Appendix 17.2: Climatic Effects Climate Change Risk Assessment Technical Report

Array EIA Report

2024

Revision	Comments	Author	Checker	Approver
FINAL	Final	RPS	RPS	RPS

Approval for Issue		
For and on behalf of Ossian OWFL	Paul Darnbrough	28 June 2024

Prepared by:	**RPS Energy**
Prepared for:	**Ossian Offshore Wind Farm Limited (OWFL)**
Checked by:	**Ed Maxwell**
Accepted by:	**Fraser Malcolm**
Approved by:	**Paul Darnbrough**

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1. INTRODUCTION

1. This Climate Change Risk Assessment (CCRA) Technical Report assesses the potential adverse effects on the Ossian Array (hereafter referred to as 'the Array') from climate change, in line with the United Kingdom's (UK) guidance on CCRAs. The Technical Report will inform the assessment of climate change impacts reported in volume 2, chapter 17.

2. The scope of the CCRA is defined in accordance with the Climate Change Committee (CCC) recommendations (CCC, 2021). This technical report considers the climate-related physical risks on the Array and identifies the current and anticipated risks throughout its 35 year lifetime. This technical report evaluates the processes utilised for managing the risks through four key stages:

- an assessment of the baseline environment to understand present day vulnerability and assess current climate-related risks, opportunities, and levels of adaptation;
- an assessment of the future baseline, using climate projections to understand future vulnerability and adaptation for Scotland and the UK;
- identify vulnerability of the Array components to climate change and undertake an assessment of their likelihood and severity; and
- review potential adaption and mitigation options.

1.1. PROJECT SUMMARY

3. The Array covers approximately 858 km^2 and is located in the North Sea, off the east coast of Scotland, approximately 80 km south-east from the nearest point of Aberdeen. The Array will comprise of the wind turbines (alongside their floating substructures, anchors and mooring lines), the fixed bottom Offshore Substation Platforms (OSPs), and inter-array and interconnector cables. The Applicant intends to commence the construction phase of the Array in 2031, with the intention to be fully operational by 2039 following an eight year construction programme. The initial operating lifetime is intended to be 35 years (refer to volume 2, chapter 3).

1.2. STUDY AREA

4. Figure 1.1 illustrates the climatic effects study area for the Array which encompasses the proposed Array area (i.e. the area in which the wind turbines and associated infrastructure will be located).

