MOTT MACDONALD

Formosa 4 Offshore Wind Farm in Taiwan

Climate Change Risk Assessment

September 2025

This page left intentionally blank for pagination.

Mott MacDonald
5F, No.92 Sec 2
Dunhua S. Road
Da'an District
Taipei City 10668
Taiwan

T +886 (0)2 8978 8978
mottmac.com

Formosa 4 Offshore Wind Farm in Taiwan

Climate Change Risk Assessment

September 2025

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	10 January 2025	F Wang S Lee	J Hooper	B Lim	Draft CCRA report submission to Client
B	24 January 2025	F Wang S Lee	J Hooper	B Lim	Updated Draft CCRA report addressing Client comments
C	25 March 2025	J Hooper F Wang	J Hooper	Y Corish	Final CCRA report
D	16 June 2025	J Hooper F Wang	J Hooper	B Lim	Updated Final CCRA Report addressing comments
E	11 July 2025	J Hooper F Wang	J Hooper	B Lim	Updated Final CCRA Report correction to table 3.4
F	17 September 2025	S Lee	K Cheung	B Lim	Revised final report for disclosure
G	22 September 2025	K Cheung	B Lim	B Lim	Revised final report for disclosure

Document reference: 614100035 | 6 | G

Contents

Tables

Figures

Tables – Appendices

Executive summary

Climate change risks such as physical damage, risk to worker safety and system interruption are plausible to occur to wind energy projects. This report identifies such risks from climate change that may be relevant to the Project.

This CCRA was undertaken in alignment with the latest updated Equator Principles IV guidance, released in May 2023. This CCRA includes three future Climate Change Scenarios, a high emissions scenario (SSP5-8.5), a middle-of-the-road scenario (SSP2-4.5) and a low-emission scenario consistent with a below 2°C future (SSP1-2.6), as recommended by TCFD guidance of climate change risk assessments.

Additionally, a greenhouse gas (GHG) emissions assessment of the estimated emissions during the construction and operational phases of the Project has been undertaken. This has found that during the operational phase of the Project Scope 1 and 2 emissions are not expected to exceed more than 1,258 tonnes CO2e per year, with annual emissions decreasing over the project life as a result of anticipated grid decarbonisation. During the construction phase, maximum annual emissions from fuel combustion are estimated to be approximately 79,234 tonnes CO2e per year, although these may be allocated as Scope 3 emissions, depending on the level of operational control that the Project will have over the construction vessels. The assumed and recommended mitigations identified for the offshore and onshore asset design, coupled with recommended management plans and interventions by the Project and project partners has rendered the net classification of these risks as being either medium or low.

It should be noted that implementation of these adaptation measures is assumed at this stage given that the Project has not yet commenced construction and the risk scoring of medium or low should be understood to be subjected to future confirmation that Project designs will embed these mitigations. The adaptation measures have been based off those which are being embedded in the neighbouring offshore wind projects with similar climate conditions. The CCRA and the measures identified should be reviewed by the Project Company and the relevant project partners and taken into account within the design to ensure the resilience of the Project. It is recommended that upon completion, the CCRA is reviewed and risks re-evaluated accounting for the measures implemented in the final design.

No high or extreme risks to the Project have been identified as a result of projected climate change to the 2050s, but a watching brief of risks identified must be maintained throughout the project lifetime and adaptively managed.

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 is to articulate its overarching maintenance guidance to consider unpredictable, worst case, acute and chronic climate extremes to keep structures and assets in good condition.

1 Introduction

1.1 Overview

Formosa 4 International Investment Co., Ltd. and its subsidiary Formosa 4 Wind Power Co., Ltd. (herein referred to as "Project Company" or "Formosa 4") is proposing to develop an offshore windfarm (OWF) in Taiwan (herein referred to as the "Project"). The Project is located approximately 18km offshore from the coast of Miaoli County, Taiwan.

The Project participated in the Energy Administration[1], Ministry of Economic Affair (EA, MoEA)'s Third Round of Offshore Wind Project Development (herein referred to as "Round 3.1") and has been awarded a grid allocation for the Project of up to 495MW with the Commercial Operation Date (COD) latest by end of 2027. MOEA announced the availability of one year extension to the COD milestone for R3.1 Project to apply in the form of an official letter to Taiwan Offshore Wind Industry Association in April 2024. The projects expect to be granted the extension as per application to MOEA.

As part of the Project's project financing approach, the Project may be required to demonstrate adherence to the Equator Principles (EP). Therefore, Mott MacDonald have been commissioned by Formosa 4 to undertake a *report title*, alongside other environmental and social (E&S) services.

1.2 Aims and objectives

In keeping with Equator Principles IV (2020), and the updated guidance[2] for undertaking a CCRA, the CCRA aims to assess whether the Project:

- Identifies and addresses current and anticipated physical climate-related risks facing the Project's operation over 20 years operating period
- Incorporates plans and processes appropriate to managing those risks

The time period covered by the assessment considers risks up until the period of 2041 – 2060. As stated above, this is based on the anticipated operating period of 20 years following the end of construction activities in 2028.

This physical climate change risk assessment considers both the chronic and acute impacts of climate change and their impacts on the project components, including impacts to physical assets, operations and value chain.

In addition to the Equator Principles, the approach to the physical climate change risk assessment broadly aligns with the following standards and guidelines:

- Asian Development Bank's (ADB) climate risks management project preparation phase and guidance in their Guidelines for Climate Proofing Investment in the Energy Sector (2013)
- ISO 31000 (2018)
- ISO 14091 (2021)
- AS 5334 (2013)

The key steps of the assessment included:

---

[1] Formerly known as Bureau of Energy (能源局); renamed the Energy Administration (能源署) in 26 September 2023.

[2] Guidance Note on Climate Change Risk Assessment, Equator Principles (May 2023)

- Development of climate change scenarios:
  - An assessment of historical baseline climate and future climate change projections for the Project area (see Section 4)
- Identification of climatic impact to project components (the consequences of a climate hazard being realised) (see Section 5)
- Qualitative risk assessment for each climate impact through consideration of the likelihood of climate impacts and severity of the impact to the project component (see Section 5.2)
- A high-level review of potential adaptation and resilience options (see Section 5.2)

The risk assessment is based upon information received from the client and publicly available data. However, when referring back to the public sources of information used for the previous projects, it was noticed that some data are no longer available or the information has been updated. Previously referenced sources, such as the Taiwan Climate Change Projection Information and Adaptation Knowledge Platform (TCCIP)[3], offers climate projection data only for four climate variables (ie average temperature, maximum temperature, minimum temperature and average precipitation), which are not sufficient enough to conduct a comprehensive CCRA.

Therefore, for the purpose of providing a more robust and consistent CCRA, this report additionally sources climate baseline and projection data from the Copernicus Interactive Climate Atlas and NASA's Sea Level Change Portal's projection tool, which are in alignment with the Intergovernmental Panel on Climate Change (IPCC) (2022) Sixth Assessment Report.[4]

Earthquake and tsunami risks are not included in this assessment as they are not typically considered to be climate induced events and there is insufficient evidence to suggest climate change will impact these phenomena in the project location.

1.3 Project background and location

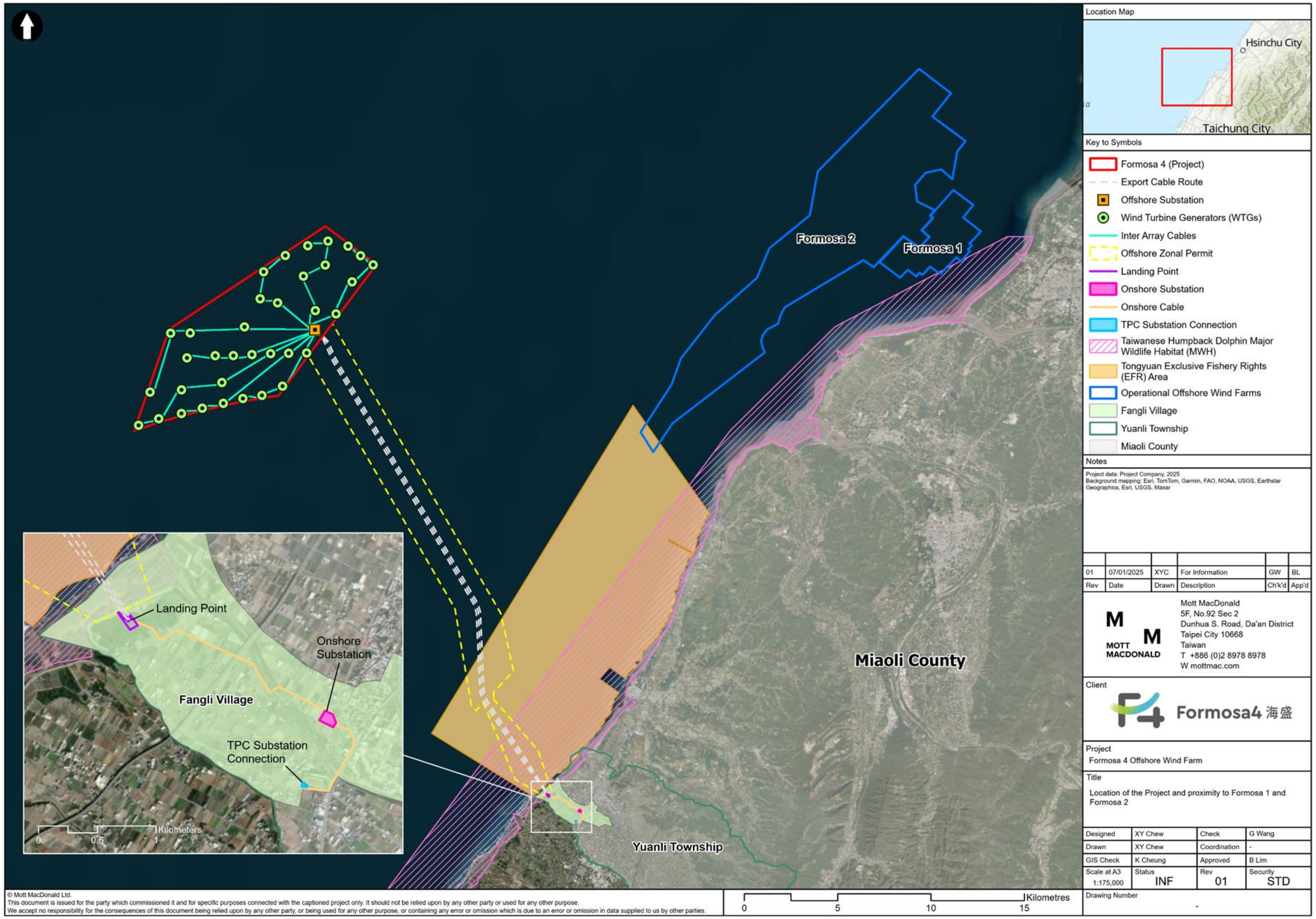
The Project's offshore windfarm area will be approximately 58km^2 in size and located 18km offshore from Tongxiao Township (通霄鎮), Miaoli County, on the western coast of Taiwan (see Figure 1.1).

The Project is located further offshore of the neighbouring Formosa 1 and Formosa 2 windfarms. The Project's location is illustrated in Figure 1.1 and Figure 1.2.

3 TCCIP (nat.gov.tw)

4 AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability — IPCC

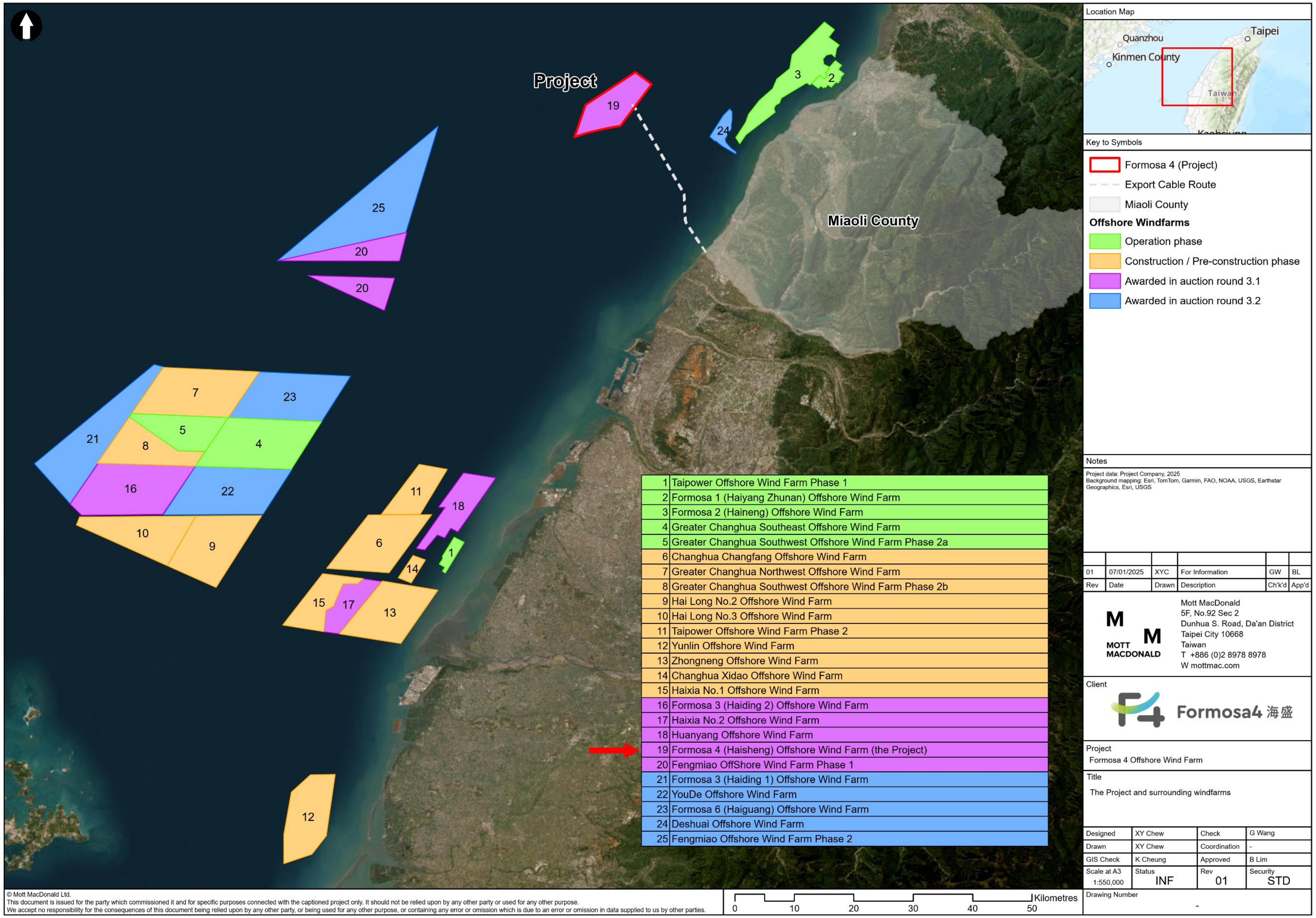
Figure 1.1: Location of the Project and proximity to Formosa 1 and Formosa 2



Source: Project Company and Mott MacDonald, 2025

Note: Project information is subject to change based on the detailed design phase

Figure 1.2: The Project and surrounding windfarms



Source: Project Company and Mott MacDonald, 2025

The Project had successfully obtained regulatory approval for its final environmental impact statement (EIS, 環境影響說明書) and environmental deviation report (EDR) from Ministry of Environment (MoEnv) on 11 August 2023 and 22 July 2024, respectively.

