Technical Appendix 15.5

Indicative Aviation Lighting Landscape and Visual Impact Mitigation Plan (IALLVIMP)

SCOTTISHPOWER RENEWABLES

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1. Introduction

1. This report provides an indicative plan to outline the available mitigation options to reduce potentially significant landscape and visual effects caused by the requirement for aviation lighting to be installed at the proposed Earraghail Renewable Energy Development. The measures described and proposed in this plan have been used to undertake **Chapter 7: Landscape and Visual Impact Assessment (LVIA),** aviation section of **Chapter 15: Other Issues,** and **Technical Appendix 15.3 – Earraghail Aviation Impact Assessment** of the Environmental Impact Assessment Report (EIAR). The Indicative Aviation Lighting Landscape and Visual Impact Mitigation Plan (IALLVIMP) should be read in conjunction with these assessment chapters and technical appendices.

2. It is proposed that should the Section 36 application for the Proposed Development be consented, then the measures proposed in the IALLVIMP would be used as the basis for detailed consultation with the Civil Aviation Authority (CAA) and the Scottish Ministers in order to agree the specification of a site-specific Aviation Lighting Landscape and Visual Impact Mitigation Plan (ALLVIMP). In addition to the embedded mitigation, the ALLVIMP would detail SPR's commitment to deploy an Aircraft Detection Lighting System (ADLS) and it is envisaged that the agreement and sign-off of the ALLVIMP would be controlled via a suitably worded planning condition, with condition wording suggested in **Section 2.9.**

3. All mitigation options proposed within the IALLVIMP utilise procedures or technologies that have previously been successfully deployed elsewhere to mitigate the effects of aviation lighting on landscape and visual environmental receptors.

2. Proposed Development

2.1 Proposed Development Outline

4. The Proposed Development includes up to 13 three-bladed horizontal axis wind turbines up to 180 m to blade tip, ground mounted solar arrays, Battery Energy Storage System (BESS) and associated infrastructure. The Proposed Development is located within the northern part of the Kintyre peninsula in Argyll & Bute.

5. Article 222 of the Air Navigation Order (ANO) (SI 2016/765 as amended)) requires the visible lighting of 'en-route obstacles' at or above 150 metres (m) above ground level (AGL), to assist their detection by aircraft. The CAA in its 2017 Policy Statement on lighting onshore wind turbines with a maximum tip height at or over 150m AGL modified the strict application of ANO Article 222 in this context. Applying the modified regulations to the Proposed Development at night would result in medium intensity red lights located on the nacelles, and low intensity red lights on the wind turbine towers, of all proposed wind turbines. As part of the aviation assessment, light minimisation strategies are being considered, including an aircraft detection lighting system (i.e. aviation warning lights are only activated when aircraft are detected in the vicinity of the Proposed Development by a surveillance system).

6. It should be noted that all periphery wind turbines would also include infra-red lighting on the wind turbine nacelles for the benefit of aircraft fitted with night vision devices (e.g. low flying military). Infra-red lights are not visible to the human eye.

7. The focus of this IALLVIMP is on the issues around visible lighting requirements of the Proposed Development and options and proposals to mitigate resultant effects.

2.2 Aviation Lighting Potential Landscape and Visual Effects

8. It is a function of the geographic situation of commercial wind turbines, driven by energy yield requirements and development controls maintaining separation between wind turbines and settlements, that new wind turbines are typically located in areas with low underlying levels of night-time lighting. Therefore, new wind turbines have the potential to give rise to landscape and visual effects where the wind turbines require visible lighting. This would

increasingly be the case as manufacturers withdraw wind turbine models below 150m to tip height from the market as they are not price competitive. Furthermore, as wind energy developments are commonly clustered around areas free from development constraints there is also potential for cumulative effects to arise across preferred development areas.

2.3 ICAO/CAA Regulations

9. ICAO (a UN body) sets international aviation standards (relevantly here Annex 14), the European Aviation Safety Agency (EASA) implements ICAO standards in European airspace. Within the United Kingdom (UK), the ICAO/EASA requirements for lighting wind turbines are implemented through the Air Navigation Order 2016 (ANO, SI 2016/765), see also CAP393) and CAA publication 'CAP 764: Policy and Guidelines on Wind Turbines'. The CAA has confirmed that UK policy broadly aligns with the international standards, including insofar as the point at which lights must be switched on at 'Night' rather than 'Twilight'.