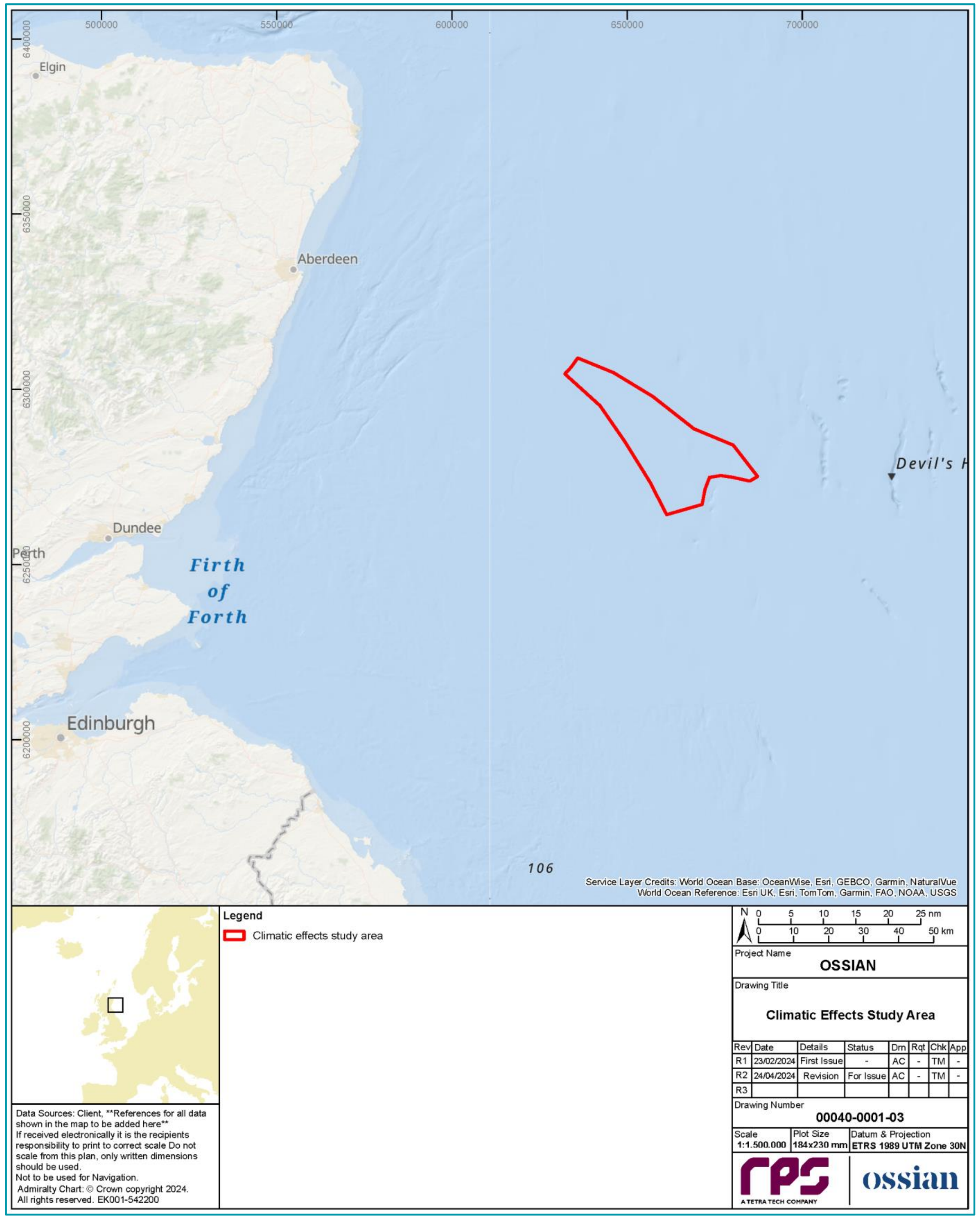

Figure 1.1: Climate Effects Study Area

2. BASELINE ENVIRONMENT

2.1. METHODOLOGY

5. To understand the impact on the Array from climate change, the baseline environment must be considered. This includes both the current baseline, and the future baseline as determined by climate projections.

6. Current baseline offshore climatic conditions have been sourced from observational data collated within the UK Offshore Energy Strategic Environmental Assessment (Department for Business, Energy and Industrial Strategy (BEIS), 2022) and Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Reporting of the physical science (IPCC, 2021). Information has also been drawn from volume 3, appendix 7.1 where relevant, in order to provide baseline information specific to the climatic effects study area.

7. It is established that climate change is already taking place in the UK, according to academic research (IPCC, 2021) and in legislation and policy (HM Government, 2008; Scottish Government, 2009; HM Government, 2022; BEIS, 2022). The risks associated with rising temperatures, more frequent extreme weather patterns and rising sea levels in Scotland are presented in the Climate Change (Scotland) Act 2009 and are further investigated within section 3.

8. The assessment of future climate has been informed by climate projections based on Representative Concentration Pathway (RCP) scenarios used by the IPCC (IPCC, 2014). The RCP scenarios describe different climatic futures, all of which are considered possible depending on the volume of Greenhouse Gases (GHGs) emitted. These provide the basis for future assessments of climate change and possible response strategies, thereby giving a low to high range in potential global GHG reduction initiatives and resulting rate of climatic effects over a given period.

