Draft technical appraisal report

Lender's Technical Advisor for 70MW Tanah Laut wind farm

April 2024

Confidential

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Issue and Revision Record

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5 Climatic change risk analysis (CCRA)

5.1 Introduction

5.1.1 Project Context

Total Eren and PT Adaro Power formed a consortium for the development and delivery of the proposed 70 MW Tanah Laut Wind Farm and associated 10 MW/10 MWH Battery Energy Storage System

(the "Project").

The Project will involve the construction of:

- 11 Wind turbine generators (WTG's);
- 1 On-site substation;
- 1 Switching station;
- 1 Energy storage system;
- 1 New access road;
- 1 Site compound;
- 1 Asset management office; and
- 1 Laydown area.

Presently there is a double circuit 150 kV transmission line located adjacent to the east of the Project boundary less than 7 km from the northern mast location. The transmission line connects between PLTU Asam-Asam and Mantuil Substations which are 43 km and 57 km away respectively from the nominated point of common coupling (PCC).

This Project is proposing to connect to the PLN 150 kV transmission line with integrated substation and switching station located approximately 50 metres from it, as shown in Figure 5.1.

5.1.2 The Purpose of this CCRA

The purpose of this Climate Change Risk Assessment (CCRA) is to assess the risk that future projected climate change may have on the design, operations and maintenance of the proposed Project, to assess the tolerability of the risk to the Project, and to propose potential adaption actions which could be included (where necessary).

This CCRA will be completed in general alignment with the following:

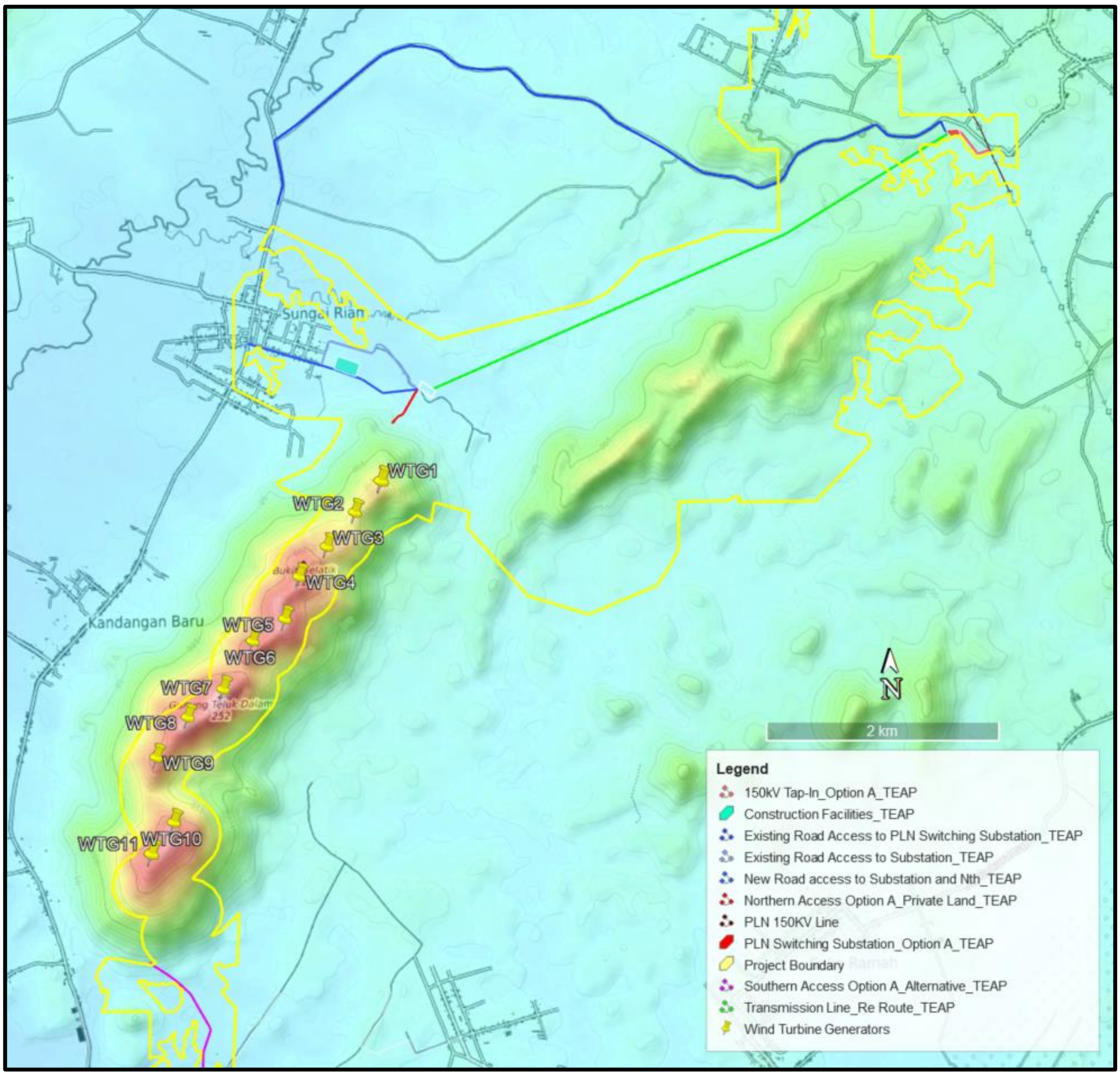
- The requirements for Climate Change Risk Assessments outlined by the Taskforce on Climate-related Financial Disclosures (TCFD)
- AS 5334-2013
- ISO 31000-2018

5.1.3 Project Location

The Project is located in Tanah Laut Regency, South Kalimantan, Indonesia. The Project boundary spans across 7km from east to west and 8.8km from north to south. The total Project boundary is approximately 636 hectares however less than 70 hectares will be required for the construction and operations of the wind farm itself. Figure 5.1 below show the Project location.

The Project is located along a prominent ridgeline and covers complex terrain from a wind flow perspective with elevations ranging from approximately 100 metres asl up to approximately 270 metres asl. The gradient along the slopes of the ridge is generally steep and the land cover along the ridgeline is mostly bushes and short trees with forest on the slopes. Figure 5.1 shows the topography of the Projects site.

Figure 5.1: Topography of Project site



5.2 Climate Change Risk Assessment

5.2.1 Assessment Methodology

The below section provides an explanation of selected timeframe and climate projection scenarios, and how climate data was selected and hazards identified and analysed for likelihood, consequence, risk and tolerance.

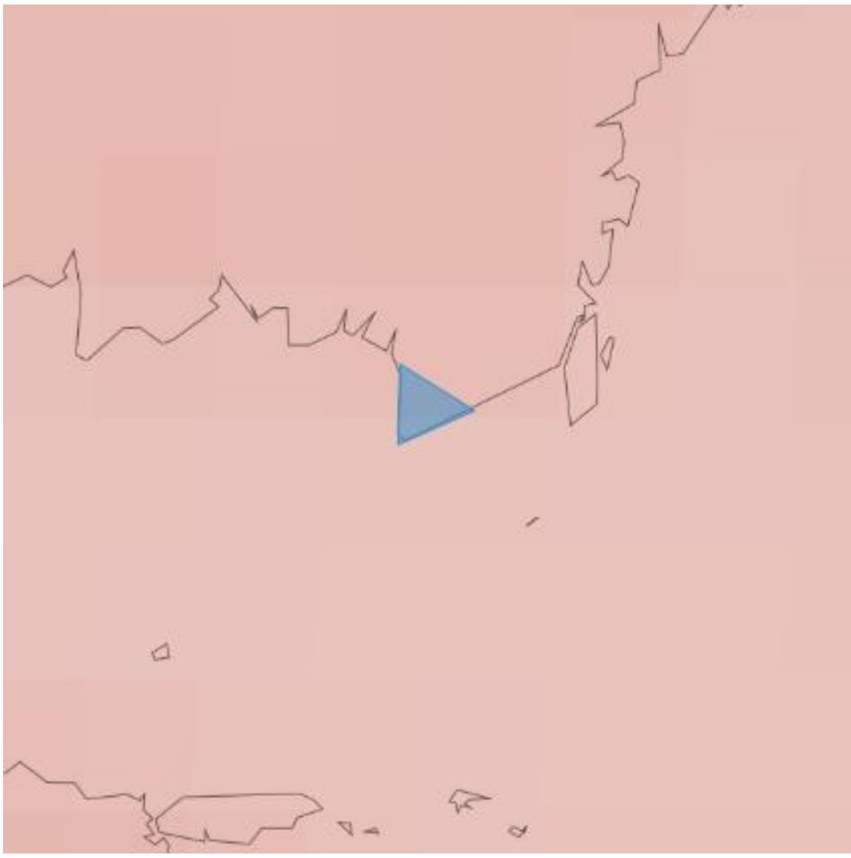
5.2.1.1 Timeframes

Based on the asset's lifecycle of 30 years, we have chosen a timeframe of 2041-2060 for our future climate projections which will cover the climate expected during the latter half of the assets operations.

In alignment with the Intergovernmental Panel on Climate Change (IPCC) (2022) Sixth Assessment Report (AR6), 1995 to 2014 has been set as the baseline climate reference period.