10. The requirements of these standards have been discussed in detail within the Windfarm Lighting Strategy Paper (2020) produced by Cyrrus on behalf of SPR. The paper considers whether there are alternative systems that can be deployed to meet regulatory requirements and provide for safe navigation with common standards for obstruction lighting of windfarms.

11. The proposed wind turbines, at up to 180 m to blade tip, would require lighting under ANO Article 222. This requires medium intensity 'steady' red aviation lights (emitting 2,000 candela (cd)) to be fitted at nacelle level. In addition, the CAA requires low intensity steady red lights to be fitted at the intermediate level on the wind turbine tower (CAA, 2017). The intermediate 'tower' lights would be 32 cd.

12. These should be turned on at 'night'; defined as ambient lighting levels at or below 50 cd/m^2. 'Night' is defined in ANO 2016 Schedule 1, as 30 minutes after sunset until 30 minutes before sunrise. The switching on and off, of lights would be controlled by a timer, and not by photocells or similar that respond to particular light levels, thereby not incurring effects in the daytime.

13. CAA, Policy Statement: Lighting of Onshore Wind Turbine Generators in the UK with a maximum blade tip height at or in excess of 150m AGL, 2017 states that "*If the horizontal meteorological visibility in all directions from every wind turbine generator in a group is more than 5km, the intensity for the light positioned as close as practicable to the top of the fixed structure required to be fitted to any generator in the windfarm and displayed may be reduced to not less than 10% of the minimum peak intensity specified for a light of this type*" This allows the minimum intensities identified above to be dimmed to 10% of their values if meteorological conditions permit (i.e. the 2,000 cd minimum intensity may be dimmed to 200 cd, if visibility is greater than 5km, i.e. in moderate to excellent or 'clear' visibility).

14. ICAO Annex 14 Table 6.3 (see also EASA CS ADR-DSN.Q852 Table Q3) provides for reduced directional intensity of the nacelle lighting as follows, noting that the final line in the table addresses 2,000 cd red lights:

Table 15.2.1 Light Distribution for Medium and High Intensity Obstacle Lights According to Benchmark Intensities

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

15. A diagrammatic interpretation of the minimum requirements set out in ICAO Annex 14 Table 6-3 is shown in **Figure 15.5.1**. It illustrates the potential light intensity from a medium-intensity nacelle mounted aviation light, required over +3° beam spread from the horizontal (0°). It also provides illustration of the likely light intensity in poor visibility <5km (2,000 cd) and clear visibility >5km (200 cd) where CAA policy (CAA, 2017) permits dimming of the lights.