9. Climate projections outlined below have been informed by the emissions scenario RCP8.5, which is a high-emissions scenario assuming 'business as usual' growth globally, with little additional mitigation[1]. This is a conservative (maximum design scenario) approach for the assessment, consistent with guidance set out in Institute of Environmental Management and Assessment (IEMA) (2020). Data is largely available for the end of the 21st Century. Whilst this is outside of the lifetime of the Array, these climate projections display climate trends that will begin to be felt throughout this century.

10. The climate projections used to inform this assessment are contemporary to the time the assessment was undertaken. It can be expected that projections of future climate will evolve due to improvements in climate modelling and scientific understanding of climate systems, alongside improved data regarding the rate of change of global atmospheric carbon dioxide (CO_2) and other GHGs. As such, there is some inherent uncertainty in the projections used. However, in line with relevant guidance (IEMA, 2020), a maximum design scenario has been used to account for such uncertainty. Ensuring the Array is resilient to worst-case future climate projections will ensure that it will be resilient to any shorter term climate fluctuations or variations in the climate not identified by projections (i.e. regarding rate of change).

11. Climate projections specific to offshore UK waters have been sourced from the United Kingdom Climate Projections 2018 (UKCP18) Marine Report (Palmer *et al.,* 2018) and are interrogated within the UK Climate Risk Independent Assessment (CCRA3), Chapter 4: Infrastructure (Jaroszweski *et al.,* 2021). The climate projections contained in these reports have been used to examine future trends for wind speed, wave height and sea levels for offshore UK waters. Additional information at a regional (northern European) and global level has been taken from the IPCC Sixth Assessment Report (IPCC, 2021), where national or sub-national (i.e. central North Sea) information is not available, such as sea surface temperatures, surface pH and storm occurrence.

2.2. RESULTS

2.2.1. CURRENT BASELINE

12. Air temperatures in the central North Sea do not tend to vary beyond the range of 0°C to 19°C, with the exception of extended periods of easterly winds which can lead to extreme cold in winter and warm conditions in summer. Mean air temperatures range from lows of 1°C in January to 16°C in July (BEIS, 2022). Global air temperatures rose by 0.85°C between 1880 and 2012, and continue to rise, with each of the last four decades warmer than any decade that preceded it since 1850. Temperatures have risen more slowly over the oceans than over land (IPCC, 2021).

13. Annual precipitation across the North Sea varies between 340 mm and 500 mm, averaging 425 mm. Precipitation rates follow a seasonal trend with April to June tending to be the driest months, and October to January being wetter. Thunderstorms are infrequent, and snow showers vary from approximately ten to 12 days in the central North Sea (BEIS, 2022).

14. The prevailing winds in the central North Sea are from the south-west and the north-north-east, and tend to be stronger over the open sea than at the coast owing to the lack of shelter. South and south-easterly winds may also arise and remain for as long as several weeks if an anticyclone develops over Europe. Wind strengths in winter are typically in the range of Beaufort scale four to six (6 m/s to 11 m/s) with higher winds of force eight to 12 (17 m/s to 32 m/s) being much less frequent. Winds of force 5 (8 m/s) and greater are recorded 60% to 65% of the time in winter and 22% to 27% of the time in summer. In April and July, winds are highly variable, with a greater incidence of north-westerly winds (BEIS, 2022).

15. Within the Array, wind speeds have been recorded up to 31.5 m/s during the 1979 to 2023 period, with winds predominantly from the south-west (see volume 3, appendix 7.1). As such, the Array experiences wind conditions comparable to the surrounding area.

16. Mean Sea Level (MSL) is a crucial element of climate change related risks for offshore wind farms, as increased sea level has the potential to both increase water damage and corrosion of components above the water line at time of construction, and/or increase mooring line tension. MSL rise also has the potential to cause increased damage from storm surge. Global MSL rose by 0.2 m between 1901 and 2018, and continues to rise (IPCC, 2021). The average rate of sea level rise increased from 1.3 mm per year between 1901 and 1971, to 1.9 mm per year between 1971 and 2006, and further to 3.7 mm per year between 2006 and 2018 (IPCC, 2021). Ice sheet and glacier mass loss were the main contributors to such global MSL rise between 2006 and 2018 (IPCC, 2021).

