Environmental Impact Assessment Report

Beinneun 2 Wind Farm

Volume 3

Technical Appendix A14.1: Aviation Lighting Proposal

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Contents

1 INTRODUCTION

Beinneun 2 Ltd is proposing a 19 turbine wind farm, Beinneun 2 Wind Farm (The Development), situated approximately 5.4 kilometres (km) northwest of Invergarry, and approximately 11.3 km southwest of Fort Augustus (the Site).

From a civilian aviation perspective, the Development is located in Class G airspace designated by the CAA as open-unrestricted airspace.

From a military aviation perspective, the turbines will be located in Low Flying Area (LFA) 14T, which supports training for RAF bases such as RAF Lossiemouth and RAF Kinloss, and includes live operations at ranges like Tain. This means that military aircraft may conduct low-level flights nearby within this designation. Operations may occur at altitudes as low as 250 ft above ground level for fixed-wing aircraft and 500 ft above ground level for helicopters. In the hours of darkness (evening civil twilight to morning civil twilight) this area converts to Night Allocated Region (NAR) 1BE. Although primarily a fast jet training area, the airspace is also used by MOD and NATO tactical transport aircraft and helicopters for day and night training. The MOD were consulted on the proposals at EIA Scoping stage and did not respond.

In addition, this area will be frequented by CSAR, Police, HEMs and Air Ambulance helicopters by day and night. This type of activity will dictate that the site will require both visible red and infra-red obstruction lighting on its turbines.

2 THE BEINNEUN 2 WIND FARM SITE

The Development includes 19 turbines as detailed below in Table 1, and shown in Figure 1.

Table 1: Development Turbines

Turbine No.	Easting	Northing	Maximum Turbine Tip Height (m)	Base Elevation (m) AOD
T1	220661	806534	200	399
T2	220767	805955	200	450
T3	220182	805374	200	479
T4	220196	804821	200	492
T5	220633	804335	200	448
T6	221378	804594	200	412
T7	222090	804595	200	409
T8	222736	804789	200	414
T9	222945	804299	200	352
T10	223449	805199	200	438
T11	224176	805530	200	458
T12	224483	805104	200	407
T13	224850	805801	200	478
T14	225412	805717	200	457
T15	225764	805397	200	389
T16	225607	806484	200	512
T17	226228	806492	200	490
T18	226530	806045	200	461
T19	226436	805411	200	399

3 STARTING ASSUMPTIONS AND LIGHTING CRITERIA

- The Beinneun 2 Wind Farm will be assessed in Class G 'en route' airspace concerning visible obstruction lighting.
- Local airspace constraints are considered for their potential impact on the Development.
- Anticipated CAA and MOD dispensations are also taken into account.
- The visible lighting design aligns with the draft CAA CAP 764 guidance[1].
- To meet MOD requirements and accommodate low-level night operators, the site is assessed for Night Vision Equipment (NVE)-compatible lighting in line with MOD obstruction lighting standards.
- Where feasible, lighting configurations are optimised to reduce visual impact on the surrounding environment.
- The proposal comprises 19 turbines, each with a maximum tip height of 200 metres.

4 CAA-ANO RED 2000/200CD LIGHTING

CAA guidance requires that:

- All perimeter turbines must be lit unless the resulting gap between lit turbines is less than 900 m (subject to extension upon CAA application).
- Any turbine within 200 m of the perimeter should be lit unless the spacing between adjacent turbines is less than 900 m (also negotiable with the CAA).
- No unlit turbine should exceed a 10° upslope from an adjacent lit turbine.

Under these criteria, and excluding potential dispensations, 17 turbines at the Development will require visible ANO red lighting as shown in Figure 2.

5 CAA-ANO RED 2000/200CD LIGHTING – REDUCED AND BALANCED OPTION

Military operators have flown low-level night sorties using night vision equipment for decades. Increasingly, civilian operators (e.g., Air Ambulance, Coast Guard, Helicopter Emergency Medical Services, and Police) also operate at night using such equipment.