The Project received approval from MoEA on 30 December 2022 for up to 495MW of installed capacity. It is planned to consist of 35 wind turbine generators (WTGs), each of 14.142MW capacity. The total installed capacity will be 495MW. The WTGs will be located at water depths approximately 56m to 72m below mean sea water level (MSWL). The Project has two export cable strings and one planned landing point at Fangli village, which is to connect to Project dedicated onshore substation (OnSS) then to Taiwan Power Company (TPC) OnSS. The operation period is planned for 20 years, based on the asset life.

1.4 Project components

The details of the Project is presented in Table 1.1 below.

Table 1.1: Summary of the Project's components and schedule

Aspect	Project
Project components	
Windfarm capacity	495MW
Windfarm area	58km^2
Number of WTGs (and capacity)	35 WTGs (14.142MW each)
Offshore substation (OSS)	One (1) planned OSS
Onshore substation (OnSS)	One (1) planned OnSS in Fangli village
Transmission	66kV / 161kV / 230kV
Inter-array cables (IAC)	Eight (8) 66kV IAC strings
Export cables	Two (2) 230kV export cable strings with approximate length of 27km to the landing point, sharing the same cable alignment route. Cable landing point is located at Fangli village, Yuanli Township.
Transmission line (onshore)	One (1) 161kV transmission cable with approximate length of 4km from OnSS to grid connection point
Grid connection point	Fangli (TPC), located in Yuanli Township, Miaoli County
Construction commencement	Onshore: Q1 2025 (targeted) Offshore: Q2 2026 (targeted)
Construction completion	Onshore: Q4 2027 (targeted) Offshore: Q4 2028 (targeted)
Commercial operation date (COD)	Targeting Q2 2029

Source: Project Company and Mott MacDonald, 2025

1.5 Implementation schedule

The key milestones for the Project's implementation, with current assumptions, are summarised in Table **1.2** below. The onshore construction is expected to commence in 2025, with the Commercial Operation Date (COD) by Q2 2029.

Table 1.2: Project implementation schedule

Project milestone	2025				2026				2027				2028			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Onshore construction																
Offshore construction																
COD	Targeting Q2 2029															

Source: Project Company and Mott MacDonald, 2025

2 Policy context and literature review

2.1 Climate change and adaptation policy

In order to improve and reinforce Taiwan's capacity to cope with the growing threat of climate change and reduce its vulnerability, Taiwan has expanded its National Council for Sustainable Development (NCSD), tasked with sustainable development policy, since 2009. A comprehensive Adaptation Strategy to Climate Change for Taiwan has been developed, setting out the following objectives with respect to climate adaptation:

1. Establishing a legal framework and government organizations corresponding to climate change
2. Drafting national policies and decision-making mechanisms that consider climatic issues
3. Establishing a climate-related effective early warning, impact-evaluating and decision-making supporting system, and reinforcing the national and local disaster prevention and systems
4. Selecting no-regret policies and measures that deal with adaptation and mitigation issues simultaneously
5. Enhancing the research and development of climate-change adaptation technology, and cultivating related specialists
6. Raising public awareness on climate change issues and educating the general public to increase knowledge about climate change
7. Setting up a climate-adaptation decision-making and action system that integrates the private and public sectors
8. Devising economic incentive programs for encouraging private and public sectors to practice the climate change adaptation policy voluntarily

Taiwan's National Climate Change Action Guidelines[5] reinforce the nation's endeavours to formulate adaptation strategies to "enhance overarching adaptability, minimise vulnerability and build-up resilience." Importantly, the guidelines capture the need for adaptation strategies to be considered while performing environmental impact assessments (EIAs). Regarding the energy sector in particular, the guidelines specify a high-level policy of improving the adaptability of Taiwan's energy supply system and industries, capturing the following associated goals, strategies and action plans:

Energy Sector Goals

1. Ensure infrastructural safety and stability of energy supply facilities
2. Build an environment that reduces climate risks and strengthens adaptive capacities
3. Elevate businesses' ability of risk management and opportunity exploration, to develop climate-resilient products and services.

---

5 Taiwan National Climate Change Action Guidelines (2024). Available at: National Climate Change Action Guidelines-Climate Change Response Policies-Climate Change Affairs｜Climate Change Administration (cca.gov.tw)

In 2018, Taiwan's Ministry of Environment and 16 ministries from the Executive Yuan jointly compiled the National Climate Change Adaptation Plan (2018-2022)[6] which goes into more detail with respect to energy sector adaptation strategies and action planning.

Energy Sector Strategies:

1. Strengthen energy industry risk assessment capabilities and establish adjustment guidelines:
    a. Formulate risk assessment criteria
    b. Build risk assessment tools
    c. Establish guidelines for adaptation strategies
2. Build a management mechanism to promote education and training and international cooperation
    a. Construct an adaptive management mechanism
    b. Establish an energy supply and demand monitoring system
    c. Promote education and training promotion and international cooperation
3. Assist the industry to improve the adjustment ability:
    a. Industrial adaptation capacity building and counselling

Energy Sector Adaptation Action Plan

1. Development of risk assessment criteria for climate change shocks in the energy sector
    a. Obtain and record the latest meteorological and disaster potential maps, track and update every year.
    b. Consider the disaster potential, sensitivity and resilience of energy facilities, and review and update the existing flood and strong wind risk assessment criteria.
    c. Consider the disaster potential, sensitivity and resilience of energy facilities, and establish high temperature and slope stability risk assessment criteria.
    d. Integrate and review the results of risk assessment criteria such as flooding, strong wind, high temperature and slope, and establish a composite disaster risk assessment criteria.
2. Establishment of risk assessment tools for energy systems
3. Research and Analysis of Regulations and International Standards Linking Mechanism of Climate Change Adjustment in Energy Industry
4. Energy system and energy industry climate change adaptation monitoring and evaluation system planning and promotion.

Taiwan's executive agency responsible for protecting and conserving the environment, the Environmental Protection Administration (EPA), recommends good international industry practice (GIIP) standards for climate adaptation on projects, such as ISO 31000 Risk Management Guidelines, UNDP's Adaptation Policy Framework and the Taiwan integrated research program on Climate Change Adaptation Technology (TaiCCAT) decision support system.

[6] Adaptation Impact Sectors (2024). Available at: Energy Supply and Industry-Adaptation Impact Sectors-Climate Change Adaptation and Resilience-Climate Change Affairs｜Climate Change Administration (cca.gov.tw)

2.2 Taskforce on Climate related Financial Disclosures

This CCRA also incorporates the Taskforce on Climate related Financial Disclosures (TCFD) guidance, as the CCRA guidance of the EP4 is developed on the principles of the climate physical risk assessment set out in the TCFD guidance. The TCFD is a voluntary disclosures taskforce principally intended to help lenders assess whether physical (and transition) climate risk is appropriately priced into their valuation of a project or company. The universally accepted definition of physical climate risk is:

- Climate Physical Risks are those risks resulting from climate change, which involve event driven (acute) or longer-term shifts (chronic) in climate patterns. Acute physical risks refer to those that are event-driven, including increased severity of extreme weather events such as cyclones, hurricanes, or floods. Chronic physical risks refer to longer-term shifts in climate patterns (ie sustained higher temperatures) that may cause sea level rise or chronic heat waves[7].

2.3 Documented physical risks to wind farms

Due to its geographical location and underlying geological properties, Taiwan regularly encounters natural hazards such as earthquakes, typhoons, mudslides and flash floods. Many of these hazards are, and will be, exacerbated by climate change, while the impacts of, and recovery from, others, such as earthquakes, may become more complex due to interactions with a changing climate.

The expansion of wind energy installed capacity is poised to play a key role in Taiwan's energy mix and ability to deliver on its climate change mitigation targets. Wind energy is, however, susceptible to global climate change impacts from a physical risk perspective. Some changes associated with a changing climate may benefit the wind energy industry while other changes may negatively impact wind energy developments, leading to levelised energy 'gains and losses'[8].

All energy systems are to some extent affected by climate change and changing risks. There are two principal ways in which climate change and intensified disaster risks can affect the wind power sector:

- Wind power generation depends on wind availability and wind speeds. Climate change can affect wind speeds and other variables such as air density, which can have either positive effects (ie enhanced energy generation) or negative effects (ie disruption to energy generation due to 'shut down' periods associated with extreme conditions or reduced energy generation with lower wind speeds or lower air density) on wind power generation.
- Wind turbine plants could be impacted by more pronounced disaster risks such as typhoons, floods, and storm surge exacerbated by chronic sea level rise (particularly in the case of offshore turbines or low-lying substations).

Changes in wind speed and patterns due to climate change differ significantly from one region to another. Studies suggest changes in global wind speeds could affect regions such as Europe and North America minimally, however it could significantly affect other parts of the world like Asia[9].

---

[7] TCFD (2017). Available at: Recommendations | Task Force on Climate-Related Financial Disclosures (fsb-tcfd.org)

[8] Pryor, S.C and Barthelmie, R.J. (2010). Available at: Climate change impacts on wind energy: A review | Request PDF (researchgate.net)

[9] Strengthening Climate Resilience, Urban, F and Mitchell, T. (2010). Available at: Climate change disasters and electricity generation.indd (publishing.service.gov.uk)

Climate models are, however, still relatively crude with respect to representing changes in mean wind speeds and extreme wind speeds associated with tropical storms, whereby there are limitations on the ability to identify future changes in their frequency and intensity. Furthermore, drawing firm conclusions in terms of changes in climate extremes such as extreme wind is typically hampered by data quality and availability in observations, the difficulties in separating natural variability from long-term trends and limitations of climate model spatial resolutions.

Most wind turbines shut down at wind speeds of approximately 25 m/s – 31 m/s[10] However, studies suggest the wind power sector might not be negatively impacted by climate change, suggesting a net-gain in higher wind speeds[11].

Mean sea level rise may have implications for offshore and near-shore wind turbines, with the increased risk of flooding or corrosion of turbines. Another aspect of importance to the foundation(s) of offshore wind turbines is wave height, which is significantly dependent on wind speeds[12].

To proactively adapt to changing wind speeds, sea level rise and changing disaster risks, turbines and associated infrastructure that is able to operate in, and which can physically withstand, extreme high wind speeds, rising seas and storms is advisable[13]. The potential effects of climate change and changing disaster risks on wind energy plant / resources and on electricity generation are summarised in Table 2.1.

[10] Modern Wind Generators.pdf

[11] Strengthening Climate Resilience, Urban, F and Mitchell, T. (2010).

[12] Strengthening Climate Resilience, Urban, F and Mitchell, T. (2010).

[13] Strengthening Climate Resilience, Urban, F and Mitchell, T. (2010).

Table 2.1: Effects of climate change and changing disaster risks on wind energy generation

Change in climate variable	Impact on wind energy plant / resources	Impact on electricity generation
Temperature increase	Indirect impact on air density and wind patterns; extreme heat could impact operating conditions and lead to shut down of turbines	Either increased or decreased electricity generation possible
Increase in average precipitation	Increase wear of the turbines – edge erosion	None
Decrease in average precipitation	None	None
Drought	None	None
Glacier melt[14]	None, unless flooding occurs. If flooding occurs risk of damage to equipment	None if no flooding occurs. If flooding occurs, disrupted / decreased electricity generation
Flood	Risk of damage to onshore equipment	Risk of disrupted / decreased electricity generation
Sea Level Rise[15]	Risk of damage to onshore equipment	Risk of disrupted / decreased electricity generation
Increased frequency and/or strength of storms / cyclones	Risk of damage to equipment and increased periods of shut down	Decreased electricity generation if wind turbines / equipment is damaged, or shut down at excessive wind speeds
Increased Lightning frequency	Risk of damage to equipment	Risk of disrupted / decreased electricity generation
Increased wind speed	Better wind conditions	Increased electricity generation, unless a storm occurs (see above)
Decreased wind speed	Worse wind conditions	Decreased electricity generation
Changes in wind patterns	Changes in air density, wind direction, wind variability	Either increased or decreased electricity generation

Source: Mott MacDonald

Adaptation to climate change and changing disaster risks are issues which have not been traditionally or adequately captured in the energy sector thus far. The focus has tended to be on mitigation by reducing emissions from energy systems – ‘transitioning’ – than finding solutions for adapting these transition-enabling technologies to chronic climatic changes and extreme events. Global best practice points to the following high-level mitigating aspects for wind farm projects:

- Enhance resilience to climate change by carefully assessing siting procedures, feasibility studies and EIAs (or similar) for new power plants, which need to take into account existing disaster risks and adaption strategies to climate change
- Design more robust infrastructure based on reasonable worst-case scenarios in terms of the above (and feasibility)
- Establish disaster risk systems, whereby procedures are in place for early warning systems to enable evacuation of staff and to secure electricity infrastructure where possible before an extreme weather event hits

[14] Note that Glacier melt is relevant to this project only in so far as it contributes to Sea Level Rise.