17. Annual mean significant wave heights in the Array area range from 1.87 m to 2.05 m, with wave direction predominantly from the north and north-north-east. With regard to extreme weather events and wave heights, an easterly storm event occurred during November 2022, with maximum significant wave height of 8.96 m within the Array area (see volume 3, appendix 7.1).

2.2.2. FUTURE BASELINE

18. It is virtually certain that sea surface temperatures will continue to increase in the 21st century, with global mean sea surface temperatures predicted to increase by approximately 2.9°C by 2100 under RCP8.5. Sea temperatures in northern Europe (including the North Sea) are predicted to rise at a greater rate than the global average, with temperatures predicted to increase by approximately 3.4°C under RCP8.5 in the same time period. Marine heatwaves (periods of extreme high sea temperature, defined as temperatures warmer than the 99th percentile of mean sea temperatures for the region) are also expected to increase around Europe over the 21st century (IPCC, 2021).

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[1] RCPs specify concentrations of GHGs that will result in total radiative forcing increasing by a target amount by 2100, relative to pre-industrial levels. Total radiative forcing is the difference between the incoming and outgoing radiation at the top of the atmosphere. Radiative forcing targets for 2100 have been set at 2.6, 4.5, 6.0 and 8.5 W/m^2, and are incorporated into the names of the RCPs; RCP2.6, RCP4.5, RCP6.0 and RCP8.5. Each pathway results in a different range of global mean temperature increases over the 21st century, with a global mean surface temperature increase of 4.3°C by 2100 compared to 1880 under RCP8.5, the high emissions scenario (Met Office Hadley Centre, 2018).

19. Similarly, it is virtually certain that CO_2 uptake by the ocean surface will increase (due to increased atmospheric CO_2 concentrations), resulting in increased ocean acidification. CO_2 uptake drives changes in seawater and calcium carbonate ($CaCO_3$) chemistry, resulting in an overall decrease of ocean pH. Northern European sea surface pH is predicted to fall by 0.4 units by 2100 under RCP8.5 (IPCC, 2021).

20. The average wave height is predicted to decrease around much of the UK at a factor of about 10% to 20% over the 21st century, with average wave heights in the North Sea decreasing by approximately 0.1 m. Maximum wave heights in the central North Sea are predicted to reduce by 0.5 m, which could compensate for the rise in sea level, leaving the elevation of the annual maximum wave unaffected. However, owing to variation between different models, confidence in projected sea wave height changes is low (Jaroszweski *et al*., 2021).

21. Changes in maximum wind speeds associated with storm surges vary across UK waters, with changes in the order of +/- 1.5 m/s. There is little consensus between models regarding the extent and pattern of such winds in relation to climate change, though some models anticipate an increase in the days of strong winds over the UK by the end of the 21st century, compared to the start of the century (Palmer *et al.* 2018). As such, conservatively an increase in maximum wind speed and an increase in the number of days with strong winds should be anticipated.

22. The frequency and amplitude of storms is anticipated to slightly increase by the middle of the 21st century and beyond for northern Europe. Clustering of storms over time may also increase in many areas in Europe. However, projections of smaller scale hazardous weather have low confidence, due to the inability of climate models to accurately simulate these phenomena (IPCC, 2021).

23. Global MSL will continue to rise throughout the 21st century, a change that is projected within all future climate change scenarios. Under RCP8.5, the UK can expect to see sea level rise of approximately 1 m by 2100. This change is regionally variable, with a lesser impact anticipated in the north of the UK. The east coast of Scotland can expect to see a MSL rise of between approximately 0.5 m and 0.6 m by 2100 (Palmer *et al.* 2018), broadly comparable to an anticipated global MSL rise of approximately 0.7 m by 2100 (IPCC, 2021).

3. CLIMATE RISK AND RESILIENCE SCOPING

3.1. METHODOLOGY

24. An initial screening exercise has identified the relevant climate change risks on the Array, based on information sourced from the UK CCRA3 (Jaroszweski *et al.,* 2021).

