# Technical Appendix 6.2

## Landscape and Visual Impact
## Visual Assessment of Turbine Lighting

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# Appendix 6.2
## Visual Assessment of Turbine Lighting

## 6.1 Introduction

1. Civil Aviation Authority (CAA) guidance requires that 'en-route obstacles' at or above 150 m above ground level are lit with visible lighting to assist their detection by aircraft. 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 visible medium intensity (2,000 candela) red coloured light fittings located on the nacelles, and on the turbine towers, of all proposed turbines. As part of the aviation assessment, light minimisation strategies are being considered, including an aviation 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).

2. 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 technical appendix (**TA6:2**) is on the visual assessment of the visible lighting requirements of the proposed Development.

3. This appendix is structured as followed:
   - 6.2 Regulations and Guidance
   - 6.3 Consultation
   - 6.4 Assessment Methodology and Significance Criteria
   - 6.5 Baseline Conditions
   - 6.6 Potential Effects
   - 6.7 Mitigation
   - 6.8 Assessment of Visual Effects
   - 6.9 Summary
   - 6.10 References

4. This visual assessment of turbine lighting is supported by a set of ZTV map figures (**Figures 6.2-1** to **6.2-5**) and night-time photomontage visualisations from five viewpoints, which are contained within **EIAR Volume 3b (Figure 6.28i-j**;; **Figure 6.36g-h**; **Figure 6.43g-h**; **Figure 6.45g-l** and **Figure 6.50i-j)**.

5. A description of the proposed turbine lighting is found within **Chapter 4 Development Description** and **Chapter 14, Section 14.2 Aviation**.

## 6.2 Regulations and Guidance

### 6.2.1 ICAO / Civil Aviation Authority (CAA) Regulations

6. ICAO (a UN body) sets international Standards; Recommendations and 'Notes' for aviation lighting in its publication 'Annex 14 to the Convention on International Civil Aviation' - Volume I Aerodrome Design and Operations (ICAO, Eighth Edition, July 2018).

7. ICAO Table 6.1 (page 6-4) identifies the international definitions of daylight; twilight and night based on measured background illuminance as follows.
   - **Daylight**: Above 500 cd/m2
   - **Twilight**: 50-500 cd/m2
   - **Night**: Below 50 cd/m2

8. For 2,000 candela medium intensity steady or fixed red lights, ICAO indicates a requirement for no lighting to be switched on until 'Night' has been reached, as measured at 50cd/$m^2$ or darker.

9. ICAO Table 6.3 (page 6-5) identifies minimum requirements and recommendations for 2,000cd aviation lights on wind turbines at 150m and above. In summary the minimum requirements are:
   - **0 to +3 ° from horizontal**: 2,000cd minimum average intensity (or 1,500cd minimum intensity)
   - **-1 degree from horizontal**: 750cd minimum intensity

10. The European Aviation Safety Agency (EASA) implements ICAO in European airspace. In pursuit of international standards for use around the globe, a project team has been established to provide clearer direction to lighting manufacturers, as there is scope for interpretation of ICAO in different ways by manufacturers.

11. 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'. 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'.

12. 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 lights to be fitted at the intermediate level on the turbine tower (CAA, 2017). The intermediate 'tower' lights will be 32 candela.

13. Air Navigation Order 2016 (CAP393) Article 223 (8) states that *"If visibility in all directions from every wind turbine generator in a group is more than 5km the light intensity for any light required by this article to be fitted to any generator in the group 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 2,000cd minimum intensity may be dimmed to 10%, or 200cd, if visibility is greater than 5km, i.e. in moderate to excellent or 'clear' visibility).

### 6.2.2 Aviation Lights - Interpretations of ICAO/CAA Regulations

14. A diagrammatic interpretation of the minimum requirements of ICAO/CAP393 based on information provided by a specific bulb manufacturer ('LuxSolar Medium Intensity Obstruction Light') is shown in **Plate TA6.2-1**. It illustrates the potential light intensity from a medium-intensity nacelle mounted aviation light, based on the ICAO minimum standard of 2000cd minimum average intensity required over +3° beam spread from the horizontal. It also provides illustration of the likely light intensity in poor visibility <5km (2,000cd) and clear visibility >5km (200cd).

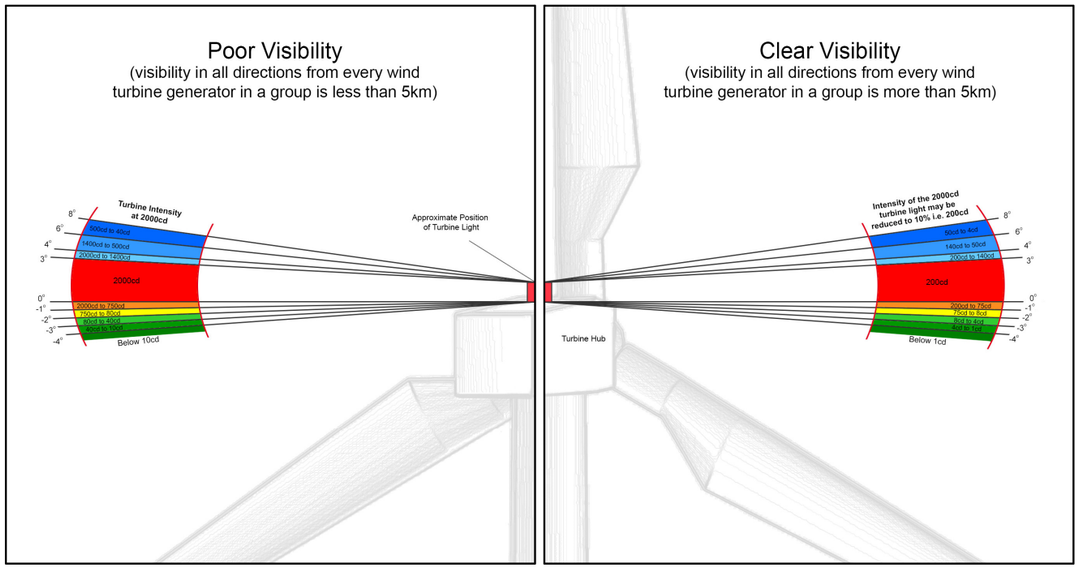


Plate TA6.2-1 Diagrammatic interpretation of minimum requirements of ICAO/CAP393 (LuxSolar Medium Intensity Obstruction Light)
Note the turbine in the diagram is only split vertically to illustrate the difference between the light intensity in poor visibility (2000cd) and clear visibility (200cd). The turbine light is designed to emit the same light intensity horizontally in 360 °. Repeated at larger size in Figure TA6.2-5.

15. The graph in **Plate TA: 6.2.2** below illustrates the ICAO (Annex 14) minimum required (red line) and maximum recommended (green line) light intensity emission that may be experienced at various vertical angles, with the horizontal plane of the lights represented by 0 degrees vertical angle. The average emission level of the LuxSolar Medium Intensity Obstruction Light is also shown (blue line) is also shown, providing an illustration of the light emissions for one particular model of light. Whilst the precise model of light to be used for the proposed Development is not known at this time, the graph clearly demonstrates that the intensity of the aviation lights requires to be 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 particular model of aviation light which offers a reduced light intensity below the horizontal and above +3° would provide mitigation of the intensity of the lights for receptors viewing them from areas below the horizontal. This is described further in **Section 6.6 Mitigation**.

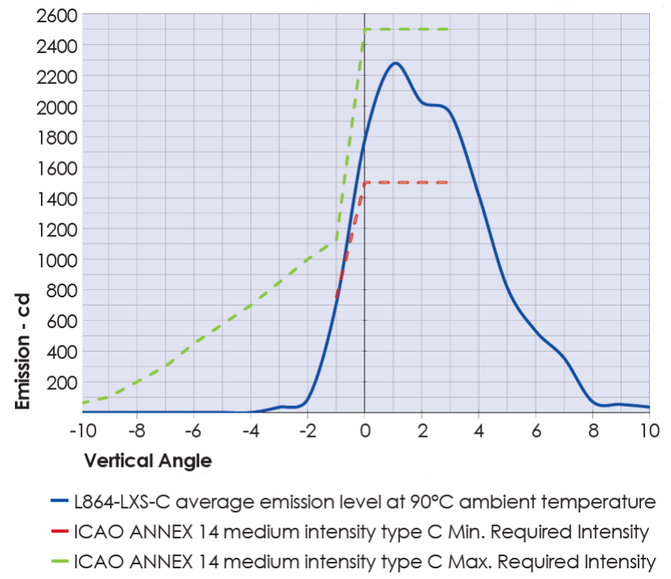


Plate TA6.2.2: Lighting Intensity Graph[1]

16. A Zone of Theoretical Visibility (ZTV) map of lighting intensity based on the LuxSolar Medium Intensity Obstruction Light is shown in **Figure TA6.2-5** and assessed further in **Section 6.7.1.3** of this **TA:6.2**. Although the model of light to be used for the proposed Development is not known at this time, the ZTV provides an illustration of the potential intensity if current aviation warning light technology is deployed.

### 6.2.3 Guidelines for Landscape and Visual Impact Assessment (GLVIA3)

17. GLVIA3 (page 103) provides the following guidance on the assessment of lighting effects: *"For some types of development the visual effects of lighting may be an issue. In these cases it may be important to carry out night-time 'darkness' surveys of the existing conditions in order to assess the potential effects of lighting and these effects need to be taken into account in generating the 3D model of the scheme. Quantitative assessment of illumination levels, and incorporation into models relevant to visual effects assessment, will require input from lighting engineers, but the visual effects assessment will also need to include qualitative assessments of the effects of the predicted light levels on night-time visibility."*

18. GLVIA3 (page 60) also provides the following guidance with regards to mitigation of obtrusive light: *'lighting for safety or security purposes may be unavoidable and may give rise to significant adverse effects; in such cases, consideration should be given to different ways of minimising light pollution and reference should be made to appropriate guidance, such as that provided by the Institution of Lighting Professionals (ILP, 2011)'.*

### 6.2.4 Institute of Lighting Professional Guidance

19. Guidance produced by the Institute of Lighting Professionals (ILP) (2011) (GN01:2011) is useful in setting out some key terminology that is used in this visual assessment of turbine lighting.

20. ***'Obtrusive Light****, whether it keeps you awake through a bedroom window or impedes your view of the night sky, is a form of pollution, which may also be a nuisance in law and which can be substantially reduced without detriment to the lighting task.* ***Skyglow*** *– the brightening of the night sky;* ***Glare*** *– the uncomfortable brightness of a light source when viewed against a darker background; and* ***Light Intrusion*** *– the spilling of light beyond the boundary of the property or area being lit, are all forms of obtrusive light which may cause nuisance to others.*

[1] LuxSolar Medium Intensity Obstruction Light CAP 168 MIOL-C: Data Sheet, January 2018.