5.2.1.2 Projection scenario selection

Figure 5.2: Area defined on Copernicus Interactive Climate Atlas for assessment



Source: Copernicus Interactive Climate Atlas

Climate change projections have been used to inform our understanding of how the risks posed by climate related hazards may change over time. All climate change projection scenario data, with the exception of Sea Level Rise, has been sourced from Copernicus Interactive Climate Atlas using a custom polygon to select the project site local area (refer to Figure 5.2). Data from the latest climate models (CIMP6) has been used which present projections according to differing shared socio-economic pathways (SSPs). The selected pathways are discussed further below. An initial subset of six Global Climate Models (GCMs) were selected based on the GCMs chosen for downscaling in the National Singapore Climate Change Study Version 3 (SGCCS v3). The SGCCS v3 analysed a total of 49 CMIP6 GCMs for performance against a wide range of climate variables and climate processes using historical climate observations and reanalysis.

The six models selected were identified as meeting the following criteria: performing well both globally and in the South East Asia region, as well as representing a good spread across the

Equilibrium Climate Sensitivity[35] range of the full set of available models, ensuring models that are independent from one another (i.e. from different model families), and having broad coverage of the projected range of future climate change. The other criteria which was selected for, but which is not relevant to this study, was a requirement for data availability at 6-hour intervals to allow for dynamical downscaling. Unfortunately, we were unable to retrieve projection data for the SSP1-2.6 scenario for one of the models, and so a total of five models were selected for producing future climate projection data.

The five models used were:

- CSIRO-ARCCSS_ACCESS-CM2_r1i1p1f1
- MIROC_MIROC6_r1i1p1f1
- MPI-M_MPI-ESM1-2-LR_r1i1p1f1
- NCC_NorESM2-MM_r1i1p1f1
- MOHC_UKESM1-0-LL_r1i1p1f2 *(there are some climate variables for which this model did not have data availability)*

Three SSP climate projection scenarios were selected for use:

- SSP1-2.6: A world with low emissions (<2°C warmer world). This is the 'Paris Pathway', which is only possible if COP26 pledges are delivered on.
- SSP2-4.5: This is a world with moderate emissions (+2.7°C warmer world). This is similar to the path we are on if we follow through on current policy commitments.
- SSP5-8.5: This is a world with high emissions (>4°C warmer world) premised on a breakdown in international cooperation around climate change and continued fossil-fuel powered development.

5.2.1.3 Uncertainty within climate projections

It should be noted that climate projections are not predictions of the future but tools to support us with exploring future scenarios to enable us to be resilient to future climate conditions. Mott MacDonald does not accept any liability for inaccuracy within projections and associated suggested adaptation measures.

It should be noted that climate change projections are constantly evolving as knowledge and modelling projections improve. A level of uncertainty exists when using projections for the future. The possibility that any single emissions pathway will occur as described in these defined scenarios is inherently uncertain.

Global climate models are averaged over large spatial areas and therefore come with data limitations related to extreme values. They do not adequately include extremes like cyclones, wind or changes in their characteristics. Key driving features such as El Niño-Southern Oscillation (ENSO) are also poorly captured within global climate models.

Sea levels around the world are rising and are projected to continue to rise in the future. Uncertainty exists in predicting future sea level rise within our warming climate (particularly with respect to larger timeframes) due to complexities associated with predicting future temperature increases, thermal expansion of ocean water, ocean circulation dynamics, and glacier and ice sheet mass loss. Despite uncertainty existing within the varying future projections, in order to build resilience, it is vital that we begin to plan and adapt for a changing climate.

[35] Equilibrium Climate Sensitivity is the global- and annual-mean near-surface air temperature rise that is expected to occur eventually, once all the excess heat trapped by the increase in GHGs has been distributed evenly from the top of the atmosphere down into the deep ocean (i.e. when both the atmosphere and ocean have reached equilibrium with one another - a coupled equilibrium state).

5.2.1.4 Analysis method

Mott MacDonald produced a Risk Register to collate potential climate hazards and impacts on different projects components using technical expertise, the climate data listed above and information collated during a literature review.

Each impact identified for a project component was assessed for:

1. **Likelihood of occurrence** within the assets lifecycle (using the descriptors in Table 5.1). Likelihood is defined as is the chance of a specific outcome occurring.
2. **Consequence of occurrence** on the asset based on damage to infrastructure, impact on operations and health & safety consequence (using descriptors in Table 5.2). Consequence is defined as the impact(s) that may occur given a projected change in climate, without considering adaptation.
3. Likelihood and consequence were then combined together to determine overall **risk rating** (using the matrix in Table 5.3). Risk is defined as the potential for adverse consequences which is determined by considering the likelihood of a climate hazard occurring and its associated impact on receptors / assets.
4. Dependent on their overall risk rating (i.e. low, medium, high etc.) each risk has differing levels of **acceptability/tolerability.** Acceptability/tolerability is defined as the value judgement of whether a risk is viewed as manageable or not.

Table 5.1: Likelihood descriptors (for likelihood of occurrence within the assets lifecycle)

Level	Likelihood	Quantitative	Qualitative
5	Almost certain	> 85%	Expected to occur frequently during time of activity or project
4	Likely	> 55% - 85%	Expected to occur occasionally during time of activity or project
3	Possible	> 30% - 55%	More likely not to occur than occur during time of activity or project
2	Unlikely	> 5% - 30%	Unlikely to occur than occur during time of activity or project
1	Rare	0% - ≤ 5%	Not expected to occur during the time of activity or project

Table 5.2: Consequence descriptors

Level	1	2	3	4	5
Consequence Descriptor	Insignificant	Minor	Moderate	Severe	Extreme
Damage to infrastructure	Minor superficial impact. No material infrastructure damage.	No permanent damage. Some minor restoration work required. Early renewal of infrastructure required 10-20% of the time. Need for new / modified equipment.	Damage recoverable by maintenance and minor repair. Early renewal of infrastructure required 20-50% of the time.	Extensive infrastructure damage requiring major repair. Early renewal of infrastructure required 50-90% of the time.	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal of infrastructure required >90% of the time.
Impact on operations	An event, the impact of which can be absorbed as part of normal activity. little change to operations	An event the impact of which can be absorbed but some additional maintenance effort is required. Short period of operational shut down of several hours to a day required. Limited and isolated impact on operations. Localised	An event, the impact of which can be absorbed but much broader maintenance effort is required. Moderate period of operational shut down of several days or weeks is required. Ongoing changes to some operations	Major event which can be absorbed, but substantial maintenance effort is required. Major loss of infrastructure service. Significant period of operational shut down of several weeks or months is required. Major	Severe event which requires extensive maintenance effort but can be survived. Operations are fundamentally compromised and / or cannot be delivered.

Level	1	2	3	4	5
		infrastructure service disruption.	required. Limited infrastructure damage and loss of service.	and permanent changes required to operations.	
Health & safety	Illness, first aid or injury not requiring medical treatment	Illness or minor injuries requiring medical treatment	Single recoverable lost-time injury or illness, alternate / restricted duties injury, or short-term occupational illness.	1-10 major injuries requiring hospitalisation and numerous days lost, or medium-term operational illness.	Any fatalities, permanent disabilities / chronic illness, and / or 10 + major injuries

Table 5.3: Overall risk rating matrix

	Consequence				
	1	2	3	4	5
Likelihood	Insignificant	Minor	Moderate	Severe	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Low	High

Table 5.4: Risk definitions & associated acceptability/tolerance levels

Rating	Acceptability/ tolerance level	Consequence on the Project
Low	Acceptable	A low level of vulnerability to specific climate risk(s). Remedial action of adaptation may be required.
Medium	Tolerable	A moderate level of vulnerability to specific climate risk(s). Mitigation action or adaptation could improve resilience, although an appropriate level of resilience is provided.
High	Potentially intolerable / Tolerable	A high level of vulnerability to specific climate risk(s). Mitigation action or adaptation is recommended.
Critical	Intolerable	An extreme level of vulnerability to specific climate risk(s). Mitigation action or adaptation is highly recommended.

5.2.2 Climate Data

Table 5.5 below shows the data values for the three future climate projection scenarios outlined in section 5.2.1.2 representing low, medium and high emission futures. The climate projection data is sourced from Copernicus Interactive Climate Atlas, with the exception of Sea Level Rise data which was extracted from the IPCC 6th Assessment Report Sea Level Projections through the NASA Sea Level Change Portal's projection tool. Historical baseline data is taken from the ERA5-Land reanalysis dataset for all variables apart from wind speed and air pressure, which were extracted from the ERA5 reanalysis dataset. Future climate projections take data from the latest CMIP6 models. Historical baseline climate data values are the mean value from the 1995-2014 baseline reference period. Future projected values are the 10^{th} Percentile (P10), median (P50), and 90^{th} Percentile (P90) values for the future timeframe period 2041-2060 across the 5 models that were referenced (or four models for future temperature variables other than mean temperatures owing to one model not providing data for these variables for the SSP1-2.6 scenario).