[15] Sea Level Rise is relevant as a driver of coastal inundation, especially in combination with Storm and / or flood events.

- Long-term insurance schemes for power yields and damage from storms could also be considered

3 GHG emissions assessment

A GHG emissions assessment was undertaken to verify that the estimated annual Scope 1 and 2 emissions of the Project during its operational phase are below 100,000 tonnes of carbon dioxide equivalent (CO_2e). In this assessment, emissions are calculated for both construction and operations phases (decommissioning is not taken into account), however, whereas emissions for operation phase is provided as an annual basis, emissions for the construction phase is calculated as total emissions produced over the construction period, divided by the scheduled duration of the construction period. This is due to uncertainties around the exact construction commencement and completion dates, the possibility for constructions delays, and the possibility of timeline changes distorting the emissions amount likely to occur in a given calendar year.

It is currently noted that the Project is yet to begin its construction phase, and therefore specific activity data and relevant information on resources used are unavailable. The Project EIA[16] does provide certain information regarding GHG assumptions, however, this is not appropriate to be used as the EIA's assumptions are based on an indicative project comprising 161 9.5MW turbines, whereas the most recent project plan comprises 35 14MW turbines. It is understood from the Project that the EIA incorporated the maximum number of turbines applicable for the selected land area, in order to take into account the worst-case scenario and due to the uncertainties inherent in the early-stage phase, even prior to the bidding process (ie. when the EIA was approved). Therefore, in order to develop the assumptions necessary to estimate the Project's construction and operational scope 1 and 2 emissions, the construction schedule of the Project, as well as operations and maintenance plans for similar offshore windfarms in the region were studied and discussed with experienced project engineers.

The specific breakdown and estimation of emissions from each of the construction phase and operations phase are provided in Section 3.1.1 and Section 3.1.2, respectively. The key assumptions for quantifying activity data and sources for emission factors are summarised in section 3.2.

3.1 Results

3.1.1 Construction Phase

3.1.1.1 Onshore construction

Onshore construction activities are expected to take place during 2025 and 2026 (see Table **1.2**). The GHG emissions generated during onshore construction are expected to to primarily include the onshore substation construction. The emissions from this activity have been estimated using the average A5 (emissions from construction stage of a built environment lifecycle emissions methodology) value (40 kg CO_2e/m^2) [17] and multiplied by the assumed substation total site area. This results in estimated emissions of 399 tonnes CO2e generated from offshore construction activity.

---

[16] Project EIA's section on greenhouse gas reduction (苗栗離岸風力發電計畫三環境影響說明書, Section 7.1.8)

[17] Whole life carbon assessment for the built environment, RICS professional standards and guidance, UK

3.1.1.2 Offshore Construction

The calculation of emissions from offshore construction activities are based on the activities and construction durations detailed in the Project Delivery Schedule[18].

Taking a conservative approach, the calculations assumed that the vessels required for each activity would be operational for every day (ie no rest days or weekends) of the respective construction duration[19] as associated with that activity. The fuel consumption estimates for vessels are based on the known vessel specifications for vessels that have been recently employed on similar offshore wind construction projects, as listed in Table 3.1. Section 3.2 further details the full list of assumptions.

Table 3.1: Vessel and fuel consumption references used for offshore construction emissions calculation

Vessel Type / Activity	Reference Vessel Name	Relevant Project	Fuel Consumption per vessel per day (L)
Offshore Installation	Brave Tern / Bold Tern	Formosa 2	27,242
Heavy Lift Transport	Aegir	Greater Changhua	29,298
AHT (Tug)	Bylgia	-	13,055.6
Cable laying	Orient Adventurer	Greater Changhua	13,364

GHG emissions during the offshore construction phase are expected to be from the operation of the fleet of working vessels that are required to transport and install the various project components. The assumptions for the types, number, operational days and fuel consumption of these vessels are as detailed in Table 3.2 below.

Table 3.2: Construction vessel number and operation day assumptions

Task	Vessel Assumption	Number of Vessels	Operation Days[20]	Fuel Consumption per vessel per day (L)
WTGs & Transition Piece Installation	Offshore Installation	1	153	27,242
	Heavy Lift Transport	1	153	29,298
	AHT (Tug)	4	153	13,055.6
	Barge	2	153	- [1]
Foundation Installation	Offshore Installation	1	214	27,242
	AHT (Tug)	4	214	13,055.6
	Barge	2	214	- [1]
Cable laying (export)	Cable-laying Vessel	1	153	13,364
Cable laying (inter-array)	Cable-laying Vessel	1	153	13,364
Substation Installation	Offshore Installation	1	122	27,242
	AHT (Tug)	2	122	13,055.6
	Barge	1	122	-

[18] Level 1 Project Delivery Schedule – IM Format (Received January 2025)

[19] The overall project schedule of major phases (ie onshore and offshore construction) is as described in Table **1.2**. For the purpose of calculations, the actual duration of specific activities (eg foundation and OSS installation, cable laying) as described in the Project Delivery Schedule are referenced.

[20] As per Formosa 4 Project delivery schedule, dated 7 January 2025

Note: [1] Barge have no fuel consumption as their propulsion is from the AHT (which consumes the fuel).

Source: Client, Mott MacDonald, 2025

The project owner intends to complete the Project's offshore construction phase between Q1 2027 (beginning with installation of foundations) and Q3 2028 (ie completion of WTG installation)[21]. It is noted that the adherence to this timeline would be subject to any weather delays, particularly during the typhoon season. The offshore construction duration could also be extended over the indicative period if there are changes in the construction schedule for an earlier start or later end date.

The results of the GHG emissions assessment for the offshore construction phase show that estimated annual emissions during the Project's construction are expected to be approximately 79,234 tonnes CO_2e in 2027, and 57,925 tonnes CO_2e in 2028, with an average of 68,579 tonnes CO_2e across the two years. (Table 3.3).

As construction activities are to be undertaken through contractors (ie appointed by the Project) and other sub-contractors (ie vessel operators), emissions from this activity may be classified as Scope 3 emissions, depending on the contractual arrangements.

Table 3.3: Annual GHG emissions from fuel combustion during Project construction

Task	Year of Activity	Activity Data Type	Quantity	Unit	Emissions Factor (kg CO_2-e/unit)	tCO_2-e
Fuel Combustion During Construction						
WTGs & Transition Piece Installation	2028	Marine Fuel Oil	16,640,647.20	L	3.1	51,596.01
Foundation Installation	2027	Marine Fuel Oil	17,005,381.60	L	3.1	52,716.68
Cable laying (export)	2027	Marine Fuel Oil	2,044,692	L	3.1	6,338.55
Cable laying (inter-array)	2028	Marine Fuel Oil	2,044,692	L	3.1	6,338.55
Substation Installation	2027	Marine Fuel Oil	6,509,188	L	3.1	20,178.48
					2027 Sub-Total	79,233.71
					2028 Sub-Total	57,924.55
	Estimated Offshore Construction Period Duration				Years	2
	Annual Average Emissions					**68,579.13**

Source: Mott MacDonald, 2025

The scope allocation of emissions from fuel combustion during the construction phase of the Project is dependent on who has effective operational control of the vessels during the construction period. As based on the current understanding, the Project will be appointing contractors (who employs/own vessels, or even sub-contract to vessel operators) to undertake the construction activity, and in this case the activity would fall under Scope 3 emissions.

[21] Level 1 Project Delivery Schedule – IM Format (Received January 2025)

There are not expected to be any material emissions from the purchase of grid electricity during the construction phase of the Project.

3.1.2 Operational Phase

The results of the GHG emissions assessment show that estimated annual Scope 1 and 2 emissions from the operational phase of the Project are far below 100,000 tonnes and are expected to be approximately 1,258.23 tonnes CO_2e per year (Table 5 3).

Table 3.4: Annual Scope 1 and 2 GHG emissions during Project operation

Asset	Activity Data Type	Quantity	Unit	Emissions Factor (kg CO_2-e/unit)	tCO_2-e
Scope 1					
Crew Transfer Vessels (CTVs)	Diesel	112,000.00	L	2.70	302.40
CTV Gensets	Diesel	5,644.80	L	2.70	15.24
Project Vehicles	Distance	40,000.00	km	0.20	8.12
Onshore Substation / Office	GFA refrigerated space	2742.21	m2	5.22	14.31
Offshore Substation / Office	GFA refrigerated space	500.00	m2	5.22	2.61
				Sub-Total	342.68
Scope 2					
Onshore Substation / Office	kWh	548,442.00	kWh	0.411	225.62
Offshore Substation / Office	kWh	100,000.00	kWh	0.411	41.14
WTGs	kWh	1,577,100.00	kWh	0.411	648.79
				Sub-Total	915.54
Total					1,258.23

Source: Mott MacDonald, 2025

The largest contributors to this total are the grid electricity drawn by the WTGs when they are idle (649 t CO_2e), and the operation of Crew Transfer Vessels (302 t CO_2e) for servicing and maintenance activities. Other sources of emissions include the generators used on the CTVs when they are stationary (15 t CO_2e), use of project vehicles (8 t CO_2e), and the operation of a combined onshore project office / substation building (41 t CO_2e from grid electricity and 3 t CO_2e from fugitive refrigerants), and the same for an offshore substation building.

It should be noted that Scope 2 emissions, which account for 731 t CO_2e, and 69% of total Scope 1 and 2 emissions, are calculated based on a projected Taiwanese Grid Electricity emissions factor for 2027. However, the Taiwanese government has a plan to reach zero emissions from electricity generation by 2050, and this will necessitate consistent decarbonisation of the energy sector, which will result in a decreasing emissions factor for grid electricity. Assuming a residual grid emissions factor of 0.04 kg CO_2e / kWh in 2050 and a linear reduction from 2022 emissions, substantially reduced Scope 2 emissions can be expected from the Project over its lifetime, decreasing from 731 t CO_2e in 2027, to just 77.21 t CO_2e in 2050. This would constituent an approx. 89% reduction in annual Scope 2 emissions and a 62% reduction in total annual operational combined Scope 1 and 2 emissions by 2050. Further emissions reductions from this assessment may occur with the electrification of land and maritime transport.

3.2 Notes, Assumptions and Limitations

As the Project does not yet have detailed construction activity data and is not operational, a number of assumptions have been made to estimate annual Scope 1 and 2 emissions during construction and operations. These assumptions, as well as notes and limitations on the GHG assessment are detailed here.

- Emissions Factors for Scope 1 fuel combustion activities and driving distances, as well as mass to volume conversion factors for fuel oil, were taken from the UK DEFRA GHG conversion factors 2024.
- The emissions factor for fugitive refrigerants used in the Onshore Substation / Office air conditioning was calculated assuming the use of R410a refrigerant, with 0.2 kW of cooling per m2, 0.25kg of charge capacity per kW, and an annual leakage rate of 5%.
- Grid emissions factors for 2027 to 2050 were calculated by assuming a linear annual reduction in the grid EF from 0.495 kg CO_2e / kWh in 2022 (data from Energy Administration, Ministry of Economic Affairs of Taiwan) to an assumed residual EF of 0.04 kg CO_2e / kWh in 2050, based on the Taiwanese governments plan to have zero emissions from electricity generation by 2050.
- The energy usage intensity of the substation / office building is assumed to be 200 kWh/m2/year, from the CRREM energy intensity assumptions for office buildings in Hong Kong (data for Taiwan was unavailable, and Hong Kong has a similar climate).
- The number of Crew Transfer Vessels are assumed from similar projects in the vicinity
- The use of Crew Transfer Vessels is calculated from the estimated servicing and repair hours per WTG from similar regional Offshore Wind projects, and assuming that crews are at the windfarm for 7 hours per day, the average travel distance from Taichung Port to the centre of the windfarm area (approximately 24 nautical miles), and the average fuel consumption of a typical crew transfer vessel. CTVs are assumed to be used for all scheduled servicing and ~20% of repair work.
- There are assumed to be 2 x Offroad project vehicles each with an annual usage of 20,000km.
- A Power Requirement of 60kVA for idling WTGs was assumed from discussion with an expert project engineer with knowledge of similar projects. The idle / non-operational time per WTG was estimated from the expected servicing and repair schedules from O&M plans from similar projects and expected unfavourable wind conditions 6% of the time.
- Emissions from vessels used in offshore construction vessels are based on the fuel consumption rates of reference vessels that are known to have been used in similar offshore wind construction projects. The reference vessels are specific to each phase of construction activity.
- Vessel fuel consumption is usually reported in vessel specifications as metric tonnes per day, and this has been converted to Litres using the DEFRA volume / mass conversion factors for Fuel Oil.
- The fuel consumption of certain vessels is specified separately for the type of activity they are conducting. For offshore installation vessels it was conservatively assumed that there was a 50% - 50% time split between transit (high fuel consumption) and crane work (low fuel consumption). For cable laying vessels the fuel consumption value for Dynamic Positioning in Moderate Seas / Economical transit speed was assumed.
- It is assumed that two AHTs (tugs) will be required to manoeuvre each barge. Barges are assumed to have no independent mode of propulsion and as such no fuel combustion.

- The operational days of each vessel for each construction task are based on the assumption that the vessels will be operational for every day of the duration specific in the project construction schedule.

4 Climate baseline and projections

4.1 Methodology

Although the Project EIA provides historical climate baseline data, this CCRA does not further utilise the dataset presented in the EIA. Instead, both historical climate baseline and the future climate projection data are independently sourced from the Copernicus Interactive Climate Atlas (CICA) and NASA's Sea Level Change Portal. These datasets were chosen due to the following reasons:

- The guidance note on CCRA by the EP4 states that the climate risk assessment should be based on a robust analysis of climate data and projection across a range of future GHG emission scenarios, published in the most recent AR5/AR6 IPCC reports.
- Both the CICA and NASA's datasets are produced using the latest climate models presented in the AR6 IPCC report, and these source provide both measured historical climate baseline data and projection data across different future climate scenarios. By comparison, the EIA provides historical climate baseline data (sourced from Taiwan's Central Weather Bureau), however it does not provide any climate projection data. Using the EIA's baseline data while sourcing climate projection data from another source would result in inconsistencies due to differences in the climate models and datasets used for each source.
- Both CICA and NASA provide an array of climate variables (ie temperature, precipitation, wind speed, etc.) and are also recommended data sources by the EP4 guidance note.