21. CPRE also identifies these same broad terms as the three types of light pollution[2]:

- ***'skyglow** – the pink or orange glow we see for miles around towns and cities, spreading deep into the countryside, caused by a scattering of artificial light by airborne dust and water droplets.*
- ***glare** – the uncomfortable brightness of a light source.*
- ***light intrusion** – light spilling beyond the boundary of the property on which a light is located, sometimes shining through windows and curtains'.*

22. Types of obtrusive light are identified in Figure 1 of the ILP (2011) guidance:

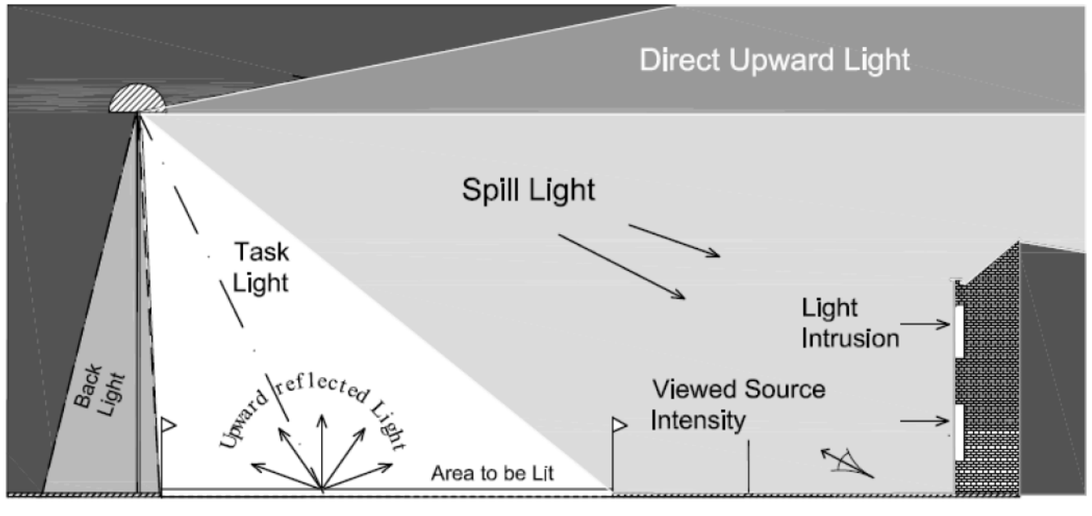


Plate 6.2-3 Types of Intrusive Light (ILP, 2011)

23. The following key guidance is noted:

- *'The most sensitive/critical zones for minimising sky glow are those between 90° and 100°* (note that this equates to 0-10° above the horizontal).
- *Keep glare to a minimum by ensuring that the main beam angle of all lights directed towards any potential observer is not more than 70°.*
- *In rural areas the use of full horizontal cut off luminaires installed at 0° uplift will, in addition to reducing sky glow, also help to minimise visual intrusion within the open landscape.*
- *Upward Light Ratio (ULR) of the Installation is the maximum permitted percentage of luminaire flux that goes directly into the sky. A ULR of 0 (zero) Candela (cd) is suggested for Dark Sky Parks.*

### 6.2.5 SNH Guidance

#### 6.2.5.1 Visual Representation Guidance

24. SNH Guidance on turbine lighting is contained in para 174-177 in Visual Representation of Windfarms (SNH, 2017) as follows:

25. *'In some circumstances it may be necessary to provide lighting on turbines if this is required to address military and/or civil aviation requirements. We recommend that where turbines are proposed in excess of 150m SNH are consulted on the requirement for night-time visualisations. It is difficult to illustrate turbine lighting well in visualisations, although some recent examples which use photographs taken in low light conditions (just before or after sunrise / sunset) have been more useful. We encourage applicants to explore new techniques to do this and emphasise the importance of early dialogue.*

26. *Where an illustration of lighting is required, a basic visualisation showing the existing view alongside an approximation of how the wind farm might look at night with aviation lighting may be useful. This is only likely to be required in particular situations where the wind farm is likely to be regularly viewed at night (e.g. from a settlement, transport route) or where there is a particular sensitivity to lighting (e.g. in or near a Dark Sky Park or Wild Land Area). Not all viewpoints will need to be illustrated in this way. The visualisation should use photographs taken in low light conditions, preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night. It is only necessary to illustrate visible lighting, not infrared or other alternative lighting requirements.*

27. *We have found that approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image. It is important that the photographs represent the levels of darkness as seen by the naked eye at the time and the camera exposure does not make the image appear artificially brighter than it is in reality. It can also be helpful to note the intensity of other lights in the area to enable comparison (e.g. television transmitters) as this can aid the assessment process. SNH may prepare further guidance on assessment of lighting in due course.*

28. *The developer should attempt to formally agree the lighting requirements with the aviation authorities in advance of the application. Where this is not possible the visualisations should illustrate the lighting as described in the current legislation'.*

#### 6.2.5.2 Evolving SNH Approaches to Turbine Lighting

29. Although SNH recognises, in its scoping response, that *'The requirement for aviation lighting of turbines is a fairly recent issue for the wind energy sector and we have limited experience of assessing the effects and understanding the impacts'*, there have in the interim, been further developments in the understanding and assessment of wind turbine lighting.

30. Recent SNH workshops indicate that a proportionate and pragmatic approach is required, both in terms of the need to assess likely significant effects under the EIA regulations, complying with current civil aviation standards and providing mitigation on a project and site-specific basis.

31. Mitigation options to eliminate or reduce the need for, and effects of, visible lighting are evolving quickly and developers are exploring these with consultees and the CAA in relation to specific sites. SNH has offered a perspective on the efficacy of different mitigation options, noting that the most effective appears to be radar activated, albeit accepting the considerable cost implications inherent in this potential option.

32. Ministers and planning authorities are using planning conditions to manage effects. It is recognised that the EIAR should not necessarily specify one mitigation option, as these are evolving rapidly, and developers need flexibility to utilise the most appropriate mitigation once they are ready to start discharging conditions. Conditions provide some flexibility for developers to identify the most appropriate mitigation option(s) post consent and prior to construction, and to agree these with the relevant decision maker.

33. In terms of visual effects, SNH's view (as expressed at a seminar in November 2019) is that lengthy debate about the exact brightness of lights (including in visualisations) is potentially not helpful and that it is better to focus on where they will be visible, how many lights will be visible and the level of change from the baseline situation. This is recognised in the visual assessment in this **TA:6.2**. SNH has also taken a pragmatic view with night-time visualisations, requesting that decision makers, consultees and communities require visualisations from a small number of relevant viewpoints to understand these effects. SNH also recognises the challenges of capturing nigh-time photography and accept that some post photographic manipulation of images to provide a good representation is acceptable.

[2] https://www.nightblight.cpre.org.uk/what-is-light-pollution

### 6.2.6 Local Development Plan (LDP) policy: Dark Skies

34. South Ayrshire Council's Dark Skies policy is contained in the adopted South Ayrshire LDP (SAC, 2014):

35. *We will support the Galloway Forest Dark Sky Park and will presume against development proposals within the boundaries of the park that would produce levels of lighting that would adversely affect its 'dark sky' status. The boundaries of the Dark Sky Park [and of the buffer zone] are shown on the map on page 40. Development will have to be in line with the supplementary guidance on lighting within the Galloway Forest Dark Sky Park, which we will produce jointly with the adjoining planning authorities and Forestry Commission Scotland. This will also provide guidance for proposed developments within the buffer zone which may have a lighting impact on the Dark Sky Park. [The supplementary guidance will define the geographical extent of the buffer zone.]*

### 6.2.7 Supplementary Guidance: Dark Sky Lighting

36. South Ayrshire Council has produced Supplementary Guidance (SG) on Dark Sky Lighting (SAC, 2016). It sets out that the purpose of the Dark Skies policy within South Ayrshire Council's LDP is to *'protect the dark sky quality and, therefore the status of the Park, from development which would result in light spillage or lighting levels that would adversely affect that quality or status'.*

37. It describes the Galloway Forest Dark Sky Park (DSP) and goes on to define the core area (darkest sky), buffer area and transition zone. It sets out a position that '*Where necessary, a condition to ensure lighting is Dark Sky compliant will be applied to planning permissions granted for developments in the Dark Sky Park'* and also states that *'The Council will support the status of the DSP by requiring external lighting associated with development proposals or illumination associated with external signage proposals to have no significant adverse impact on the overall night sky and natural environment'.*

38. The SG also sets out the type, level of technical and supporting information that is required to be submitted with a planning application, so as to enable a proper assessment of the potential impacts of proposals on the Dark Sky Park (DSP), as follows:

39. *"All development proposals falling within the Dark Sky Park boundary and requiring planning permission will be required to include the following information for any external lighting associated with an application proposal:-*

- *An explanation of the purpose of the external lighting.*
- *A layout plan highlighting location of light(s) within the application site with beam orientation indication for each elevation.*
- *Light spillage analysis for each external light.*
- *Light design type- details of light fitting and casing (including details of any cowling to prevent spillage of light above the horizontal).*
- *Mounting Height.*
- *Light angle.*
- *Luminaires.*
- *Hours when lighting shall be in operation.*

40. The SG also include an example condition relating to wind turbine aviation lighting:

41. *"Where it has been demonstrated to the satisfaction of the planning authority that aviation obstruction warning lighting needs to be installed on wind turbines within the DSP and that such lighting will have no significant adverse impact on the dark sky quality of the Park, precise details of the proposed lighting shall be submitted to, and approved in writing by, the planning authority, before the turbines/masts are erected. Thereafter, the lighting shall be installed and operated in accordance with the approved layout and specification and retained in situ in an effective operating condition for the lifetime of the development".*

# 6.3 Consultation

### 6.3.1 Consultation Responses

42. A request for a Scoping Opinion was submitted to the Scottish Government Energy Consents Unit (ECU) in March 2019. The ECU compiled the final consultation responses from key consultees including SNH, SAC and Dumfries and Galloway Council (D&GC). A summary of the Scoping Opinion is provided in Chapter 6: Scoping and Consultation. Key information provided by consultees relevant to this visual assessment of turbine lighting is provided in **Table TA6.2.1**, which also describes how issues raised by during these consultations have been addressed in this **TA:6.2**.