Previously, night flights without Night Vision Equipment were conducted only under pre-planned and pre-flown routes. Today, most non-Night Vision Equipment equipped aircraft fly at or above safety altitudes unless under Air Traffic Control.

Depending on the operation phase, aircraft fly at safety altitudes of 1000 ft (300 m), 1500 ft (450 m), or 2000 ft (600 m) above local terrain—covering turbine tip heights. At these altitudes, lighting only needs to define the wind farm's shape and extent.

Therefore, the Development turbine layout could be delineated using visible red lighting on turbines T1, T3, T4, T5, T9, T16, T17, T18, and T19, forming a clear perimeter outline.

6 MOD IR LIGHTING

MOD requirements include:

- All perimeter turbines must be lit unless lighting gaps are less than 500 m where the Development can be considered a "small site".
- Any turbine that is prominent due to its location or height must be lit.

The Development does not meet the MOD's "small site" exemption criteria, which would allow non-perimeter central turbines to remain unlit. As the Development site exceeds the size threshold, all turbines must be fitted with IR lighting, totalling 19 hub-mounted IR lights.

[1] UK Civil Aviation Authority (CAA). (2024). *Draft CAP 764: Policy and Guidelines on Wind Turbines* (Ed. 7). [online] Available at: https://consultations.caa.co.uk/policy-development/proposed-revision-to-cap-764-caa-policy-and-guidel/supporting_documents/Draft%20CAP764%20Ed7%20Red%20Underline.pdf [Accessed 24 Jun 2025].

7 COMBINED CAA ANO AND MOD IR LIGHTING PROPOSAL FOR BEINNEUN 2

As detailed in Sections 5 and 6 above, the Development will require lighting on specific turbines. Although all turbines will require MOD IR lighting, only seven of the 19 turbines are proposed to have CAA-ANO Red 2000/200CD lighting. This is detailed in table 2 below.

Table 2: Proposed Lighting Proposal for Beinneun 2 Wind Farm

Turbine No.	Easting	Northing	Maximum Turbine Tip Height (m)	Base Elevation (m) AOD	CAA ANO	MOD IR
T1	220661	806534	200	399	2000/200cd	600mW/sr
T2	220767	805955	200	450		600mW/sr
T3	220182	805374	200	479	2000/200cd	600mW/sr
T4	220196	804821	200	492	2000/200cd	600mW/sr
T5	220633	804335	200	448	2000/200cd	600mW/sr
T6	221378	804594	200	412		600mW/sr
T7	222090	804595	200	409		600mW/sr
T8	222736	804789	200	414		600mW/sr
T9	222945	804299	200	352	2000/200cd	600mW/sr
T10	223449	805199	200	438		600mW/sr
T11	224176	805530	200	458		600mW/sr
T12	224483	805104	200	407		600mW/sr
T13	224850	805801	200	478		600mW/sr
T14	225412	805717	200	457		600mW/sr
T15	225764	805397	200	389		600mW/sr
T16	225607	806484	200	512	2000/200cd	600mW/sr
T17	226228	806492	200	490	2000/200cd	600mW/sr
T18	226530	806045	200	461	2000/200cd	600mW/sr
T19	226436	805411	200	399	2000/200cd	600mW/sr

Figure 3 shows the lighting arrangement when accounting for the proposed CAA ANO and MOD IR lighting scheme.

8 LIGHT SPECIFICATIONS

8.1 MEDIUM TO LOW INTENSITY HUB MOUNTED LIGHTS

The ANO 2000/200cd Lights will conform to the ICAO specification as set-out in Annex 14 to the Convention on International Civil Aviation: Aerodromes – Volume I: Aerodrome Design and Operations (and as shown below in Plate 1 and Plate 2)[2]. The lights will also be controlled such that when the met visibility is greater than 5 km in all directions from all turbine hubs, the lights will be reduced to 200 cd (10% of normal power).

This reduction in power will not apply to MOD IR Lights.

[2] International Civil Aviation Organization (ICAO). (2022). *Annex 14 to the Convention on International Civil Aviation: Aerodromes – Volume I: Aerodrome Design and Operations* (9th ed.). Montreal, Canada: ICAO.

