Technical Appendix 13.3

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

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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 Harestanes South Windfarm Extension (the Proposed Development). The measures described and proposed in this plan have been used to undertake the night time landscape and visual assessment, **Chapter 5: Landscape and Visual Impact Assessment (LVIA)**, and aviation section of **Chapter 13: Other Issues**, both reported in the Harestanes South Windfarm Extension EIA Report. The IALLVIMP should be read in conjunction with these assessment chapters.

2. It is proposed that should the section 36 application for the Proposed Development be consented, then the measures proposed in the IALLVIMP shall 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 ALLVIMP. It is envisaged that the agreement and sign-off of the ALLVIMP shall 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 8 wind turbines with a tip height of up to 200m. It is located approximately 13km to the north of Dumfries in Dumfries and Galloway and entirely outwith the Galloway Dark Sky Park including buffer and transition zones.

5. Article 222 of the Air Navigation Order (SI 2016/765 as amended) requires the visible lighting of 'en-route obstacles' at or above 150 m above ground level, to assist their detection by aircraft. The Civil Aviation Authority (CAA) in its 2017 Policy Statement on lighting onshore wind turbines with a maximum tip height at or over 150 m AGL modified the strict application of ANO Article 222 in this context. As such, there is potential that parts of the Proposed Development may be visible at night. The effect of the Proposed Development at night would result from medium intensity red coloured light fittings located on the nacelles, and low intensity lights on the turbine towers, of all proposed turbines. While only periphery turbines require lighting, the turbine layout in practice requires all turbines to be lit. 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 development by a surveillance system).

6. It should be noted that all turbines would also include infra-red lighting on the turbine hubs which would not be visible to the human eye. 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

7. It is a function of the geographic situation of commercial wind turbines, driven by energy yield requirements and development controls maintaining separation between turbines and settlements, that new turbine developments are typically located in areas with low underlying levels of night-time lighting. Therefore, new turbine development has the potential to give rise to landscape and visual effects where the turbines require visible lighting. This will increasingly be the case as manufacturers withdraw turbines models, below 150 m 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.

8. The potential night time landscape and visual effects caused by aviation lighting have been assessed in **Chapter 5: LVIA** and accompanying **Appendix 5.5 LVIA of Turbine Lighting** of the EIAR. The assessment is based upon a worst-case scenario as outlined in **Section 2.4** below. The assessment found that the effects are likely to be;

- Predicted significant effects on landscape receptors;
  - Foothills with Forest – Ae unit, and Foothills – Beattock unit
  - Upland Fringe – Ae Fringe unit
- Significant effects on local residents and walkers;
  - within 5 km
  - in Annandale, within 5km to 10km

9. As significant effects are predicted, SPR has considered what mitigation options are available to reduce the magnitude of effects to a level where they will be considered to be not significant.

2.3 ICAO / Civil Aviation Authority (CAA) Regulations

10. 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 UK, the ICAO/EASA requirements for lighting wind turbines are implemented through CAA publication 'CAP 764: Policy and Guidelines on Wind Turbines', and 'CAP393: Air Navigation Order 2016'. The CAA have 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'.

11. The proposed turbines, at 200m to blade tip, would require lighting under Article 222 of the Air Navigation Order (ANO, 2016). This requires medium intensity 'steady' red aviation lights (emitting 2,000 candela) 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 turbine tower (CAA, 2017). The intermediate 'tower' lights will be 32 candela.

12. These should be turned on at 'night'; defined as ambient lighting levels at or below 50 candela/m^2. 'Night' is defined in Air Navigation Order 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 United Kingdom with a maximum blade tip height at or in excess of 150 m Above Ground Level, 2017 states that "*If the horizontal meteorological visibility in all directions from every wind turbine generator in a group is more than 5 km, 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 5 km, 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:

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

Table 13.3-1 Light distribution for medium and high intensity obstacle lights according to benchmark intensities

15. A diagrammatic interpretation of the minimum requirements set out in ICAO Annex 14 Table 6-3 is shown in **Plate 13.3-1**. It illustrates the potential light intensity from a medium-intensity nacelle mounted aviation light, required over +3° beam spread from the horizontal. It also provides illustration of the likely light intensity in poor visibility <5 km (2,000 cd) and clear visibility >5 km (200 cd) where CAA policy (CAA, 2017) permits dimming of the lights.