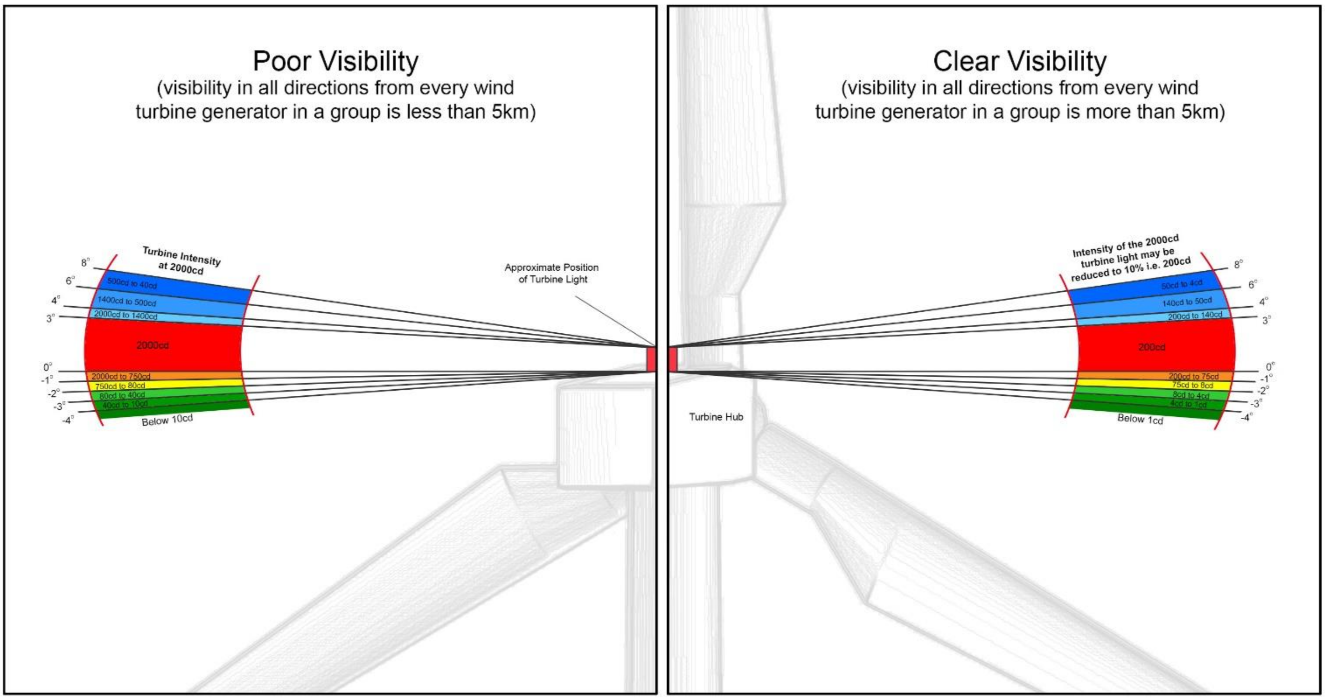

Figure 15.5.1 Diagrammatic Interpretation of Minimum Requirements of ICAO/CAP393 (LuxSolar Medium Intensity Obstruction Light).
Note: the wind turbine light is designed to emit the same light intensity horizontally in 360°.

16. **Figure 15.5.1** illustrates light intensity emission at various vertical angles, with the horizontal plane of the lights represented by 0° vertical angle. This information is in relation to a specific model of Medium Intensity Obstruction Light provided by the manufacturer. Whilst the precise model of light to be used for the Proposed Development is not known at this time, the illustration clearly demonstrates that the intensity of the aviation lights is most intense between 0° to +3° from horizontal and that the intensity of emitted light required by IACO is lower below the horizontal. The use of a model of aviation light which offers a reduced light intensity below the horizontal and above

+3° would provide inherent mitigation of the intensity of the lights for receptors viewing them from areas below the horizontal.

2.4 Basis of Aviation Lighting Assessment

17. The basis of the initial night-time landscape and visual assessment reported in **Chapter 7: LVIA** of the EIAR is that the nacelles of all 13 wind turbines would be fitted with a Medium Intensity Obstruction Light operating to the parameters described above; at night (controlled with a timer) with the light intensity reduced from 2000 cd to 200 cd during clear conditions and directional intensity, together with the required 32 cd tower lighting. The assessment found that the significant effects are likely to be experienced by:

- residents and recreational users on the on the beaches or Portavadie Resort within the western Ardlamont peninsula; and
- residents and tourists on the northern end of Arran at Lochranza / Catacol.

18. As significant effects are predicted, ScottishPower Renewables (hereafter referred to as the Applicant) has considered what mitigation options are available to reduce the magnitude of effects to a level where they would be considered to be not significant.

19. The night-time assessment has then considered what the residual landscape and visual effects would be following successful application of the proposed mitigation measures in **Section 2.8**.

2.5 Mitigation Options

20. The options for mitigation of visual effects of aviation lighting that are reasonably expected to be available for the Proposed Development are outlined in **Table 13.3.2**.

Table 13.3.2 Wind Turbine Lighting Mitigation Options

Mitigation Option	How it Works	Current Status
Reduce intensity of lights from 2,000cd to 200cd	Already provided for in CAA guidance (CAA, 2017). 2,000 cd aviation lights may be dimmed to 10% of their intensity (200 cd) where visibility conditions permit, when visibility from every wind turbine within the windfarm group is >5km. Visibility conditions are measured using a visibility sensor, which can then be dimmed automatically to respond to prevailing meteorological conditions. 2,000 cd lights will therefore only be experienced in visibility of <5km; and their intensity would be dimmed to 200 cd in visibility of >5 km.	Embedded in design development.
Directional intensity	Established in ICAO (Annex 14) guidance. This focusses the 2,000 cd lighting in the horizontal plane (+ or – a few degrees) and reduces the intensity of the light from above and from below the horizontal plane. Most current aviation light models on the market will incorporate this as standard, for example, LuxSolar Medium Intensity Obstruction Light and Obelux Medium-Intensity Red Obstruction Light.	Embedded in design development.
Aircraft detection lighting system (or 'surveillance activated')	ANO Article 222 contains provisions that allow exemption from its lighting requirements where this is agreed by the CAA. An aircraft detection lighting system causes the obstacle lights to illuminate only when an aircraft is in a defined volume of airspace around the wind turbines. The CAA is in the process of preparing a consultation draft of a new policy statement on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation. The draft guidance would allow the aviation lights only to be illuminated when an aircraft is detected by a surveillance system entering a volume bounded by 4km (horizontal distance) from the perimeter wind turbines and 300m above the highest wind turbine tip of the Proposed Development and 150m above	Applicant has consulted with the CAA and local airspace users.

