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Volume 7B Proposed Development (Offshore) Appendices

Appendix 12-6 Visibility Frequency and Range

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Acronyms and Abbreviations

EIAR	Environmental Impact Assessment Report
GLVIA3	Guidelines for Landscape and Visual Impact Assessment, Third Edition
SLVIA	Seascape, Landscape and Visual Impact Assessment
WTG	Wind Turbine Generator
ZTV	Zone of Theoretical Visibility

1 Introduction

1.1.1.1 This appendix of the Environmental Impact Assessment Report (EIAR) sets out the considerations used to assess visibility frequency and range, of relevance to the Seascape, Landscape and Visual Impacts Assessment (SLVIA) of the Proposed Development (Offshore), as set out in the following EIAR chapters:

- Volume 2, The Proposed Development (Offshore), Chapter 12: Seascape, Landscape and Visual Impacts Assessment;
- Volume 3, Caledonia North, Chapter 12: Seascape, Landscape and Visual Impacts Assessment; and
- Volume 4, Caledonia South, Chapter 12: Seascape, Landscape and Visual Impacts Assessment.

1.1.1.2 This information is displayed in relation to the Zone of Theoretical Visibility (ZTV) analysis in Volumes 7B, 7C and 7D, Appendix 12-2: Seascape, Landscape and Visual Impacts Assessment Figures (Figure 12-12).

2 Frequency and Likelihood of Visual Effects – Weather Conditions

2.1.1.1 The judgements made in the SLVIA are based on optimum ‘very good’ to ‘excellent’ visibility of the offshore elements of Proposed Development (Offshore). Visibility is categorised in the SLVIA in accordance with Met Office (2024¹) definitions as follows:

- Very Poor: <1km;
- Poor: 1–4km;
- Medium: 4–10km;
- Good: 10–20km;
- Very Good: 20–40km; and
- Excellent: >40km.

2.1.1.2 This assumption is assessed as the worst-case scenario in the SLVIA, but in reality, the degree and extent of visual effects arising from the offshore elements of the Proposed Development (Offshore) will be influenced by the prevailing weather and visibility conditions. Viewing conditions and visibility have been found, during field work, to vary in the study area. The varied clarity or otherwise of the atmosphere will reduce the number of days upon which views of the Proposed Development (Offshore) will be available from the coastline and hinterland, and is likely to inhibit clear views, rendering the Wind Turbine Generators (WTGs) more visually recessive within the wider seascape. The effects of the Proposed Development (Offshore) will vary according to the weather and prevailing visibility. This means that effects that are assessed to be significant in the SLVIA under very good or excellent visibility conditions, may be not significant under moderate, poor or very poor visibility conditions.

2.1.1.3 Understanding the frequency of visibility assists in defining the characteristics of the potential impact and is one of the matters that are considered when assessing whether an effect is significant or not using professional judgement. This accords with the factors identified in Schedule 3, Paragraph 3 of the screening paragraphs of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (2017²).

2.1.1.4 A description of visibility frequency is provided in the SLVIA, using Meteorological Terminal Air Report visibility data from the nearest Met Office station that records visibility. Information for the Highland and Orkney receptors information is derived from the Wick Airport station data and is provided for Aberdeenshire and Moray receptors based on data from the Lossiemouth station. This is used to highlight potential trends in the visibility conditions of the study area. Both Landscape Institute with the Institute of Environmental Management and Assessment (2013³) Guidelines for Landscape and Visual Impact Assessment, Third Edition

(GLVIA3) (8.15) and Scottish Natural Heritage (2017⁴; paragraph 39)ⁱ guidance refer to use of this Met Office visibility data to assess typical visibility conditions within an area.

- 2.1.1.5 Visibility sensors measure the meteorological optical range which is defined as the length of atmosphere over which a beam of light travels before its luminous flux is reduced to 5% of its original value. The use of light within the visible spectrum allows the sensor to simulate human perception of visibility most accurately. Reasonably accurate measurements are possible over a range of visibility extending from a few tens of metres to a few tens of kilometres.
- 2.1.1.6 Although there are limitations to how this data can be applied to judgements about wind farm visibility, the 'visibility' data provides some understanding and evidence basis for evaluating the actual visibility of the wind turbines against their background.
- 2.1.1.7 The maximum optical range of visibility was measured every hour over a ten-year period (Jan 2014 to December 2023) at both stations. Charts illustrating the percentage of the frequency of maximum optical range that occurs at different ranges are presented in Table 2-1 for Wick Airport station and Table 2-2 for Lossiemouth station.
- 2.1.1.8 Given that the sensor picks up the maximum distance over a 360-degree swept arc it is likely that the longest distances are picked up over the landward part of the arc where the relative humidity is lower, rather than out to sea. The data is therefore likely to overestimate the range of visibility in a seaward direction due to its generally higher relative humidity.
- 2.1.1.9 It is notable from the data that Excellent visibility conditions (i.e., over 40km range) at Wick Airport are recorded much less frequently than they are at Lossiemouth. It is also reasonable to conclude that the closer WTGs within the Array Area will be visible more frequently than those further away.
- 2.1.1.10 Whilst this 'visibility' analysis is a useful indicator, other factors such as contrast (largely influenced by lighting by the sun) scale, orientation, visual acuity, and movement of the structures also need to be considered when determining the likely impact of optimum visibility at a certain range.