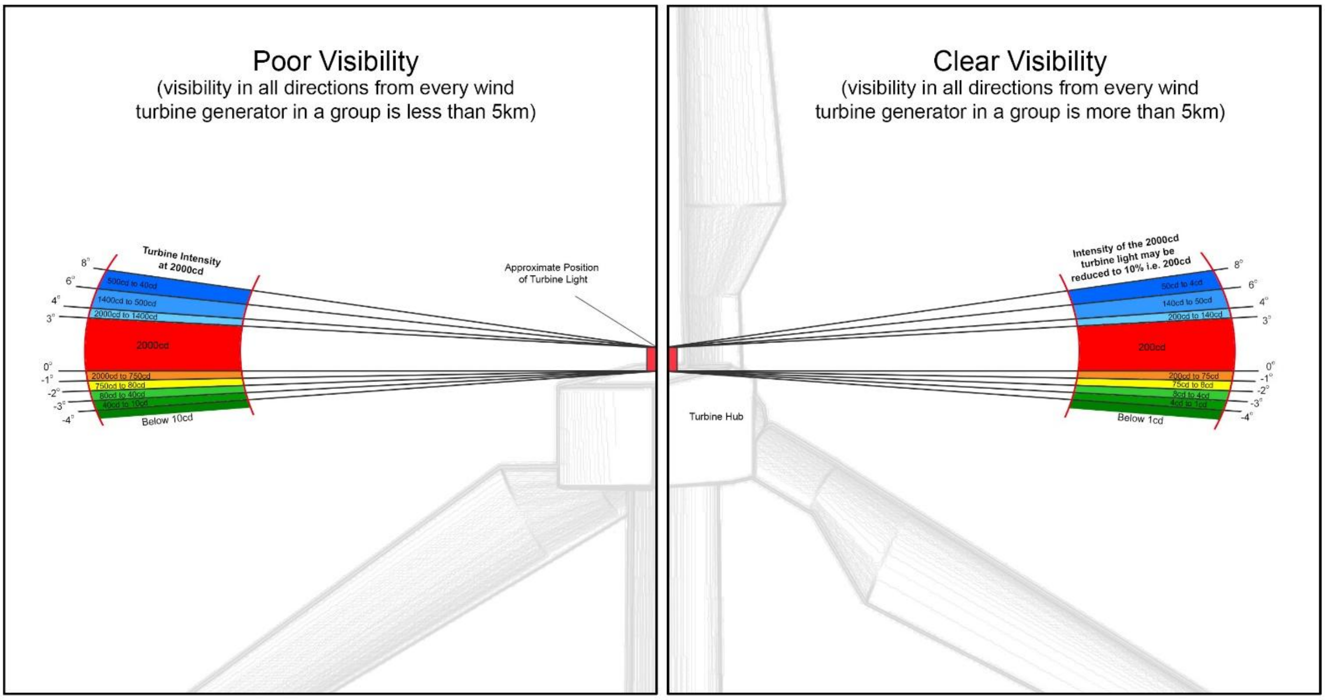

Plate 13.3-1 Diagrammatic interpretation of minimum requirements of ICAO/CAP393 (LuxSolar Medium Intensity Obstruction Light)
Note: the turbine light is designed to emit the same light intensity horizontally in 360 °.

16. The graphic illustrates light intensity emission at various vertical angles, with the horizontal plane of the lights represented by 0 degrees 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 5: LVIA** is that the nacelles of all 8 wind turbines would be fitted with a Medium Intensity Obstruction Light operating to the parameters described above; at night time, with the light intensity reduced from 2000 cd to 200 cd during clear conditions, together with the required 32 cd tower lighting.

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

2.5 Mitigation Options

19. 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**.

Mitigation option	How it works	Current status
Reduce intensity of lights from 2,000cd to 200cd	Already provided for in CAA guidance (CAA, 2017) . 2,000cd aviation lights may be dimmed to 10% of their intensity (200cd) where visibility conditions permit, when visibility from every turbine within the wind farm group is >5 km. 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 <5 km; and their intensity would be dimmed to 200 cd in visibility of >5 km.	Embedded in Development design
Directional intensity	Established in ICAO (Annex 14) guidance. This focusses the 2,000cd 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 Development design
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 turbines. The CAA is in the process of consulting on 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 turbines and 300m above the highest turbine tip of the Site. The aviation lighting would not be activated when commercial airlines pass over the Site, as these operate at high altitudes, in Controlled Airspace (CAS)	Applicant is consulting with regulator and local airspace users
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. In the event that interim mitigation is required pending regulatory adoption of an Aircraft Detection Lighting System, the Applicant would prepare a reduced lighting scheme whereby only the cardinal or selected peripheral turbines would be lit. The lighting of cardinal or selected periphery turbines is a mitigation option that has been approved by the CAA at onshore wind energy developments elsewhere.	Applicant is consulting with regulator and local airspace users

Mitigation option	How it works	Current status
	Lighting schemes which substantially reduce the number of 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) has yet been consented. This measure will 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. It may remove effects completely where a specific receptor, such as a nearby dwelling would no longer have visibility of any lights.	