4.1.1 Copernicus Interactive Climate Atlas

On the Copernicus Interactive Climate Atlas's web-based public interface, spatially averaged climate data was retrieved by drawing a custom polygon around the project site in order to extract site-specific (including both onshore and offshore components) climate data for both historical climate baseline data and future projection data. A separate polygon was drawn to only include the sea areas relevant to the Project, for the purpose of extracting sea surface temperature data (Figure 4.1). The boundaries of the domain are approximately framed within the following coordinates:

Both onshore and offshore coverage:

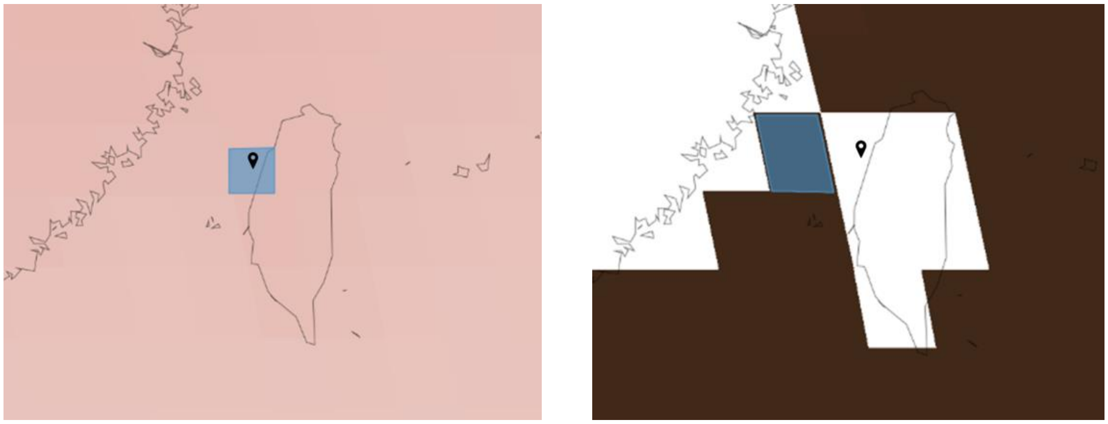
- 24.00, 121.00
- 25.00, 121.00
- 24.00, 120.00
- 25.00, 120.00

Coverage for only sea surface temperature (note that pelagic climate data is only available where an area of sea comprises a full tile at the dataset's spatial resolution. As the project site is located on a tile that is a mix of land and sea, pelagic climate data is not available and therefore the closest adjacent tile to the west was chosen):

- 25.00, 119.00
- 24.00, 119.00

- 25.00, 120.00
- 24.00, 120.00

Figure 4.1: Defined polygons on Copernicus Interactive Climate Atlas, in relation to the project site (marked in black). Left for analysing both onshore and offshore average climate, and right for analysing only sea surface temperature.



Source: CICA

From within the defined polygons, a subset of Global Climate Models (GCM) from the latest model generation (CIMP6) were identified for use. In order to maintain internal consistency within the data for each climate variable analysed, the selection of the subset of models used for each individual climate variable was based on the criteria that full datasets are available across all three chosen climate change scenarios (ie SSP1-2.6, SSP2-4.5, and SSP5-8.5) for both baseline period and future projection period. The climate variables were categorised according to similar phenomena (ie temperature, precipitation and 'wind speed and air pressure'), and the number of qualifying GCMs available for use differs for each climate group.

Of the total of 35 GCMs for which data was provided on the Copernicus Interactive Climate Atlas for the polygons selected across all climate variables, the chosen models provided projection datasets for all three selected scenarios and for all climate variables categorised within each climate phenomena group. Using all of the available models, would result in a different number of models being aggregated for each climate scenario (ie the maximum number available for that scenario) and would therefore compromise accurate comparisons between scenarios because a different set of GCMs would have been used for each, affecting the consistency of the data.

The following seven models were identified to be consistent throughout and available for use to access temperature related climate variables:

- CMCC_CMCC-ESM2_r1i1p1f1
- CNRM-CERFACS_CNRM-CM6-1_r1i1p1f2
- CNRM-CERFACS_CNRM-ESM2-1_r1i1p1f2
- CSIRO-ARCCSS_ACCESS-CM2_r1i1p1f1
- INM_INM-CM5-0_r1i1p1f1
- KIOST_KIOST-ESM_r1i1p1f1
- MPI-M_MPI-ESM1-2-LR_r1i1p1f1

The following 20 models were identified to be consistent throughout and available for use to access precipitation related climate variables:

- CAS_FGOALS-g3_r1i1p1f1
- CCCR-IITM_IITM-ESM_r1i1p1f1
- CMCC_CMCC-ESM2_r1i1p1f1
- CNRM-CERFACS_CNRM-CM6-1_r1i1p1f2
- CNRM-CERFACS_CNRM-ESM2-1_r1i1p1f2
- CSIRO-ARCCSS_ACCESS-CM2_r1i1p1f1
- EC-Earth-Consortium_EC-Earth3-Veg-LR_r1i1p1f1
- INM_INM-CM4-8_r1i1p1f1
- INM_INM-CM5-0_r1i1p1f1
- IPSL_IPSL-CM6A-LR_r1i1p1f1
- MIROC_MIROC-ES2L_r1i1p1f2
- MIROC_MIROC6_r1i1p1f1
- MOHC_HadGEM3-GC31-LL_r1i1p1f3
- MOHC_UKESM1-0-LL_r1i1p1f2
- MPI-M_MPI-ESM1-2-LR_r1i1p1f1
- MRI_MRI-ESM2-0_r1i1p1f1
- NCC_NorESM2-MM_r1i1p1f1
- NOAA-GFDL_GFDL-ESM4_r1i1p1f1
- CCCma_CanESM5_r1i1p1f1
- NIMS-KMA_KACE-1-0-G_r1i1p1f1

The following 24 models were identified to be consistent and available for use to access wind speed and air pressure related climate variables:

- AS-RCEC_TaiESM1_r1i1p1f1
- AWI_AWI-CM-1-1-MR_r1i1p1f1
- CAS_FGOALS-f3-L_r1i1p1f1
- CAS_FGOALS-g3_r1i1p1f1
- CCCR-IITM_IITM-ESM_r1i1p1f1
- CCCma_CanESM5-CanOE_r1i1p2f1
- CMCC_CMCC-CM2-SR5_r1i1p1f1
- CMCC_CMCC-ESM2_r1i1p1f1
- CNRM-CERFACS_CNRM-CM6-1-HR_r1i1p1f2
- CNRM-CERFACS_CNRM-ESM2-1_r1i1p1f2
- CSIRO-ARCCSS_ACCESS-CM2_r1i1p1f1
- EC-Earth-Consortium_EC-Earth3-Veg-LR_r1i1p1f1
- FIO-QLNM_FIO-ESM-2-0_r1i1p1f1

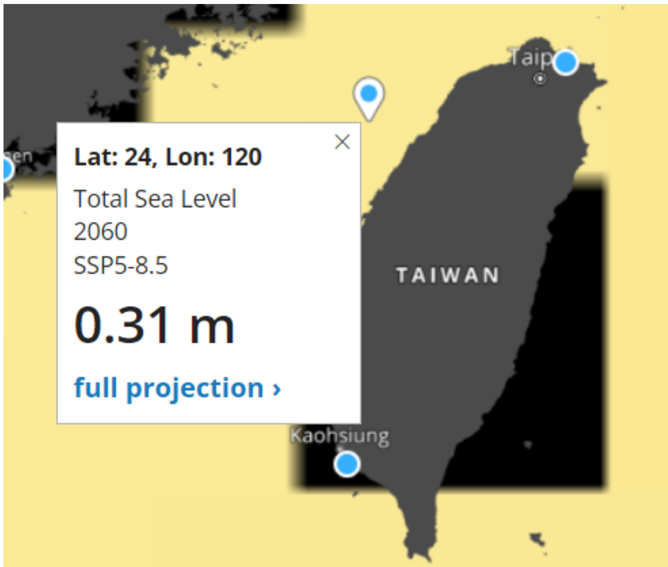
- INM_INM-CM4-8_r1i1p1f1
- INM_INM-CM5-0_r1i1p1f1
- KIOST_KIOST-ESM_r1i1p1f1
- MIROC_MIROC-ES2L_r1i1p1f2
- MIROC_MIROC6_r1i1p1f1
- MOHC_HadGEM3-GC31-LL_r1i1p1f3
- MOHC_UKESM1-0-LL_r1i1p1f2
- MPI-M_MPI-ESM1-2-LR_r1i1p1f1
- MRI_MRI-ESM2-0_r1i1p1f1
- NCC_NorESM2-MM_r1i1p1f1
- NOAA-GFDL_GFDL-ESM4_r1i1p1f1

It is important to note that the historical climate values presented are taken from climate models (GCMs) and are not observed or re-analysis values. The reason for this decision is to preserve the magnitude of projected change between historical and future climate scenarios – as in the instance where the climate models provide a good representation of historical climate values, for the purpose of the climate change risk assessment process, the magnitude of change in climate variables vs the historical baseline is more important to assess the future climate risk profile than having actual measured historical climate data, which may not be fully consistent with the future climate models. This can occur for a variety of reasons, including the spatial scale over which the GCMs are run creates an aggregate for a 0.5 x 0.5 degree (geographical grid) area rather than being measured at a specific point, and may not adequately integrate local topography. An additional table (Table B.1 has been included in Appendix B presenting the historical reanalysis climate values from ERA5 alongside the historical modelled values in order that the differences between measured and modelled historical climate values can be compared and understood.

4.1.2 NASA Sea Level Projection Tool

For sea level rise, a location marker was placed on a coordinate of Latitude: 24, Longitude: 120 (which is the approximate location of the Project) on the NASA sea level projection tool in order to extract site-specific data on sea level rise.

Figure 4.2: Defined marker on NASA Sea Level Projection Tool



Source: NASA

4.1.3 Assessed climate variables

In this assessment, the following climate variables are assessed:

- Temperature
  - Mean temperature (Summer)
  - Mean of daily maximum temperature
  - Maximum of daily maximum temperature
  - Sea surface temperature
- Precipitation
  - Mean of daily accumulated precipitation
  - Maximum of 1-day accumulated precipitation
  - Maximum of 5-day accumulated precipitation
- Wind speed and air pressure
  - Mean wind speed (near surface)
  - Average air pressure at mean sea level
- Sea level rise

4.1.4 Historical climate baseline

In alignment with the Intergovernmental Panel on Climate Change (IPCC) (2022) Sixth Assessment Report (AR6), the timeframe of 1995 – 2014 has been set as the baseline climate reference period. For each climate variable, the historical climate data for the defined timeframe were extracted from the applicable subset of identified GCMs. From these models, the median value within the timeframe was identified and used as the historical baseline for each of the climate variables (refer to Table 4.1).

4.1.5 Future climate projection

In accordance with the Project's expected lifecycle of 20 – 25 years, and alignment with the IPCC AR6 report, the future climate timeframe of 2041 – 2060 has been set as the future climate projection reference period.

Three future socioeconomic pathways (SSP) were selected for this assessment:

- 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.

For each climate variable and for each SSP, future climate projection data for the defined timeframe were extracted from the applicable subset of identified GCMs. From each subset of models, the 10th percentile (P10), the median and the 90th percentile (P90) values were extracted and used for the future projections for each of the climate variables and for each SSP (refer to Table 4.1).

4.2 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 a range of plausible future climate conditions. Mott MacDonald does not accept any liability for inaccuracy within projections and associated suggested adaptation measures.

It should also 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 (horizontal resolution of between 50km and 250km[22]) 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.

Please refer to Appendix A for more details on climate change uncertainties.

[22] CMIP6: Global climate projections - Copernicus Knowledge Base - ECMWF Confluence Wiki

4.3 Climate data

Table 4.1 below summarises the data values for the three future climate projection scenarios outlined in Section 4.1.5 representing low, medium and high emission futures. Historical baseline climate data values are the median values from the 1995-2014 baseline reference period of each subset of GCMs used for each climate variable group baseline from the six GCMs (modelled baseline). Future projection values are the 10th Percentile (P10), median (P50), and 90th Percentile (P90) values for the future timeframe period 2041-2060 across the same subset of 6 GCMs (Please refer to Section 4.1.1 for more information on the subset of GCMs used for each climate variable group).[23]

Table 4.1: Baseline (1995 – 2014) and climate projections (2041 – 2060)

Climate Variable	Unit		1995-2014 (modelled)			SSP1-2.6			SSP2-4.5			SSP5-8.5		
			P10	Baseline (median)	P90	P10	Median (P50)	P90	P10	Median (P50)	P90	P10	Median (P50)	P90
Mean temp	℃	Absolute	21.61	25.40	27.35	22.33	26.08	28.84	22.75	26.34	28.96	22.89	26.69	29.17
		Change				0.72	0.68	1.49	1.14	0.94	1.61	1.28	1.28	1.82
Mean of daily max temp	℃	Absolute	24.07	26.93	28.85	24.65	27.75	30.34	24.94	28.39	30.29	25.17	28.30	30.66
		Change				0.58	0.82	1.49	0.87	1.46	1.44	1.10	1.37	1.81
Max of daily max temp	℃	Absolute	27.04	29.68	31.45	27.43	30.47	32.74	27.49	30.67	33.03	27.74	31.11	33.29
		Change				0.39	0.79	1.30	0.45	0.98	1.59	0.70	1.43	1.85
Sea surface temperature	℃	Absolute	24.49	27.59	28.58	25.10	28.69	29.61	25.40	28.91	29.72	25.43	29.12	30.00
		Change				0.61	1.10	1.03	0.91	1.32	1.15	0.94	1.53	1.42
Mean of daily accumulated precipitation	mm	Absolute	3.30	5.08	7.53	3.44	5.03	7.73	3.45	5.08	7.76	3.42	5.01	7.63
		Change				0.13	-0.05	0.20	0.14	0.00	0.23	0.11	-0.07	0.11
Max of 1-day accumulated precipitation	mm	Absolute	43.63	75.11	142.45	46.45	81.13	201.57	46.76	82.95	152.52	46.28	83.77	153.87
		Change				2.82	6.02	59.12	3.14	7.84	10.06	2.66	8.66	11.42
Max of 5-day accumulated precipitation	mm	Absolute	108.00	169.23	305.74	108.95	174.54	324.47	110.31	188.64	309.29	113.32	179.46	330.90
		Change				0.95	5.31	18.73	2.31	19.41	3.55	5.32	10.23	25.15
Mean wind speed *(near surface, may not be site specific[24])*	m/s	Absolute	*2.90*	*4.34*	*5.75*	*2.80*	*4.35*	*5.74*	*2.81*	*4.33*	*5.73*	*2.76*	*4.35*	*5.70*
		Change				-0.10	0.02	-0.01	-0.08	-0.01	-0.01	-0.13	0.01	-0.04
Average air pressure at MSL	Pa	Absolute	101238.74	101398.41	101575.16	101245.53	101428.67	101576.64	101248.69	101422.26	101584.37	101248.56	101423.18	101588.58
		Change				6.80	30.26	1.48	9.96	23.85	9.20	9.83	24.77	13.41
Sea Level Rise (2060)[25]	m	Change				0.01	+0.24	+0.49	+0.04	+0.27	+0.52	+0.08	+0.31	+0.58

Source: Copernicus Interactive Climate Atlas, NASA Sea Level Change Portal

[23] An additional table has been included in Appendix B presenting the historical reanalysis climate values from ERA5 alongside the historical modelled values in order that the differences between measured and modelled historical climate values can be compared and understood.