ⁱ In 2020, Scottish Natural Heritage was re-branded as NatureScot; however, its legal persona and statutory functions has remained unchanged.

Table 2-1: Visibility Frequency at Wick Airport.

Visibility (km)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ALL OBS	Visibility Range	Visibility Definition	Visibility over 10 years (%)
0.00 => 0.99	0.32	0.27	0.39	2.38	3.26	3.04	4.66	2.50	2.92	0.69	0.43	0.15	1.76	< 1km	Very Poor	1.40
1.00 => 1.99	0.30	0.23	0.33	0.59	1.18	1.20	1.44	0.98	0.79	0.47	0.30	0.36	0.69	1 - 4km	Poor	2.66
2.00 => 2.99	0.42	0.52	0.42	0.61	0.89	0.98	1.28	1.13	1.15	0.97	0.94	0.61	0.83			
3.00 => 3.99	0.86	0.74	0.86	1.03	1.23	1.33	1.65	1.36	1.47	1.19	1.43	0.53	1.14			
4.00 => 4.99	0.97	0.71	1.06	1.17	1.61	1.27	1.65	1.39	1.96	1.48	1.46	0.99	1.32	4 - 10km	Moderate	9.74
5.00 => 5.99	1.04	0.89	1.03	1.38	1.49	1.37	1.44	1.57	1.93	1.39	1.82	0.73	1.34			
6.00 => 6.99	1.19	1.06	1.55	2.29	1.82	1.58	1.33	1.49	2.38	1.79	2.31	1.08	1.65			
7.00 => 7.99	1.40	1.03	1.45	2.72	1.80	1.63	1.68	1.50	2.30	1.99	2.26	1.04	1.73			
8.00 => 8.99	1.77	1.29	2.01	2.60	1.86	1.84	1.62	1.62	2.04	1.83	2.02	1.28	1.81			
9.00 => 9.99	1.67	1.68	2.26	2.29	2.05	1.67	1.77	1.58	2.07	1.62	2.28	1.84	1.89	10 - 20km	Good	20.75
10.00 => 10.99	1.69	1.95	2.26	2.89	2.31	2.03	1.68	1.57	1.70	1.87	2.05	1.73	1.96			
11.00 => 11.99	1.58	2.13	2.14	2.57	2.21	1.72	1.65	1.44	1.81	1.69	1.93	1.38	1.84			
12.00 => 12.99	1.81	2.11	2.07	2.66	2.38	1.96	1.84	1.66	1.52	1.91	1.73	1.89	1.95			
13.00 => 13.99	1.96	1.92	1.77	2.32	2.31	2.13	1.70	1.51	1.93	1.88	2.06	1.65	1.92			
14.00 => 14.99	2.31	2.18	2.13	2.13	2.31	2.38	1.75	1.32	1.84	2.05	1.96	1.88	2.01			
15.00 => 15.99	2.42	2.48	2.49	2.53	2.54	2.33	1.68	1.43	1.81	2.11	1.89	1.82	2.11			
16.00 => 16.99	2.24	2.66	2.05	2.74	2.18	2.70	1.63	1.87	1.53	2.27	1.76	1.80	2.11			
17.00 => 17.99	2.39	2.29	2.67	2.33	2.35	2.40	1.76	1.75	1.81	2.06	1.64	2.07	2.12			
18.00 => 18.99	2.40	2.74	3.05	2.91	2.51	2.14	1.90	1.53	1.74	2.12	1.84	2.43	2.26			
19.00 => 19.99	2.59	3.05	3.64	3.06	2.54	2.40	1.68	1.73	2.36	2.40	1.93	2.32	2.46	20 - 40km	Very Good	47.48
20.00 => 20.99	3.25	3.14	3.22	3.00	2.35	2.56	1.87	1.83	2.36	1.98	2.10	2.34	2.49			
21.00 => 21.99	2.78	3.97	3.26	2.81	2.21	2.35	2.36	2.13	2.41	2.29	2.28	2.78	2.62			
22.00 => 22.99	3.06	3.81	4.11	3.17	2.48	3.03	2.29	1.99	2.10	2.83	2.36	2.55	2.79			
23.00 => 23.99	2.96	3.93	4.09	3.33	2.75	3.25	2.43	2.39	2.46	2.81	2.18	3.02	2.95			
24.00 => 24.99	3.01	3.93	3.44	2.88	2.47	2.84	2.49	2.86	2.88	2.74	2.36	2.79	2.88			
25.00 => 25.99	2.98	4.24	3.86	2.71	2.64	3.00	2.65	2.53	2.71	2.99	2.38	2.90	2.95			
26.00 => 26.99	2.91	3.89	2.66	2.60	2.48	3.31	2.75	3.08	2.78	2.49	2.48	3.59	2.92			
27.00 => 27.99	2.98	2.93	2.73	2.52	2.80	2.80	2.81	2.72	2.99	3.02	2.80	3.67	2.90			
28.00 => 28.99	2.67	2.48	2.73	2.53	2.71	2.72	2.61	3.04	3.03	2.30	2.54	3.23	2.72			
29.00 => 29.99	2.51	2.60	2.93	2.67	2.22	2.94	2.67	3.36	2.78	2.98	2.65	3.25	2.80			
30.00 => 34.99	10.07	10.46	9.92	9.78	11.56	11.94	14.17	14.24	9.99	11.22	11.57	11.64	11.41	40km >	Excellent	17.60
35.00 => 39.99	6.75	5.82	6.67	6.89	8.17	7.89	10.18	9.74	8.39	9.60	8.78	7.25	8.05			
40.00 => 44.99	5.69	4.71	4.65	4.77	5.81	5.25	6.69	7.28	7.11	6.93	6.89	6.13	6.03			
45.00 => 49.99	7.52	5.93	5.15	3.78	4.71	4.82	4.82	6.88	6.38	6.65	6.69	7.29	5.92			
50.00 => 59.99	9.54	6.22	4.94	3.36	3.84	3.19	3.44	4.83	4.45	5.29	7.16	9.56	5.52			
60.00 => 69.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.08	0.10	0.69	0.34	0.11			
>= 70.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.06	0.11	0.02			
ALL OBS	100	100	100	100	100	100	100	100	100	100	100	100	100			

