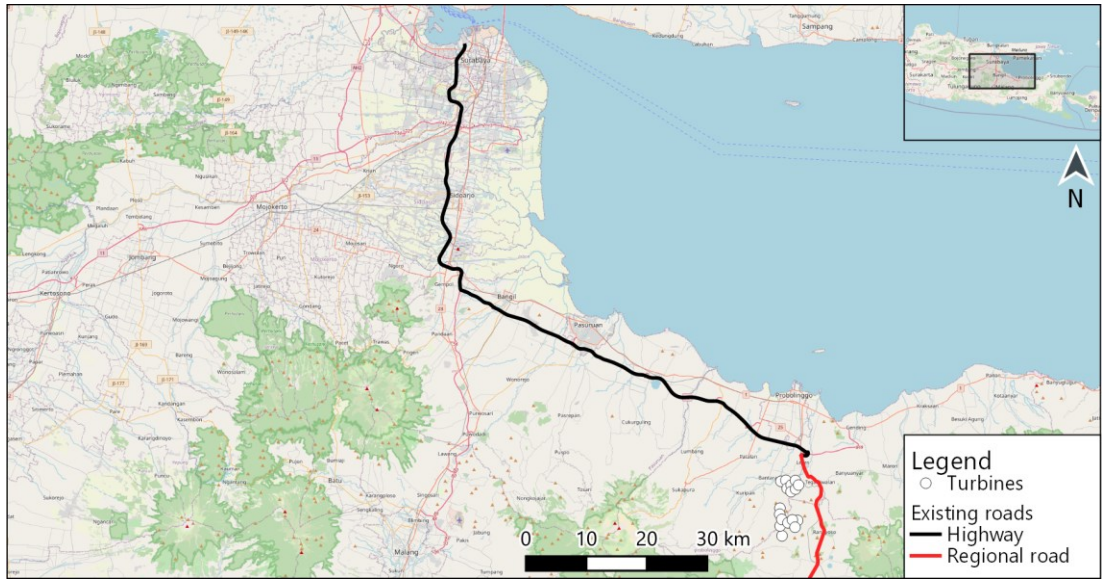


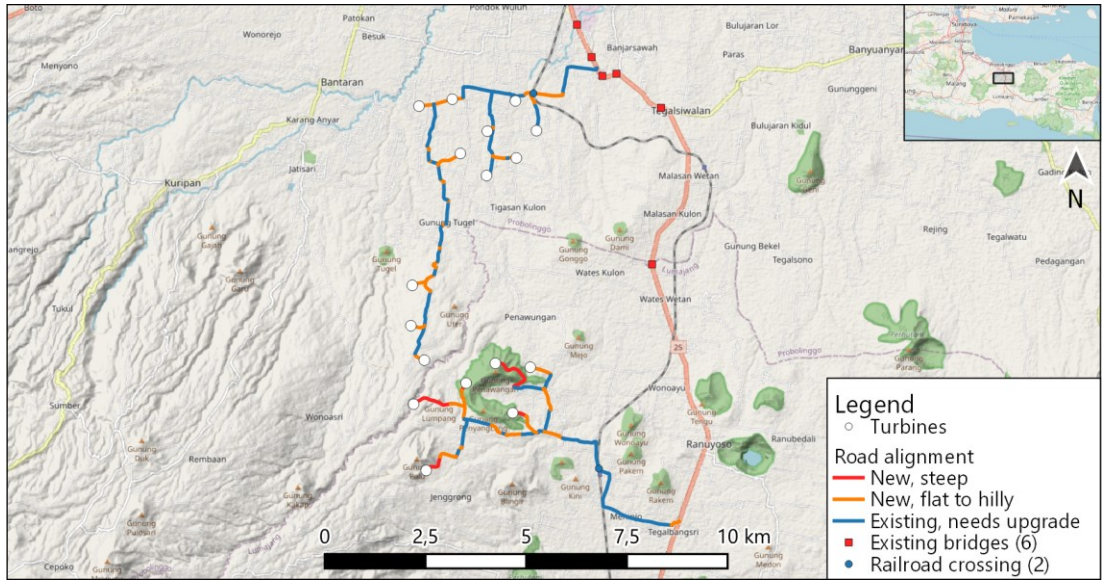


Probolinggo – Lumajang:
Wind farm accessibility

- **Port-to-site options:** Port of Surabaya is the most suitable
  - Highway and regional road are suitable for transport
  - Several bridges might require strengthening