Table TA6.2.1 Summary of Consultation Relevant to Visual Assessment of Lighting

| Consultee Name and date | Consultee Comments | Consultant Comments/Action |
|---|---|---|
| Energy Consents Unit (20/5/2019) | Note that the blade tip height of the turbines exceeds 150m. As such, viewpoints will be required to consider the effects of aviation lighting and how chosen lighting mitigates the effects. | Effects of aviation lighting on night-time views are assessed in **Section 6.7** of this **TA:6.2**. |
| | Advise that South Ayrshire Council specific comment on lighting and SNH comments on night-time assessment should be considered. | Effects of aviation lighting on night-time views are assessed in **Section 6.7** of this **TA:6.2**. |
| South Ayrshire Council (2/5/2019) | Consideration should be given to the impacts on the Galloway Dark Sky Park. | Effects of aviation lighting on night-time views from the Galloway Forest Dark Sky are assessed in **Section 6.7** of this **TA:6.2**. |
| | Viewpoints listed in paragraph 5.5.5 of the Scoping Report which lie within the Dark Skies Park should form the basis for the assessment of the effects of night-time lighting on the Dark Skies Park. Confirm night-time effects of the proposal should be additionally considered in nearby locations where current lighting levels are low. | Effects of aviation lighting on night-time views from the Galloway Forest Dark Sky are assessed in **Section 6.7** of this **TA:6.2**. Viewpoints within and on the edge of the Dark Sky Park form the basis for the assessment of effects. Night-time photomontage visualisations are presented from five viewpoints in **Figure 6.28i-j**; **Figure 6.36g-h**; **Figure 6.43g-h**; **Figure 6.45h-l and Figure 6.50h-j**. |
| | Require further information on the nature of turbine lighting proposed and clarification on whether reduced intensity lighting or radar activated proximity lighting will be used. | Effects of aviation lighting on night-time views are assessed in **Section 6.7** of this **TA:6.2**. |
| SNH (11/4/2019) | The extent of the lighting assessment study area for LVIA should be informed by the Zone of Theoretical Visibility (ZTV) map and an understanding of the nature of the likely effects. As a starting point we highlight advice in our existing landscape guidance, however our advice is evolving and we advise that the LVIA-related lighting assessment should include the following. | The study area for the visual assessment of turbine lighting is shown in **Figure TA6.2-1a**. |
| | Recommend that effects on night skies should be appropriately considered given the proximity of the proposed Development to the Galloway Dark Sky Park and advise that the LVIA-related lightning assessment should include the following. | Effects of aviation lighting on night-time views from the Galloway Forest Dark Sky are assessed in **Section 6.7** of this **TA:6.2**. |

| Consultee Name and date | Consultee Comments | Consultant Comments/Action |
|---|---|---|
| | Clear information on the positions and intensity of lighting proposed on the turbines themselves and a plan showing which turbines (numbered turbines) would be lit. | Information on the positions and intensity of lighting proposed on the turbines is provided in **Section 6.7.** The visual assessment in this **TA:6.2** assumes that all turbines in the layout will be lit, as described in **Section 6.4.1.** |
| | Production of a ZTV map which shows the areas from which the nacelle and tower lights may be seen. | ZTV maps of the turbine hub lighting are provided in **Figure TA6.2-2** (45km) and **Figure TA6.2-3** (Dark Skies Park Study Area). A ZTV of the tower lighting is provided in **Figure TA6.2-4**. A ZTV of the potential lighting intensity is provided in **Figure TA6.2-5**. |
| | Annotation of the positions of turbine lighting (including intermediate tower lights) on all wirelines from every viewpoint. | The visual assessment of turbine lighting assumes that all turbines will be fitted with nacelle mounted lighting and intermediate tower lighting. These are not shown in the wirelines, however both are shown in the photomontage visualisations from five representative viewpoints in **Figure 6.28i-j**; **Figure 6.36g-h**; **Figure 6.43g-h**; **Figure 6.45h-l and Figure 6.50h-j**. |
| | A table which lists how many lit turbines will be visible from each viewpoint. | A table which lists how many lit turbines will be visible from each viewpoint is presented in **Table 6.2-3** of this **TA:6.2**. |
| | SNH's scoping opinion also notes, with particular reference to the Galloway Forest Dark Sky Park (DSP), that *'Darkness/dark skies in these areas (which contain limited artificial lighting) may be valued by many people, a proportion of whom may be actively seeking out and enjoying good views of the night sky (e.g. in particular the Galloway Forest DSP and its buffer area)'.* | Effects of aviation lighting on night-time views from the Galloway Forest Dark Sky are assessed in **Section 6.7** of this **TA:6.2**. |
| SNH (12/11/2019) | Following a site visit into the Merrick WLA, SNH requested an additional viewpoint from the summit of Benyellary. From this hill - and from the path descending from it - walkers tend to look westwards out from the WLA. The turbines and night-time aviation lights (if required) would be clearly visible and may have more of an impact upon views from this location than from the Merrick summit. SNH suggest that this viewpoint is used for the night-time lighting assessment as an alternative location to the Merrick. | Benyellary viewpoint added as an 'illustrative' daytime viewpoint to support the assessment of the Merrick WLA, and as an additional 'representative' night-time viewpoint, as an alternative location to the Merrick summit (**Figure 6.50**, Viewpoint 24). |

# 6.4 Assessment Methodology and Significance Criteria

### 6.4.1 Key Parameters for Assessment

43. Based on the description of proposed turbine lighting in **Chapter 4 Development Description** and the ICAO/CAA regulations and standards described in **Section 6.2,** the following assumptions have been made for the visual assessment with regards to lighting of the proposed Development:

- the CAA requires that all obstacles at or above 150 m above ground level are fitted with medium intensity (2,000cd) visible aviation lighting and, in the case of wind turbines, these should be located on the nacelle;
- the CAA requires that a secondary light (of the same specification) is fitted for use only when the primary light fails and would not be lit concurrently; and
- there is an additional requirement for low intensity (32cd) aviation lights to be provided at an intermediate level of half the nacelle height. These would need to be fitted around the towers to allow for 360° horizontal visibility.

44. The visual assessment of turbine lighting is based on the following key parameters:

- all turbines would have red, medium intensity, steady red, visible lights mounted on the nacelle (125 m);
- 2,000cd and 200cd intensity lights have been assessed representing 2 differing worst case situations. 2,000cd represents the maximum intensity possible. 200cd represents the maximum intensity that the 2,000cd light would be operated at when visibility extending from the windfarm exceeds 5 km;
- potential light intensity is assumed to accord with the ICAO minimum standard of 2,000cd minimum intensity required over +3 ° beam spread from the horizontal plane;
- all turbines would also have low-intensity lights (32 cd) to be provided on the turbine towers at an intermediate level of half the nacelle height (62.5 m);
- it is assumed that the visual effect of turbine lighting at night would result from visible lighting located on the nacelles, and on the towers, of all turbines with the windfarm layout shown in **Figure 4.1: Site Layout**.
- the steady red lighting fixed to the top of the nacelles and to the turbine towers may appear to flicker on and off with the blade movement. This would occur when the turbine blades pass between the lights and the observers.

45. It should be noted that the turbines would also include infra-red lighting on the turbine hubs, which would not be visible to the human eye. Details of the lighting would be agreed with the MoD. The focus of the night-time visual assessment in this **TA6:2** is on the visible lighting requirements of the proposed Development.

46. On the basis of the CAA requirements, it is evident that the effect of the visible lights of the proposed Development will be dependent on a range of factors, including the intensity of lights used, the clarity of atmospheric visibility and the degree of negative/ positive vertical angle of view from the light to the receptor. In compliance with EIA regulations, the likely significant effects of a 'worst-case' scenario for turbine lighting are assessed and illustrated in this visual assessment. A worst-case approach is applied which considers the effects of 2,000cd lights and 200cd lights during periods of clear visibility. It should be noted however, that as the required medium intensity lights are only likely to be operated at their maximum 2,000cd during periods of poor visibility, that 2,000cd intensity actually represents an unrealistic worst case position, as it is unlikely to ever be experienced at that maximum illumination level. Similarly, 200cd is unlikely to be experienced by observers at locations lower or higher (in the case of some hilltops) than the turbine nacelle heights due to the reduction in light intensity at negative/ positive elevation angles from the light.

47. Whilst it is noted that the actual light perceived at assessment viewpoints (and within the study area) is likely to be less intense than the maximum intensity of the light (2,000cd in visibility <5km and 200cd in visibility >5km), this **TA6.2** assesses the maximum possible intensity of light observed at each of the viewpoints considered and represents this maximum intensity in corresponding visualisations.

### 6.4.2 Spatial Scope

48. Based on relevant guidance and the consultation responses received from relevant stakeholders, the assessment of visual effects of turbine lighting in this **TA:6.2** includes both – an assessment of the effects of lighting on users of the DSP (with reference to viewpoints and key routes/visitor locations within the DSP); and an assessment of the effects of lighting on people in other nearby locations, outside the DSP, where current lighting levels are low.

49. The study area for the visual assessment of turbine lighting is shown in **Figure TA6.2-1a** and takes in the proposed Development, its immediate surroundings extending to include the core area and buffer zone of the Galloway Forest Dark Sky Park to the east, north-east and south-east; and limited to the north by areas with higher levels of baseline lighting in the more settled parts of South Ayrshire.

### 6.4.3 Types of Effect

50. The visual assessment of turbine lighting in this **TA6:2** is intended to determine the likely effects that the proposed Development will have on the visual resource i.e. it is an assessment of the effects of aviation lighting on views experienced by people at night.

51. The assessment of turbine lighting in this **TA6:2** does not consider effects of aviation lighting on landscape character (i.e. landscape effects). For 2,000 candela medium intensity steady or fixed red lights, ICAO indicates a requirement for no lighting to be switched on until 'Night' has been reached, as measured at 50cd/m2 or darker. This is helpful as it does not require 2,000 candela medium intensity to be on during 'twilight', when landscape character may be discerned. It is considered that the proposed aviation lighting will not affect the perception of landscape character, which is not readily perceived at night in darkness, particularly in rural areas. While aviation lighting will be visible and result in visual effects, as assessed in this **TA6.2**, the effects of aviation lighting on the perception of landscape character are scoped out of this assessment.

### 6.4.4 Assessment of Significance

52. The significance of effects of turbine aviation lighting is assessed through a combination of the sensitivity of the visual receptor and the magnitude of change that would result from the visible aviation lighting, in accordance with the approach adopted for daytime LVIA set out in **TA6.1 LVIA Methodology**. For the assessment of lighting effects, the visual sensitivity and magnitude criteria described in **TA: 6.1** has been applied. The matrix in **Table TA6.1-1** of **TA6.1** gives an understanding of the threshold at which significant effects may arise.

53. A significant effect occurs where the aviation lighting would provide a defining influence on a view or visual receptor. A not significant effect would occur where the effect of the proposed Development is not material, and the baseline characteristics of the view or visual receptor continue to provide the definitive influence. In this instance the aviation lighting may have an influence, but this influence would not be definitive.

54. In determining significance, particular attention is paid to the potential for 'Obtrusive Light' i.e. whether the lighting impedes a particular view of the night sky; creates sky glow (brightening of the night-sky); glare (uncomfortable brightness; or light intrusion (the spilling of light beyond the site or area being lit) (ILP) (2011) (GN01:2011).

### 6.4.5 Cumulative Effects of Aviation Lighting

55. Operational and under-construction windfarms shown within 45km of the proposed Development (**Figure 6.4** of **EIAR Volume 3a**) are assumed to be part of the baseline conditions, however none of the operational or under-construction windfarms within the study area for this aviation lighting assessment (**Figure 6.2-1**) are fitted with visible aviation lighting (since none of these operational turbines are above 150m in height and therefore they do not require visible aviation lighting). There are also no consented windfarms within this area which are above 150m in height (**Table 6.11.1** of Chapter 6).

56. The cumulative effects of aviation lighting is therefore only assessed for the application scenario, in **Section 6.7.5**, which includes other application stage windfarms within the study area for this aviation lighting assessment with proposed wind turbines above 150m that require to be identified with visible lighting – Arecleoch Extension, Kilgallioch Extension, Stranoch 2 and Windy Standard III.

### 6.4.6 Visual Representations

#### 6.4.6.1 ZTVs

57. ZTV maps have been produced to show the areas from which the medium-intensity nacelle lights and low-intensity tower lights may be seen. These ZTV maps of the turbine nacelle lighting are provided in **Figure TA6.2-2** (45km) and **Figure TA6.2-3** (Study Area/Dark Skies Park). A ZTV of the tower lighting is also provided in **Figure TA6.2-4**. These ZTVs can be used to identify where the aviation lights and tower lights may theoretically be visible and how many lights may be theoretically visible from different locations. These ZTVs illustrates the 'bare ground' situation, and do not take into account the screening effects of vegetation, buildings, or other local features that may prevent or reduce visibility. They also do not indicate the decrease in visibility of the lights that occurs with increased distance. The nature of what is visible from 3 km away would differ markedly from what is visible from 10 km away, although both are indicated on the Nacelle Light ZTV as having the same level of visibility (e.g. 16-18 lights visible).