[24] Wind speed that matters for WTG would be measured at a height of 100m and may have different results from surface wind speed.

[25] 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: 24, Long: 120, for the year 2060.

4.4 Discussion on climate variables

This section provides discussions on the baseline and projection data for each of the climate variables listed in the previous section. Supporting documentation from Taiwan's Central Weather Administration are also referenced for discussion on typhoons.

4.4.1 Temperature

Baseline climate conditions:

- Modelled historical data for the project site area for the reference baseline period of 1995 – 2014 saw a mean temperature of 25.40°C, with a mean maximum daily temperature of 26.93°C, and absolute maximum daily temperatures of 29.68°C. During the same reference period, the sea surface temperature in the offshore area averaged at 27.59°C.[26]

Future projections:

- Overall, all projected median values (P50) and the P90 values for each temperature variable depict an increase in temperatures across all three scenarios by 2041 – 2060, as compared to the baseline period:
  - Mean temperature is projected to increase under all three future scenarios, ranging from +0.68°C under SSP1-2.6 scenario to +1.28°C under the high emissions SSP5-8.5 scenario.
  - Mean maximum daily temperature is projected to increase under all three future scenarios, ranging from +1.49°C under SSP1-2.6 scenario +1.81°C under the high emissions SSP5-8.5 scenario.
  - Absolute maximum daily temperature is projected to increase under all three future scenarios, ranging from +1.30°C under SSP1.26 scenario +1.85°C under the high emissions SSP5-8.5 scenario.
  - Mean sea surface temperature is projected to show some variability under all three future scenarios. For all three scenarios, a median decrease of -0.05°C under SSP1-2.6 scenario and -0.07°C under the SSP5-8.5 scenario. Whereas P10 and P90 values shows an increase for all three scenarios, ranging from +0.11°C to +0.23°C.

4.4.2 Precipitation

Baseline climate conditions:

- Modelled historical data for the reference baseline climate period (1995 – 2014) saw an average daily accumulated precipitation of 5.08mm and a maximum 1-day accumulated precipitation of 75.11mm, as well as a maximum 5-day accumulated precipitation of 169.23mm.

Future projections:

- Overall, precipitation variability is seen across all three scenarios by 2041 – 2060, as compared to the baseline period:
  - For average daily accumulated rainfall, variability in P10, median and P90 values are noted across all three emission scenarios. Across the three scenarios, median values for all three future climate scenarios project a slight decrease in median daily precipitation (-0.07mm to +0.0mm). Whereas slight increase is noted for the P10 (+0.11mm to +0.13mm) and P90

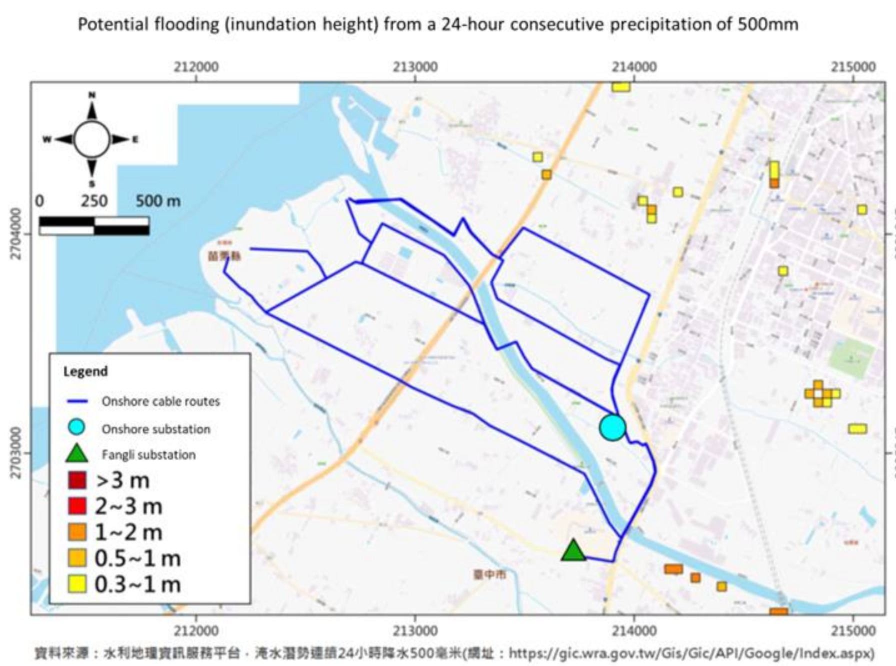
[26] Copernicus Interactive Climate Atlas.

(+0.11mm to +0.23mm). This show that although there is some probability of increase in daily accumulated precipitation throughout the project's lifecycle, there are some uncertainty.

– Maximum 1-day accumulated rainfall is projected to increase across all three emission scenarios. For P90 values show a drastic variation in 1-day accumulated precipitation across the three scenarios, where SSP1-2.6 shows an increase by +59.12mm, SSP2-4.5 shows an increase by +10.06mm, whereas SSP5-8.5 shows an increase by +11.42mm. This show that there is certain probability of increase in maximum 1-day accumulated precipitation throughout the project's lifecycle.
– Maximum 5-day accumulated precipitation is projected to increase all three emission scenarios, ranging from +18.73mm under the SSP1-2.6 scenario to +25.12mm under the SSP5-8.5 scenario This show that there is certain probability of increase in maximum 5-day accumulated precipitation throughout the project's lifecycle.

It is currently identified that the planned location of the onshore substation is adjacent to the Fangli river. Although no historical flooding or river surge has been reported along this river, it is noted from the Project EIA and a public source[27] that several areas adjacent to the onshore substation (within a 500m radius) may be prone to flood risks in the event of heavy precipitation (ie cumulative rainfall of 500mm or more in a 24-hour period)(refer to Figure 4.3 and Figure 4.4). It is understood from historical typhoon data that typhoon occurrences in Taiwan accompanies such heavy precipitation events or torrential rain. In July 2024, Typhoon GAEMI recorded 24-hour rainfalls of more than 1,000mm in several counties[28].

Figure 4.3: Hazard map showing areas with potential flooding (inundation height) from a 24-hour cumulative rainfall of 500mm



Source: Formosa 4 EDR

[27] 3D 災害潛勢地圖

[28] Taiwan warns of torrential rain as Typhoon Gaemi moves away | Taiwan News | Jul. 25, 2024 10:00

Figure 4.4: Hazard map showing areas with potential flooding (inundation height) from a 24-hour cumulative rainfall of 650mm

Source: National Science and Technology Center for Disaster Reduction, Taiwan

4.4.3 Wind and typhoons

Baseline Climate Conditions[29]:

- The modelled historical data for the region around the project site from reference baseline period (1995 – 2014) reports a near surface mean wind speed of 4.34m/s, as well as an average air pressure at mean sea level of 1013.9hPa (101398.41Pa). According to information within the EIA and previous monitoring, average wind speed at 140m above the MSL is approximately 11.2m/s
- Taiwan is located in a region that is often prone to typhoons (tropical cyclones), where most typhoons are at their strongest intensity around the moment they make landfall in Taiwan. According to the Central Weather Administration, between 1991 to 2020, an average of 25.43 typhoons were generated yearly over the North West Pacific. In 2022, 25 typhoons were generated in the North West Pacific, however, the Taiwanese government issued warnings for only three and only typhoon HINNAMNOR caused some limited damage to Taiwan. Most typhoons occur between July and October (Figure 4.6).[30]
- A climatological analysis of typhoon occurrences in the North West Pacific (Taiwan included) throughout the past four decades (from 1977 - 2016), revealed that the recent years of 2013 - 2016 recorded the maximum average frequency of 7 super typhoons per year.[31]

---

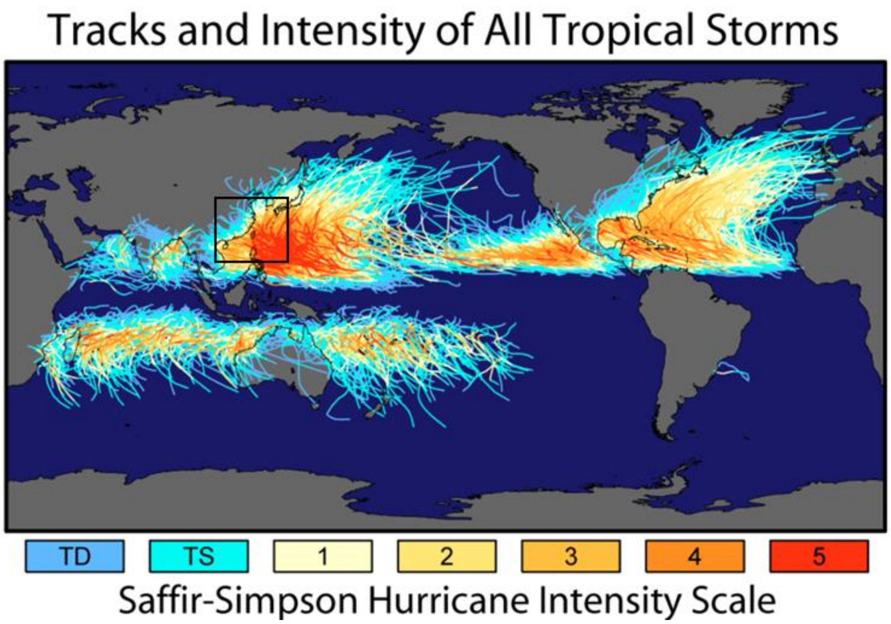
[29] Please refer to Section 2.3 for commentary on typhoon impacts on wind farms.

[30] Publish_20230914153735.pdf (cwa.gov.tw)

[31] Typhoon strength rising in the past four decades - ScienceDirect

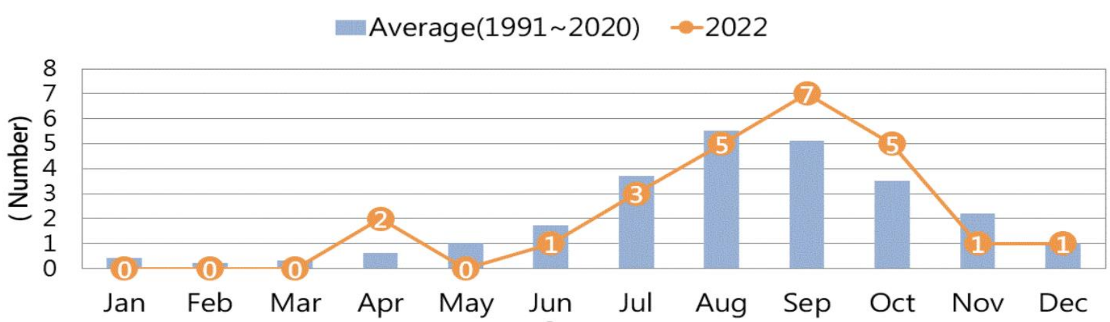
- Both 2023 and this year 2024 (to date of this report) each saw 3 typhoons with a typhoon category of 4, causing substantial impact on Taiwan, which is the most number of super typhoons encountered per year since 2018.[32]
- For the recent year (ie 2024) statistics from the Central Emergency Operation Center, it shows that typhoons GAEMI and KRATHONS caused a total of 14 deaths, more than a thousand injuries and more than a million households were cut-off from electricity in Taiwan.[33,34]

Figure 4.5: Track of tropical cyclones showing strengths along individual tracks. Taiwan located at the centre of the black square



Source: Historic Tropical Cyclone Tracks (nasa.gov)

Figure 4.6: Monthly distribution of typhoons throughout 2022 and average for 1991 – 2020



Source: Central Weather Administration Taiwan

[32] Recent typhoons in Taiwan

[33] rdc28.cwa.gov.tw/TDB/public/typhoon_detail?typhoon_id=202403

[34] rdc28.cwa.gov.tw/TDB/public/typhoon_detail?typhoon_id=202418

- Wind speed is well known to show correlations to wave heights as well. According to the Beaufort Scale, a wind speed of 5 m/s can cause waves with a wave height of 0.6m. Typhoon wind speeds are seen to cause wave heights above 14m[35]. According to the Lidar information provided, the maximum significant wave height (H_{m0}) recorded was 11m[36].