Mitigation Option	How it Works	Current Status
	ground level of the lowest turbine base. The aviation lighting would not be activated when commercial airlines pass over the Proposed Development, as these operate at higher altitudes, in Controlled Airspace (CAS). The Applicant has surveyed local airspace users to ascertain the level of low level night flight and the aircraft equipage in terms of transponders and other Electronic Conspicuity (EC) systems and shared its findings with the CAA (SPR/Cyrrus Windfarm Lighting Strategy Paper dated 30 December 2020).	
Reduced Lighting Scheme	As per above, ANO Article 222 contains provisions that allow exemption from its lighting requirements where this is agreed by the CAA. Lighting schemes which substantially reduce the number of wind turbines fitted with visible aviation lighting have been approved by the CAA for Viking Windfarm (Variation), Crystal Rig IV, Rothes III and Clash Gour windfarms. However, of these windfarms, only Viking Windfarm (Variation) and Crystal Rig IV have been consented. While a reduced lighting scheme would typically reduce the density of lights at a site, which may reduce the level of predicted effects sufficiently to make them unlikely to be significant, this would require an 'exception' to do so and there would still be some lights present. To this end, the Applicant has proposed a condition which requires the use of an Aircraft Detection Lighting System and does not rely on a reduced lighting scheme.	For information only

2.6 Consideration of Mitigation Options

21. The mitigation options outlined above are given consideration for application in the context of the Proposed Development design, geographic location and the nature of the landscape and visual effects predicted.

Reduced Intensity

22. It is proposed that visibility sensors are installed on relevant wind turbines to measure prevailing atmospheric conditions and visibility range. Should atmospheric conditions mean that visibility from every wind turbine within the Site is >5km from the Proposed Development, CAA policy permits lights to operate in a lower intensity mode of 200 cd (being a minimum of 10% of their capable illumination). If visibility is restricted to 5km or less, the lights would operate at 2,000 cd.

23. This feature has been assumed to be part of the proposal as embedded mitigation. It is likely to reduce the magnitude of landscape and visual effects particularly for distant receptors, however this feature would not remove visibility of aviation lighting completely for any nearby receptors. It would work in conjunction with other measures proposed/approved to lessen effects.

Directional Intensity

24. The inherent directional intensity of 2,000 cd lights can be used to reduce vertical downwards lighting impacts at elevations less than -1° degree vertical angle from the horizontal plane from the aviation light. By ensuring that the lights installed comply with the ICAO recommendations set out in Annex 14 Table 6-3, it is possible to attenuate the vertical downwards light to a level that reduces the visual impact from receptors at ground levels below the lights. Implementing the ICAO recommendations, at -1 degrees the aviation lights should only be 1,125 cd and at -10 degrees should only be 75cd (when visibility is > 5km).

25. This has potential to reduce visual effects at nearby receptors located at elevations below the wind turbine nacelles.

Aircraft Detection Lighting System

26. ANO Article 222 contains provisions that allow exemption from its lighting requirements where this is agreed by the CAA.

27. Article 222 (6) provides that: "*A permission may be granted for the purposes of this article for a particular case or class of cases or generally".*

28. Article 222 (7) adds: "*This article does not apply to any en-route obstacle for which the CAA has granted a permission to the person in charge permitting that person not to fit and display lights in accordance with this article".*

29. An ADLS may be permitted under either of these two Articles.

30. An ADLS utilises a surveillance system to detect when an aircraft is in a defined volume of airspace around the wind turbines; the aviation lights would only be switched for a short period of time while the aircraft transits the airspace volume over and around the Proposed Development. The aircraft detection part of the system can be achieved by using a primary (non-co-operative) surveillance system that would detect and track any aircraft sized object in the detection volume (PSR ADLS). Alternatively, a co-operative surveillance system that detects aircraft via their onboard electronic identification transponder or other forms of Electronic Conspicuity (EC), could be used (EC ADLS). An EC ADLS is the Applicant's preferred approach and is further discussed in **Section 2.7**.