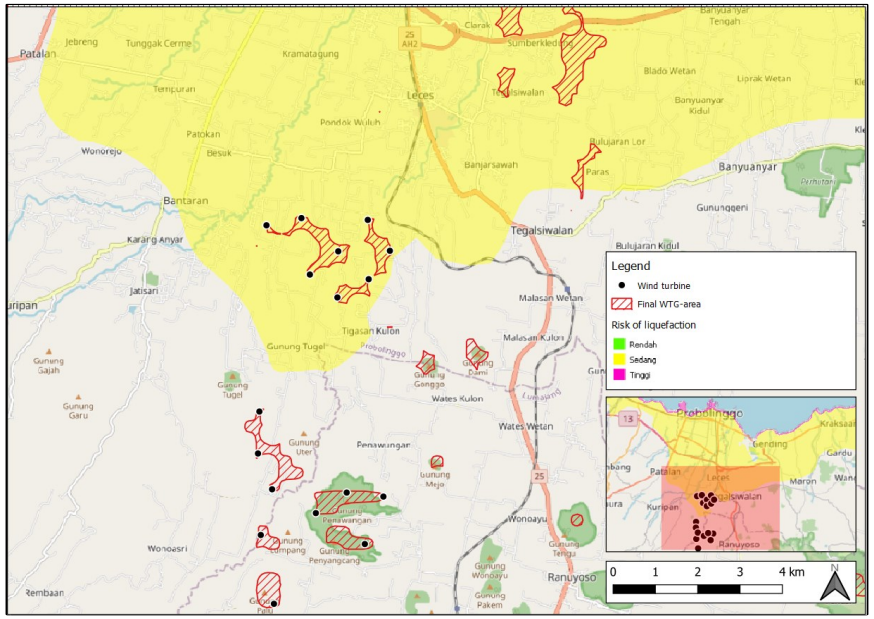
- **Transport within the site:** new roads and upgraded roads required