Table 2-2: Visibility Frequency at Lossiemouth.

Visibility (km)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ALL OBS	Visibility Range	Visibility Definition	Visibility over 10 years (%)
0.00 => 0.99	0.28	0.21	0.50	0.90	1.05	0.91	1.04	0.69	1.45	0.43	0.86	0.71	0.75	< 1km	Very Poor	1.40
1.00 => 1.99	0.13	0.19	0.19	0.43	0.54	0.68	0.66	0.62	0.71	0.35	0.31	0.18	0.42	1 - 4km	Poor	1.68
2.00 => 2.99	0.24	0.22	0.43	0.42	0.58	0.92	0.50	0.44	0.74	0.76	0.42	0.32	0.50			
3.00 => 3.99	0.47	0.37	0.69	0.71	0.70	1.11	0.89	0.50	1.17	1.18	0.79	0.58	0.76			
4.00 => 4.99	0.63	0.75	1.10	1.10	0.93	1.42	1.10	1.00	1.16	1.18	1.02	0.75	1.01	4 - 10km	Moderate	5.21
5.00 => 5.99	0.51	0.68	0.89	0.95	0.78	0.78	0.89	0.90	0.85	0.78	1.13	0.46	0.80			
6.00 => 6.99	0.77	0.74	0.70	0.93	0.74	0.89	0.94	0.73	1.21	0.80	0.93	0.59	0.83			
7.00 => 7.99	1.18	1.34	1.39	1.53	1.75	1.37	1.60	1.17	1.60	1.18	1.13	1.29	1.38			
8.00 => 8.99	0.55	0.64	0.74	1.11	0.96	0.88	0.61	0.61	0.85	0.80	0.97	0.51	0.77			
9.00 => 9.99	0.42	0.18	0.52	0.60	0.49	0.50	0.20	0.27	0.56	0.45	0.63	0.34	0.43			
10.00 => 10.99	1.13	0.89	1.60	1.74	1.20	1.32	1.10	1.04	0.95	1.51	1.42	0.90	1.23			
11.00 => 11.99	0.05	0.03	0.24	0.24	0.12	0.32	0.27	0.22	0.33	0.27	0.33	0.20	0.22	10 - 20km	Good	7.84
12.00 => 12.99	1.40	1.09	1.57	1.82	1.62	1.57	1.10	1.04	1.39	1.30	1.42	1.08	1.37			
13.00 => 13.99	0.15	0.15	0.19	0.21	0.12	0.13	0.22	0.20	0.31	0.47	0.28	0.20	0.22			
14.00 => 14.99	0.13	0.09	0.44	0.25	0.18	0.31	0.23	0.17	0.31	0.34	0.29	0.18	0.24			
15.00 => 15.99	3.37	3.03	3.83	3.99	4.08	3.07	2.46	2.29	2.73	2.43	3.27	2.79	3.11			
16.00 => 16.99	0.16	0.28	0.22	0.24	0.32	0.42	0.18	0.19	0.32	0.34	0.28	0.36	0.27			
17.00 => 17.99	0.27	0.16	0.19	0.56	0.36	0.31	0.30	0.24	0.33	0.36	0.31	0.38	0.31			
18.00 => 18.99	0.58	0.52	0.58	0.74	0.62	1.03	0.54	0.34	0.54	0.61	0.56	0.53	0.60			
19.00 => 19.99	0.27	0.30	0.17	0.21	0.27	0.24	0.27	0.22	0.24	0.31	0.29	0.35	0.26			
20.00 => 20.99	5.70	4.54	4.83	6.15	5.74	4.36	3.45	3.89	2.92	3.58	4.67	3.89	4.48			
21.00 => 21.99	0.31	0.43	0.16	0.25	0.35	0.26	0.26	0.30	0.45	0.45	0.40	0.48	0.34	20 - 40km	Very Good	39.19
22.00 => 22.99	0.44	0.58	0.39	0.58	1.10	0.50	0.30	0.43	0.65	0.68	0.49	0.58	0.56			
23.00 => 23.99	0.43	0.46	0.20	0.26	0.40	0.32	0.24	0.40	0.47	0.57	0.39	0.51	0.39			