58. A further ZTV of the potential lighting intensity is provided in **Figure TA6.2-5** which provides an illustration of the potential intensity of the nacelle aviation lights, shown in candelas, at different vertical angles based on a specific light manufacturers interpretation of the requirements of the ICAO minimum standard[3].

#### 6.4.6.2 Photomontage Visualisations

59. Night-time baseline view panoramas and photomontage visualisations showing medium-intensity nacelle mounted aviation lighting and low-intensity tower lighting are presented from five viewpoints in **EIAR Volume 3b** – **Figure 6.28h-j** (Viewpoint 2: Minor Road south of Barrhill); **Figure 6.36f-h** (Viewpoint 10: A714 Creeside); **Figure 6.43f-h** (Viewpoint 16: Kirriereoch Picnic Site)[4]; **Figure 6.45g-l** (Viewpoint 19: B734 approach to Barr) and **Figure 6.50h-j** (Viewpoint 24: Benyellary).

60. Although aviation lighting manufacturers must meet the minimum requirements, their products may vary in relation to recommended limits set out in ICAO standards, which makes it difficult producing accurate visualisations as the lighting characteristics of different light fittings, of the same intensity, may vary outside the minimum requirements stipulated by ICAO. The night-time photomontages shown in these figures have been produced to show both 2,000cd and reduced intensity 200cd lighting, to inform the assessment of worst-case effects assessed. If the horizontal meteorological visibility in all directions from every wind turbine generator in a group is more than 5km, the CAA allows that the intensity for the light may be reduced to not less than 10% of the minimum peak intensity specified for a light of this type, or 200cd in this case. The night-time photomontage representations assume full lighting intensity of the 2,000 candela (cd) warning lights, as a worst-case and are therefore likely to over-represent the likely visibility of aviation warning lighting experienced in reality as visibility is likely to be poorer when they operate at that level.

61. In terms of how lighting is captured in visualisations, SNH guidance (SNH, 2017) recommends that visualisations *' should use photographs taken in low light conditions, preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night"… "We have found that approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image."*

62. The night-time photography has therefore been captured in such low light conditions, when 'night' has been reached and where possible, when other artificial lighting (such as street-lights and lights on buildings) is on, to show how the aviation lighting would look compared to the existing baseline at such times.

63. Existing lights shown in the photographs appear larger and more blurred than those seen to the naked eye in the field when the photographs were captured. The term used in photography to describe this effect is 'Bokeh' which has been defined as 'the way the lens renders out-of-focus points of light'. This has proved difficult to avoid when taking photographs of light at varied distances across a view. The blurred nature of the lights is also exacerbated

[3] LuxSolar Medium Intensity Obstruction Light CAP 168 MIOL-C: Data Sheet, January 2018.

[4] Visualisations in Figure 6.43f-h (Kirriereoch) are night-time simulations, which apply a night filter to daytime exposures to create a visual representation. They do not capture the baseline lighting in the view.

by their movement, particularly on vehicle headlights. Where the lights of the proposed Development have been added to the night-time views this effect has been emulated.

64. The lighting represented in the viewpoint visualisations has been calibrated using examples of existing, equivalent, turbine lighting observed in the field in other parts of Scotland, during similar periods of dusk / darkness as captured in the photography for the agreed viewpoints.

65. The turbine blades, when they intermittently pass in front of the aviation lights, would cause randomised flickering when the lights are switched 'on'. The turbines used in the night-time visualisations have been positioned so that their blades face away from the viewpoint so that all the lights are visible and on within the visualisations, representing a worst-case impression. The flickering effect caused by the blades interacting with the lights would be most usually apparent from a south-westerly direction due to the prevailing south westerly wind. As the blades turn around in front of the lights there may are also incidences whereby the emitted light spills across the blades producing a further incidental effect. These effects associated with turbine rotor movement are difficult to capture within the limitations of the photomontages.

# 6.5 Baseline Conditions

### 6.5.1 Study Area - Overview

66. Campaign to Protect Rural England (CPRE) has produced interactive maps of the UK's light pollution and dark skies as part of a national mapping project (LUC/CPRE, 2016)[5]. This Open Source data[6] has been used to help understand and illustrate the existing baseline lighting levels of the Study Area and is mapped in **Figure TA6.2-1a**.

67. Each pixel in the mapping shows the level of radiance (night lights) shining up into the night sky, which have been categorised into colour bands to distinguish between different light levels, from colour band 1 (darkest) to 9 (brightest). The map clearly identifies the main concentrations of night-time lights, creating light pollution that spills up into the sky. Most notably, this is in, and around the main settlements, particularly the Girvan/Prestwick area and Newton Stewart, but also other smaller settlements on the coast such as Turnberry and Ballantrae. Smaller villages are also shown as having concentrations of night-time lights, including Barr and Colmonell. In addition, the map also identifies transport infrastructure such as parts of the A714 as having lower levels of light, particularly where they pass through settled areas.

68. By contrast, the map also identifies areas where there is little night-time lighting. The proposed Development is located in an area within colour band 1 (darkest), which occur within the areas where the sky would be expected to be truly dark. With the exception of localised areas, the majority of the Galloway Forest DSP core area and buffer zone fall within these darkest areas, however they also extend to include other areas with low levels of lighting around its transition zone.

69. A NASA Earth Observatory image showing the study area at night is shown in **Figure TA6.2-1b**, which supports the representation of baseline lighting in the areas described from the CPRE mapping.

### 6.5.2 Galloway Forest Dark Sky Park (DSP)

70. The Galloway Forest Park received Gold Tier Dark Sky Park Status from the International Dark Sky Association (IDA) in 2009 due to the exceptional quality of the night sky. Dark Sky Parks can be either publicly or privately-owned spaces protected for natural conservation that implement good outdoor lighting and provide dark skies information for residents and visitors. This award highlights how clear the night environment is in Galloway Forest Dark Sky Park (DSP) and gives recognition to its qualities. The DSP provides an important resource in providing opportunity for people to see a truly dark sky that is not affected by light pollution.

71. The DSP provides a tourist attraction for the south west of Scotland, particularly in winter months due to its unique and clear astronomy and star viewing opportunities. Planning policies in the LDP encourage sustainable and sympathetic development to provide facilities for tourists and strengthen and expand rural businesses within the DSP and an area of 10 miles outwith of the Park, referred to as the 'Transition Zone'.

72. The DSP is composed of two zones, namely a Core Area and Buffer Zone (**Figure TA6.2-1a**). The status is dependent on the conditions within the Core Zone, but both form part of the DSP. The conditions for DSP status require stringent lighting guidance for the Core Zone. The Buffer Zone is required around the Core Zone to protect the status of the Core but does not in itself need to reach to the same dark sky class in order for the DSP to keep its status. The proposed Development is located within the Buffer Zone of the DSP, but not within the Core Zone (with the closest turbine being approximately 3.9km to the west of the Core Zone), as shown in **Figure TA6.2-1a.**

73. The DSP attracts people wishing to appreciate the night-time sky with an absence of night-time light pollution. Forestry Land Scotland (FLS) promotes 10 viewing locations in the DSP, as locations '*where to view the wonders of the night sky in Galloway Forest Park',* which offer stopping points to view the night sky. These 'dark skies viewing locations' are mapped in **Figure TA6.2-1a**. The sensitivity of the 10 viewing locations to the potential effects of the turbine aviation lights is higher than other areas of the DSP, as they are specifically promoted in DSP leaflets to encourage visitors to these sites with the express intention of viewing the night sky and this experience could be affected by other sources of light.

74. As well as these specific dark skies viewing locations, Forestry and Land Scotland also promotes 'Forest Park Favourites' in its guide to the Galloway Forest Park. These include three scenic drives – the Queen's Way, Carrick Forest Drive and Raider's Road; as well as the Glentrool and Clatteringshaws visitor centres. The Southern Upland Way and National Cycle Route 7 (NCR7)/Glentrool Forest Road also pass through the Galloway Forest DSP; and the A714 partially skirts the south-eastern edge of the buffer zone. These principal visual receptors are mapped in **Figure TA6.2-1a** as the main routes and visitor centres where people may also experience incidental views of the night sky within the DSP.

75. Three representative viewpoint locations within the Galloway Forest DSP, in addition to the 10 dark skies viewing locations, have been identified from these principal visual receptors, to illustrate the night-time baseline conditions and consider the visual effects of the proposed turbine aviation lighting. These are located at Benyellary (Viewpoint 24) within the core area of the DSP; at Kirriereoch Picnic Site (Viewpoint 17) in the buffer zone, between the core area and the proposed Development; and on the A714 on the edge of the buffer zone, as mapped in **Figure TA6.2-1a**.

76. Night-time baseline panoramas from these three viewpoints are presented in **Figure 6.36f** (Viewpoint 10: A714, Creeside); **Figure 6.43f** (Viewpoint 17: Kirriereoch Picnic Site) and **Figure 6.50h-j** (Viewpoint 24: Benyellary). The baseline conditions are described in the assessment of these viewpoints in **Section 6.7**.

### 6.5.3 Other Areas with Low Levels of Lighting

77. In addition to the defined Galloway Forest DSP, further assessment of effects of lighting on people in other nearby locations where current lighting levels are low is carried out in **Section 6.7**. Broadly this area is defined as being around the edges or transition zone around the DSP, including the Stinchar Valley to the north; the Duisk Valley to the west/south-west and adjacent plateau areas, which are relatively near the proposed Development, but outside the Dark Skies Park, where current lighting levels are low. Low lighting areas are informed with reference to CPRE maps of "light pollution" (CPRE, 2016) as shown in **Figure TA6.2-1a**. Areas to the north of the Stinchar Valley into settled areas of South Ayrshire are generally subject to higher levels of baseline lighting due to the influence of lighting within urban/settled areas and are not assessed any further.

78. Two representative night time viewpoints are considered in the LVIA to illustrate and allow assessment of lighting effects from landscapes where lighting levels are low that may be experienced by people. These are located near to the two closest settlements of Barr (Viewpoint 19: A734 Approach to Barr) and Barrhill (Viewpoint 2: Minor Road south of Barrhill), just outside the DSP looking towards the proposed Development from nearby areas with low level of lighting **Figure TA6.2-1a**.

[5] https://www.nightblight.cpre.org.uk/maps/

[6] Light Pollution data source – Earth Observation Group,NOAA National Geophysical Data Center. Data processed by LUC on behalf of CPRE

79. Night-time baseline panoramas from these two viewpoints are presented in **Figure 6.28h** (Viewpoint 2: Minor road to the south of Barrhill); **Figure 6.45g** (Viewpoint 19: B734 approach to Barr). The baseline conditions are described in the assessment of these viewpoints in **Section 6.7**.