Table 5.5: 2041-2060 Climate Projections

Variable	Unit		1995-2014	SSP1-2.6			SSP2-4.5			SSP5-8.5			Model Availability #
			Baseline (mean)	P10	Median (P50)	P90	P10	Median (P50)	P90	P10	Median (P50)	P90	
Mean temp	℃	**Absolute**	**26.22**	**26.73**	**28.41**	**30.02**	**26.86**	**28.85**	**30.25**	**27.09**	**29.07**	**30.90**	**5**
		Change		0.50	2.19	3.80	0.64	2.63	4.03	0.87	2.85	4.68	
Mean of daily max temp	℃	**Absolute**	**29.15**	**29.85**	**31.15**	**32.02**	**29.80**	**31.38**	**32.17**	**30.20**	**31.68**	**32.53**	**4**
		Change		0.70	2.00	2.87	0.65	2.23	3.02	1.05	2.53	3.38	
Max of daily max temp	℃	**Absolute**	**30.77**	**31.97**	**33.21**	**33.74**	**31.94**	**33.43**	**34.10**	**32.00**	**33.61**	**34.40**	**4**
		Change		1.21	2.45	2.97	1.18	2.66	3.33	1.23	2.84	3.63	
Days with max temp above 35ºC (bias adjusted)	No.	**Absolute**	**0.00**	**0.00**	**0.17**	**1.21**	**0.00**	**0.46**	**2.53**	**0.00**	**1.38**	**5.87**	**4**
		Change		0.00	0.16	1.21	0.00	0.46	2.53	0.00	1.37	5.87	
Mean of daily accumulated precipitation	mm	**Absolute**	**7.02**	**5.01**	**6.62**	**8.37**	**4.96**	**6.44**	**8.31**	**4.91**	**6.52**	**8.92**	**5**
		Change		-2.01	-0.40	1.35	-2.06	-0.57	1.30	-2.11	-0.50	1.90	
Max of 1-day accumulated precipitation	mm	**Absolute**	**24.31**	**17.25**	**27.38**	**38.52**	**17.69**	**27.85**	**38.60**	**17.94**	**27.88**	**38.65**	**5**
		Change		-7.07	3.07	14.20	-6.62	3.54	14.29	-6.37	3.56	14.34	
Max of 5-day accumulated precipitation	mm	**Absolute**	**69.41**	**57.97**	**74.13**	**96.05**	**55.91**	**71.54**	**95.57**	**55.23**	**70.77**	**97.20**	**5**
		Change		-11.44	4.72	26.63	-13.50	2.13	26.16	-14.18	1.36	27.79	
Consecutive dry days	No.	**Absolute**	**17.87**	**7.00**	**19.50**	**50.20**	**7.00**	**19.50**	**50.00**	**6.90**	**23.50**	**74.00**	**5**
		Change		-10.87	1.63	32.33	-10.87	1.63	32.13	-10.97	5.63	56.13	
Mean wind speed *(near surface, not site specific)*	m/s	**Absolute**	*2.73*	***1.17***	***2.63***	***3.68***	***1.22***	***2.79***	***3.56***	***1.15***	***2.62***	***3.60***	**5**
		Change		-1.55	-0.10	0.95	-1.50	0.06	0.84	-1.58	-0.11	0.87	
Average air pressure at MSL	Pa	**Absolute**	**100969.94**	**100661.03**	**100949.86**	**101018.70**	**100667.18**	**100949.13**	**101012.52**	**100642.16**	**100943.05**	**101033.35**	**5**
		Change		-308.92	-20.08	48.75	-302.76	-20.82	42.57	-327.79	-26.89	63.41	
Sea Level Rise (2060)[36]	m	**Change**		**0.12**	**0.23**	**0.39**	**0.15**	**0.26**	**0.42**	**0.19**	**0.30**	**0.48**	-

[36] Data for projected sea level rise is taken from the IPCC 6th Assessment Report Sea Level Projections through the Sea Level Projection Tool – NASA Sea Level Change Portal for the coordinates Lat: -4, Long: 114 for the year 2060.

5.2.3 Discussion

5.2.3.1 Temperature

Baseline climate conditions:

- During the 2006 – 2015 period, data from the closest meteorological station to the project site extracted from the Environmental Impact Assessment, recorded that the month with the lowest average minimum temperature at 22.5℃ was July, while the month with the highest average maximum temperature at 32.6℃ was May. The annual average temperature was 26.6℃ and records show minimal seasonal variation throughout the year.[37]
- Reanalysis data for the project site area for the reference baseline period of 1995 – 2014 saw a mean temperature of 26.22℃, with a mean maximum daily temperature of 29.15℃, and absolute maximum daily temperatures of 30.77℃. During the same reference period, the region experienced no days with temperatures above 35℃.[38]

Future projections:

- Overall, all projected median values (P50) and the P10 ~ P90 range for each temperature variable depict an increase across all three scenarios by 2041 – 2060, as compared to the baseline period:
  - For mean temperature, SSP1-2.6 depicts an increase of +2.19℃ (+0.5℃ ~ +3.8℃), SSP2-4.5 shows a positive change of +2.63℃ (+0.64℃ ~ +4.03℃), and SSP5-8.5 respectively shows the greatest increase of +2.85℃ (+0.87℃ ~ +4.68℃). It is highly likely that mean temperature will increase throughout the project's lifecycle.
  - For mean maximum daily temperature, SSP1-2.6 depicts an increase of +2℃ (+0.7℃ ~ +2.87℃), SSP2-4.5 respectively shows a positive increase of +2.23℃ (+0.65℃ ~ +3.02℃), and SSP5-8.5 shows a temperature increase of 2.53℃ (1.05℃ ~ 3.38℃). It is highly likely that mean maximum daily temperatures will increase throughout the project's lifecycle.
  - For absolute annual maximum daily temperature, SSP1-2.6 depicts an increase of +2.45℃ (+1.21℃ ~ +2.97℃), SSP2-4.5 shows an increase of +2.66℃ (+1.18℃ ~ +3.33℃), and SSP5-8.5 shows an increase of +2.84℃ (+1.23℃ ~ +3.63℃). It is highly likely that the annual maximum daily temperature will increase throughout the project's lifecycle.
  - During the future projection timeframe, the region is projected to begin to experience days above 35℃, with 1.21 days, 2.53 days, and 5.87 days above this threshold respectively under SSP1-2.6, SSP2-4.5, and SSP5-8.5 scenarios. It is highly likely that the annual number of days with temperatures above 35℃ will increase over the project's lifecycle.

5.2.3.2 Precipitation

Baseline climate conditions:

- For the 2006 – 2015 period, the most proximal met station to the project site observed that the monthly rainfall distribution follows the monsoon pattern, with an average lowest monthly rainfall occurring in August (56mm) and an average peak rainfall occurring in December (329mm)[39].
- The reanalysis-based reference baseline climate period (1995 – 2014) saw an average daily accumulated precipitation of 7.02mm and a maximum 1-day accumulated precipitation of

[37] Historical data from Banjarbaru Climatology Station (located 50km awats from Project site), Project EIA.

[38] Copernicus Interactive Climate Atlas.

[39] Historical data from Banjarbaru Climatology Station (located 50km away from Project site), Project EIA

24.31mm, as well as a maximum 5-day accumulated precipitation of 69.41mm. During the same reference period, the region saw an annual average maximum dry period duration of 17.87 consecutive dry days[40].

- The region experiences a unique weather system, known as the Borneo Vortex, which features a cyclonic characteristic and is responsible for extreme weather in Borneo. Although it is understood that Borneo Vortices contribute to extreme precipitation mostly over Northern Borneo, to a more moderate degree they are known to also affect South Kalimantan.[41]
- The region surrounding the Project site is currently flagged as having a high risk of riverine flood occurrence and is historically known to experience flood events that have impacted daily operations and livelihoods.[42,43,44]

Future projections:

- Overall, across the three emissions scenarios, the future projections suggest a nuanced change in precipitation patterns for the period 2041 – 2060, with less overall precipitation but more intense individual precipitation events compared to the baseline period:
  - For average daily accumulated rainfall, all three future climate scenarios project small but meaningful (<10%) reductions in median daily precipitation, suggesting that the region is expected to receive less precipitation overall. However, it should be noted that P90 values would result in a substantial increase in daily accumulated precipitation (+1.3 – 1.99 mm) across the three emission scenarios showing that there is some uncertainty around the signal for future average daily rainfall.
  - For maximum 1-day accumulated precipitation, the projections across all three emissions scenarios show a substantial increase of approximately 3 – 3.6 mm (10-15%) in maximum 1-day precipitation at the P50 (median) level. Again, the large range between P10 and P90 values (approx. -7 to +14 mm), which are similar across all three scenarios, suggest that there is a higher level of uncertainty, but on balance it is likely that maximum one day rainfall will increase.
  - For maximum 5-day accumulated precipitation, similar to max 1-day precipitation, the projections for all three emissions scenarios show an increase at the P50 median level, however this increase is more pronounced for the lower SSP1-2.6 emissions scenario, median +4.72mm (P10 – P90, -11.44 to +26.63) representing a 7% increase, than for the middle SSP2-4.5, median +2.13mm (P10 – P90, -13.5 to +26.16), and high SSP5-8.5, median +1.36mm (P10 – P90, -14.18 to +27.79), emissions scenarios. Overall, it is more likely than not that maximum 5 day rainfall will increase.
  - For number of consecutive dry days, all three projections depict an increase at the median (P50) and P90 levels, although a decrease at P10 values. However, the wide range between P10 and P90 values, indicates a higher level of uncertainty. Both the SSP1-2.6 and the SSP2-4.5 projections share very similar values with a shared median increase in consecutive dry days of +1.63 with a P10 – P90 range of approximately -11 to +32 days. The SSP5-8.5 projection shows a greater increase in consecutive dry days, median +5.63 days (P10 – P90, -10.97 to +56.13 days). While uncertainty exists, the projections for all scenarios suggests a future with longer dry weather periods.
  - In addition to the specific climate projection data, it is expected that intense rainfall events will increase in frequency and magnitude in the future as a direct result of a warmer atmosphere being able to hold more moisture. The rate of increase of intensity of extreme

[40] Maximum of consecutive days when daily accumulated precipitation amount is below 1mm.
[41] Borneo Vortices in a warmer climate, Liang et. al., Climate and Atmospheric Science (2023)
[42] Aqueduct Water Risk Atlas (wri.org)
[43] Climatological analysis of flood event in Tanah Laut Regency, South Kalimantan Climatology Station
[44] Indonesia National Agency for Disaster Countermeasure (BNPB), disaster report, 8 March 2022

rainfall with temperature is governed by the Clausius-Clapeyron relationship which gives an approximate 7% increase in moisture per 1°C of warming. Despite the apparent simplicity of the relationship, there are a range of factors including moisture availability, temperature, cloud type and location which can result in much higher rates of scaling (in some cases 21% increase in moisture per °C of warming).