24.00 => 24.99	0.42	0.55	0.27	0.25	0.51	0.38	0.19	0.44	0.49	0.47	0.47	0.73	0.43			
25.00 => 25.99	6.30	6.53	6.00	6.87	7.53	5.80	4.42	5.37	4.19	5.78	5.83	5.70	5.86			
26.00 => 26.99	0.48	0.47	0.40	0.36	0.49	0.36	0.40	0.35	0.53	0.66	0.65	1.00	0.51			
27.00 => 27.99	0.52	0.49	0.36	0.32	0.43	0.31	0.39	0.39	0.58	0.46	0.61	1.02	0.49			
28.00 => 28.99	0.55	0.44	0.39	0.33	0.49	0.70	0.35	0.46	0.72	0.72	0.58	1.00	0.56			
29.00 => 29.99	0.26	0.50	0.42	0.33	0.51	0.38	0.35	0.38	0.53	0.61	0.70	0.82	0.48			
30.00 => 34.99	17.63	19.44	16.96	15.84	15.62	13.06	12.82	14.95	15.09	17.48	19.52	18.73	16.41			
35.00 => 39.99	10.24	10.46	7.96	8.22	6.66	7.43	7.35	7.44	8.92	10.16	9.60	9.82	8.68			
40.00 => 44.99	19.58	18.47	18.90	16.09	15.51	16.75	17.29	15.91	16.02	17.09	16.59	19.74	17.33	40km >	Excellent	45.32
45.00 => 49.99	3.80	3.69	4.21	3.80	3.19	5.18	5.85	5.52	4.93	4.39	3.83	4.54	4.42			
50.00 => 59.99	12.59	13.08	13.65	12.46	13.18	15.38	17.58	17.54	15.43	12.43	11.93	12.46	13.99			
60.00 => 69.99	5.59	5.05	6.01	6.28	7.21	6.70	8.26	8.56	5.89	5.74	4.83	4.46	6.23			
>= 70.00	2.43	2.96	2.70	2.95	3.68	3.96	5.41	4.82	4.45	2.89	2.28	1.82	3.37			
ALL OBS	100	100	100	100	100	100	100	100	100	100	100	100	100			

3 Offshore Wind Turbine Visibility

3.1.1.1 The Best Practice Guidance (University of Newcastle, 2002⁵) provides further detail on how human perception is also a factor in how a wind farm will be seen. Importantly it states at paragraph 3.4.5 that:

"People perceive size, shape, depth and distance by using many cues, so that context is critically important. When people see partial or incomplete objects, they may mentally "fill in" the missing information, so that partial views of turbines may have less effect than imagined. Although people may be able to physically "see" an object, inattentional "blindness" caused by sensory overload, or a lack of contrast or conspicuousness, can mean they fail to "perceive" the object. In a contrary way, large size, movement, brightness and contrast, as well as new, unusual or unexpected features, can draw attention to an object. In all these effects, issues such as experience, familiarity and memory may have an important role to play. Therefore, perception depends on experience, the visual field, attention, background, contrast and expectation, and may be enhanced or suppressed".