# 6.6 Mitigation

### 6.6.1 Mitigation Options

80. The options for mitigation of visual effects of aviation lighting that are currently available for the proposed Development are outlined in **Table TA6.2-2**. Mitigation measures that will be embedded in the project design are shaded in green. Mitigation measures that are being considered for the proposed Development, in discussion with regulators, are shown in grey.

Table TA6.2-2 Turbine Lighting Mitigation Options

| Mitigation Option | How it works |
|---|---|
| Reduce intensity of lights from 2,000cd to 200cd | Already provided for in CAA guidance CAP 393. 2,000cd aviation lights may be dimmed to 10% of their intensity (200cd) in where visibility conditions permit, when visibility from every turbine within the wind farm group is >5km. Visibility conditions are measured using a visibility sensor, which can then be dimmed automatically to respond to prevailing meteorological conditions. 2,000cd lights will therefore only be experienced in visibility of <5km; and their intensity would be dimmed to 200cd in visibility of >5km. |
| 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. |
| 'Smart' aviation lighting (or 'surveillance activated') (aviation obstruction lighting detection system) | 'Smart' aviation lighting would only be switched on when aircraft approach a defined airspace around the wind farm. 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 4 km (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 such aircraft ordinarily operate in Controlled Airspace (CAS). |

### 6.6.2 Proposed Mitigation

81. The proposed Development will incorporate the following mitigation measures in respect of turbine aviation lighting:

- **Reduce intensity of lights from 2,000cd to 200cd** - 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 candela (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 candela.

82. Consideration is also being given to use of lights with specific **directional intensity,** in order to reduce or eliminate vertical downwards light impact at elevations less than -1° degree vertical angle from the horizontal plane from the aviation light. By implementing the ICAO recommendations with current models of aviation lights, 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 1,125cd and at -10 degrees should only be 75cd (when visibility is >5km). This is considered further for specific receptors in **Section 6.7**.

83. In addition to the control measures that may be applied to dim the lighting in certain conditions, as described above, it is proposed to explore the possibility of using 'smart' aviation lighting (aviation obstruction lighting detection system) whereby the lights would only be switched on when aircraft approach them (see **Chapter 14, Section 14.2 Aviation**).

84. 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. It is expected that this guidance will be finalised and released during 2019. As this technology is not yet fully approved at the time of writing, the assessment has not considered this mitigation in its conclusions. The draft guidance would allow the aviation lights only to be illuminated when an aircraft is detected by a radar entering a volume bounded by 4 km (horizontal distance) from the perimeter group of turbines and 300m above the highest turbine tip of the Site. Our calculations estimate that the upper boundary of this volume would be around 3,000 ft above ground level[7].

85. The aviation lighting would not be activated when commercial airlines pass over the Site, as such aircraft ordinarily operate in Controlled Airspace (CAS), the base of which CAS over the Site being 5,000 ft and above. Given the lights are only required for general aviators flying at night in the vicinity of the Site at altitudes of up to 3,000 ft, it is anticipated that the lights will be rarely turned on in this quiet airspace. According to the Aviation Study, included as **TA 14.2,** it is predicted that the aviation lights would only be on for approximately 2-4 minutes, provided the radar can track the aircraft across the windfarm, resulting in the aviation lights having short duration visual effects of limited frequency.

86. If this technology could be installed, the level of exposure of visual receptors in the area to turbine lights would be greatly reduced, in line with the amount of time during which passing air traffic would activate the aviation lights. As this technology is not yet approved, the assessment has not assessed this mitigation in the impact assessment contained in **Section 6.7**.

# 6.7 Assessment of Visual Effects

### 6.7.1 Zone of Theoretical Visibility (ZTV)

#### 6.7.1.1 Nacelle light ZTV

87. The turbine nacelle lighting ZTV (**Figure TA6.2-3)** can be used to identify where the aviation lights may theoretically be visible and how many lights may be theoretically visible from different locations. It is based on the hub height ZTV, given the location of the aviation lights on the hub/nacelle of each of the proposed turbines. The base mapping has been darkened to give an indication of those areas that will not be affected by visibility of the aviation lighting.

88. In general terms, the ZTV indicates that areas of higher visibility of the aviation lights (16-18 lights) occur within 20km and are more prevalent to the south of the proposed Development than to the north, where in overall terms, visibility of the aviation lights will be more limited in geographical extent and in terms of the number of visible lights. These areas to the north are also, broadly speaking, areas with higher levels of lighting in the baseline, whereas areas to the south, east and west of the proposed Development tend to be darker.

89. Higher levels of visibility of the aviation lights (16 – 18 lights) occur primarily along the rising landscape immediately around the site extending to the east to the Merrick Hills and across the forested plateau moorlands of South Ayrshire and Galloway to the south and south-west of the proposed Development. In general, these are relatively

[7] 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 409 m AOD. With 200 m turbines and 300 m above the highest part of the turbine, the maximum height of the radar coverage required would be 909 m or 2982 ft, rounded up to 3000 ft.

remote, heavily forested areas with limited access, and high levels of darkness, yet relatively few visual receptors, with access on unclassified roads and forest access tracks. Settlement in these elevated plateau landscapes is limited to scattered rural dwellings and farmsteads. Higher levels of visibility (16 – 18 lights) also extends to the western flanks of the core area of the Galloway Forest DSP, to the east of the Site, where the higher landforms of these rugged uplands provide elevated views, sometime at or above the horizontal plane of the lights. The majority of the core area of the Galloway Forest DSP, beyond the 'range of the Awful Hand' (formed by Benyellary, Merrick Kirriereoch Hill, Tarfessock and Shalloch on Minnoch), will experience no visibility of the aviation lighting, since it is physically and visually separated from the lights by this range of high uplands between the lower-lying interior of the core area and the proposed Development.

90. There will also be views of the aviation lights from the foothills of South Ayrshire to the north, on either side of the Stinchar Valley, however this tends to be of a reduced number of lights due to the screening provided by the intervening upland ridgeline of the lights that are set back further to the south of the Site. The areas to the north and north-east of the proposed Development, beyond the Carrick Hills, afford very limited visibility of the aviation lights, generally of 1-3, 4-6 or 7-9 turbines, limited to localised areas of rolling higher ground affording visibility at long distances. The ZTV shows that there are patches of theoretical visibility of the aviation lights from isolated landmark hill locations within South Ayrshire, to the north-west of the proposed Development, but that the majority of the lower lying valleys and settled landscapes within Ayrshire will have limited or no visibility of the aviation lights.

91. The lower lying valleys and glens that penetrate into the plateau moorland, will also generally experience limited visibility. The ZTV only shows theoretical visibility along the Duisk Valley to the south-west of the aviation lighting on the north-east facing slopes of the Duisk Valley near Barrhill, where there will be mid-range views back across the valley to the Site and the distinctive upland backdrop formed by the Galloway Hills/Merrick uplands to the south of the Site. The majority of the Duisk Valley will have no visibility of the aviation lights. Similarly, views from the Stinchar Valley are restricted by the intervening rising landform on the southern side of the valley, which limits views of the lights, as the proposed turbines are generally set back into the uplands behind the skyline. Visibility is restricted to isolated locations along the Stinchar Valley with views of several more prominent turbines and their associated aviation lights on the northern edge of the Site, and to the south facing slopes on the northern side of the Stinchar Valley, where there are views back across the valley and the village of Barr, to the proposed turbines and their aviation lights on the upland skyline.

#### 6.7.1.2 Tower light ZTV

92. A ZTV of the intermediate level, low intensity, tower lighting is also provided in **Figure TA6.2-4**, which can be used to identify where the tower lights may theoretically be visible and how many tower lights may be theoretically visible from different locations. This ZTV has limitations, in that it does not illustrate the reduced intensity of the 32cd tower lights, and simply indicates areas where they may be theoretically visible when located at 62.5m half-way up the wind turbine towers.

93. Due to the lower height of the intermediate level tower lights, their ZTV is much more restricted, particularly to the north, where there is almost no visibility of the lights beyond the foothills to the north of the Stinchar Valley; and from wider areas of the Galloway Forest DSP core area and buffer zone, beyond the enclosing uplands to the north-east and east of the proposed Development. Visibility of the intermediate level tower lights is likely to be concentrated to relatively close locations around the proposed Development, with higher areas of theoretical visibility of 16-18 tower lights concentrated to the south and south-west; and east and south-east of the proposed Development; from the largely uninhabited forested plateau that surrounds the site in these areas; the roads that cross the plateau into the Duisk Valley and the western flanks of the Merrick uplands forming the western edges of the core area of the DSP.

#### 6.7.1.3 Lighting Intensity ZTV

94. A further ZTV of the potential lighting intensity is provided in **Figure TA6.2-5**. With specific relation to the proposed Development, **Figure TA6.2-5**, provides an illustration of the potential intensity of the nacelle aviation lights, shown in candelas, at different vertical angles based on a specific light manufacturer's interpretation of the requirements of the ICAO minimum standard[8], with the corresponding light intensity reductions for each of the 2,000cd and 200cd lighting situations shown. This ZTV is based on the graph in plate **TA: 6.2.1**, for the light emissions of the LuxSolar Medium Intensity Obstruction Light and shows how the intensity of 2,000cd light emissions are likely to be focused within the horizontal plane (between 0 and +3°) and reduces in intensity outside this main beam, above +3° and from below the horizontal plane. This ZTV provides an illustration, based on a specific light model, however most current aviation light models on the market will incorporate this form of directional intensity as standard in addressing ICAO requirements.

95. Generally, the lighting intensity ZTV in **Figure TA6.2-5** shows that the full 2,000cd light intensity would only be experienced from particular parts of the study area that are at a similar height to the horizontal plane of the directional beam of the aviation lights, or on slightly more elevated terrain, between 0-3° above the horizontal. These areas of maximum intensity of the example 2,000cd aviation lights are shown in red in **Figure TA6.2-5** and are concentrated to the smooth, rounded uplands immediately north/north-east of the Site, between Fell Hill and Rowantree Hill; and from the western flanks and summits of the 'Range of the Awful Hand' core area of the Galloway Forest DSP. All of these summit areas of highest light intensity within the core area of the DSP are located over 5km from the proposed Development, therefore would only afford visibility of 2,000cd lighting in poor visibility conditions; and would in periods of clear visibility, afford visibility of the 200cd lights (dimmed to 10% of the 2,000cd when visibility is >5km).

96. **Figure TA: 6.2-5** illustrates that the vast majority of the area between 5km and 20km would afford views of the turbine lighting from below the horizontal, due to the height of the aviation lights on the turbines on elevated ground above the main receptors, and at a vertical angle of between 0 and -2°, which would result in an approximate range of lighting intensity of between 2,000-80cd when visibility <5km and 200-8cd when visibility >5km.

97. Much of the area within 5km of the proposed Development, including the plateau to the south and upper parts of the Stinchar Valley to the north, would experience the turbine lighting at a vertical angle of between -1 and -3°, which would result in an approximate range of lighting intensity of between 750-40cd when visibility <5km and 75-4cd when visibility >5km. The ZTV provides some illustration that from many of the lower-lying surrounding areas with low levels of lighting (including the upper parts of the Stinchar and Duisk Valley), the aviation lights are likely to be experienced at substantially reduced intensity, due to the directional intensity of the lights being focused in the zone most visible to aircraft and with reduced intensity of light viewed from these areas below the horizontal plane of the light.