5.2.3.3 Wind and Storms

Baseline Climate Conditions:

- A 100m tall meteorological mast (Met Mast) was installed and measurements commenced on 16th April 2016 at the top of the ridge (where the WTGs are planned) as part of the Project feasibility study. Based on the Wind resource and energy yield assessment section, the long-term average wind speed at a mast height of 98m (approx. 351 m amsl) was 7.23m/s, and predominantly from the South-east during dry season (boreal summer) and from the North-west during wet season (boreal winter), and average air pressure of 979hPa.
- Throughout 2006 – 2015, at the local Banjarbaru Met station (separate location from the project site ridge), it was observed that wind would blow from the Southeast at an average wind speed of 3.01m/s during dry season, and wind would blow from the East and Northwest at an average wind speed of 3.36m/s during rainy season. The maximum wind speed was measured at 9m/s with a frequency of 0.18% while the average wind speed throughout the 10 years was 3.15m/s.
- The reanalysis data for the region around the project site from reference baseline period (1995 – 2014) reports a near surface mean wind speed of 2.73m/s, as well as an average air pressure at mean sea level of 1009.7hPa (100969.94Pa).
- There are no historical records of typhoon or tropical storm tracks coming within 180 nautical miles South Kalimantan. Tropical storms do not form within 5 degrees of the equator due to the weak Coriolis force at very low latitudes. However, Borneo Vortices (discussed in section 5.2.3.2) are cyclonic weather events primarily effecting the north coast of Borneo that can also impact wind speeds and direction in South Kalimantan.

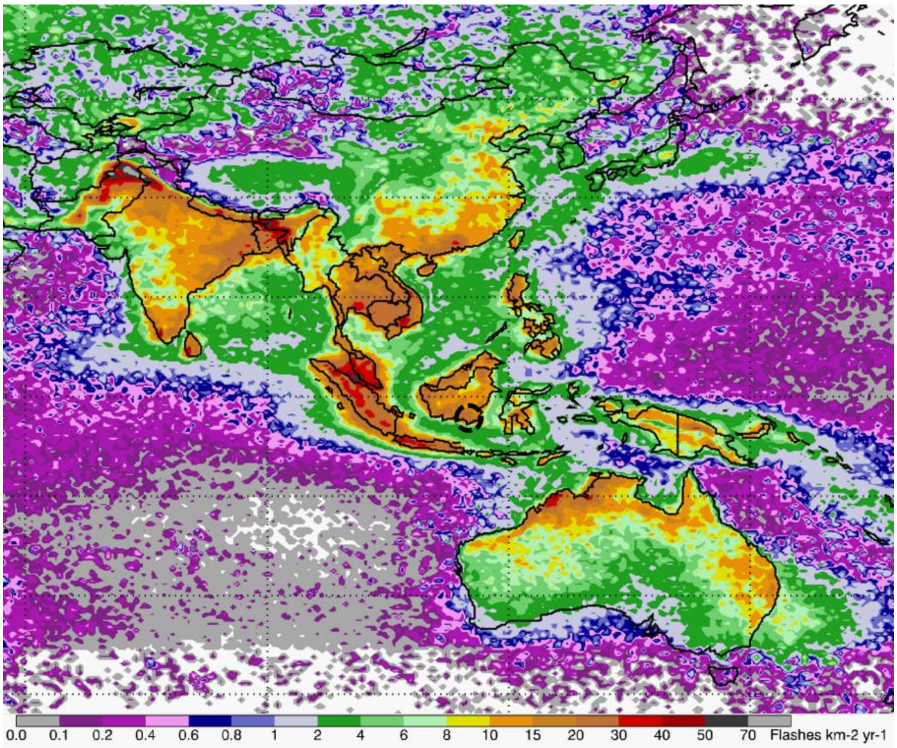
Future projections:

- The three projection scenarios for near surface mean wind speed in the project region (but not project site specifically) show very little change in the median value (+/- 0.1 m/s) for projected values in 2041 – 2060. P10 – P 90 values are similar across the three scenarios and show a range of between -1.6 to +1 m/s for change in wind speeds. The impact of climate change on future wind speeds are uncertain, but projection data points to little or no change.
- All three projection scenarios for average air pressure at MSL point to a modest reduction in air pressure, although the large range between P10 and P90 values suggests uncertainty with these projections.
- It is uncertain as to how Borneo vortices may change in future as a result of climate change and therefore any impact on wind speeds is unknown.

5.2.3.4 Lightning

Research into lightning activity across the maritime continent of Indonesia discovered that the southern parts of Kalimantan are prone to lightning activity particularly during the transition seasons of March to May, and September to November. It was found that lightning activity is mostly concentrated over land instead of ocean, which is in accordance with diurnal convective precipitation events due to the existence of numerous mountainous islands across Indonesia. In relation to climate change, annual trends of lightning flashes in adjacent regions (Malacca Strait and Greater Jakarta) have substantially increased yearly.[45]

Figure 5.3: Lightning flash rate density averaged over 17 years[46]



There is a consensus that an increase in mean temperature will lead to an increase in convective activity. For example, research from the United States suggests that for every 1.0 °C rise in global temperature, lightning strikes are estimated to increase by 12% ± 5% per °C of global warming, and about 50% over the 21st century overall (Romps et al., 2014).

Furthermore, separate research conducted in 2008 also suggests that there is a positive relationship between temperature and lightning, with lightning increasing anywhere from 10% to 100% for every one degree of surface warming (Price, 2009). It is understood that the above research is predominantly concerned with an increase in the frequency of lightning activity.

Accepting that not all storm events may be electrical by nature, there are empirical relationships which suggest that if the number of thunderstorm days (Keruanic level) doubles, so does the number of flashes per square kilometre (EPRI, 2004). This would suggest that it could be expected that the number of lightning events in South Kalimantan might increase through the 21st century.

With regard to whether the intensity of lightning might increase as a result of climate change, the understanding is less clear. The magnitude of the current discharge, the rate of rise of the current and the number of discharges collectively determine whether a flashover occurs. The projected increase in temperature is likely to lead to more convective storms, and therefore also likely more lightning strikes. However, the changes in intensity (heat and electrical power) are not known. The intensity of a lightning strike in terms of the associated heat and electrical power are so large that any increase or decrease is not likely to affect the impact of a lightning strike.

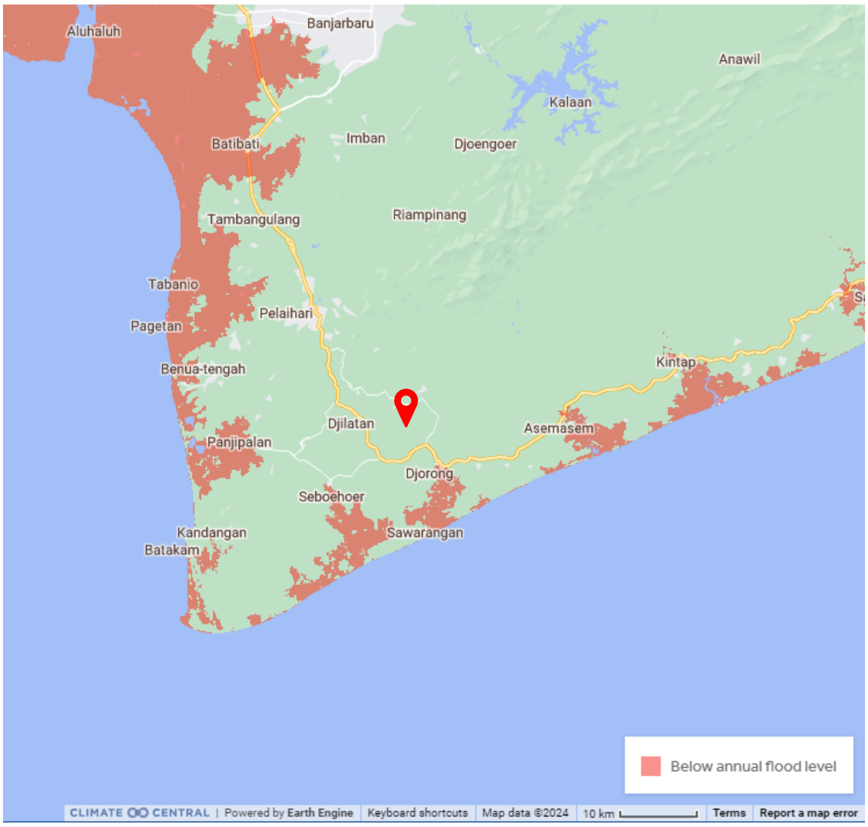
[45] Y Ilhamsyah et al., 2017. Lightning hazard region over the maritime continent observed from satellite and climate change threat. IOP Conf. Ser.: Earth Environ. Sci. 56 012010