Plate 1: Excerpt Table 6-3 from ICAO Annex 14 – Aerodromes

Table 6-3. Light distribution for medium- and high-intensity obstacle lights according to benchmark intensities of Table 6-1

Benchmark intensity	Minimum requirements					Recommendations				
	Vertical elevation angle (b)			Vertical beam spread (c)		Vertical elevation angle (b)			Vertical beam spread (c)	
	0°		-1°			0°	-1°	-10°		
	Minimum average intensity (a)	Minimum intensity (a)	Minimum intensity (a)	Minimum beam spread	Intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum beam spread	Intensity (a)
200 000	200 000	150 000	75 000	3°	75 000	250 000	112 500	7 500	7°	75 000
100 000	100 000	75 000	37 500	3°	37 500	125 000	56 250	3 750	7°	37 500
20 000	20 000	15 000	7 500	3°	7 500	25 000	11 250	750	N/A	N/A
2 000	2 000	1 500	750	3°	750	2 500	1 125	75	N/A	N/A

Note.— This table does not include recommended horizontal beam spreads. 6.2.1.3 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

a) 360° horizontal. All intensities are expressed in Candela. For flashing lights, the intensity is read into effective intensity, as determined in accordance with the *Aerodrome Design Manual* (Doc 9157), Part 4.
b) Elevation vertical angles are referenced to the horizontal when the light unit is levelled.
c) Beam spread is defined as the angle between the horizontal plane and the directions for which the intensity exceeds that mentioned in the "intensity" column.

Note.— An extended beam spread may be necessary under specific configuration and justified by an aeronautical study.

Plate 2: Excerpt Table 6-2 from ICAO Annex 14 – Aerodromes

Table 6-2. Light distribution for low-intensity obstacle lights

	Minimum intensity (a)	Maximum intensity (a)	Vertical beam spread (f)	
			Minimum beam spread	Intensity
Type A	10 cd (b)	N/A	10°	5 cd
Type B	32 cd (b)	N/A	10°	16 cd
Type C	40 cd (b)	400 cd	12° (d)	20 cd
Type D	200 cd (c)	400 cd	N/A (e)	N/A

Note.— This table does not include recommended horizontal beam spreads. 6.2.1.3 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

a) 360° horizontal. For flashing lights, the intensity is read into effective intensity, as determined in accordance with the *Aerodrome Design Manual* (Doc 9157), Part 4.
b) Between 2 and 10° vertical. Elevation vertical angles are referenced to the horizontal when the light is levelled.
c) Between 2 and 20° vertical. Elevation vertical angles are referenced to the horizontal when the light is levelled.
d) Peak intensity should be located at approximately 2.5° vertical.
e) Peak intensity should be located at approximately 17° vertical.
f) Beam spread is defined as the angle between the horizontal plane and the directions for which the intensity exceeds that mentioned in the "intensity" column.

The ANO 2000/200cd lights will meet ICAO Annex 14 Table 6-3 specifications. IR Light Specifications

IR lighting will be designed in compliance with the MOD lighting specifications outlined in current guidance documentation[3]. Appendix 1: IR Lighting Specification Requirements within this guidance presents the below (shown as Plate 3).

Plate 3: IR Lighting Specifications.

	25cd Red	200cd Red	25cd or 200cd/IR Combi	IR
				7-8nm pickup range
IR wavelength			As per IR specification	**750-900nm** ideally concentrated 800- 850nm for optimum detection.
Intensity	Equal or better than 25cd.	Equal or better than 200cd.	As per visible and IR specifications.	**600mW/sr min at peak flash** **1200W/sr max** Typically a 300mW/sr steady burn LED IR light will generate 600mW/sr at peak flash.
Horizontal Pattern	**360° unrestricted**			
Vertical Pattern	25cd minimum intensity between +15 deg and level (0 deg).	200cd minimum intensity between +15 deg and level (0 deg).	As per visible and IR specifications.	600 mW/sr Min flash intensity between +30 deg and -15 deg elevation. Up to 50% reduction between +25 to +30 deg and -10 to -15 deg is acceptable.
Overspill	Upwards overspill is acceptable. Downwards overspill is to be minimised such that the red light intensity is no more than 10% of the intensity at 0 deg.			Vertical overspill is acceptable.
Flash Pattern	60 flashes per min at 100-500ms duration (ideally 250ms).			
Synchronisation	All lights to be visually synchronised across a windfarm site.			