98. These illustrative intensity calculations, mapped on **Figure TA6.2-5** using the approximate lighting intensity levels of the LuxSolar Medium Intensity Obstruction Light example, illustrate that whilst there is theoretical visibility of aviation lights from areas shown on the Nacelle Light ZTV (**Figure TA6.2-3**), the actual intensity of these lights would vary considerably depending on the position of the receptors, their ground level and the height of the proposed turbine aviation lights.

### 6.7.2 Preliminary Viewpoint Assessment

99. Using the nacelle light ZTV and tower light ZTV, a table which lists how many lit turbines will be theoretically visible[9] from each of the representative viewpoints included in the LVIA is presented in **Table TA6.2-3**.

[8] LuxSolar Medium Intensity Obstruction Light CAP 168 MIOL-C: Data Sheet, January 2018.

[9] Table 6.2-3 shows theoretical visibility based on the ZTV/terrain and does not allow forestry screening of aviation lights.

Table 6.2-3: Theoretical Lighting Visibility from LVIA Viewpoints

| Turbine No. | VP 1 | VP 2 | VP 3 | VP 4 | VP 5 | VP 6 | VP 7 | VP 8 | VP 9 | VP 10 | VP 11 | VP 12 | VP 13 | VP 14 | VP 15 | VP 16 | VP 17 | VP 18 | VP 19 | VP 20 | VP 21 | VP 22 | VP23 | VP24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance (closest turbine) | 12.9 km | 8.0 km | 8.5 km | 14.4 km | 16.2 km | 14.0 km | 5.5 km | 10.5 km | 4.7 km | 7.3 km | 12.8 km | 9.7 km | 7.5 km | 17.0 km | 12.2 km | 11.1 km | 4.1 km | 4.2 km | 5.2 km | 3.0 km | 3.9 km | 26.1 km | 40.3km | 10.0km |
| Turbine 1 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | O | X | O | X | Xx | Xx | Xx | Xx | X | X | X | Xx | Xx | X | X | Xx |
| Turbine 2 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | O | X | O | Xx | Xx | O | Xx | Xx | Xx | O | O | Xx | X | X | X | Xx |
| Turbine 3 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | O | Xx | O | O | Xx | O | Xx | Xx | Xx | O | O | X | O | Xx | O | Xx |
| Turbine 4 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | Xx | Xx | Xx | Xx | Xx | X | Xx | Xx | Xx | Xx | Xx | Xx | Xx |
| Turbine 5 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | O | Xx | O | Xx | Xx | Xx | Xx | Xx | X | O | O | Xx | X | Xx | X | Xx |
| Turbine 6 | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | Xx | O | O | Xx | Xx | Xx | Xx | Xx | O | O | O | O | O | X | Xx |
| Turbine 7 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | O | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx |
| Turbine 8 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | X | Xx | Xx | Xx | Xx | Xx | X | X | X | X | Xx | Xx | Xx |
| Turbine 9 | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | Xx | O | O | Xx | Xx | Xx | X | X | O | O | O | O | O | X | Xx |
| Turbine 10 | Xx | Xx | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | X | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | X | Xx | Xx | Xx |
| Turbine 11 | Xx | Xx | Xx | Xx | Xx | Xx | O | Xx | O | Xx | O | O | Xx | Xx | Xx | X | Xx | O | O | O | O | O | O | Xx |
| Turbine 12 | Xx | Xx | X | Xx | Xx | Xx | O | Xx | O | Xx | O | O | Xx | Xx | X | O | X | O | O | O | O | O | O | Xx |
| Turbine 13 | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | Xx | O | X | Xx | Xx | Xx | X | Xx | O | X | X | O | X | X | Xx |
| Turbine 14 | Xx | Xx | X | Xx | Xx | Xx | O | Xx | O | Xx | O | O | Xx | Xx | X | O | Xx | O | O | O | O | O | X | Xx |
| Turbine 15 | Xx | Xx | X | Xx | X | Xx | O | Xx | O | Xx | O | O | Xx | X | O | O | Xx | O | O | O | O | O | O | Xx |
| Turbine 16 | Xx | Xx | X | Xx | Xx | Xx | O | Xx | O | Xx | O | O | Xx | Xx | O | O | Xx | O | O | O | O | O | O | Xx |
| Turbine 17 | Xx | Xx | X | Xx | Xx | Xx | O | Xx | O | Xx | O | O | Xx | Xx | X | X | X | O | O | O | O | X | O | Xx |
| Turbine 18 | Xx | Xx | Xx | Xx | Xx | Xx | X | Xx | O | Xx | O | O | Xx | O | Xx | Xx | Xx | O | O | O | O | O | O | Xx |
| Key | | | | | | | | | | | | | | | | | | | | | | | | |
| Xx | Lights theoretically visible on nacelle and tower | | | | | | | | | | | | | | | | | | | | | | | |
| X | Lights visible as single light on nacelle | | | | | | | | | | | | | | | | | | | | | | | |
| O | Lights not visible | | | | | | | | | | | | | | | | | | | | | | | |

100. There are several points to note from Table **TA6.2-3**. In particular, the majority of representative viewpoints (18) are beyond 5km from the proposed Development and will therefore experience 200cd lighting intensity in 'clear' visibility. The number of representative viewpoints over 5km is indicative of the general lack of receptors within closer 5km range, limited mainly to the settlement of Barr and the trails to the east/south of this village; the B734 along the Stinchar Valley; the Glentrool Forest Road and NCR7/Kirriereoch Picnic Site on this road. Many of the representative viewpoints within these closest areas, including VP9, VP18, VP20 and VP21, will have views of relatively few aviation lights, often just having visibility of several lights rather than the full array.

101. From wider areas between 5-15km, there tends to be theoretical visibility of a higher number of the turbine lights, including in views from the elevated western flank and summits of the core area of the DSP, such as Merrick (VP8) and Shalloch on Minnoch (VP13); and in views from plateau to the south-west such as Chirmorrie (VP1), Minor Road to south of Barrhill (VP2) and SUW Hill of Ochiltree (VP6); however, due to the distance of these viewpoints, the intensity of the aviation lights will be experience at a reduced 200cd lighting intensity in 'clear' visibility.

102. In long distance views, over 20km, the aviation lights are still likely to be visible, based on experience of other operational windfarm aviation lights viewed in the field, however the distance and reduced intensity are mitigating factors with increasing distance.

### 6.7.3 Galloway Forest Dark Sky Park (DSP)

103. The assessment of effects of aviation lighting on users of the Galloway Forest DSP is informed by the nacelle light ZTV (**Figure TA6.2-3)** and an understanding of the nature of the likely effects of the proposed lighting, gained from observing windfarm aviation lighting at operational windfarms. The ZTV and wirelines of the proposed Development have been used to review the visibility of lighting using from viewing locations within the Galloway Forest DSP and consider the potential effects. As described in the baseline in Section 6.5.2, there are 10 dark skies viewing locations mapped and promoted by the DSP as specific viewing sites. These viewpoints, in particular, have been considered in the visual assessment of the DSP due to their potential sensitivity as viewing sites that people visit with the express intention of viewing the night sky.

104. With reference to **Figure TA6.2-2**, visible aviation lighting of the proposed turbines would not be seen from any of the 10 dark skies viewing locations, which are shown in this map relative to the ZTV. All of the 10 dark skies viewing locations will afford no visibility of the proposed turbines, their aviation lights and tower lights to people viewing the night sky from these locations, because they are all outside the area of theoretical visibility shown in the ZTV in **Figure TA6.2-2.** None of the proposed turbines will be visible from any of these dark skies viewing locations. This has been confirmed using wireline analysis to test the visibility of the proposed Development from each dark skies viewing location. This is a key finding of the visual assessment since it demonstrates that there will be no visual effect as result of the visible aviation lights on the appreciation of the dark skies of the DSP from any of the promoted dark skies viewing locations. Fundamentally, people will be still be able to visit any of these promoted dark skies viewing locations and will not have their views of the night sky impeded, as a result of the proposed aviation lighting.

105. While these locations are identified as being suitable viewing sites, people could feasibly be viewing the night sky from other accessible parts of the DSP particularly the 'Forest Park Favourites' promoted in the guide to the Galloway Forest Park. The three scenic drives – the Queen's Way, Carrick Forest Drive and Raider's Road; as well as the Glentrool and Clatteringshaws visitor centres will afford no visibility of the proposed turbines, their aviation lights and tower lights, because all parts of these routes and visitor centres are outside the area of theoretical visibility shown in the ZTV in **Figure TA6.2-2**. There is also no visibility of the aviation lights from the route of the SUW through the DSP. This supports the key finding of the visual assessment that there will be no visual effect as result of the aviation lights on the appreciation of the dark skies of the DSP from the main accessible public routes through the DSP that are promoted to view the dark skies, so people travelling and stopping incidentally along these routes will not have their views of the night sky impeded in any way.

106. While the 10 dark skies viewing locations and the main accessible 'favourite' routes and visitor centres of the DSP are identified as the most likely night sky viewing sites, people could feasibly be viewing the night sky from any part of the Galloway Forest DSP. Parts of the Core Zone of the DSP around the western flank and summits of the Merrick uplands (the 'Range of the Awful Hand') that offer visibility of the proposed Development are remote upland areas which are not, in all likelihood, somewhere that people often go at night to view the night sky (in general, people would tend to use the more accessible viewing locations or key routes through the DSP). The DSP information leaflet does not identify any specific locations within the core area as dark skies viewing locations, perhaps for this reason that public access to these remote uplands areas at night is not really encouraged.

107. The potential visual effects of aviation lighting arising from the proposed Development are contained, in the main, to the western flank of the core area of the DSP, formed by the range of the Awful Hand, consisting the Benyellary, Merrick, Kirrieroech Hill, Tarfessock to Shalloch on Minnoch ridgeline. The parts of the core area of the DSP which demonstrate the highest overall darkness are within the lower-lying 'interior', where the assessment has found that the aviation lighting will not be visible and will have no effects on the darkness experienced from within this 'interior' of the core area of the DSP as it is entirely not visible from this interior, due to the visual and physical separation and containment provided by the mountains of the intervening 'Awful Hand'.

108. An assessment of the effects of the aviation lighting on views experienced from the core area of the DSP is undertaken with reference to representative views with the Galloway Forest DSP in the following viewpoint assessment.

#### 6.7.3.1 Representative Night-time Viewpoints

109. An assessment of the visual effects of visible aviation lighting has been carried out from three representative viewpoint locations within the Galloway Forest DSP, as shown in **Figure TA6.2-1a**: A714 Creeside (Viewpoint 10); Kirriereoch Picnic Site (Viewpoint 17) and Benyellary (Viewpoint 24). Night-time photomontage visualisations ( **Figure 6.36g-h; Figure 6.43g-h and Figure 6.50i-j**) have been produced to inform this assessment, which is set out for each these representative night-time viewpoints as follows.