[46] LIS OTD Climatology Data Sets - Data - Browse - Documentation | GHRC Lightning (nasa.gov)

5.2.3.5 Sea Level Rise

Sea level rise as a result of climate change is a global phenomenon impacting coastal communities and infrastructure worldwide. Rising temperatures cause ice sheets and glaciers to melt adding water to the oceans and the volume of the oceans also increase through thermal expansion of sea water, with both of these factors contributing to higher sea levels. There is overwhelming scientific evidence that the chronic threat of sea level rise associated with climate change is projected to occur throughout the 21st century and beyond[47,48]. Projections for the seas adjacent to the project site location depict future sea level rise to range between +0.12m (P10 value of SSP1-2.6) and +0.48m (P90 value of SSP5-8.5), within median increase of +0.23m, +0.2m6 and +0.3m for SSP1-2.6, SSP2-4.5 and SSP5-8.5 respectively by 2060 relative to a 1995-2014 baseline. Sea level rise may influence flood events in the plains surrounding the site, either through inundation or increased ground water levels, thus impacting components located on low elevation grounds or limit access to the site.

Figure 5.4: Land projected to be below annual flood level in 2060



Climate Central allows a high-level screening of flood risk as a result of sea-level rise by decadal year for a range of scenarios[49]. The results of the analysis for the Project landing infrastructure location by 2060 (Under SSP8.5 scenario) for land below annual flood level is shown in Figure 5.4[50]. This screening does not seem to indicate direct impact on Project components, however, this may pose a risk for components located on low elevation grounds or limit access to site.

[47] IPCC (2021). Available at: Summary for Policymakers (ipcc.ch)

[48] IPCC (2021). Available at: IPCC_AR6_WGI_Chapter_09.pdf

[49] Climate Central (2021). Available at: Maps & Tools | Surging Seas: Sea level rise analysis by Climate Central

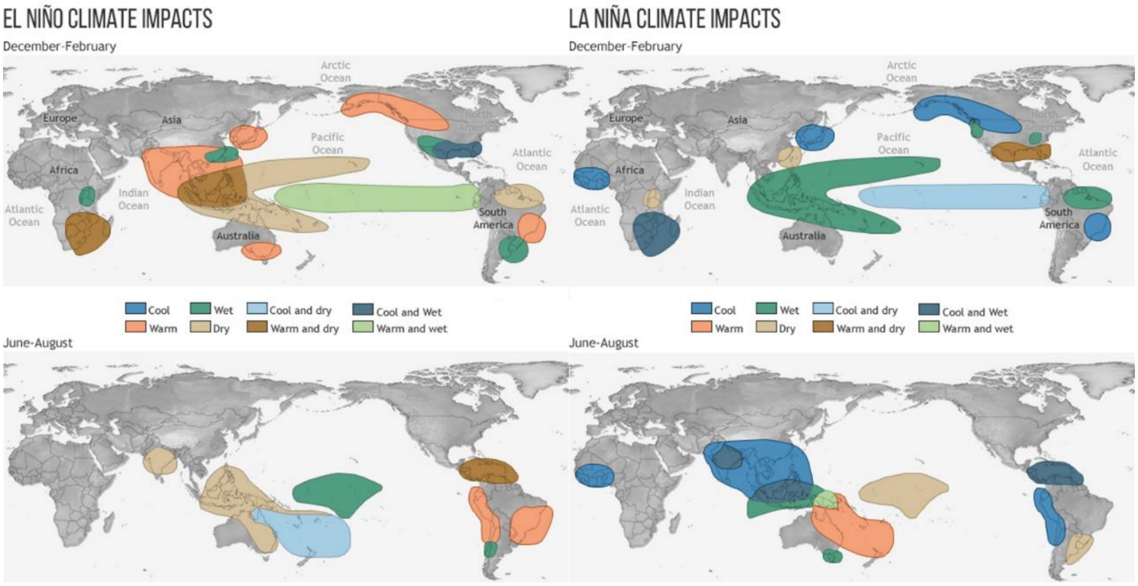
[50] Parameters used to determine future sea level rise via Climate Central: Year: 2060; Projection Type: Sea level rise + annual flood.

5.2.3.6 Key Climate Drivers

The key drivers of large-scale climate variability in Borneo, impacting precipitation, temperature, extreme sea levels and regional cyclone activity, are ENSO and the Indian Ocean Dipole (IOD).

ENSO refers to a recurring climate pattern across the tropical Pacific that has warm and cool phases. El Niño events tend to result in warmer and drier conditions in Borneo from December – February. La Niña events often see greater precipitation and cooler conditions during June – August (Figure 5.5). Climate change may combine with ENSO cycles and result in more variable and extreme temperatures and precipitation. The uncertainty associated with future climate is compounded by the fact that climate change is occurring on top of existing inter-annual variability in climate caused by ENSO.

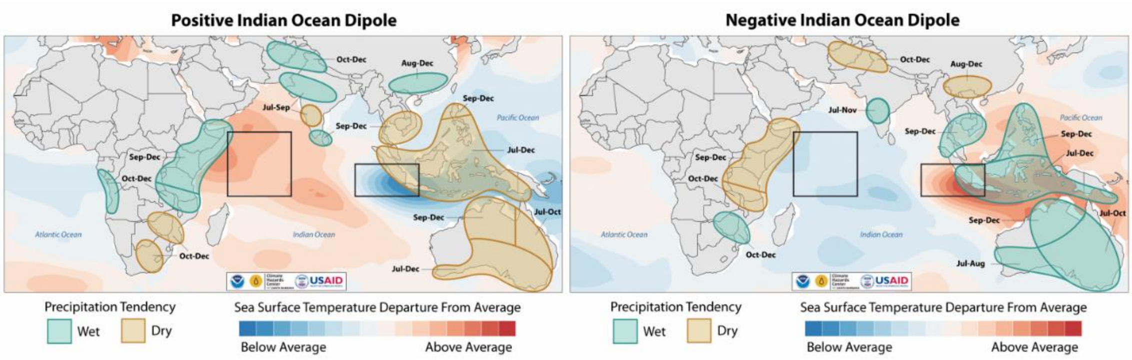
Figure 5.5: El Niño and La Niña climate impacts during different seasons



Climate model simulations suggest that central Pacific ENSO variability may increase under greenhouse forcing, but instrumental records of tropical Pacific Sea surface temperatures (SSTs) are too short to provide robust constraints on recent trends in ENSO variability (Liu, et al., 2017). As such, while it is fairly certain that the climate of Borneo is changing and will continue to change, ENSO increases the uncertainty associated with these changes.

The Indian Ocean Dipole (IOD) refers to sustained changes in the difference between sea surface temperatures (SSTs) in the eastern and western tropical Indian Ocean. There are three phases of the IOD: Positive, Neutral and Negative. During a Positive Phase SSTs in the western Indian Ocean flanking Africa are warmer than usual, while SSTs in the eastern Indian Ocean (along the Malay Peninsula and Indonesian Archipelago) are cooler than usual (Figure 5.6). During a negative phase this situation is reversed. Typically, during a positive IOD event Borneo will experience drier conditions, while a negative IOD event will see greater precipitation in Borneo. However, negative IOD phases often coincide with La Niña events, and since 1960, all negative IOD phases have occurred under either neutral ENSO conditions or when ENSO is in, or developing into, a La Nina phase. On average, in Borneo, the wettest conditions occur when a negative IOD event co-occurs with a La Niña event.

Figure 5.6: Positive and Negative Phase SSTs in the Indian Ocean



5.3 Conclusion

5.3.1 Risks identified

No fatal flaws in the form of high or extreme risks to the Project have been identified as a result of projected climate change to the 2060, but a watching brief of risks identified must be maintained throughout the Project lifetime and adaptively managed.

- A total of 32 risks were identified. Of the identified risks 19 were deemed as medium, and 13 were deemed as low.
- The 19 medium risks were deemed as tolerable. The 13 low risks were deemed acceptable. No intolerable risks were identified.

It should be noted the risk of physical damage, and risks to worker safety and system interruptions is present irrespective of climate change.

Note risk and acceptability classification have been drawn based on the assumption that all practices considered within BAU risk controls (included within Risk Register in Appendix J) are being carried out.

The scoring of medium or low should be read with caution given it has not yet been confirmed that Project designs will embed the BAU risk controls listed within Appendix J. As these BAU controls are considered standard practice, it has been assumed they will be embedded into the Project. The identified risks, BAU risk controls, and additional adaptation measures should be reviewed by the Project Company and the relevant Project contractor and taken into account within the design to ensure the resilience of the Project.

While the management of worker safety is relatively easy to control for, little is known about the interaction of the effects of future climate change on materials or corrosion. Concepts such as the durability or lifespan of assets are not commonly available in this regard. The Project must articulate its overarching maintenance guidance to consider unpredictable, worst case, acute and chronic climate extremes to keep structures and assets in good condition.