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) across all three scenarios. P10 to P 90 values show some decrease (although not significant) across the three scenarios and show a range of between -0.08m/s to -0.04m/s for change in wind speeds. The impact of climate change on future wind speeds are uncertain, but projection data points to little change, however weighing very slightly more towards a decrease in mean wind speed. It should be noted that projection for wind speed at turbine height was not available, however based on the above information, it is assumed that the wind speed at turbine height will show little to no change.
- All three projection scenarios show an increase in average air pressure at MSL. an increase P10 values show an increase across the three scenarios (+6.80Pa to +9.96Pa), as well as and P90 values with a slight increase (+1.48Pa to +13.41Pa). In comparison, the median values for all three future climate scenarios project a significant increase (+23.85Pa to +30.26Pa). This show that there is certain probability of increase in air pressure at MSL throughout the project's lifecycle.
- According to NOAA, although the average number of typhoons generated each year is projected to decrease or remain the same, climate models show that proportion of intense typhoons with a typhoon category of 4 and above is projected to increase further due to warming of the surface ocean[37] (Correspondingly, climate model studies project a reduction in the proportion of weak typhoons). This is likely to bring a greater proportion of storms having more intense wind speeds, higher storm surges, and more extreme precipitation.[38]

---

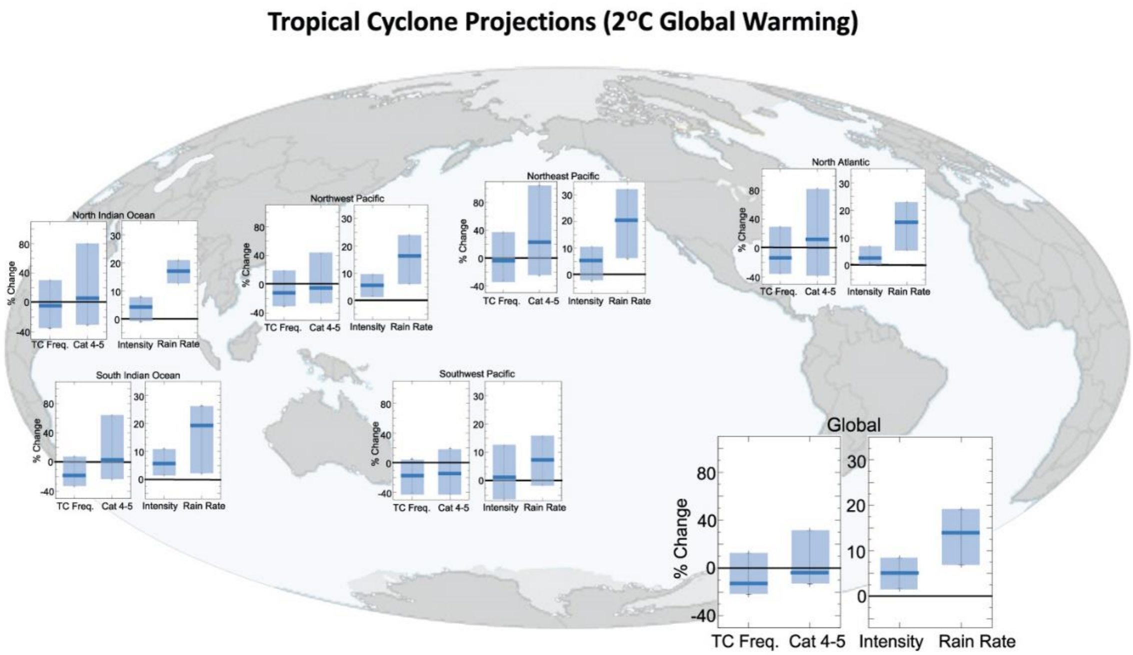
[35] Beaufort wind force scale - Met Office

[36] Document titled "Formosa 4 Offshore Wind Farm – Detailed Design Metocean Study"

[37] Typhoons with a category of 4 observe wind speeds of at least 209 km/h. This is strong enough to uproot trees and topple power poles. Tropical Cyclone Classification | National Oceanic and Atmospheric Administration (noaa.gov)

[38] Summary of a series on "Critical Issues in Climate Change Science" prepared for the COP26 climate conference held in Glasgow, 2021. Climate change is probably increasing the intensity of tropical cyclones | NOAA Climate.gov

Figure 4.7: Typhoon projections under a 2℃ global warming scenario



Source: Climate.gov

4.4.4 Sea Level Rise

Projections for the seas adjacent to the project site location (Longitude: 24, Latitude: 120) depict future sea level rise to range between +0.01m (P10 value of SSP1-2.6) and +0.58m (P90 value of SSP5-8.5), within median increase of +0.24m, +0.27m and +0.31m for SSP1-2.6, SSP2-4.5 and SSP5-8.5 respectively by 2060 relative to a 1995-2014 baseline.[39] Sea level rise may increase coastal flood events in the areas surrounding the onshore project infrastructure, either through inundation or increased ground water levels, thus impacting components located on low elevation grounds or limiting access to the site.

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[40]. The results of the analysis for the Project landing infrastructure location by 2050 for land below the annual flood level is shown in Figure 4.8[41]. As based on this screening, it is observed that the immediate coastal zone is likely to be impacted. However, it has been noted that there is a seawall along the coast of where the Transition Joint Bay is located.

This seawall has been identified as having a height of 7m above the national datum (TWD2001). It has also been identified that between 2005-2024 the highest high water levels (HHWL) recorded at the Waipu tidal station on the coast of Miaoli County are approximately 3m above the national datum (TWD2001), with the highest values usually recorded in October each year with a height of

---

39 Sea Level Projection Tool – NASA Sea Level Change Portal

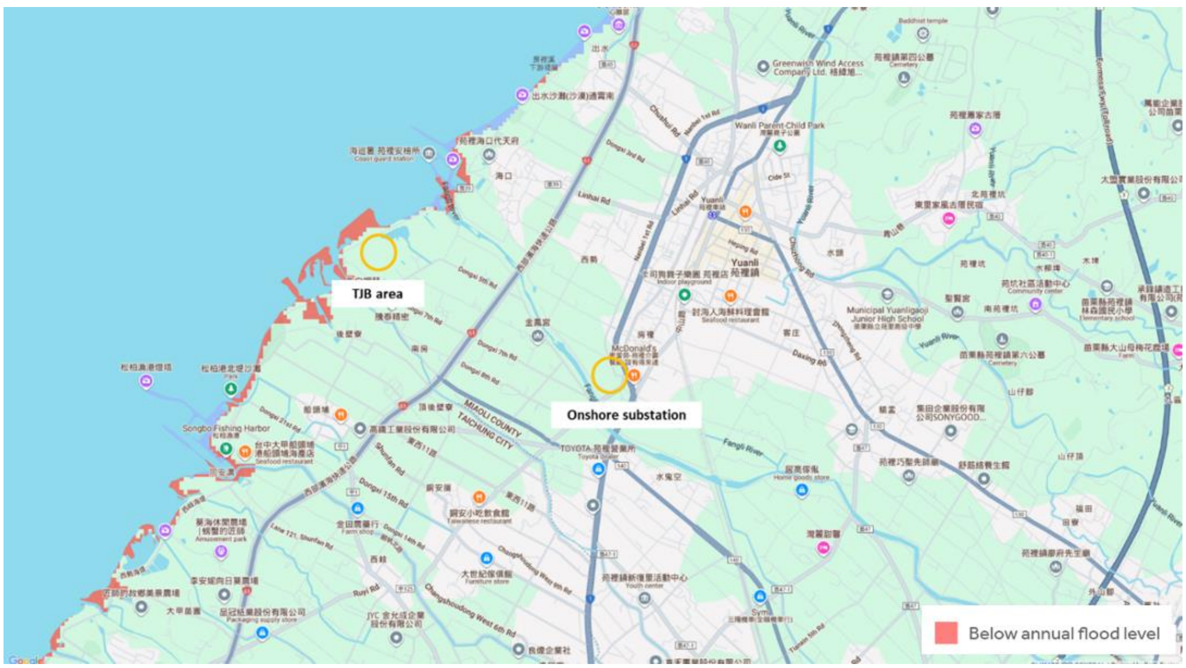
40 Climate Central (2024). Available at: Maps & Tools | Surging Seas: Sea level rise analysis by Climate Central

41 Parameters used to determine future sea level rise via Climate Central: Year: 2050; Project Type: Sea level rise + annual flood; Pollution pathway: unchecked pollution; and Luck: bad.

3.219m above the datum[42]. As such, normal tidal conditions do not pose a threat to the area from coastal flooding, even when uplifted by the p90 sea level rise increase of 0.58m under the high emissions scenario by 2060. To consider a plausible worst case scenario we can also include the potential cumulative impact of a storm surge (occurring as a result of the typhoons that regularly impact Taiwan – see section 4.4.3) occurring on top of a HHWL event uplifted by a reasonable worst scenario sea level rise. The greatest storm surge anomaly recorded at the Waipu tidal station in a Taiwanese national dataset of extreme storm surge events[43] occurred on 7th August 2015 during Typhoon Soudelor had a positive anomaly of 0.88m. If the timing of such an event aligned with HHWL under the high emissions scenario in 2060, the maximum local water level could plausibly reach 4.68 m above datum. Even if a further uplift is applied to account for the projected increase in intensity of the most intense typhoons (see Section 4.4.3), it is highly unlikely that the area would see over-topping of the sea wall at 7m.

From the above information, it is assumed unlikely for coastal waters to overtop the seawall and impact the TJB.

Figure 4.8: Land projected to be below annual flood level in 2050



Source: Climate Central, adapted by Mott MacDonald

4.4.5 Lightning

There is insufficient lightning data near the site to accurately map the baseline or to accurately predict the lightning hazards that would be expected under a climate change scenario. There is a consensus that an increase in mean temperature will lead to an increase in convective activity. Research suggests that for every 1.0°C rise in global temperature, lightning strikes in the

[42] Tide Statistics | Central Weather Administration

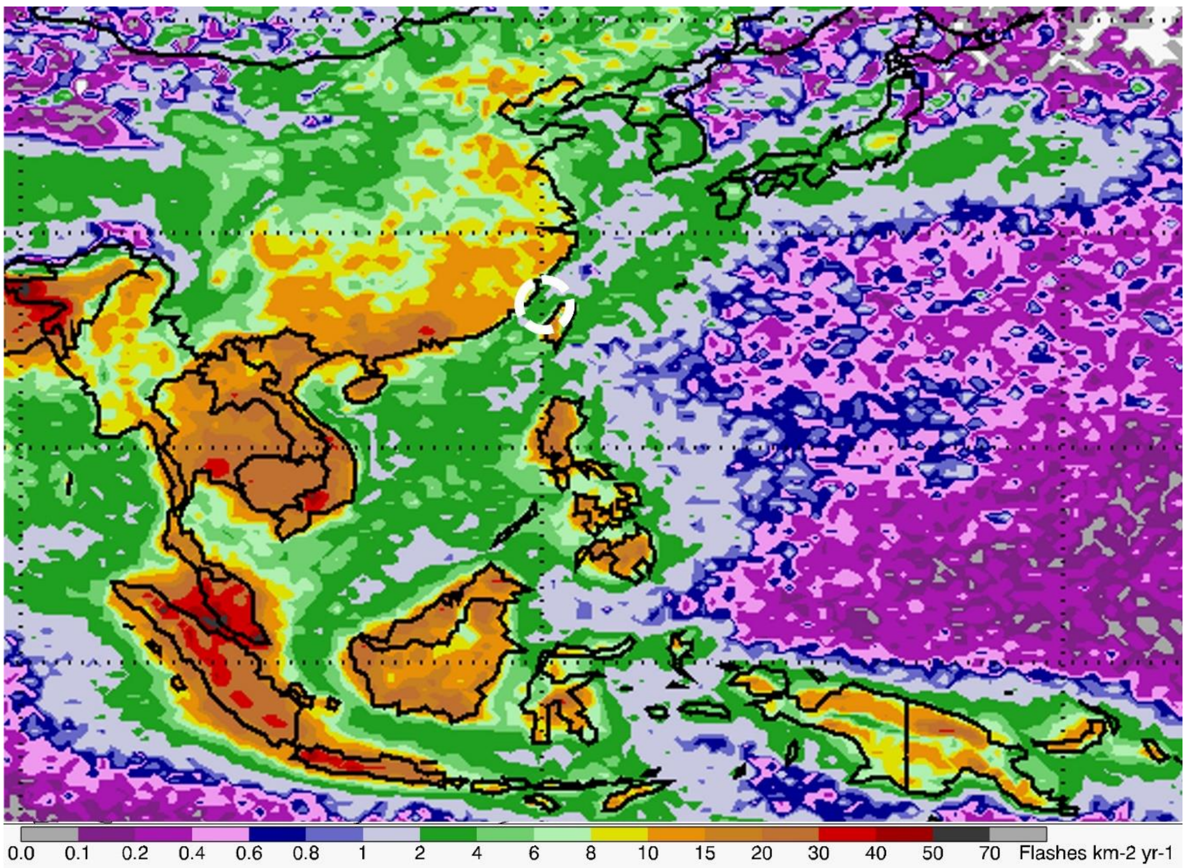
[43] Typhoon Storm Surge Statistics - Historical Typhoon Storm Surge Extreme Value Statistics in Taiwan ｜ 政府資料開放平臺

contiguous United States are estimated to increase by 12% ± 5% and about 50% over this century[44].

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[45]. 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[46]. This would suggest that it could be expected that the number of lightning events in Taiwan might increase as we move through the century.

Figure 4.9: Historical lightning flash frequency map



Source: NASA's Global Hydrometeorology Resource Center Distributed Active Archive Center (GHRC DAAC), adapted by Mott MacDonald

[44] D. M. Romps et al., “Projected increase in lightning strikes in the United States due to global warming”, Science, vol. 346, issue 1162, pp. 851-854, 14 November 2014 (DOI: 10.1126/science.1259100)

[45] C. Price, “Thunderstorms, Lightning and Climate Change”, Lightning: Principles, Instruments and Applications, ed. H.D. Betz, U. Schumann and P. Laroche, Springer Publications, pp. 521-536, 2009

[46] Electric Power Research Institute (EPRI), “Handbook for Improving Overhead Transmission Line Lightning Performance”, December

However, historical lightning frequency data shows that the Taiwan straight typically has a lightning flash density of between 2-6 flashes per km^2 per year, which is not high by global comparison (other areas of SE Asia exceed 20-30 flashes per km^2 per year).