#### 6.7.3.2 Viewpoint 10: A714 near Creeside

Table 6.2-4: Viewpoint 10: A714 near Creeside

| **Baseline conditions** |
|---|
| **Existing view and Sensitivity** (Figure 6.36f) |
| This viewpoint is located on the A714 to the south of Creeside, near Wheeb Bridge/Arnimean, on the edge of the buffer zone of the DSP. In line with the assessment in the daytime LVIA, the viewpoint is considered to have medium-low value. The viewpoint is representative of views experienced by motorists travelling northbound on A714 at this location, passing the edges of the DSP, where there are fleeting views across the plateau towards the smooth slopes and rounded summits of Cairn Hill/Pinbreck Hill/Craigenreoch. There is no existing lighting in the baseline view towards the proposed Development, however there are intermittent lights associated with traffic flow along the A714. The overall impression of the night-time view at this location is of a dark forested landscape with a dark upland backdrop. The enclosure by forestry to some parts of the view enhances the impression of darkness. There is no visible wind turbine lighting in the view. The viewpoint is representative of incidental views across the buffer area of the DSP, experienced by motorists passing on the main A714, and is not likely to be used by people as specific viewing location or stopping point.<br>Taking these factors into account, the susceptibility to change of motorists passing on the A714 at this viewpoint is assessed as **Medium-low** and the sensitivity to change is assessed as **Medium-low**. |
| **Assessment** |
| **Visual Effect of Aviation Lighting (2000cd lights)** |
| The predicted view of the aviation lights at 2,000cd is shown in the photomontage in **Figure 6.36g**.<br>The red, medium intensity 2,000 cd lights on the nacelle of 12 of the proposed turbines will only be visible in poor visibility conditions and will introduce new lighting into a section of the view that currently has very limited visible lighting as part of the baseline. The nacelle lights and tower lights will be visible from this location at a distance range between 7.2km to the closest light and 9.6km to the most distant light. The majority of the intermediate level tower lights will also be visible at lower intensity (32cd).<br>The proposed turbines will be difficult to distinguish at night, however the nacelle lights would be seen as an array of red lights on each turbine nacelle, across the forested plateau above the viewpoint in an area where high levels of darkness are currently experienced. The introduction of the aviation lighting will create a new and unusual point of attention in part of the view where there is currently not much that has visible influence, due to the levels of darkness experienced, and will be visible as multiple points of light in the view, which increases the influence of human/man made elements.<br>Due to the elevation of the proposed turbines on ground above the height of the viewpoint, the majority of the aviation lights will be backdropped by sky, above the upland backdrop. This is important to the assessment, since the aviation lights will partially interrupt the night sky, however due to the distance of the viewpoint and the height of the lights, they are relatively low to the horizon and do not extend high into the sky above the viewpoint, thus limiting the amount of the night-sky that is impeded. The aviation lights are not expected to result in obtrusive light that impedes the wider expanse of night sky, which can be experienced readily above the aviation lights, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies in this view.<br>A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium**, however when combined with the Medium-low sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect, occurring primarily due to this being a fleeting and incidental view, from a main road where there will be car lights, and the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape and the partial interruption of the night-sky just above the upland skyline. |
| **Visual Effect of Aviation Lighting (200cd lights)** |
| The predicted view of the aviation lights at 200cd is shown in the photomontage in **Figure 6.36h**.<br>The red, medium intensity 200 cd lights on the nacelle of 12 of the proposed turbines will be visible in clear visibility, having similar effects as described above (for 2,000 cd) but at notably reduced intensity. The effect differs due to a reduction in intensity. It is considered therefore that the 200cd lights whilst still perceptible would not form as noticeable an addition to the existing baseline as the 2,000cd lights.<br>A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium-low**, and when combined with the Medium-low sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect. |
| **Potential Further Mitigation**<br>Use of lights with specific directional intensity, in order to reduce vertical downwards light impact (based on measured intensity of the 'LuxSolar Medium Intensity Obstruction Light' at different vertical angles). |
| The use of lights which allow a reduced vertical downwards effect of light would provide further mitigation. In periods of poor visibility (<5km) a 2,000cd light would be required, which at this viewpoint would be perceived as 40cd. In periods of clear visibility (>5km) the 2,000cd light may be dimmed to 200cd, resulting in an intensity at this viewpoint of 4cd. |

#### 6.7.3.3 Viewpoint 17: Kirriereoch Picnic Site

Table 6.2-5: Viewpoint 17: Kirriereoch Picnic Site

| **Baseline conditions** |
|---|
| **Existing view and Sensitivity** (Figure 6.43f) |
| The viewpoint is located at Kirriereoch Picnic site, which is just off the Glentrool Forest Road, near the Water of Minnoch, and is located in the DSP buffer zone between the proposed Development and the core area of the DSP, which lies around 2km to the east. The viewpoint is representative of views experienced by people visiting the picnic site, potentially cyclists (using NCR7) but likely people driving along the Glentrool Forest Road and potentially stopping at this location to view the night sky. It is not a dark skies viewing point, but does offer a logical stopping place along the Glentrool Forest Road. In line with the assessment in the daytime LVIA, the viewpoint is considered to have medium value. The viewpoint is representative of views experienced by people passing between the proposed Development and the core area of the DSP, where there are views of the forested plateau towards the smooth slopes and rounded summits of Cairn Hill/Pinbreck Hill/Craigenreoch. There is no existing lighting in the baseline view towards the proposed Development, however there are intermittent lights associated with traffic on the Glentrool Forest road. The overall impression of the night-time view at this location is of a dark forested landscape with a dark upland backdrop of the core area of DSP in the opposite direction, across Kirriereoch Loch. The enclosure by forestry to some parts of the view enhances the impression of darkness. There is no visible wind turbine lighting in the view. Taking these factors into account, the susceptibility to change of people stopping at this viewpoint at night, potentially to view the dark sky, is assessed as **Medium-high** and the sensitivity to change is assessed as **Medium-high**. |
| **Assessment** |
| **Visual Effect of Aviation Lighting (2,000cd lights)** |
| The predicted view of the aviation lights at 2,000cd is shown in the photomontage in **Figure 6.43g**.<br>The red, medium intensity 2,000 cd lights on the nacelle of 10 of the proposed turbines will be visible and will introduce new lighting into a section of the view that currently has very limited visible lighting as part of the baseline. The nacelle lights and tower lights will be visible from this location at a distance range between 4.1km to the closest light and 9.2km to the most distant light. Due to forestry and landform screening, only three of the intermediate level tower lights will be visible at lower intensity (32cd).<br>The proposed turbines will be difficult to distinguish at night, however the nacelle lights would be seen as an array of red lights on each turbine nacelle, across the forested plateau above the viewpoint in an area where high levels of darkness are currently experienced. The introduction of the aviation lighting will create a new and unusual point of attention in part of the view where there is currently not much that has visible influence, due to the levels of darkness experienced, and will be visible as multiple points of light in the view, which increases the influence of human/man made elements.<br>Due to the elevation of the proposed turbines on ground above the height of the viewpoint, the majority of the aviation lights will be backdropped by sky, above the forested skyline. This is important to the assessment, since the aviation lights will partially interrupt the night sky, however due to the distance of the viewpoint and the height of the lights, they are relatively low to the horizon and do not extend high into the sky above the viewpoint, thus limiting the amount of the night-sky that is impeded. The aviation lights are not expected to result in obtrusive light that impedes the wider expanse of night sky, which can be experienced readily above the aviation lights, or in the wider view east towards the core area of the DSP, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies in this view.<br>A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium-high** and when combined with the Medium-high sensitivity of the viewpoint, this results in a **Significant** and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape and the partial interruption of the night-sky just above the upland skyline, from a viewpoint that may be used for the purpose of viewing the night sky. Fundamentally, the visual effect of the aviation |

lights will not occur in the view towards the core area of the DSP, but in the opposite direction, and would not impede the wider expanse of night sky to the point of being obtrusive.

**Visual Effect of Aviation Lighting (200cd lights)**

The predicted view of the aviation lights at 200cd is shown in the photomontage in **Figure 6.43h**.

The red, medium intensity 200 cd lights on the nacelle of 10 of the proposed turbines will be visible in clear visibility, having similar effects as described above (for 2,000 cd) but at notably reduced intensity. The effect differs due to a reduction in intensity. It is considered therefore that the 200cd lights whilst still perceptible would not form as noticeable an addition to the existing baseline as the 2,000cd lights.

A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium**, and when combined with the Medium-high sensitivity of the viewpoint, this results in a **Significant** and adverse visual effect.

**Potential Further Mitigation**

Use of lights with specific directional intensity, in order to reduce vertical downwards light impact (based on measured intensity of the 'LuxSolar Medium Intensity Obstruction Light' at different vertical angles).

The use of lights which allow a reduced vertical downwards effect of light would provide further mitigation. In periods of poor visibility (<5km) a 2,000cd light would be required, which at this viewpoint would be perceived as 40cd. In periods of clear visibility (>5km) the 2,000cd light may be dimmed to 200cd, resulting in an intensity at this viewpoint of 4cd.

### 6.7.3.4 Viewpoint 24: Benyellary

Table 6.2-6: Viewpoint 24 Benyellary: Night-time Visual Effects

**Baseline conditions**

**Existing view and Sensitivity** (Figure 6.50h)

This viewpoint represents views from the summit of the Beyellary (843m) within the core area of the Galloway Forest DSP at night. The Benyellary viewpoint is considered to have high value. It is, however, located in a remote upland area which is not, in all likelihood, somewhere that people often go at night to view the night sky and it is expected that visitor numbers at this location at night will be very low. There is no firm data available to quantify visitor numbers to the upland core of the DSP at night, so this is a relative judgement, with comparatively few people at this location, compared with more people likely to experience the DSP from the more accessible and promoted dark skies viewing locations, visitor centres and favourite routes.

A baseline panorama (**Figure 6.50h**) and photomontage image (**Figure 6.50i-j)** from Benyellary showing aviation lighting has been produced to assist with the assessment of the views at night from the core area of the DSP.

From Benyellary - and from the path descending from it - walkers tend to look westwards out from the WLA and may have more influence than from the Merrick summit itself, therefore as agreed with SNH, Benyellary is used for the night-time lighting assessment as an alternative location to the Merrick. It is considered that there is more likelihood that people may experience a dusk/night-time view from Benyellary because it is on the descent walk from the Merrick and relatively nearer to access from the car park at Bruce's Stone.

In the view from Benyellary, there is limited existing lighting context in the view west towards the proposed Development across the upland foreground and extensive forested plateau, with lighting expected to be limited to occasional residential dwellings and cars using the Glentrool Forest road, with the overall impression of the night time view at this location is of a very dark upland landscape, with distant light arising the more settled Ayrshire coast and settled lowlands of Ayrshire to the north-west. In the evening the contrast between land and sky on the west skyline will be seen beyond dusk as the setting sun maintains a low glow against the skyline to the west for a sustained period. None of the operational turbines in the view are lit at night.

Taking these factors into account, and in particular due to the view being visited or gained by relatively few people, consisting of just the most committed hill walkers prepared to ascend a mountain at night, susceptibility is assessed as **Medium** and the sensitivity to change is assessed as **Medium-high**.

**Assessment**

**Visual Effect of Aviation Lighting (2,000cd lights)**

The predicted view of the aviation lights at 2,000cd is shown in the photomontage in **Figure 6.50i**.

The red, medium intensity 2,000 cd lights on the nacelle of all of the proposed turbines will only be visible in poor visibility conditions and will introduce new lighting into a section of the view that currently has very limited visible lighting as part of the baseline. All the nacelle lights and tower lights will be visible from this location at a distance range between 10.0km to the closest light and 15.0km to the most distant light. All of the intermediate level tower lights will also be visible at lower intensity (32cd).