3.1.1.2 Two further factors of depth perception and size constancy are also discussed as being fundamental to perception and the following conclusions drawn (University of Newcastle, 2002⁵; paragraph 3.4.8):

"...that the magnitude or size of windfarm elements, and the distance between them and the viewer, are basic physical measures that affect visibility, but the real issue is human perception of visual effects, and that is not simply a function of size or distance".

3.1.1.3 Other factors of relevance to the understanding of the seascape, landscape and visual effect of the Proposed Development (Offshore) include (University of Newcastle, 2002⁵):

- Lighting – It was observed that direct light shining on the turbines has the effect of increasing the prominence of the structures and this effect operated over a wide middle-distance range. Viewpoints to the south of a wind farm (in the arc from east through south to west) were said to experience this effect whereas back-lit effects occurred at viewpoints to the north (in the arc from east through north to west). It was also noted that (paragraph 5.2.8):

"The seasonal effects of light (linked with weather and cloud cover) should be considered in relation to human receptors. For residents, year-round conditions are relevant. For tourists and other recreationists, winter conditions will affect fewest people and summer conditions will affect most".

- Movement and Orientation – It was found that the movement of the blades, in all cases where this was visible, increased the visual effect of the turbines because it tended to draw the eye. Movement was more

perceptible when back-dropped against dark vegetation compared to grey sky. In addition, due to the fact that the prevailing wind in the UK is generally from the south-west, viewpoints in the quadrants from south through south-west to west, and from north through north-east to east, experience the longest periods of exposure to visible movement. It was also judged that rotors seen in the plane oriented at 180 degrees to the viewpoint appear relatively nearer.

- Distance, Colour and Contrast - At short distances the study found that colour is clearly seen and colour and light do not have a dramatic modifying effect on visibility, except in extreme overcast conditions or at dawn or dusk. As distance increases, the eye cannot distinguish colour and all structures are seen as grey. Light coloured (lit) turbines appeared closer than grey (unlit) turbines at similar distances, noting the following (paragraph 5.2.12):

“Seen against a blue or pale sky, but not sunlit, grey turbines appear dark. As the sky darkens, because of cloud cover or time of day or season, the contrast between sky and turbines decreases and at long distances (e.g. over approximately 10 km) the turbines may become indistinct because of this. Turbines can appear white against a dark sky if they are lit by sun through patches of cloud”.

- Landscape character and receptors - The character of the landscape and especially elements within it was found to affect perceptions of magnitude. In landscapes that were free of man-made elements the turbines were sometimes much more conspicuous in the middle and long-distance ranges and this affected the author’s judgements of their magnitude.

3.1.1.4 These factors have been considerations when undertaking the assessment of the magnitude of change for the Proposed Development (Offshore), bearing in mind the impact relates to a worst-case scenario and excellent visibility conditions.

4 References

¹ Met Office (2024) 'Definitions of codes'. Available at:

<https://www.metoffice.gov.uk/services/data/datapoint/code-definitions> (Accessed 15/10/2024)

² Scottish Government (2017) 'The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017'. Available at:

<https://www.legislation.gov.uk/ssi/2017/101/contents> (Accessed 15/10/2024)

³ Landscape Institute and Institute of Environmental Management and Assessment (IEMA) (2013) 'Guidelines for Landscape and Visual Impact Assessment: Third Edition (GLVIA3)'

⁴ Scottish Natural Heritage (2017) 'Visual Representation of Wind farms, Guidance (Version 2.2)'. Available at: <https://www.nature.scot/sites/default/files/2019-09/Guidance%20-%20Visual%20representation%20of%20wind%20farms%20-%20Feb%202017.pdf> (Accessed 15/10/2024)

⁵ University of Newcastle (2002) 'Visual Assessment of Windfarms Best Practice'. Scottish Natural Heritage Commissioned Report F01AA303A. Available at:

<https://typeset.io/pdf/visual-assessment-of-windfarms-best-practice-2n74nzs83f.pdf> (Accessed 15/10/2024)

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