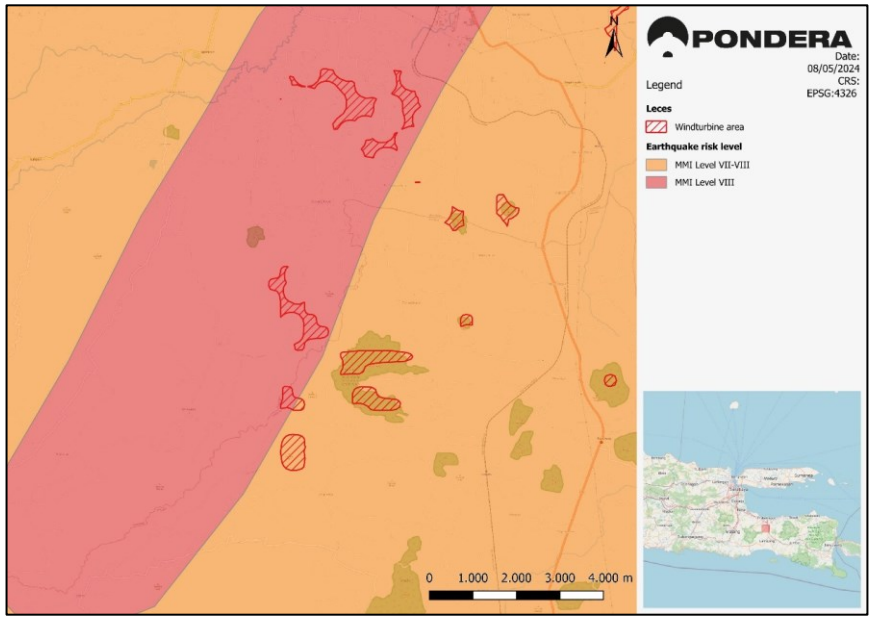




Probolinggo – Lumajang:
Site conditions: soil, land movement and seismicity

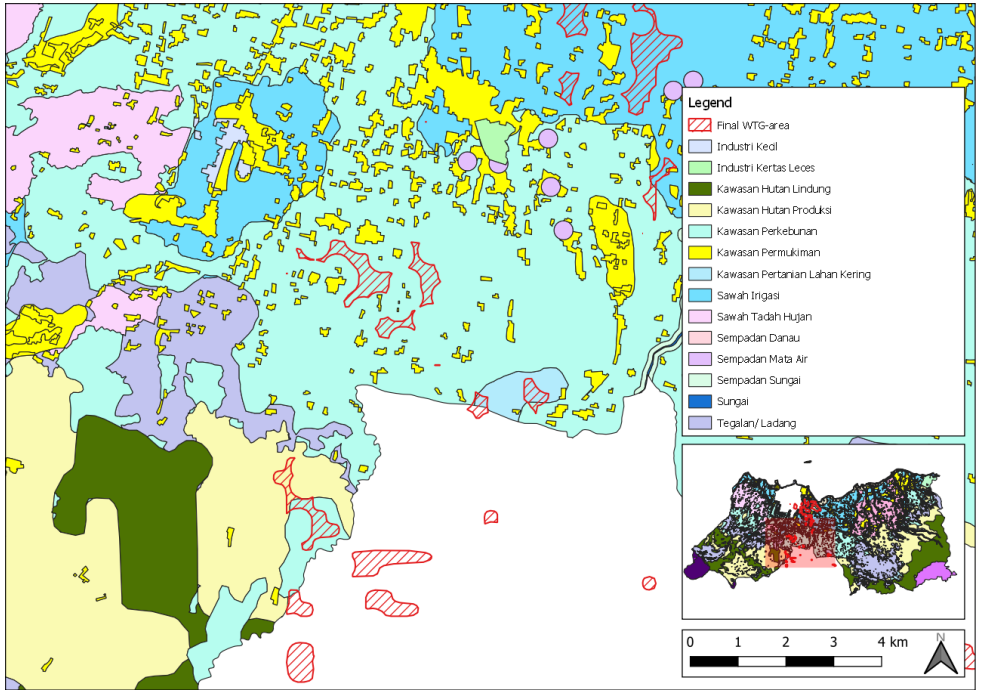
- **Soil**: turbines are located on the lower end of the slopes of the Bromo (west) and Lemongan (east) volcanoes, the subsurface mostly consists of volcanic debris and ash because of past eruptions
- **Land Movement Vulnerability Index:** Medium to high-risk areas
- **Seismicity:**
  - The site has potential to be hit by strong earthquakes with an intensity VII-VIII on the Modified Mercalli Intensity (MMI) scale
  - The northern wind turbine locations lie in an area with the medium risk of liquefaction
  - The foundation design should consider the land movement vulnerability, liquefaction, and seismic risk by adhering to the IEC 61400 standards for this.