25. Given the variability in the nature of the potential effects of climate change on the Array, receptors have been identified on a risk-specific basis, whereby all receptors relate to the continued safe and effective operation of the Array. In line with IEMA (2020) guidance, the vulnerability and susceptibility have been considered in determining the severity of risk.

26. A high level assessment of such risks has been undertaken, considering the hazard, potential severity of effect on the Array and its users, probability of that effect, and level of influence the Array design can have on the risk. The severity of effect score considers the potential consequences of the hazard and the sensitivity of the receptor(s) affected. Each element of the risk assessment has been scored on a scale of one to three, representing low, medium or high, respectively; the scores are then summed to give a combined risk score. Table 3.1 defines each of these terms. A combined risk score of five or more when considering the factors in Table 3.2 has been defined as an impact that would be a significant adverse/beneficial effect on the Array.

27. The assessment of effects has considered the designed in measures adopted as part of the Array in determining the combined risk score. As detailed above, a score of five or more is assessed as a significant effect which is presented in the 'significant effect' column. Should an effect be significant after designed in measures, secondary mitigation is presented where relevant to reduce the residual effect to negligible and not significant in EIA terms.

Table 3.1: Severity, Probability and Influence Factor Definitions (aligning with IEMA (2020) Guidance)

Factor	Score Definition
Severity: the magnitude and likely consequences of the impact should it occur.	1 = unlikely or low impact: for example, low-cost and easily repaired property damage; small changes in occupiers' behaviour.
	2 = moderate impacts with greater disruption and/or costs.
	3 = severe impact, e.g. risk to individual life or public health, widespread property damage or disruption to business.
Probability: reflects both the range of possibility of climatic parameter changes illustrated in UKCP18 projections and the probability that the possible changes would cause the impact being considered.	1 = unlikely or low probability of impact; impact would occur only at the extremes of possible change illustrated in climate projections.
	2 = moderate probability of impact, plausible in the central range of possible change illustrated in climate projections.
	3 = high probability of impact, likely even with the smaller changes illustrated as possible in the climate projections.
Influence: the degree to which design of the proposed development can affect the severity or probability of impacts.	1 = no or minimal potential to influence, outside control of developer, e.g. reliance on national measures or individuals' attitudes/actions; or hypothetical measures would be impracticable.
	2 = moderate potential to influence, e.g. a mixture of design and user behaviour or local and national factors; measures may have higher costs or practicability challenges.
	3 = strong potential to influence through measures that are within the control of the developer and straightforward to implement.

28. Table 3.2 shows the climate change risks to the Array that have been identified and the risk scores assigned, following the approach set out in Table 3.1. Designed in measures have been identified as necessary to accordingly reduce the risk to an acceptable level and mitigate a potential significant effect.

3.2. CLIMATE CHANGE RISK ASSESSMENT

29. The climate change risks to the Array that have been identified and assessed are presented in Table 3.2. These risks relate to consistently heightened air and sea surface temperatures, MSL rise, changes to rainfall patterns, increased wind speeds, increased wave heights and increased frequency and severity of extreme events such as storms. Designed in measures are identified for each risk.

30. Considering the designed in measures within Table 3.2, the potential risk posed to the Array would be reduced to negligible (non-significant level) in EIA terms.