9 TIMINGS

Both ANO and IR lights will operate from Evening Civil Twilight (ECT) to Morning Civil Twilight (MCT) according to the UK Almanac, averaging approximately 11 hours per day annually. Alternatively, lights can be activated when vertical light levels fall below 500 Lux, as measured by a Lux meter.

10 INTENSITY REDUCTION (ANO LIGHTING: 2000CD DOWN TO 200CD)

The CAA SARG Policy Statement (01/06/2017)[4] permits hub-height lighting to be reduced to 10% of peak intensity in good weather. This allows ANO lights to operate at 200 cd when meteorological visibility exceeds 5 km. The proposed lights will be programmed to reduce output to 200 cd (10% of full intensity, or Low Intensity obstacle lights as detailed above in Plate 2) when visibility exceeds 5 km from all turbine hubs.

[3] UK Ministry of Defence (MOD) (2020). *MOD Obstruction Lighting Guidance*. [online] Available at: https://www.contarnex.com/infrared-obstruction-lighting/MOD%20Obstruction%20Lighting%20Guidance%202020.pdf [Accessed 24 Jun 2025].

[4] UK Civil Aviation Authority, Safety & Airspace Regulation Group (SARG). (2017). *Policy Statement: Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150 m Above Ground Level*. [online] Available at: https://www.caa.co.uk/publication/download/16178 [Accessed 24 Jun 2025].

This intensity reduction will not apply to MOD IR lights.

11 VISIBILITY METER LOCATIONS

The CAA requires visibility to be monitored from suitable positions across the wind farm.

At the Development, installing visibility meters on turbines T1, T3, T4, T5, T9, T16, T17, T18, and T19 will satisfy this requirement.

12 MID-MAST LIGHTING

Historically, mid-mast lights provided visual cues for altitude and horizon orientation prior to widespread use of NVE. When used on a single structure, mid-mast lights offered limited reference value. However, modern turbine clusters provide sufficient visual horizon and range cues through tip and hub-mounted lighting alone.

Commercially available 32 cd mid-mast lights are often overly bright (up to 70 cd across -30° to +40° angles), producing significant environmental light pollution—often greater than hub-mounted 2000/200cd lights. Consequently, this document proposes no mid-mast lighting for the Development.

13 CONCLUSION

This Lighting Brief outlines a proposed obstruction lighting plan that prioritises both environmental sensitivity and operational safety for night low-level aviation.

Following CAP 764 draft guidance, the configuration requires only nine of 19 turbines to have ANO 2000cd visible red lights, while meeting safety and visibility requirements. This, paired with MOD IR lighting on all turbines, achieves a safe, compliant, and environmentally considerate lighting solution.

Final Configuration – all at hub height, as shown on Figure 3 and Table 2:

- **9** × ANO Visible Red 2000/200 cd lights; and
- **19** × MOD IR 600 mW/sr lights.

Beinneun 2 Wind Farm

Figure 1: Site Location

LEGEND

Site Boundary

N

Scale: 1:500,000 at A3

0 15 30 km

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Beinneun 2 Wind Farm

Figure 2: Visible ANO Red Lighting Scheme

LEGEND

- Site Boundary
- Proposed Wind Turbine
- Visible ANO Red Lighting

N

Scale: 1:25,000 at A3

0 0.75 1.5 km

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Beinneun 2 Wind Farm

Figure 3: Proposed Visible ANO Red Lighting and MOD IR Lighting

LEGEND

- Site Boundary
- Proposed Wind Turbine
- Visible ANO Red Lighting and MOD IR Lighting
- MOD IR Lighting

N

Scale: 1:25,000 at A3

0 0.75 1.5 km

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