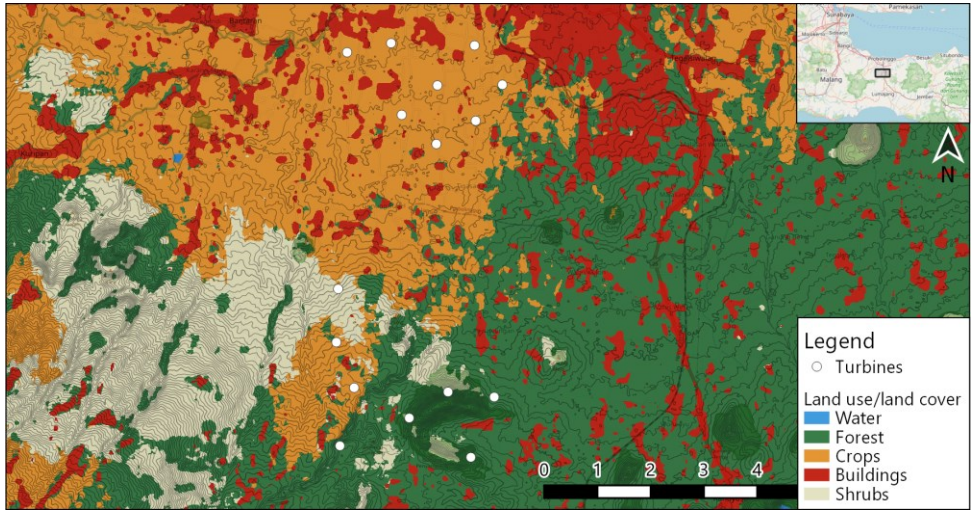




Probolinggo – Lumajang:
Site conditions: biodiversity and social impact

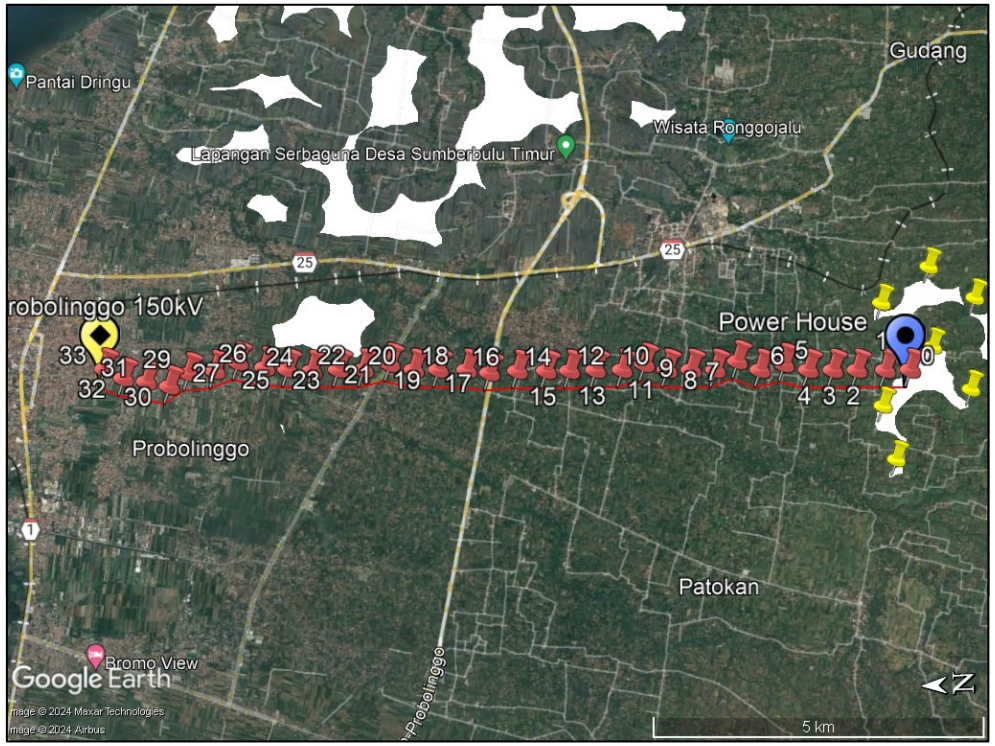
- **General impression:** The northern part and southern part of the site differ from each other both in topography, land use, and population density.
  - While still elevated 80 to 100 m above sea level, the northern part lies in an area that can be counted as coastal plains.
  - The southern part is located at the foot of Mount Bromo.
- **Biodiversity:**
  - Several endangered and vulnerable animal and plant species were observed in the area that are categorized in the IUCN global red list category.
  - Protected forest was excluded from the wind farm area
- **Social impact:** Numerous small villages are located in the area. The envisioned turbines are placed in between these villages. With the current land use, the visual impact in the southern part (east of the gorge) of the site may be quite limited. The mobility of the population nearby is likely to be increased when public roads are upgraded