Table 3.2: Risk Scores for the Array

Risk	Potential Consequence	Measures Adopted as Part of the Array	Severity	Probability	Influence	Total	Significance After Mitigation
Operation and Maintenance							
Increases in average and extreme air temperatures, both in winter and summer	• Heating/overheating of turbine mechanisms may result in failure of electrical equipment and gear boxes. • Heating/overheating may inhibit power infrastructure performance and export. • Consistently heightened temperatures could lead to efficiency losses due to overheating, or the failure of electrical equipment within the offshore substations.	• Safety margin within the turbine design to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast during storms. • The OSP electrical plant will be located within an internal structure. Appropriate cooling plant will be designed to account for a range of temperature conditions.	1	1	2	4	Negligible (not significant)
Increases in sea surface temperatures and ocean acidification	• Increased temperatures and ocean acidification may lead to accelerated corrosion of submerged structures, including inter-array and inter-connector cables, OSP foundations and wind turbine floating platforms, mooring cables and anchors.	• Application of anti-corrosion protective coatings.	1	1	2	4	Negligible (not significant)
Changes to rainfall patterns, leading to increased annual precipitation	• Increased wear and tear resulting in erosion and degradation of blade surfaces, increased drag and thereby decreased energy production. • Increased wear and tear resulting in erosion and degradation of the OSPs, increasing repair and maintenance requirements.	• Regular inspections to be carried out to assess turbine condition, where conditions allow. • Use of durable materials within the OSP structures.	1	2	1	4	Negligible (not significant)
Increased frequency and intensity of extreme weather i.e. storms	• More frequent and higher loads on turbine platforms, mooring lines and anchors and OSP foundations and platforms causing structural damage from storm waves. • Increased wear and tear of mechanical systems from high wind speeds. • Increased loading from ice build-up. • Increased wear and tear resulting in erosion and degradation of the OSP. • Reduced accessibility for maintenance and inspection due to worse weather conditions.	• Turbines to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast during storms. • Application of anti-corrosion protective coatings. • Application of appropriate design standards for structural safety of offshore wind in the North Sea. • Existing appropriate standards for safety. Modelling suggests negligible change in accessibility (Jaroszweski *et al.,* 2021).	1	2	1	4	Negligible (not significant)
Increased wind speeds and changes to wind patterns	• Increased wear and tear of mechanical systems from high wind speeds. • Increased wear and tear resulting in erosion and degradation of the OSPs. • Increased occurrence of wind speeds beyond the cut-off point of the turbines leading to a more frequent shut down of turbines	• Application of appropriate design standards for structural safety of offshore wind in the North Sea. • Regular inspections to be carried out to assess turbine condition, where conditions allow. • Turbines to be fitted with automatic shutdowns/lockdowns with regards to spinning too fast from storms. • Use of durable materials within the OSP structures.	1	2	1	4	Negligible (not significant)
Increase in mean sea level	• Damage to OSP platforms and foundations owing to increased water damage and corrosion. • Exceedance of mooring line length and/or increased mooring line tension causing damage to mooring lines. • Additional loading on the turbine and OSP structures, resulting in structural stress and additional corrosion.	• Application of anti-corrosion protective coatings, accounting for MSL rise. • Application of appropriate design standards for structural safety of offshore wind in the North Sea with allowance for increased MSL.	1	2	1	4	Negligible (not significant)
Increased wave height	• Degradation of wind turbine and OSP structures and foundations/mooring and anchors due to additional loading. • Degradation to wind turbine floating platform, mooring lines and anchors, OSP foundations, and interconnector and inter-array cabling due to scour from sediment transfer. Failure at cable joints may also result.	• Floating design means risk of wear to floating platform and turbines is reduced relative to bottom fixed offshore wind farm design. • Regular inspection of offshore structures for any weaknesses or potential failure points. • Integrated scour protection. • Application of appropriate design standards for structural safety of offshore wind in the North Sea.	1	1	2	4	Negligible (not significant)
Changes in the tidal range	• Degradation to wind turbine mooring lines and anchors, OSP foundations, and undersea cabling due to scour from sediment transfer. Failure at cable joints may also result.	• Integrated scour protection and regular inspection for condition of scour protection.	1	1	2	4	Negligible (not significant)