31. The maximum height of the detection volume around the Proposed Development is calculated to be 3,000 ft above mean sea level (based on 300m above the maximum tip height of wind turbine 8, the highest wind turbine). Commercial air traffic operating in this area would be flying at a minimum of 6,000 ft above mean sea level, in CAS. Given the lights are only required for general aviators flying at night in the vicinity of the Proposed Development at altitudes of up to 3,000 ft, it is anticipated that the lights would be rarely turned on in this quiet airspace. The longest transit of the Site is approximately 3.5km (from wind turbine 7 to wind turbine 3). This means the longest extent of the detection volume would be 12 km. At aircraft ground speeds of between 125 kts and 250 kts, the aviation lights would only be on for approximately 1.5 to 3 minutes, resulting in the aviation lights having short duration visual effects of limited frequency. This would be sufficient to remove the aviation lighting associated significant landscape and visual effects.

2.7 EC ADLS

The Applicant Strategic Approach

32. The Applicant is developing several sites, with wind turbine heights of over 150m proposed, in the southwest of Scotland, where wind turbine aviation lighting is an environmental assessment consideration. In order to fully explore the potential implications of wind turbine lighting and review the merits of the available mitigation options, The Applicant has published a strategic lighting study with aviation experts Cyrrus. This study used the Applicant's development portfolio across the south west of Scotland as a case study to identify what the optimum solution would be to maintain aviation safety while avoiding significant landscape and visual impacts, at an individual project level, and also cumulatively across the wider region. The study examined:

- the existing regulatory framework around night-time flying and aviation lighting;
- an aeronautical study to identify the aviators present in the region who are, or could be, using the airspace at night-time;
- audit and appraisal of what equipment these aviators have and use currently, and what night flight procedures are currently followed;
- consideration of the scale of the requirement for an effective aviation lighting mitigation across the Applicant's portfolio and regional cumulative impacts in the absence of a widely deployable mitigation solution;
- examination of the drivers, barriers and likely efficacy of identified mitigation options;
- discussion on solutions successfully being implemented in other territories in Europe and United States; and
- recommended mitigation options with a roadmap to enable mitigation deployment.

33. This strategic lighting study, dated 30 December 2020, was shared with the CAA in early January 2021. The study concluded that the most effective and achievable mitigation option to avoid significant aviation lighting landscape

and visual impacts for the Applicant's portfolio of sites, including the Proposed Development, and across the wider region, is an EC ADLS. The CAA responded to the Applicant in April 2021, welcoming the study as a "timely and helpful input to the ongoing consideration of alternative approaches that can be employed to ensure safe air navigation while reducing the visual impacts of obstacle lighting" and a useful restart to the CAA's ADLS policy work.

EC ADLS Drivers

34. The compelling benefit of an EC ADLS is that it removes lighting from the night sky for all but a tiny fraction of time when the lights would be required to maintain aviation safety. By relying on co-operative surveillance, it is much simpler to track the aircraft across the volume. The system is already being successfully deployed in Germany (where retrofitting of aircraft detection lighting systems has been mandated to address night lighting concerns); indeed, the Applicant's parent company Iberdrola is retrofitting an EC ADLS at its Wikinger offshore windfarm in the German Baltic Sea.

35. An EC solution falls in step with wider developments in the regulation of the aviation industry to introduce electronic conspicuity of all aircraft within the next decade as part of the CAA Airspace Modernisation Strategy (CAP 1711; see also Airspace Modernisation – Progress Report 2020 published as CAP2016). This allows high confidence that the solution can be delivered and operated successfully for the Proposed Development and wider renewables industry to maintain traction in renewable energy delivery and progress toward net zero carbon targets. The Applicant's research shows how implementation of this technology could be expedited and the cost and wider benefits that this would deliver.

36. An EC ADLS avoids the requirement to develop, procure, operate and maintain multiple additional radar installations in remote locations that would be required for a PSR ADLS. Such systems also suffer from shadowing from the wind turbines and increase pressure on radar spectrum bandwidth, while also being currently cost prohibitive.

37. An EC ADLS would benefit all of the stakeholders consulted, reducing the concerns of landscape conservation consultees, avoiding the CAA being overwhelmed by applications for reduced lighting schemes and allowing developers with otherwise acceptable development proposals to proceed and deliver renewable energy projects along with their other associated benefits.