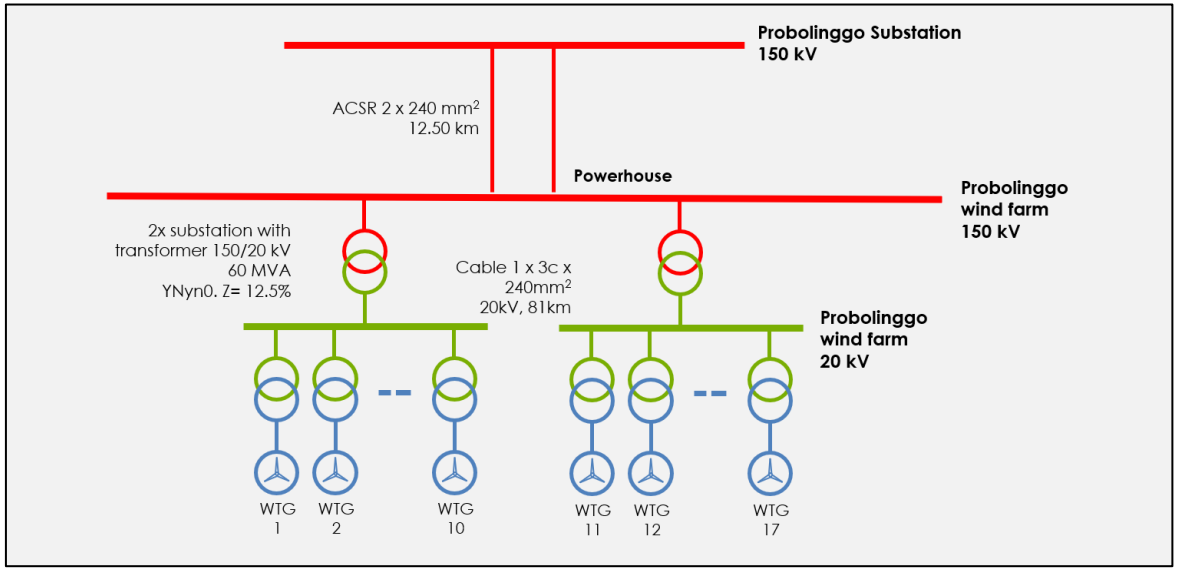




Probolinggo – Lumajang:
Transmission network

- **Point of connection:** closest point of connection to the existing PLN grid is the Probolinggo 150 kV PLN substation
- **Transmission line:** 12.5 km transmission line with 34 towers are required
- **Schematic electrical design:**