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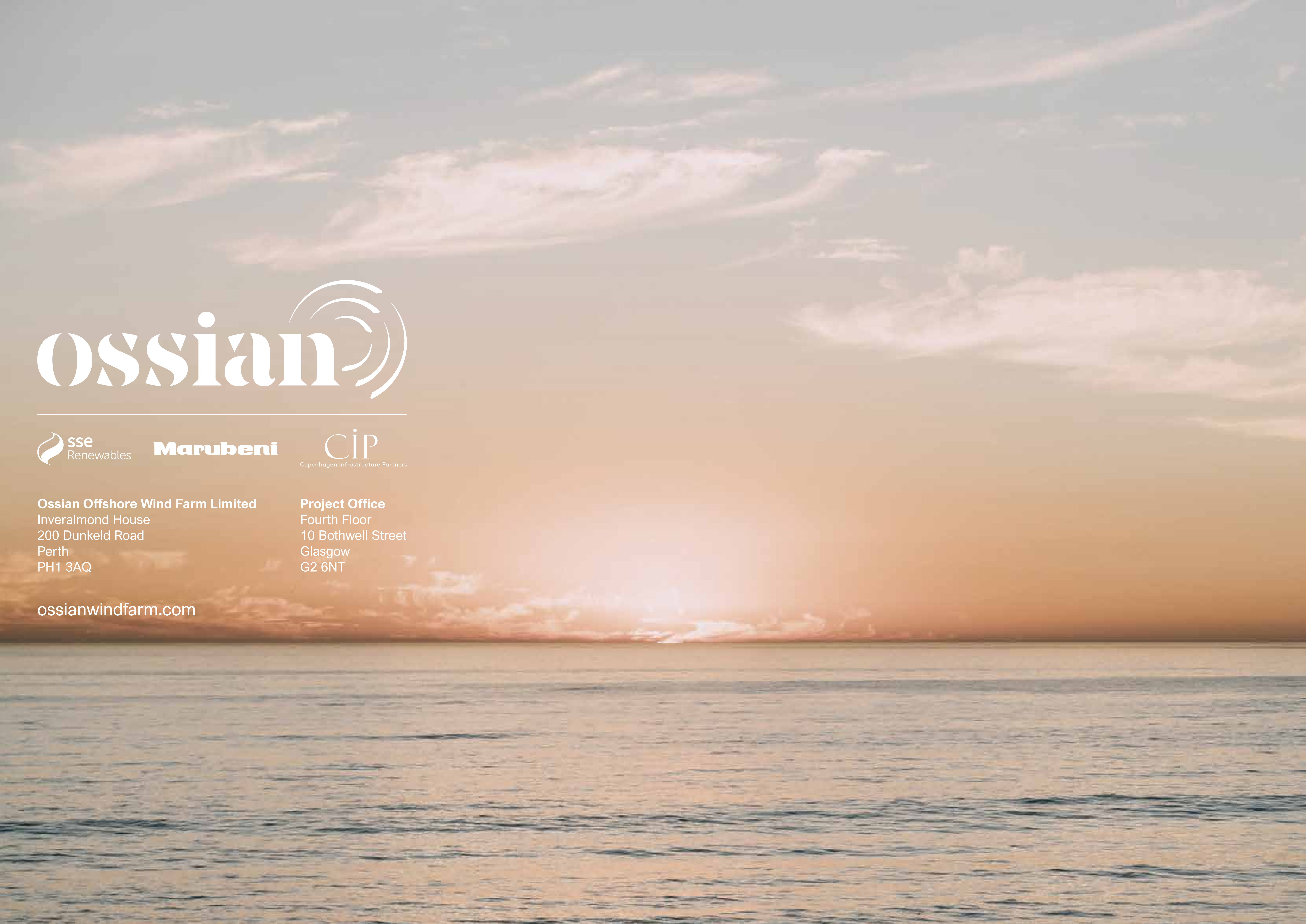

ossian

sse Renewables

Marubeni

CIP
Copenhagen Infrastructure Partners

Ossian Offshore Wind Farm Limited
Inveralmond House
200 Dunkeld Road
Perth
PH1 3AQ

Project Office
Fourth Floor
10 Bothwell Street
Glasgow
G2 6NT

ossianwindfarm.com