Table 13.3-2 Turbine Lighting Mitigation Options

2.6 Consideration of mitigation options

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

Reduced intensity

21. Reducing intensity of lights from 2,000 cd to 200 cd - it is proposed that visibility sensors are installed on relevant turbines to measure prevailing atmospheric conditions and visibility range. Should atmospheric conditions mean that visibility from every turbine within the Site is >5 km 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 5 km or less, the lights would operate at 2,000 cd.

22. 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 will not remove visibility of aviation lighting completely for any nearby receptors. It will work in conjunction with other measures proposed/approved to lessen effects.

Directional intensity

23. 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 > 5 km).

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

Reduced aviation lighting scheme

25. ANO Article 222 contains provisions that allow exemption from its lighting requirements where this is agreed by the CAA. The lighting of cardinal or selected periphery turbines has been agreed with the CAA in a limited number of cases, following careful assessment with regard to aviation safety.

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.*

26. 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.*

27. SPR has reviewed the potential to implement a reduced aviation lighting scheme at Harestanes South and considered the extent to which this could reduce the landscape and visual effects of the lights. Reduced aviation lighting schemes typically consist of cardinal or perimeter turbines being lit and dispensation not to light certain turbines in between. This can substantially reduce the density of turbines being illuminated.

28. The layout of turbines at the Proposed Development is characterised as a narrow band of turbines, rather than a broad cluster, with no clearly defined “interior” turbines in the Site’s layout.

29. The draft section in the current CAP764 revision suggests that lit periphery turbines should be not more than 900m apart. Considering the layout of the turbines and the spacing between them it is unlikely that a reduced lighting scheme would reduce the need for nacelle lights on all turbines although it may eliminate the need for tower lights. However, this would be subject to the findings of a detailed aeronautical study and consultation with local airspace users and subsequent discussion with the CAA.

30. It should be noted that implementation of any reduced lighting scheme would be at the discretion of the CAA and it is understood by SPR that this approach is not likely to be permitted in the majority of cases.

Aircraft detection lighting system

31. An aircraft detection lighting system utilises a surveillance system to detect when an aircraft is in a defined volume of airspace around the turbines; the aviation lights would only be switched for a short period of time while the aircraft transits the Site. The aircraft detection part of the system can be achieved by using a primary (non-co-operative) radar system that will detect and track any aircraft sized object in the volume, Radar Activated Lighting (RAL). Alternatively, a co-operative radar system that detects aircraft via their onboard electronic identification transponder could be used, Transponder Activated Lighting (TAL). A TAL system is SPR’s preferred approach and is further discussed in **Section 2.7**.

32. The maximum height of the detection volume around the Proposed Development is calculated to be 2,900 ft above mean sea level (based on 300 m above the maximum tip height of turbine 7, the highest turbine). Commercial air traffic operating in this area would be flying at a minimum of 9,000 ft above mean sea level, in CAS. Given the lights are only required for general aviators flying at night in the vicinity of the Site at altitudes of up to 2,900 ft, it is anticipated that the lights will be rarely turned on in this quiet airspace. The longest transit of the Site is approximately 3 km (from turbine 1 to turbine 8). This means the longest extent of the detection volume would be 11 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 Transponder Activated Lighting system

SPR strategic approach

33. SPR is developing several sites, with turbine heights of over 150 m proposed, in the southwest of Scotland, where turbine aviation lighting is an environmental assessment consideration. In order to fully explore the potential implications of turbine lighting and review the merits of the available mitigation options, SPR has commissioned a strategic study with aviation experts Cyrrus. This investigation uses SPR’s development portfolio across the south west 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 examines:

- 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 SPR’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.
- recommended mitigation options with a roadmap to enable mitigation deployment.

34. This study has yet to be completed; however, preliminary findings point towards the most effective and achievable mitigation option to avoid significant aviation lighting landscape and visual impacts for SPR’s portfolio of sites,

including the Proposed Development, and across the wider region, being a Transponder Activated Lighting system.