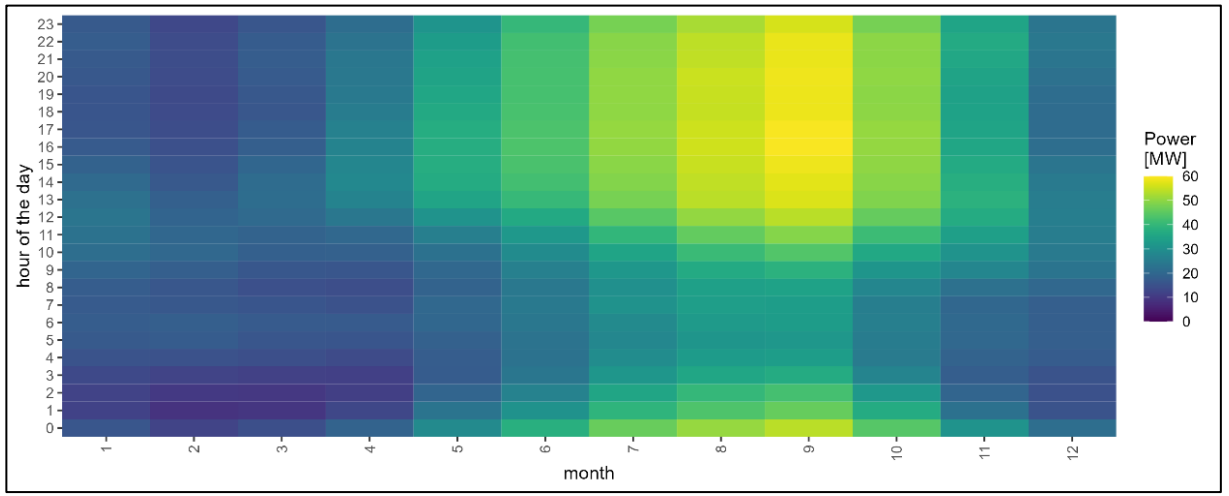




Probolinggo – Lumajang:
Energy yield

- **Wind turbine location specific analysis:** Long-term average wind speed calculated at a height of 140 m. Subsequent iterations recommended.
- **P50 Net AEP calculation:** gross AEP minus losses (15.6%).
- **P90 AEP 25 years calculation:** P_{50} * (1 – 1.28*σ), in which σ is the uncertainty percentage (20%).
- **Monthly/hourly production variation:**

Parameter [Unit]	Amount
Number of new WTGs	17
Rated Power per WTG [MW]	4.0
Total rated Power [MW]	68.0
Rotor diameter [m]	~170
Hub height [m]	140
Air density [kg/m^3]	1.136
Wind speed [m/s]	7.2
Gross result [MWh/yr]	309,857
Gross results including wake effects [MWh/yr]	301,056
P50 [MWh/yr]	**261,831**
P90 (25 yr) [MWh/yr]	**194,721**
P50 [hrs/yr]	3,850
P90 (25 yr) [hrs/yr]	2,864



Probolinggo – Lumajang:
Business case

- **Cost assumptions:** lower-, baseline-, and upper bound total investment cost
- **Financial parameters:**
  - 25 years operation
  - Gearing 70/30
  - Debt tenure 10 years
  - Interest rate 9%
  - Tariff*
    - Year 1-10: $9.54 cents / kWh
    - Year 11-25: $5.73 cents / kWh
- **Preliminary conclusion:** business case outcome looks very promising. DSCR needs to increase > 1

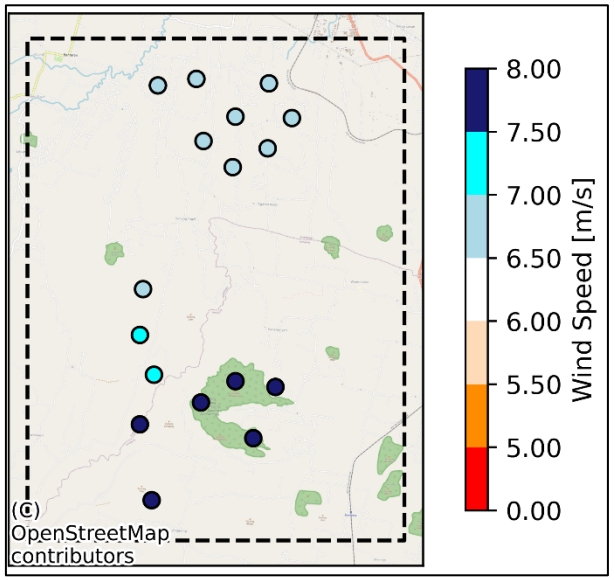
Cost component	Baseline cost including VAT	Comment	Cost range
Preparation works	USD 2,525,000	DEVEX: Prior to Financial Close	90% - baseline -120%
Project management	USD 5,383,000	DEVEX: Until CoD	Baseline
Wind turbines	USD 47,384,000	CAPEX: Including transport and installation	90% - baseline -120%
Civil works: foundations	USD 6,812,000	CAPEX	80% - baseline -150%
Civil works: roads	USD 12,945,000	CAPEX	80% - baseline -150%
Civil works: crane hardstands	USD 1,885,000	CAPEX	80% - baseline -150%
Electrical works	USD 21,021,000	CAPEX	90% - baseline -120%
Land acquisition	USD 15,095,000	CAPEX	90% - baseline -150%
Risk contingencies	USD 8,613,000	DEVEX + CAPEX	Baseline
Lower bound total investment cost (DEVEX + CAPEX)	**USD 108,732,000**	**Investment cost per MW: USD 1,599,000**	
Baseline total investment cost (DEVEX + CAPEX)	**USD 121,663,000**	**Investment cost per MW: USD 1,789,000**	
Upper bound total investment cost (DEVEX + CAPEX)	**USD 154,218,000**	**Investment cost per MW: USD 2,268,000**	
Baseline operational expenditure (OPEX)	**USD 2,093,000 / year**	**Operational cost per MW / year: USD 31,000**	