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. It is clear that there will be an increase in the number of storms and therefore, the frequency of lightning. 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.

4.5 Other climate variability

4.5.1 ENSO

Taiwan is susceptible to climate variability and extreme weather events, in part due to the influence of the El Niño–Southern Oscillation (ENSO), and in part due to anthropogenic climate change. Taiwan's most significant ENSO related impacts are due to flooding during the wet season and typhoons.

ENSO is the strongest and most consequential year-to-year climate fluctuation on the planet[47]. ENSO events have global impacts, however the effects are different depending on the region and the time of year (Figure 4.10). During El-Niño events, which usually peak during the northern-hemisphere winter, precipitation over Taiwan tends to be lower during September – November, while wetter conditions are experienced during northern-hemisphere spring[48].

Recent studies have reported that anthropogenic climate change has resulted in an enhancement in the frequency of the central Pacific El-Niño[49], and this trend is projected to continue under a warming climate[50]. Another paper found that the central Pacific ENSO has become more influential in determining spring rainfall compared to the Pacific Decadal Oscillation (PDO), with warmer SSTs in the central Pacific resulting in increased Spring precipitation even when the PDO phase would normally cause the opposite signal[51].

Climate change is expected to interact with ENSO. The result is more variable precipitation patterns, and more extreme ENSO conditions. Furthermore, 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.

However, while Climate model simulations suggest that central Pacific ENSO variability may increase under greenhouse forcing, instrumental records of tropical Pacific sea surface

47 Geng et al, (2022). Available at: Emergence of changing Central-Pacific and Eastern-Pacific El Niño-Southern Oscillation in a warming climate | Nature Communications

48 Liu et al. (2005). Available at: 2005.pdf (cwb.gov.tw)

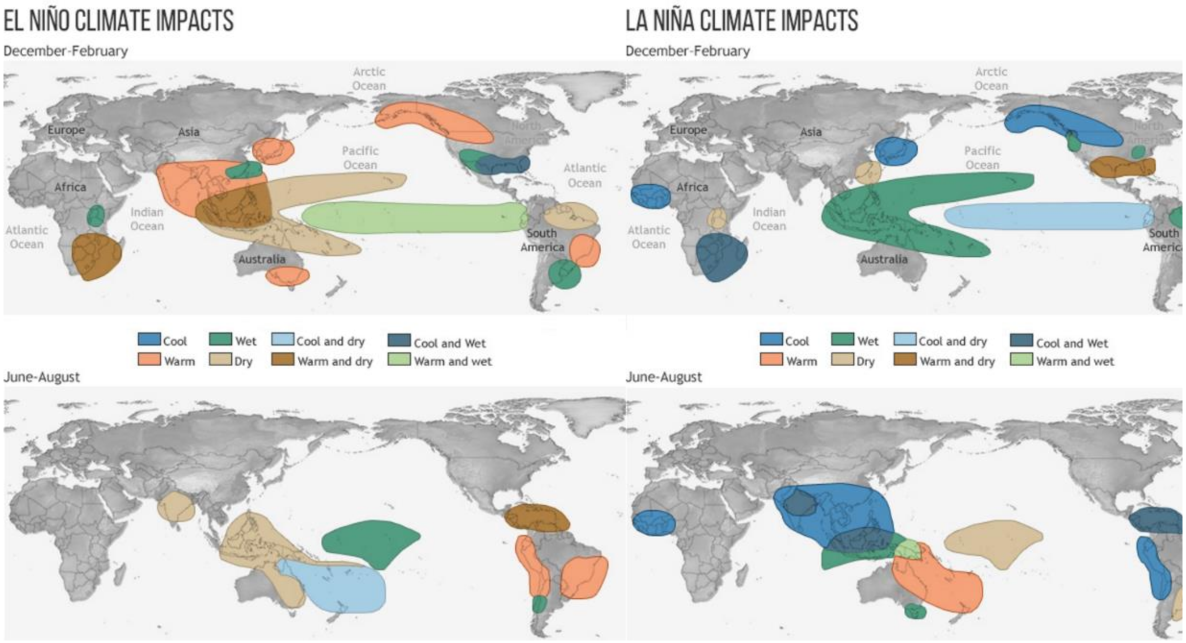
49 Liu et al. (2017). Available at: Recent enhancement of central Pacific El Niño variability relative to last eight centuries | Nature Communications

50 Shin et al. (2022). Available at: More frequent central Pacific El Niño and stronger eastern pacific El Niño in a warmer climate | npj Climate and Atmospheric Science (nature.com)

51 Kao et al. (2018). Available at: Increasing influence of central Pacific El Niño on the inter-decadal variation of spring rainfall in northern Taiwan and southern China since 1980 - Kao - 2018 - Atmospheric Science Letters - Wiley Online Library

temperatures (SSTs) are too short to provide robust constraints on recent trends in ENSO variability[52,53]. As such, while studies suggest that anthropogenic warming may result in more frequent central Pacific El-Niño events delivering more Spring precipitation to Taiwan, there is still substantial uncertainty around this trend.

Figure 4.10: Inter-annual ENSO climate impacts during different seasons Figure



Source: NOAA

---

[52] Liu et al. (2017).

[53] Chen et al. (2008). Available at: chen.li.shih2008.pdf (hawaii.edu)

5 Physical Climate Change Risk Assessment

5.1 Analysis method

Mott MacDonald produced a Risk Register to collate potential climate hazards and impacts on different project components based on interpreting the climate data listed above and information collated during a literature review, and discussing the potential impacts to the Project with experienced offshore wind project engineers.

Each impact identified for a project component was assessed for:

- **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.
- **Consequence of occurrence** on the asset based on damage to infrastructure, impact on operations and health & safety consequences (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.
- 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.
- Dependent on their overall risk rating (ie 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. Applying the precautionary principle, the risk rating was calculated assuming the high emission future scenario SSP5-8.5.

5.1.1 Likelihood

The likelihood of impacts to the infrastructure is rated based on a uniform scale below. This has been determined based on an evaluation of current and projected (future) climate data, using a representation of the likelihood of impacts. The current climate impact is based on an estimated impact return period, using the information we have collected.

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

Rating	Likelihood of recurring events
Rare	Unlikely during next 25 years, or has not occurred in the past five years
Unlikely	May arise once in 10 years, or may have occurred in the last five years
Possible	May arise once in five years, or has happened during the past five years but not every year
Likely	May arise about once per year, or has happened at least once in the past year and in each of the previous five years
Almost certain	Could occur several times per year

Source: Mott MacDonald

5.1.2 Consequences

The potential consequences of the climate impact is rated based on a uniform scale below. This has been determined based on a combination of expert judgement and review of available evidence and literature.

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 infrastructure service disruption.	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 required. Limited infrastructure damage and loss of service.	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 and permanent changes required to operations.	Severe event which requires extensive maintenance effort but can be survived. Operations are fundamentally compromised and / or cannot be delivered.
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

Source: Mott MacDonald

5.1.3 Risk

The risk to the assets of the Project is scored using the risk matrix below, which categorises the level of risk as low, medium, high, or extreme as defined in Table 5.3 and Source: Mott MacDonald

Table 5.4.

Table 5.3: Overall risk rating matrix

	Consequence				
	1	2	3	4	5

	Consequence				
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

Source: Mott MacDonald

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.
Extreme	Intolerable	An extreme level of vulnerability to specific climate risk(s). Mitigation action or adaptation is highly recommended.

Source: Mott MacDonald

5.2 Physical Climate Change Risk Assessment

It should be noted that other detailed information on the Project design and requests for information were not available at the time of writing as some of the documentation (ie Technical Due Diligence) are pending finalisation. Additional information will be made available as the Project progresses. As such, where detailed project information was unavailable this assessment referenced other nearby offshore wind projects to make qualified assumptions.

In summary, this CCRA has identified a total of 19 risks, of which 11 are identified to be of a medium risk rating and the remaining 8 risks are of a low rating. The medium risks are summarised in more detail in Table 5.5.

A tabulated summary of all identified risks with the corresponding proposed adaption actions are presented in Table 5.6.

Table 5.5: Summary of climate risks

Hazard - Climatology	Project component	Impact type	Consequence/impact	Risk
Temperature - Increase in extreme temperatures	Substation (onshore)	Working Conditions	Changes to ground moisture and ground temperature influence efficiency of substation earthing & lightning protection which could pose a safety risk on-site.	Medium
	O&M (both offshore and onshore)	Working Conditions	Extreme heat impacts on workers leading to heat exhaustion, or reductions in outside work time for repair and maintenance activities.	Medium
Precipitation - Increase in extreme precipitation events	Wind Turbine Generators	Damage to Infrastructure	Extreme precipitation could cause enhanced erosion of leading edges. Additionally there is a risk of water ingress into the nacelle, causing damage to	Medium

Hazard - Climatology	Project component	Impact type	Consequence/impact	Risk
			electrical boards and wiring and corrosion of key components.	
	O&M (both offshore and onshore)	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	Medium
Typhoon - Increased proportion of super typhoons	Wind Turbine Generators	Damage to Infrastructure	Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to turbine blades or to the tower.	Medium
	O&M (both offshore and onshore)	Working Conditions	Typhoons with a category of 4 and above are always accompanied by strong winds that can impact access to sites leading to delays in maintenance.	Medium
	Substations (both offshore and onshore)	Damage to Infrastructure	Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to buildings and infrastructure.	Medium
	Onshore cables and grid connection	Damage to Infrastructure	Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to transmission lines and poles.	Medium
Flooding - Flooding as a result of variable precipitation and extreme precipitation events)	Substation (onshore)	Damage to Infrastructure	The onshore substation is located directly adjacent to Fangli River, and therefore susceptible to flooding during events that combine extreme precipitation and riverine flooding (ie overflow).	Medium
	Site Access	Reduced Access	River surge flooding along the Fangli River could cause access roads to the onshore substation to be flooded, restricting access to onshore components.	Medium
Flooding - Rise in sea level and increase precipitation	Cables & Grid Connections	Damage to Infrastructure	Damage to underground cables - water intrusion into cable ducts	Medium

Source: Mott MacDonald

Table 5.6: Physical Climate Change Risk Assessment of the Project

Projection Scenario: SSP5-8.5 / Timeframe: 2041-2060 (excl. Construction)

Hazard - Climatology	Project component	Impact type	Risk description		Risk rating with BAU controls			Acceptance level	Potential proposed adaptation actions
			Consequence/impact	Current BAU risk controls	L/hood	Consequence	Risk		
Temperature - Increase in 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. It is noted from the Project develop that the turbines are to be equipped with cooling and ventilation systems for the nacelle to mitigate high temperatures. The turbine specification for the Project notes that the High Temperature Ride Through (HTRT) enables reduced operation up to the design temperature. 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 turbine specification for the Project notes that the turbines are equipped with cooling and ventilation systems for the nacelle to mitigate high temperatures	L2 Unlikely	S2 Minor	Low	Acceptable	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 regular checking of equipment performance and regular maintenance.
Temperature - Increase in extreme temperatures	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 loads. Increasing air temperatures (T) lead to decreasing air densities (ρ). Rotor thrust (FT) is not only proportional to the square of the wind speed (v) but also to the air density: FT ~ ρv2	While it is not quantified how much impact this would have to the air density. It is assumed that the EYA would factor in uncertainty range for future energy generation, which account for the uncertainty in site environment.	L2 Unlikely	S2 Minor	Low	Acceptable	Ensure that the estimated yield used have taken uncertainty into account.
Temperature - Increase in extreme temperatures	Substations (both offshore and onshore)	Power Transmission	Increased temperatures may result in de-rated component capacity at substations and transformers. This results in a lower capacity of the system to transmit energy.	It is noted from the Project that facilities are to be equipped with cooling and ventilation systems in order to mitigate high temperature conditions for electrical components.	L2 Unlikely	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.
Temperature - Increase in extreme temperatures	Substations (both offshore and onshore)	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 noted from the Project that facilities are to be equipped with cooling and ventilation systems in order to mitigate high temperature conditions for electrical components.	L2 Unlikely	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.

Projection Scenario: SSP5-8.5 / Timeframe: 2041-2060 (excl. Construction)

Hazard - Climatology	Project component	Impact type	Risk description		Risk rating with BAU controls			Acceptance level	Potential proposed adaptation actions
			Consequence/impact	Current BAU risk controls	L/hood	Consequence	Risk		
Temperature - Increase in extreme temperatures	Substation (onshore)	Working Conditions	Changes to ground moisture and ground temperature influence efficiency of substation earthing & lightening protection which could pose a safety risk on-site.	An annual substation O&M check will be undertaken, and will include the typical grounding resistance check and should the parameters become out of the range, rectification will be implemented.	L3 Possible	S3 Moderate	Medium	Tolerable	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.
Temperature - Increase in extreme temperatures	O&M (both offshore and onshore)	Working Conditions	Extreme heat impacts on workers leading to heat exhaustion, or reductions in outside work time for repair and maintenance activities.	Working in Hot Weather is covered within the project HSE plan. All personnel are required to be made aware of the weather conditions, remain hydrated and take regular breaks to avoid heat exhaustion. Contractors shall make personnel on Site aware of the impacts of hot weather during toolbox talks and ensure that personnel are provided with adequate rest breaks, shade during rest breaks, water and sunscreen.	L3 Possible	S3 Moderate	Medium	Tolerable	Recommended 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
Temperature - Increase in extreme temperatures	O&M (both offshore and onshore)	Damage to Infrastructure	Extreme high temperatures can cause loss of information through communication networks or reduced quality of service, leading to sub-optimal operation or in the worst case damage to WTGs	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. Cables are fibre-optic and buried under sea-bed making them less susceptible to temperature fluctuations.	L2 Unlikely	S2 Minor	Low	Acceptable	Ensure that hardened back-up communication and data systems exist to maintain control of critical functions even in extreme circumstances
Precipitation - Increase in extreme precipitation events	Wind Turbine Generators	Damage to Infrastructure	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.	WTGs are rated to specifications with consideration of extreme weather. As such it is assumed that the selected 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. Blade edges are checked with binoculars and drones on a regular basis.	L3 Possible	S3 Moderate	Medium	Tolerable	It is recommended for the project to conduct regular monitoring to check for anomalies in electrical components and operations. Leading edge protection should be checked/monitored at least on an annual basis.
Precipitation - Increase in extreme precipitation events	O&M (both offshore and onshore)	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.	Adverse weather is covered within the project HSE plan. Requiring weather to be monitored, considered and weather windows must be ascertained to be of adequate duration relative to the task. 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 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.
Wind - Wind speed variability	Wind Turbine Generators	Power Generation	Changes in wind patterns impact on power output within operating range.	The cut in wind speed (point at which the WTG is able to generate power) is defined in the WTG technical specifications.	L2 Unlikely	S1 Insignificant	Low	Acceptable	
Typhoon - Increased proportion of super typhoons	Wind Turbine Generators	Damage to Infrastructure	Studies show that there is possibility that although the number of typhoon is projected to stay the same, the proportion of typhoons with a typhoon category of 4 and above is likely to increase. Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to turbine blades or to the tower.	It is understood from the Project description that the turbines have a design wind speed in accordance with international design standard requirements. As the air density is lower during typhoon events, it is anticipated for the wind turbines to withstand slightly beyond the above threshold.	L3 Possible	S3 Moderate	Medium	Potentially intolerable / Tolerable	Recommend the WTG to conduct a typhoon resistance structural analysis based on the finite element method (FEM). Recommend additional monitoring of WTGs during and after extreme wind events.