TAL system drivers

35. The compelling benefit of the TAL system 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, SPR's parent company Iberdrola is retrofitting a TAL system at its Wikinger offshore windfarm in the German Baltic Sea.

36. The transponder 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)[1]. 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. SPR's research shows how implementation of this technology could be expedited and the cost and wider benefits that this would deliver.

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

38. A TAL system 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

39. The CAA is in the process of consulting on a new policy statement on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation. SPR 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 guidance is now anticipated.

40. The draft guidance envisages that the aviation lights need only be illuminated when an aircraft is detected by the surveillance system entering a volume bounded by 4 km (horizontal distance) from the perimeter group of turbines and 300 m above the highest turbine tip of the Site. Our calculations estimate that the upper boundary of this volume would be around 2,900 ft above ground level[2].

41. SPR acknowledges that the approval of the CAA will be required to implement TAL systems at wind energy developments. CAA guidance on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation will in effect form a class exemption under ANO Article 222 which, together with the mandating of electronic conspicuity devices by aircraft operating at night, would provide for TAL system deployment. SPR is actively engaged with the CAA and other industry interest groups in working towards implementation of the required regulatory revision. Given the experience in Germany and the Airspace Modernisation Strategy, SPR anticipates the TAL systems will be deployable at wind energy sites in Scotland by 2025 at the latest.

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[1] Airspace Modernisation Strategy – CAP1711 – Initiative No. 11 in Table 1 on Page 10, available at; https://publicapps.caa.co.uk/docs/33/CAP%201711%20Airspace%20Modernisation%20Strategy.pdf

[2] In terms of the maximum height of the coverage volume, this is calculated as follows (300m above the highest part of the turbine or group of turbines). The highest height above sea level within the Proposed Development is turbine 7 located at 564m AOD. With 200m turbines and 300m above the highest part of the turbine, the maximum height of the radar coverage required would be 864m or 2,835ft, rounded up to 2,900ft.

2.8 Mitigation measures proposed

42. SPR 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 ALLVIMP, in addition to the standard use of reduced intensity lighting.

43. SPR shall seek approval to deploy lights that reduce intensity below zero degrees of horizontal to reduce the intensity of light at close proximity ground-based receptors.

44. SPR shall also undertake exploratory discussions with NatureScot and CAA to consider whether a reduced lighting scheme would be appropriate and whether it could sufficiently reduce the level of night time landscape and visual effects at the Proposed Development to address consultee concerns. SPR notes that there are likely to be site specific challenges to deploying a reduced lighting scheme in this instance.

45. SPR shall continue to seek to engage with the CAA in its design of guidance on En-Route Aviation Detection Systems for Wind Turbine Obstruction Lighting Operation to include the opportunity for TAL systems, as well as expediting the mandating of electronic conspicuity device carriage at night.

46. SPR shall work with aviation and landscape conservation stakeholders to develop and agree a specification and working protocol for installation and operation of a TAL system at the Proposed Development. The details of this and the final specification of all of the agreed mitigation measures shall 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 turbines at the Proposed Development. SPR 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

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

48. (1) No development shall commence unless and until an Aviation Lighting Landscape and Visual Impact Mitigation Plan (ALLV IMP) has been submitted to and approved in writing by the Scottish Ministers following consultation with the Civil Aviation Authority.

49. (2) The mitigation plan shall provide:

   a. for the use of an aircraft detection lighting system or a scheme which demonstrates minimisation of the visual impact of the proposed lighting including:

      i. the extent of reduction of lighting intensity during good meteorological visibility as allowed by CAA policy and guidelines on wind turbines; and

      ii. the extent of cardinal or strategic lighting of selected turbines; and

   b. the timescale of and parameters for the periodic review of the operation and effectiveness of the ALLVIMP following its approval over the lifetime of the Development, to allow for adaptation and modification (with the written approval of the Scottish Ministers in consultation with the Civil Aviation Authority) in light of monitoring, reviews and changes in technology and relevant policy.

50. (3) The approved ALLVIMP shall be fully implemented throughout the lifetime of the Development, unless otherwise approved in writing by the Scottish Ministers as a result of a periodic review.

3. References

Civil Aviation Authority Statement (June 2017). 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. Available at: https://publicapps.caa.co.uk/docs/33/DAP01062017_LightingWindTurbinesOnshoreAbove150mAGL.pdf [Accessed 22/10/19]

The Electricity Act 1989

The Air Navigation Order 2016

Airspace Modernisation Strategy – CAP1711

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