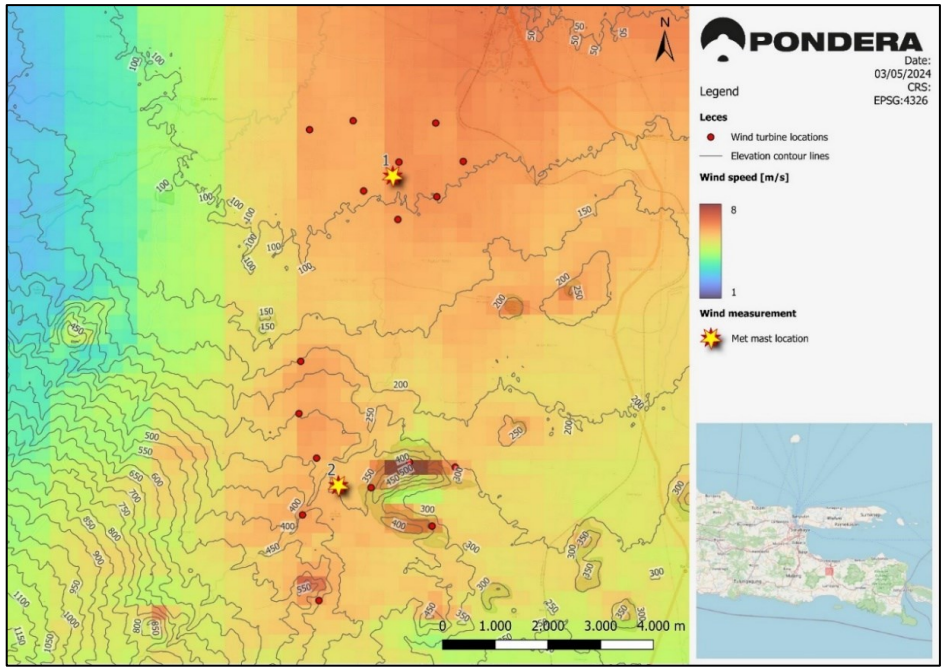
Business case outcome	Lower bound cost scenario	Baseline bound cost scenario	Upper bound cost scenario
Project (before taxes) Internal Rate of Return (IRR) at P50	16.08%	13.75%	9.48%
Average Debt Service Coverage Ratio (DSCR) at P90	1.09	0.99	0.81
Net profit at P50 over 25 years	USD 150,155,000	USD 134,675,000	USD 95,760,000

*Based on Presidential Regulation 112/2022 ceiling tariff (with location factor)

Probolinggo – Lumajang:
Conclusion & Recommendations

- **Conclusion:** The overall techno-economic viability of a wind farm near Probolinggo could be promising based on the IRR and DSCR. The expected good wind speeds are the main driver for this. However, optimizations can be sought to further enhance the business case for this project. Potential cost savings by determining the need for strengthening 6 bridges and building new infrastructure.
- **Recommended further analysis:**
  - Validation of wind resource by wind measurements
  - Detailed assessment of the land use / ownership
  - Assessment of offloading and storing the wind turbine components at Port of Surabaya
  - Conducting geotechnical soil investigation and soil stability analysis.
  - On-site biodiversity study
  - Grid impact study and early alignment on PPA conditions





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