Medium risks identified have been summarised & condensed in Table 5.3 below. Refer to Appendix J for full list of all risks.

Table 5.6: Medium risks summary table

Hazard	Consequence/ Impact

Flooding	The substation is located at low elevation below the ridge, and within a region with a history of flooding (Tanah Laut). Flooding from extreme rain may cause damage to electrical equipment, interrupting power transmission and requiring maintenance / early replacement. Damage to underground cables - water intrusion into cable ducts Flooding in low lying areas surrounding the project site may result in access roads becoming impassable, hindering the ability of workers to attend to operational & maintenance issues at the project site. Health & safety risk to construction workers from flash floods
Landslides	Due to the site's elevation and topography, it is potentially vulnerable to landslides triggered due to weakening of sediments from extreme rain events. This has the potential to be exacerbated by the added weight of the WTGs & the removal of vegetation required for this project. Underground cables and/or overhead cable pylons transmitting power from the WTGs to the substation may be vulnerable to damage by land slippage. Landslides could endanger construction workers & damage machinery. The substation and access roads are located beneath the ridge have the potential to be impacted by landslides impeding site access.
Temperature	Fatigue and degradation of turbines as a result of extreme heat leading to increased maintenance requirements
	Increased temperatures may result in exceedance of design conditions for electrical equipment resulting in failure of equipment, requiring maintenance and replacement.
	Extreme heat impacts on workers leading to heat exhaustion, or reductions in outside work time for repair and maintenance activities.
Precipitation	Extreme precipitation could cause enhanced erosion of leading edges. Additionally, there is a risk of water ingress into the nacelle, causing damage to electrical boards and wiring and corrosion of key components.
	Extreme precipitation may result in elevated risks to the health and safety of workers on site resulting from poor visibility, wet clothing, slip hazards and erosion to access roads etc
Wind	Future downscaled model projections of Borneo Vortex activity suggest the potential for an increase in maximum wind speeds associated with these events. While this is predominantly expected to affect the North of Borneo, there may be peripheral or occasional impacts to the project location. Strong winds can cause damage to overhead transmission and distribution lines. Additional maintenance requirements or early replacement of assets may be required. If a significant storm event damages the wider electrical grid and causes a power outage, this may affect ability to restart WTGs or function of safety feature of the WTG.
Lightning	The WTGs are located on a ridgeline and therefore risk of lightning strikes is elevated relative to the surrounding area. Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an increase in lightning activity. WTGs with improper lightning protection could get damaged or catch fire due to lightning strikes resulting in additional maintenance or replacement of assets due to damage.
	Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an increase in lightning activity. Substations are vulnerable to lightning due to the electrical nature of the infrastructure (static field). The prominent position of the WTGs on a ridgeline and the high presence of static electricity of the project infrastructure means that workers may be exposed to elevated danger during maintenance operations, especially when tending to an urgent site emergency.
Wildfires	South Kalimantan is known to experience wildfires as a result of deforestation and subsequent rice paddy burning activities. The WTG is located along a mountain ridge, surrounded by grass and wooded vegetation providing a flammable environment. The compound effects of an increase in temperature, along with variable precipitation and wind speeds, as well as lower soil vegetation and increased lightning activity may create more favourable conditions for wildfires to spread, resulting in damage to the WTGs and to the substation and other ground infrastructure.

5.3.2 Next steps and recommended adaptation measures

The Risk Register attached in Appendix J contains a list of recommended adaptation measures which will serve to further reduce risk profile, taking more risks from tolerable to acceptable.

In particular the resilience of access roads should be considered in design and construction, as the potential risk of flooding and landslides in response to an increase in the intensity of extreme precipitation events is projected to increase overtime which may impede site access. Additionally where possible and within scope, climate hazards impacting the resilience of the Project's connection to the wider transmission grid should be considered.

It is important the effectiveness of the proposed adaptation measures are monitored post construction. In alignment with adaptive management processes, the proposed adaptation measures should be periodically re-assessed to ensure they are effective and remain appropriate for purpose.

5.4 Reference

[36] Sea Level Projection Tool – NASA Sea Level Change Portal

[37, 39] Banjarbaru Climatology Station, Information provided from Project EIA and Feasibility Study.

[38] Copernicus Interactive Climate Atlas

[41] Borneo Vortices in a warmer climate | npj Climate and Atmospheric Science (nature.com)

[42] Aqueduct Water Risk Atlas (wri.org)

[43] Climatological analysis of flood event in Tanah Laut Regency, South Kalimantan Climatology Station

[44] Indonesia National Agency for Disaster Countermeasure (BNPB), disaster report, 8 March 2022

[11] Y Ilhamsyah et al., 2017. Lightning hazard region over the maritime continent observed from satellite and climate change threat. IOP Conf. Ser.: Earth Environ. Sci. 56 012010

[12] LIS OTD Climatology Data Sets - Data - Browse - Documentation | GHRC Lightning (nasa.gov)

[13] UIPCC (2021). Available at: Summary for Policymakers (ipcc.ch)

J. Risk Register

Table J.9: Projection Scenario: SSP5-8.5 / Timeframe: 2041 – 2060 (excluding construction)

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
Temperature – Increase in average and extreme temperatures	Wind Turbine Generators	Damage to Infrastructure	Fatigue and degradation of turbines as a result of extreme heat leading to increased maintenance requirements	Turbines typically have sensors measuring temperatures, and other variables, at different time intervals. This real time measurement data is combined with historical data and wind farm system understanding to optimise power output, scheduled and corrective maintenance, detecting and diagnosing installation and warranty issues, amongst others. Targeted monitoring and replacement of components with expected life times shorter than the remaining wind-farm lifetime. Where data shows the turbine has been operating / or is at risk of operating outside of specified parameters, targeted pre-emptive and/or remedial maintenance and servicing will be actioned. The WTG specification notes that the operational temperature range of the WTGs is -20°C to 45°C.	L2 Unlikely	S3 Moderate	Medium	Tolerable	Review assumed allowances within the design and take these into account if not already implemented. Turbines are understood to operate effectively under local temperature conditions including fluctuations from 'normal' range. Sustained heatwave conditions may require more regular checking of equipment performance and more regular maintenance. Including replacements of consumables.
	Wind Turbine Generators	Power Generation	Lower energy yield as a result of increased air temperatures. The air temperature has an indirect impact on wind turbine performance. Increasing air temperatures (T) lead to decreasing air densities (ρ), which affects the energy outputs from wind turbines.	It is not quantified how much impact the temperature rise would have to the air density. We note that the EYA has factored in uncertainty range for the site environmental conditions.	L3 Possible	S2 Minor	Low	Acceptable	Ensure that the estimated yield used for the financial modeling has taken the uncertainty in to account.

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
	Substation & Transformers	Power Transmission	Increased temperatures may result in de-rated component capacity at substations and transformers. This results in a lower efficiency of the system to transmit energy.	It is assumed that designs will account for functionality in high temperatures.	L3 Possible	S2 Minor	Low	Acceptable	Ensure that systems are rated appropriately for future increases in temperature and that appropriate ventilation and/or A/C equipment is included to maintain temperatures within operating ranges.
	Substation & Transformers	Damage to Infrastructure	Increased temperatures may result in exceedance of design conditions for electrical equipment resulting in failure of equipment, requiring maintenance and replacement.	It is assumed that designs will account for functionality in high temperatures.	L3 Possible	S3 Moderate	Medium	Tolerable	Ensure that systems are rated appropriately for future increases in temperature and that appropriate ventilation and/or A/C equipment is included to maintain temperatures within operating ranges.
	Substation & Transformers	Working Conditions	Changes to ground moisture and ground temperature influence efficiency of substation earthing & lightening protection which could pose a safety risk on-site.	It is assumed that the annual substation O&M check will include the typical grounding resistance check and should the parameters become out of the range, rectification will be implemented.	L3 Possible	S2 Minor	Low	Acceptable	Ensure that earthing and lightning protection equipment takes into account and is designed to operate for a range of plausible temperatures and ground moisture conditions.
	Cables & Grid Connections	Power Transmission	Increased temperatures may result in de-rated component capacity of transmission cables in order to avoid permanent damage. This results in a lower efficiency of the system to transmit energy.	It is assumed that designs will account for functionality in high temperatures.	L3 Possible	S2 Minor	Low	Acceptable	

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
	Operation & Maintenance	Working Conditions	Extreme heat impacts on workers leading to heat exhaustion, or reductions in outside work time for repair and maintenance activities.	Indonesia has a law for working in high temperatures that requires the application of certain work/rest patterns. BAU mitigation measures to minimise heat exposure and reduce the risk of potential heat stress, include: – Implementing portable air conditioning to provide localised cooling for technicians – Installing centrifugal fans in the nacelle to improve air flow and exchange hot air with cooler air from outside – Adequate work and rest patterns – Employing light workwear and PPE suitable for work in tropical climates – Adapting shifts to work at cooler times of day (for example, night work) – First aid kits are extended with tools in case of heat stroke incidents – Special care is taken to ensure that technicians are hydrated It is assumed that all contractors will be required to provide health & safety plans for their respective scope of works and teams deployed to site.	L2 Unlikely	S3 Moderate	Medium	Tolerable	HSE risks are significantly reduced if appropriate health & safety plans are in place to manage climatic extremes like heat. Heat exhaustion is a residual risk if workers need to tend to an emergency.
	Operation & Maintenance	Damage to Infrastructure	Extreme high temperatures can cause loss of information through communication networks or reduced quality of service, leading to sub-optimal operation	It is assumed that communications and data services with the WTGs will be designed to be resilient in a wide range of operating conditions, including in high temperatures.	L2 Unlikely	S2 Minor	Low	Acceptable	Ensure that hardened back-up communication and data systems exist to maintain control of