Regulatory Approval

38. The CAA is in the process of preparing a consultation draft of a new policy statement on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation. The Applicant has had an opportunity to review the CAA's proposal as part of an industry working group considering this guidance. Pre-Covid19, it had been expected that this guidance would be finalised and released during 2020. A delay in finalisation of this policy is now anticipated, but the CAA's response to the Applicant's Windfarm Lighting Strategy Study suggests that work to finalise this policy has recommenced.

39. The draft policy envisages that the aviation lights need only be illuminated when an aircraft is detected by the surveillance system entering a volume bounded by 4km (horizontal distance) from the perimeter group of wind turbines and 300m above the highest wind turbine tip of the Proposed Development and 150m above ground level of the lowest turbine base. The calculations estimate that the upper boundary of this volume would be around 3,000 ft AGL[1].

40. The Applicant acknowledges that the approval of the CAA would be required to implement an EC ADLS at wind energy developments. CAA guidance on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation would in effect form a class exemption under ANO Article 222 which, together with the mandating of electronic conspicuity devices by aircraft operating at night / promulgating a night transponder mandatory zone in lower airspace, would provide for EC ADLS deployment. The Applicant is actively engaged with the CAA and other industry interest groups in working towards implementation of the required regulatory

[1] In terms of the maximum height of the coverage volume, this is calculated as follows (300m above the highest part of the wind turbine or group of wind turbines). The highest height above sea level within the Proposed Development is turbine 5 located at 400m AOD. With 200m wind turbines and 300m above the highest part of the wind turbine, the maximum height of the radar coverage required would be 900m or 2,953ft, rounded up to 3,000ft.

revision. Given the experience in Germany and the Airspace Modernisation Strategy, the Applicant anticipates an EC ADLS would be deployable at wind energy sites in Scotland by 2025 at the latest.

2.8 Proposed Mitigation Measures

41. The Applicant is committed to reducing significant environmental effects predicted during the development of its sites and therefore propose that the following mitigation measures are deployed at the Proposed Development as part of the IALLVIMP:

   a. Application of the embedded mitigation of reduced intensity lighting in good visibility as permitted by the 2017 CAA Policy;

   b. Utilisation of modern ICAO Annex 14 lights which demonstrate a tightly focused beam as set out in Table 13.3.1 above which would reduce intensity below zero degrees of horizontal to reduce the intensity of light at close proximity ground-based receptors; and

   c. Application of an ADLS.

42. The Applicant will continue to work with the CAA and wider industry for the promulgation of an En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation policy, including the option for EC ADLS.The Applicant will continue to support the expedition of the mandating of electronic conspicuity device carriage at night.

43. The Applicant will work with aviation and landscape conservation stakeholders to develop and agree a specification and working protocol for installation and operation of an EC ADLS at the Proposed Development. The details of this and the final specification of all of the agreed mitigation measures would be included in a detailed ALLVIMP to be developed in consultation with all stakeholders to confirm the approved measures, post consent and prior to erection of wind turbines at the Proposed Development. The Applicant proposes that this is controlled by way of a planning condition applied to the consent for the Proposed Development.

2.9 Suggested Aviation Lighting Condition Wording

44. It is proposed that the implementation of mitigation measures to control the potential Aviation Lighting Landscape and Visual Impact would be controlled through the imposition within a Section 36 consent condition. The wording below is proposed as a suggestion for a suitable planning condition:

No development shall commence unless and until an Aviation Lighting Landscape and Visual Impact Mitigation Plan (ALLVIMP) for:

(i) the use of an aircraft detection lighting system;

(ii) the reduction of lighting intensity during good meteorological visibility; and

(iii) the specification of lighting;

has been submitted to and approved in writing by the Scottish Ministers following consultation with the Civil Aviation Authority, and NatureScot.

The approved ALLVIMP shall be fully implemented throughout the lifetime of the Development, unless any change to the ALLVIMP is otherwise approved in writing by the Scottish Ministers.

Reason: in the interests of aviation safety, and to minimise landscape and visual impacts

3. References

Civil Aviation Authority (2017). Lighting of onshore wind turbine generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level. Available at: https://publicapps.caa.co.uk/docs/33/DAP01062017_LightingWindTurbinesOnshoreAbove150mAGL.pdf

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