Projection Scenario: SSP5-8.5 / Timeframe: 2041-2060 (excl. Construction)

Hazard - Climatology	Project component	Impact type	Risk description: Consequence/impact	Risk description: Current BAU risk controls	Risk rating with BAU controls: L/hood	Risk rating with BAU controls: Consequence	Risk rating with BAU controls: Risk	Acceptance level	Potential proposed adaptation actions
			If a significant typhoon event damages the WTG, this may affect generation operations and an increased budget for replacement of components and maintenance.						
Typhoon - Increased proportion of super typhoons	O&M (both offshore and onshore)	Working Conditions	Studies show that there is possibility that although the number of typhoon is projected to stay the same, the proportion of typhoons with a typhoon category of 4 and above is likely to increase. Typhoons with a category of 4 and above are always accompanied by strong winds that can impact access to sites leading to delays in maintenance. Strong winds can accompany flying debris, which would be a health & safety risk for operations & maintenance workers Strong winds can also create high waves that are not safe for working conditions in offshore areas. Delays in maintenance activities due to reduced access to sites.	Adverse weather is covered within the project HSE plan. Requiring weather to be monitored, considered and weather windows must be ascertained to be of adequate duration relative to the task. 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.	L3 Possible	S3 Moderate	Medium	Potentially intolerable / Tolerable	Ensure that the project incorporate H&S procedures for extreme weather events, including cessation of work where necessary and select locations for 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.
Typhoon - Increased proportion of super typhoons	Substations (both offshore and onshore)	Damage to Infrastructure	Studies show that there is possibility that although the number of typhoon is projected to stay the same, the proportion of typhoons with a typhoon category of 4 and above is likely to increase. Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to buildings and infrastructure. If a significant typhoon event damages the substations, this may affect power transmission operations and an increased budget for maintenance of the housing.	It is assumed that infrastructure will be built to appropriate design codes to withstand force of extreme wind gusts. Buildings in Taiwan are required to be built in compliance with the national "Specifications for Building Wind Resistant Design", based on the corresponding international ASCE standard. This stipulates the required return period and load calculation.	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.
Typhoon - Increased proportion of super typhoons	Onshore cables and grid connection	Damage to Infrastructure	Studies show that there is possibility that although the number of typhoon is projected to stay the same, the proportion of typhoons with a typhoon category of 4 and above is likely to increase. Typhoons with a category of 4 and above are always accompanied by strong winds that can cause damage to transmission lines and poles. If a significant typhoon 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. It is assumed WTG also have back up power system to handle the grid outage. Buildings in Taiwan are required to be built in compliance with the national "Specifications for Building Wind Resistant Design", based on the corresponding international ASCE standard. This stipulates the required return period and load calculation.	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.

Projection Scenario: SSP5-8.5 / Timeframe: 2041-2060 (excl. Construction)

Hazard - Climatology	Project component	Impact type	Risk description		Risk rating with BAU controls			Acceptance level	Potential proposed adaptation actions
			Consequence/impact	Current BAU risk controls	L/hood	Consequence	Risk		
Flooding - Flooding as a result of variable precipitation and extreme precipitation events)	Substation (onshore)	Damage to Infrastructure	The onshore substation is located directly adjacent to Fangli River, and therefore susceptible to flooding during events that combine extreme precipitation and riverine flooding (ie overflow).	It has been noted that the design ground level is above the 100-year flood level, thus relative elevation of vital components have been considered.	L2 Unlikely	S2 Minor	Low	Acceptable	It is recommended that appropriate designs to mitigate flooding around the substation to be further considered and / or incorporated, such as but not limited to; sufficient drainage around the substation, portable temporary flood barriers at the entrance of the substation building, etc.
Flooding - Rise in sea level and increase precipitation	Cables & Grid Connections	Damage to Infrastructure	Damage to underground cables - water intrusion into cable ducts	The detailed cable design is currently unknown at this stage, however, it is common practice for underground cables to implement water-proofing (enclosed duct banks), as seen with similar projects.	L2 Unlikely	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.
Flooding - Rise in sea level and increase precipitation	Operation & Maintenance	Reduced Access	Flooding in the harbor and coastal areas might restrict access to the site for O&M activities.	Flood design measures for local access roads are unknown (ie. ground elevation of relevant roads, drainage condition of roads, etc.) It is currently understood that there is a sea wall with a height of 7m above the national datum (TWD2001), which is assumed to help mitigate any coastal flooding. A 1-month tidal height prediction curve puts the Highest High Water tidal levels of the coasts in Miaoli County at approximately 3m above the same datum. And where modelling projects sea level rise to increase at most by 0.58m (P90 value of SSP5-8.5), tidal conditions are not expected to be a risk. The risk could be higher in a cumulative condition of high tide, storm surge and sea level rise. However, historical data shows that a cumulative event has the potential to further increase water levels (from predicted tidal levels) by up to 1.46m, thus likely for coastal water levels to reach a height of 4.68m above the national datum (sum of all the above conditions). This level is well under the 7m height of the sea wall, and thus assumed low risk from water overtopping the seawall.	L2 Unlikely	S2 Minor	Low	Acceptable	It is recommended for the access routes to be reviewed as to whether further mitigation is required to prevent the roads from flooding in order to improve resilience against flooding removing access to the project site.
Flooding - Flooding as a result of variable precipitation and extreme precipitation events)	Site Access (Onshore)	Reduced Access	River surge flooding along the Fangli River could cause access roads to the onshore substation to be flooded, restricting access to onshore components.	Flood design measures for local access roads are unknown (ie. ground elevation of relevant roads, drainage condition of roads, etc.)	L3 Possible	S2 Minor	Medium	Tolerable	It is recommended to assess the conditions of access roads and consider improving resilience against flooding for vital locations.
Flooding - Rise in sea level and increase precipitation	Transition Joint Bay	Damage to Infrastructure	The Transition Joint Bay (TJB) is located directly adjacent to the coast (ie less than 50ms away), and therefore susceptible to flooding during events that combine sea level rise, storm surge and extreme precipitation.	It is currently noted that there is a seawall (height of +7m TWND) that exists directly between the coast and the TJB. Design of the TJB remains outstanding and is pending conclusion to site investigations. It is anticipated that the project will consider drainage requirements relation to both water table and rainwater.	L2 Unlikely	S2 Minor	Low	Acceptable	It is recommended that necessary designs to mitigate flooding around the TJB to be incorporated, such as but not limited to; constructing a flood wall around the TJB, elevating the ground levels of the foundation of the TJB, sufficient drainage around the TJB, etc.
Lightning - Increase in frequency of lightning strikes	Wind Turbine Generators	Damage to Infrastructure	Greater lightning activity could result in more frequent lightning strikes to WTGs resulting in fire and /or damage to electrical components. However, historical lightning frequency data shows	The WTGs are specified to the relevant/appropriate lightning protection standards which are expected to provide adequate protection.	L2 Unlikely	S2 Minor	Low	Acceptable	Review assumed allowances within the design and take these into account if not already implemented. Given there are likely to be protections in place, the risk to infrastructure is

Projection Scenario: SSP5-8.5 / Timeframe: 2041-2060 (excl. Construction)

Hazard - Climatology	Project component	Impact type	Risk description		Risk rating with BAU controls			Acceptance level	Potential proposed adaptation actions
			Consequence/impact	Current BAU risk controls	L/hood	Consequence	Risk		
as a result of increased temperature			that the Taiwan straight typically has a lightning flash density of between 2-6 flashes per km2 per year, which is not high by global comparison.						low. Maintenance guide must account for possibility of damage caused by increased lightning strikes.

Source: Mott MacDonald, 2025

6 Conclusion

GHG emissions

A greenhouse gas (GHG) emissions assessment of the estimated emissions during the construction and operational phases of the project has been undertaken. This has found that during the operational phase of the project Scope 1 and 2 emissions are not expected to exceed more than 1,258 tonnes CO_2e per year, with annual emissions decreasing over the project life as a result of anticipated grid decarbonisation. During the construction phase, maximum annual emissions from fuel combustion are estimated to be approximately 79,234 tonnes CO_2e per year in 2027, although these may be allocated as Scope 3 emissions, depending on the level of operational control that the Project will have over the construction vessels. The assumed and recommended mitigations identified for the offshore and onshore asset design, coupled with recommended management plans and interventions by the Project and project partners has rendered the net classification of these risks as being either medium or low.

Physical climate change risk

The risk of physical damage, risks to worker safety and system interruptions with respect to wind energy projects is present irrespective of climate change. The physical CCRA presented in Section 5.2 identifies Project and asset risks that may be magnified by climate change. The assumed and recommended mitigations identified for the offshore and onshore asset design, coupled with recommended management plans and interventions by the Project and partners has rendered the net classification of these risks as being either medium or low.

The measures have been based off those which are being embedded in the neighbouring project which shares similar climate conditions. The CCRA and the measures identified should be reviewed by the Project as well as relevant partners to be taken into account within the design to ensure the resilience of the Project. The CCRA should then be reviewed and scored appropriately in line with the measures implemented taken into account.

No high or extreme risks to the Project have been identified as a result of projected climate change to the 2050s, but a watching brief of risks identified is recommended to be maintained throughout the Project lifetime and adaptively managed.

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.

Appendices

A. Climate change limitations and disclaimer

The assessments in this report are based on freely available information available from third parties for purposes such as this report, being observational data from local weather stations, a number of readily available climate change projections and informed by a selected range of existing climate change research and literature at the time of writing this assessment. The following limitations and disclaimer should be noted:

- Climate change projections: climate projections are not predictions or forecasts but simulations of potential scenarios of future climate under a range of hypothetical emissions scenarios and assumptions. The results, therefore, from the experiments performed by climate models cannot be treated as exact or factual, but projection options. They represent internally consistent representations of how the climate may evolve in response to a range of potential forcing scenarios and their reliability varies between climate variables. Scenarios exclude outlying “surprise” or “disaster” scenarios in the literature and any scenario necessarily includes subjective elements and is open to various interpretations. Generally global projections are more certain than regional, and temperature projections more certain than those for precipitation. Further, the degree of uncertainty associated with all climate change projections increases for projections further into the future.
- Validation of information: Mott MacDonald has not independently verified the observational or projection data and does not accept responsibility or liability for any inaccuracies or shortcomings in this information. Should these information sources be modified by these third parties we assume no responsibility for any of the resulting inaccuracies in any of our reports. Issued reports are relevant to the project information provided and are not intended to address changes in project configuration or modifications which occur over time. The data is obtained to provide a general ‘sense check’ on the published literature on existing observational and climate projections for the region.
- We have not undertaken any climate modelling and rely solely on freely available data on climate projections in this region. Accordingly, any further research, analysis or decision-making should take account of the nature of the data sources and climate projections and should consider the range of literature, additional observational data, evidence and research available - and any recent developments in these.
- Detailed information on the Project design and other requests for information were not available at the time of writing as the Project is at an early stage (pre final investment decision). Additional information will be made available as the Project progresses. Three individual CCRAs were undertaken for the neighbouring offshore wind farms between 2023 and 2024, and includes certain detail on the measures taken into account within the design in relation to climate change. It is therefore assumed that similar allowances for climate change and embedded resilience measures to reduce vulnerability has been applied to the Project. As such, these embedded measures have been referenced when conducting the assessment, and risk ratings have been scored with support of these project details.

B. Comparison of measured vs modelled historical climate data

The following Table B.1 presents the ERA5 historical reanalysis climate values for the project area alongside the historical modelled values used in this report, which were produced by an ensemble of Global Climate Models (as listed for each climate variable in Section 4.1). The table shows the differences between measured and modelled historical climate values for comparison.

Table B.1: Comparison of measured vs modelled historical climate data

Variable	Unit		Model	1995-2014		ERA 5	1995-2014	
			P10	median	P90	P10	median	P90
Mean temp	°C	Absolute	21.61	25.40	27.35	22.63	23.01	23.34
Mean of daily max temp	°C	Absolute	24.07	26.93	28.85	23.92	24.32	24.63
Max of daily max temp	°C	Absolute	27.04	29.68	31.45	30.30	30.69	31.51
Sea surface temperature	°C	Absolute	24.49	27.59	28.58	23.99	24.40	24.80
Mean of daily accumulated precipitation	mm	Absolute	3.30	5.08	7.53	3.45	4.78	6.03
Max of 1-day accumulated precipitation	mm	Absolute	43.63	75.11	142.45	88.24	116.43	187.74
Max of 5-day accumulated precipitation	mm	Absolute	108.00	169.23	305.74	184.92	249.71	334.45
Mean wind speed *(near surface, not site specific)*	m/s	Absolute	*2.90*	*4.34*	*5.75*	*6.58*	*6.89*	*7.11*
Average air pressure at MSL	Pa	Absolute	101238.74	101398.41	101575.16	101192.44	101270.80	101335.00
Sea Level Rise (2060)	m	-						

mottmac.com