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			or in the worst case damage to WTGs						critical functions even in extreme circumstances
Precipitation – Increase in extreme precipitation events	Foundations	Damage to Infrastructure	Extreme precipitation may result in localised erosion of the top soil around WTG bases, which may reduce its bearing capacity.	The design of the foundations is assumed to be a typical gravity base and that appropriate drainage, skirting and erosion protection measures are incorporated during design and construction and ongoing monitoring and maintenance will occur throughout the project life.	L3 Possible	S2 Minor	Low	Acceptable	
Precipitation – Precipitation variability	Wind Turbine Generators	Damage to Infrastructure	Extreme precipitation could cause enhanced erosion of WTG blade leading edges. Additionally there is a risk of water ingress into the nacelle, causing damage to electrical boards and wiring and corrosion of key components.	It is assumed that the selected WTG blade design is appropriate for local climatic conditions and the turbine model has incorporated water-proofing measures suited to the rainy climate of the tropics.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended for the project to conduct regular monitoring for tightness of nacelle and towers and to check for anomalies in electrical components and operations. The WTG blade leading edge protection should be checked/monitored in accordance with OEM's operating manual.
	Operation & Maintenance	Working Conditions	Extreme precipitation may result in elevated risks to the health and safety of workers on site resulting from poor visibility, wet clothing, slip hazards and erosion to access roads etc	It is assumed that the health & safety plan takes into account extreme weather events and appropriate working conditions. It is also assumed that WTG operations will come to a stop during extreme weather events.	L2 Unlikely	S3 Moderate	Medium	Tolerable	It is recommended for the project to incorporate H&S procedures for extreme weather events, including cessation of work where necessary and select locations for

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
									evacuation/shelter of workers. It is recommended that the weather forecast be checked regularly throughout the project lifecycle, to proactively plan work around extreme weather events to avoid any accidents and casualties.
	Operation & Maintenance	Damage to Infrastructure	It is projected that there will be variation in annual precipitation from year to year, but that overall there will be a slight reduction in annual precipitation in South Kalimantan, leading to dryer periods and an increased risk of drought. Drier climate conditions contribute to increased amount of dust in the atmosphere, and changing soil moisture conditions that could result in subsidence. Infiltration of dust within electrical components may cause damage to systems and machinery, causing additional maintenance, while subsidence could result in damage to structures.	It is assumed that structural foundations will be designed appropriately for the local soil / rock type to avoid the risk of post construction settling and subsidence causing damage. We expect that minor augmentation is possible for higher dust prevention similar to the WTGs located in the dessert area.	L2 Unlikely	S2 Minor	Low	Acceptable	It is recommended that soil stability and settling is regularly monitored throughout the project life and that appropriate maintenance measures are implemented where signs of subsidence occur. It is recommended for the project to conduct regular monitoring to check for anomalies in electrical components and operations.
Wind – Uncertain minor decrease in	Wind Turbine Generators	Power Generation	Changes in wind patterns impact on power output within operating range.	Cut in wind speed (point at which the WTG is able to generate power): 3.0m/s. Uncertainty in wind speed variation based on historical data is included in the yield	L2 Unlikely	S1 Insignificant	Low	Acceptable	Consider energy yield results that consider uncertainty and provide sufficient comfort.

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
average wind speed				analysis and yield results with probability consideration.					
Wind – Extreme wind events	Wind Turbine Generators	Damage to Infrastructure	Future downscaled model projections of Borneo Vortex activity suggests the potential for an increase in maximum wind speeds associated with these events. While this is predominantly expected to effect the North of Borneo, there may be peripheral or occasional impacts to the project location. Extreme high wind speeds may damage blades, result in increased loading on WTG components and affect equipment lifetime.	BAU is to design wind farms with consideration of 1 in 50-year storm event. The design extreme wind speed (50 year, 10-min. average) is 45.0 m/s which is well within the site suitability study done by the WTG suppler at 26.3 m/s.	L3 Possible	S2 Minor	Low	Acceptable	Recommend additional monitoring of WTGs during and after extreme wind events. Follow the operating manual and prepare equipment for extreme wind when possible.
	Operation & Maintenance	Working Conditions	Future downscaled model projections of Borneo Vortex activity suggests the potential for an increase in maximum wind speeds associated with these events. While this is predominantly expected to effect the North of Borneo, there may be peripheral or occasional impacts to the project location. Extreme wind can impact access to sites leading to delays in maintenance. Strong winds can accompany flying debris, which would be a	It is assumed that appropriate actions regarding working conditions during a extreme wind event are implemented within health & safety plans. Health & safety risks are significantly reduced if appropriate plans are in place to manage climatic extremes such as high wind events. Danger to life is a residual risk if workers need to tend to an emergency in stormy and windy conditions.	L2 Unlikely	S2 Minor	Low	Acceptable	

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			health & safety risk for operations & maintenance workers Delays in maintenance activities due to reduced access to sites.						
	Cables & Grid Connections	Damage to Infrastructure	Future downscaled model projections of Borneo Vortex activity suggests the potential for an increase in maximum wind speeds associated with these events. While this is predominantly expected to effect the North of Borneo, there may be peripheral or occasional impacts to the project location. Strong winds can cause damage to overhead transmission and distribution lines. Additional maintenance requirements or early replacement of assets may be required. If a significant storm event damages the wider electrical grid and causes a power outage, this may effect ability to restart WTGs or function of safety feature of the WTG.	It is assumed that infrastructure will be built to appropriate design codes to withstand force of extreme wind gusts. WTG also have back up battery system to handle the grid outage.	L3 Possible	S3 Moderate	Medium	Tolerable	Review assumed allowances within the design and take extreme winds into account if not already implemented. Maintenance guide should specify regular monitoring of potential wind-related damage, wear and tear.
Flooding – Increase in extreme precipitation events	Substation & Transformers	Damage to Infrastructure	The substation is located at low elevation below the ridge, and within a region with a history of flooding (Tanah Laut). Flooding from extreme rain may cause damage to electrical equipment,	Drainage design/plan of the site and components are currently unknown, however, it is assumed that adequate drainage measures will be incorporated for vulnerable components.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended that necessary designs to mitigate flooding around the substation to be incorporated, such as but not limited

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			interrupting power transmission and requiring maintenance / early replacement.	Elevation of any buildings/substations are unknown at this stage, however, it is assumed that the relative elevation of vital components will be considered.					to; constructing a flood wall around the substation, elevating the ground levels of the foundation of the substation, sufficient drainage around the substation, portable temporary flood barriers at the entrance of the substation building, etc.
	Cables & Grid Connections	Damage to Infrastructure	Damage to underground cables - water intrusion into cable ducts	The cable design is currently unknown at this stage, however, it is assumed that underground cables will implement water-proofing, as seen with similar projects located in the tropics.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended for cable junctions to be well sealed and protected to prevent water ingress and for underground cable routes to avoid flow paths and low lying areas where water may pool.
	Operation & Maintenance	Reduced Access	Flooding in low lying areas surrounding the project site may result in access roads becoming impassable, hindering the ability of workers to attend to operational & maintenance issues at the project site.	Flood design measures for local access roads are unknown.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended that access route be designed with enhanced drainage or elevated to improve resilience against flooding removing access to the project site.
	Operation & Maintenance	Working Conditions	Limitation in moving/utilizing machinery and construction materials to site due to impact on	It is assumed that naturally occurring hazards are accounted for within the	L3 Possible	S2 Minor	Low	Acceptable	It is recommended that the weather forecast be checked regularly,

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			access roads. May cause delay in maintenance schedule.	maintenance schedule as contingency for delays.					to proactively plan work around extreme weather events to avoid disruption and delays. Ensure maintenance facilities, equipment/ material storage and heavy machinery is located above the floodplain and appropriate flood protection is used.
	Operation & Maintenance	Working Conditions	Health & safety risk to construction workers from flash floods	It is assumed that appropriate actions regarding working conditions during a flood event are implemented within the health & safety plan.	L2 Unlikely	S3 Moderate	Medium	Tolerable	It is recommended that appropriate responses are incorporated in the health & safety plan for flooding events. It is recommended that maintenance workers are given appropriate health & safety training for working on site. It is recommended that the weather forecast be checked regularly, to proactively plan work around extreme weather events to avoid disruption and delays. Ensure maintenance

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
									facilities, equipment/ material storage and heavy machinery is located above the floodplain and appropriate flood protection is used.
Landslide – Increase in extreme precipitation events	Wind Turbine Generators	Damage to Infrastructure	Due to the sites elevation, the added weight of the WTGs & the removal of vegetation for this project required, saturation of soils as a result of extreme rain events may cause instability and landslides. Landslides could affect integrity of WTG foundations. However if this was to occur, it would likely be localised and only effect a small number of WTGs. Additionally, cracks in the base rock were noted within a geotechnical assessment undertaken by Kwarsa Hexagon in 2018. There is the potential for the increased precipitation to increase weathering & erosion within these cracks, potentially increasing land instability over time. However increases in weathering & erosion are unlikely	It is assumed that WTG locations and foundation design take into account local soil characteristics and that foundation depths are adequate. The geotechnical assessment recommended the crack rocks around WTGs be grouted. This grouting will likely mitigate against increased weathering & erosion within these cracks. However dependent on the scale of grouting across the site surface, this may decrease site drainage, causing pooling. It is important that sufficient drainage is included around the WTGs. The geotechnical assessment recommended pile should be installed on each of the bottom of the foundation to increase foundational stability around the WTGs.	L1 Rare	S3 Moderate	Low	Acceptable	It is recommended that soil stability on slopes is monitored and maintained through the use of appropriate drainage systems and natural or engineered slope stability measures where landslides could pose a risk to the resilience of WTG foundations.

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			to impact the site significantly within the life time of the asset.						
	Substation & Transformers	Damage to Infrastructure	The substation is located beneath the ridge, potentially making it vulnerable to landslides triggered due to weakening of sediments from extreme rain events	It is assumed that the location of the substation will take into account and avoid the debris paths of any slopes vulnerable to land slippages.	L2 Unlikely	S4 Major	Medium	Tolerable	It is recommended that soil stability on slopes is monitored and maintained through the use of appropriate drainage systems and natural or engineered slope stability measures where landslides could pose a risk to the substation.
	Cables & Grid Connections	Damage to Infrastructure	Underground cables and/or overhead line pylons transmitting power from the WTGs to the substation may be vulnerable to damage by land slippage as a result of extreme precipitation episodes.	It is assumed that the overhead line routing will take into account and avoid any slopes vulnerable to land slippages and their potential debris paths.	L2 Unlikely	S4 Major	Medium	Tolerable	It is recommended that soil stability on slopes is monitored and maintained through the use of appropriate drainage systems and natural or engineered slope stability measures where landslides could pose a risk to cables and/or pylons.
	Operation & Maintenance	Working Conditions	Due to the sites elevation, the added weight of the WTGs & the removal of vegetation for this project required, saturation of soils as a result of extreme rain events may cause instability and landslides. Landslides could endanger construction workers &	It is assumed that appropriate actions regarding working conditions during and after extreme precipitation is implemented within the health & safety plan.	L1 Rare	S4 Major	Medium	Tolerable	It is recommended that the site is surveyed for any areas of potential high landslide risk and that these areas are monitored regularly, including following extreme precipitation events, for any signs

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			damage machinery & impede site access.						of slippage. In the case that slippage is observed suitable barriers should be erected and changes to worker and vehicle movements implemented to ensure worker safety.
Lightning – Increase in frequency of lightning strikes as a result of increased temperatures	Wind Turbine Generators	Damage to Infrastructure	The WTGs are located on a ridgeline and therefore risk of lightning strikes is elevated relative to the surrounding area. Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an increase in lightning activity. WTGs with improper lightning protection could get damaged or catch fire due to lightning strikes resulting in additional maintenance or replacement of assets due to damage.	Lightning intensity patterns are considered during planning of daily technician work shifts so that they accommodate the higher likelihood of lightning at those times, even where lightning has not been directly observed. It is assumed that the wind farm is equipped with lightning detection system which can detect lightning accurately from long range. The WTGs has lightning protection designed according to the industry standard IEC 61400-24. Additionally it is assumed that WTG maintenance would be halted when lightning is detected nearby and during extreme weather events.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended that regular weather monitoring and prediction is undertaken throughout the life of the project, with proactive shut down of turbines in order to reduce electrostatic fields
	Substation & Transformers	Damage to Infrastructure	Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an	It is assumed that the wind farm is equipped with lightning detection system which can detect lightning accurately from long range. In keeping with most electricity generation projects, it is assumed that infrastructure with high electricity (static)	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended for the project to conduct a lightning risk assessment of the project as per the international IEC 62305-2 standard.

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			increase in lightning activity. Substations are vulnerable to lightning due to the electrical nature of the infrastructure (static field).	presence will be required to install lightning rods as a protective measure.					
	Cables & Grid Connections	Damage to Infrastructure	Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an increase in lightning activity. The project includes overhead transmission lines, which are vulnerable to lightning strikes. Such strikes can cause overvoltage on the transmission lines, damage substations and transformers, and cause a wider grid disruption. Lightning strikes on or near overhead transmission lines can cause short-circuit faults, which will trigger the electrical protection and the disconnection of the lines. Such faults are usually transient and are thus rapidly restored to service. However, the voltage surge caused by the strike may be transferred along the line and cause damage to equipment, such as transformer wings. In	It is assumed that infrastructure with high electricity (static) presence will be required to install lightning rods as a protective measure.	L3 Possible	S2 Minor	Low	Acceptable	It is recommended for the project to conduct a lightning risk assessment of the project as per the international IEC 62305-2 standard.

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			addition, direct lightening strikes have the potential to cause damage to equipment.						
	Operation & Maintenance	Working Conditions	Although data is insufficient to assess lightning strike frequencies in the area, Borneo Island observes frequent thunderstorms. Scientific research shows that an increase in mean temperature will likely lead to an increase in lightning activity. The prominent position of the WTGs on a ridgeline and the high presence of static electricity of the project infrastructure means that workers may be exposed to elevated danger during maintenance operations, especially when tending to an urgent site emergency.	Lightning intensity patterns are considered during planning of daily technician work shifts so that they accommodate the higher likelihood of lightning at those times, even where lightning has not been directly observed. It is assumed that the wind farm is equipped with lightning detection system which can detect lightning accurately from long range. It is assumed that all contractors will be required to provide health & safety plans for their respective scope of works and teams deployed to site, whereby lightning risk to workers are to be addressed. In extreme cases, any ongoing maintenance will cease and evacuation of site will proceed.	L2 Unlikely	S4 Major	Medium	Tolerable	It is recommended for the project to incorporate H&S procedures for extreme weather events and select locations for evacuation/shelter. It is recommended that regular weather monitoring and prediction is undertaken throughout the life of the project, with proactive shut down of turbines in order to reduce electrostatic fields, and cessation of work to avoid any accidents and casualties.
Wildfire – Conditions more conducive to wildfire as a result of projected increase in average and extreme	Wind Turbine Generators	Damage to Infrastructure	South Kalimantan is known to experience wildfires as a result of deforestation and subsequent rice paddy burning activities. The WTG is located along a mountain ridge, surrounded by grass and wooded vegetation providing a flammable environment. The compound effects of an increase in temperature, along with	It is assumed that regular clearance of vegetation is to be conducted to a suitable distance around the WTGs throughout the lifetime of the project, in order to ensure a buffer zone from potential wildfires.	L2 Unlikely	S4 Major	Medium	Tolerable	It is recommended for the owner to coordinate with the local fire department and discuss focal contact person, access to site, share asset locations and implementation of suitable action plans

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
temperatures, precipitation variability, variable wind speeds, reduction in soil moisture content			variable precipitation and wind speeds, as well as lower soil vegetation and increased lightning activity may create more favourable conditions for wildfires to spread, resulting in damage to the WTGs.						for tackling wildfires in the vicinity of the project site. It is recommended for fire extinguishers and suitable fire fighting equipment to be placed at suitable easily-accessible locations throughout the project site.
	Substation & Transformers	Damage to Infrastructure	South Kalimantan is known to experience wildfires as a result of deforestation and subsequent rice paddy burning activities. The WTG is located along a mountain ridge, surrounded by grass and wooded vegetation providing a flammable environment. The compound effects of an increase in temperature, along with variable precipitation and wind speeds, as well as lower soil vegetation and increased lightning activity may create more favourable conditions for wildfires to spread, resulting in damage to the substation and other ground infrastructure.	It is assumed that regular clearance of vegetation is to be conducted to a suitable distance around the substation and other ground infrastructure throughout the lifetime of the project, in order to ensure a buffer zone from potential wildfires.	L2 Unlikely	S4 Major	Medium	Tolerable	It is recommended for the owner to coordinate with the local fire department and discuss focal contact person, access to site, share asset locations and implementation of suitable action plans for tackling wildfires in the vicinity of the project site. It is recommended for fire extinguishers and suitable fire fighting equipment to be placed at suitable easily-accessible locations throughout the project site.
	Cables & Grid Connections	Damage to Infrastructure	South Kalimantan is known to experience wildfires as a result of deforestation and subsequent rice	It is assumed that regular clearance of vegetation is to be conducted to a suitable distance either side of cables and	L2 Unlikely	S3 Moderate	Medium	Tolerable	It is recommended for the owner to coordinate with the

Hazard - Climatology	Project Component	Impact Type	Risk description		Risk rating			Acceptance level	Potential adaptation actions
			Consequence	Current BAU risk controls	L/hood	Impact	Risk		
			paddy burning activities. The WTG is located along a mountain ridge, surrounded by grass and wooded vegetation providing a flammable environment. The compound effects of an increase in temperature, along with variable precipitation and wind speeds, as well as lower soil vegetation and increased lightning activity may create more favourable conditions for wildfires to spread, resulting in damage to cables and transmission lines.	transmission lines throughout the lifetime of the project, in order to ensure a buffer zone from potential wildfires.					local fire department and discuss focal contact person, access to site, share asset locations and implementation of suitable action plans for tackling wildfires in the vicinity of the project site. It is recommended for fire extinguishers and suitable fire fighting equipment to be placed at suitable easily-accessible locations throughout the project site.