The proposed turbines will be difficult to distinguish at night, however, the nacelle lights would be seen as an array of red lights on each turbine nacelle, within the forested plateau below the viewpoint in an area where high levels of darkness are currently experienced. The dark forested backdrop will increase the perceived contrast of the closest turbine aviation lights, while the higher turbines are backdropped by the sea beyond. Due to the elevation of the viewpoint above the proposed Development, none of the aviation lights will be backdropped by sky, the aviation lights are entirely backdropped by land or water. This is critical to the assessment, since the aviation lights will be below the skyline they will not interrupt the night sky and although they will be visible as points of light in the view and increase the influence of human/man made elements, the aviation lights are not expected to result in obtrusive light that impedes the view of the night sky, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies in this view.

Although there are mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium**, and when combined with the Medium-high sensitivity of the viewpoint, this results in a **Significant** and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape. Fundamentally, the visual effect of the aviation lights will not result in obtrusive light that impedes the view of the night sky.

**Visual Effect of Aviation Lighting (200cd lights)**

The predicted view of the aviation lights at 200cd is shown in the photomontage in **Figure 6.34j**.

The red, medium intensity 200 cd lights on the nacelle of all of the proposed turbines will be visible in clear visibility, having similar effects as described above (for 2,000 cd) but at notably reduced intensity. The effect differs due to a reduction in intensity. It is considered therefore that the 200cd lights, whilst still perceptible, would not form as noticeable an addition to the existing baseline as the 2,000cd lights.

A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium-low**, and when combined with the Medium-high sensitivity of the viewpoint, this results in a **Significant** and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape. Fundamentally, the visual effect of the aviation lights will not result in obtrusive light that impedes the view of the night sky.

**Potential Further Mitigation**

Use of lights with specific directional intensity, in order to reduce vertical downwards light impact (based on measured intensity of the 'LuxSolar Medium Intensity Obstruction Light' at different vertical angles).

In periods of poor visibility (<5km) 2,000cd light intensity would be required, which at this viewpoint would, as a worst case, be potentially perceived as 2,000cd because the viewpoint is within the main 0° to 3° directional beam intensity of the lights. The use of lights which allow a reduced vertical downwards effect of light would not provide further mitigation, due to the height of the aviation lights relative to the viewpoint/tops of the western flank of the core area of the DSP. 2,000cd would, however, only be experienced in poor visibility conditions. In periods of clear visibility (>5km) the 2,000cd light may be dimmed to 200cd, which provides effective mitigation in periods of clear visibility.

## 6.7.4 Other Areas with Low Levels of Lighting

110. In addition to the defined Galloway Forest DSP, further assessment has been undertaken of the potential effects of aviation lighting on people in other nearby locations where current lighting levels are low. Broadly this area is defined as being around the edges or transition zone around the DSP, including the Stinchar Valley to the north; the Duisk Valley to the west/south-west and adjacent plateau areas, which are relatively near the proposed Development, but outside the Galloway Forest DSP, where current lighting levels are low.

111. Two representative night time viewpoints are considered in the LVIA to illustrate and allow assessment of visible aviation lighting effects that may be experienced by people from these areas. These are located near to the two closest settlements of Barrhill (Viewpoint 2: Minor Road south of Barrhill) and Barr (Viewpoint 19: A734 Approach to Barr), (**Figure TA6.2-1a)** just outside the DSP looking towards the proposed Development from nearby settled areas with relatively low level of lighting. Night-time photomontages from these two viewpoints have been produced in **Figure 6.28i-j** (Viewpoint 2); **Figure 6.45h-i** (Viewpoint 19) to inform this assessment, which is set out for each these representative night-time viewpoints in the following viewpoint assessment.

#### 6.7.4.1 Viewpoint 2 Minor Road south of Barrhill

Table 6.2-7: Viewpoint 2: Minor Road south of Barrhill

**Baseline conditions**

**Existing view and Sensitivity** (Figure 6.28h)

This viewpoint is located on the minor road that runs between Barrhill and New Luce. The road crosses the upland plateau between the Duisk valley, connecting isolated properties along the Cross Water of Luce. The viewpoint is located to the south of the Barrhill train station. While not representing views experienced by residents of Barrhill, which is enclosed by the valley and has very limited visibility of the proposed Development, the viewpoint is representative of views from near Barrhill, including some isolated dwellings, motorists and rail passengers at Barrhill Station. In line with the assessment in the daytime LVIA, the viewpoint is considered to have medium value. There are few existing lights in the baseline view towards the proposed Development, just including occasional lights from dwellings on the edge of the valley/Barrhill and cars on the minor road. The core area of the DSP forms a dark upland backdrop to the east. There is no visible wind turbine lighting in the view. The viewpoint is representative of incidental views across the Duisk valley and buffer area of the DSP, to the core area of the DSP beyond and to the east and is not likely to be used by people as specific night sky viewing location.

Taking these factors into account, the susceptibility to change of people at this viewpoint is assessed as **Medium** and the sensitivity to change is assessed as **Medium**.

**Assessment**

**Visual Effect of Aviation Lighting (2,000cd lights)**

The predicted view of the aviation lights at 2,000cd is shown in the photomontage in **Figure 6.28i**.

The red, medium intensity 2,000 cd lights on the nacelle of all of the proposed turbines will only be visible in poor visibility and will introduce new lighting into a section of the view that currently has very limited visible lighting as part of the baseline. The nacelle lights and tower lights will be visible from this location at a distance range between 8km to the closest light and 13.4km to the most distant light. All of the intermediate level tower lights will also be visible at lower intensity (32cd).

The proposed turbines will be difficult to distinguish at night, however the nacelle lights would be seen as an array of red lights on each turbine nacelle, across the Duisk Valley and behind Mark Hill Windfarm, in an area where high levels of darkness are currently experienced. The introduction of the aviation lighting will create a new and unusual point of attention in part of the view where there is currently not much that has visible influence, due to the levels of darkness experienced, and will be visible as multiple points of light in the view, which increases the influence of human/man made elements.

Due to the elevation of the proposed turbines on ground above the height of the viewpoint, the majority of the aviation lights will be backdropped by sky, above the forested skyline, although several will be backdropped by the upland landform behind the Site. The aviation lights will therefore partially interrupt the night sky, however due to the distance of the viewpoint and the height of the lights, they are relatively low to the horizon and do not extend high into the sky above the viewpoint, thus limiting the amount of the night-sky that is impeded. The aviation lights are not expected to result in obtrusive light that impedes the wider expanse of night sky, which can be experienced readily above the aviation lights, or in the wider view to the core area of the DSP, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies in this view. The aviation lights avoid interrupting the view of the core area of the DSP formed by the Galloway Hills RSA/Merrick WLA, which extend further south in the wider view, and will not replace or interfere with the dark backdrop formed by these uplands of the DSP core area in this part of the view.

A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium** and when combined with the Medium sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape and the partial interruption of the night-sky just above the upland skyline, from a viewpoint that is not used specifically for the purpose of viewing the night sky. Fundamentally, the visual effect of the aviation lights will not occur in the view of the core area of the DSP and would not impede the wider expanse of night sky to the point of being obtrusive.

**Visual Effect of Aviation Lighting (200cd lights)**

The predicted view of the aviation lights at 200cd is shown in the photomontage in **Figure 6.28j**.

The red, medium intensity 200 cd lights on the nacelle of all of the proposed turbines will be visible in clear visibility, having similar effects as described above (for 2,000 cd) but at notably reduced intensity. The effect differs due to a reduction in intensity. It is considered therefore that the 200cd lights whilst still perceptible would not form as noticeable an addition to the existing baseline as the 2,000cd lights.

A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium-low**, and when combined with the Medium sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect.

**Potential Further Mitigation**

Use of lights with specific directional intensity, in order to reduce vertical downwards light impact (based on measured intensity of the 'LuxSolar Medium Intensity Obstruction Light' at different vertical angles).

The use of lights which allow a reduced vertical downwards effect of light would provide further mitigation. In periods of poor visibility (<5km) a 2,000cd light would be required, which at this viewpoint would be perceived as 40cd. In periods of clear visibility (>5km) the 2,000cd light may be dimmed to 200cd, resulting in an intensity at this viewpoint of 4cd.

#### 6.7.4.2 Viewpoint 19 B734 approach to Barr

Table 6.2-8: Viewpoint 19: B734 approach to Barr

**Baseline conditions**

**Existing view and Sensitivity** (Figure 6.45g)

This viewpoint is located on the B734 on the approach to Barr. It is representative of the views of motorists travelling southbound on the B734, as well as workers associated with the Hadyard Hill Wind Farm, the Penwhapple Reservoir and the surrounding farmland and forestry. The direction of the view towards the Site is south across the Stinchar Valley and the village of Barr to the uplands that form the skyline beyond. In line with the assessment in the daytime LVIA, the viewpoint is considered to have medium value. There are few existing lights in the baseline view towards the proposed Development, just including occasional lights from dwellings in the valley and cars on the road, but Barr itself is not visible until further along the road. The core area of the DSP is not visible in the view, but the uplands that form the skyline of the view form the edge of the DSP buffer zone and forms a dark upland backdrop to the valley. There is no visible wind turbine lighting in the view. The viewpoint is representative of incidental views across the Stinchar valley to the edge of the buffer area of the DSP and is not likely to be used by people as specific night sky viewing location.

Taking these factors into account, the susceptibility to change of people at this viewpoint is assessed as **Medium-low** and the sensitivity to change is assessed as **Medium-low**.

**Assessment**

**Visual Effect of Aviation Lighting (2,000cd lights)**

The predicted view of the aviation lights at 2,000cd is shown in the photomontage in **Figure 6.45h**.

The red, medium intensity 2,000 cd lights on the nacelle of six of the proposed turbines will only be visible in poor visibility and will introduce new lighting into a section of the view that currently has very limited visible lighting as part of the baseline. The nacelle lights will be visible from this location at a distance range between 5.2km to the closest light and 6.1km to the most distant light. Most of the tower lights are screened by intervening landform and forestry forming the skyline, with just the tower lights of two turbines likely to be visible over the skyline. Due to forestry and landform screening, only two of the intermediate level tower lights will be visible at lower intensity (32cd).

The proposed turbines will be difficult to distinguish at night, but at dusk they will be more prominent backdropped on the upland skyline. The nacelle lights would be seen as a grouping of several visible red lights, across the Stinchar Valley, in an area where relatively high levels of darkness are currently experienced. The introduction of the aviation lighting will create a new and unusual point of attention in part of the view where there is currently not much that has visible influence, due to the levels of darkness experienced, and will be visible as multiple points of light in the view, which increases the influence of human/man made elements.

Due to the elevation of the proposed turbines on ground above the height of the viewpoint, the six visible aviation lights will be backdropped by sky, above the forested skyline. The aviation lights will therefore partially interrupt the night sky, however due to the distance of the viewpoint and the height of the lights, they are relatively low to the horizon and do not extend high into the sky above the viewpoint, thus limiting the amount of the night-sky that is impeded. The aviation lights are not expected to result in obtrusive light that impedes the wider expanse of night sky, which can be experienced readily above the aviation lights, or in the wider view, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies in this view. The majority of the DSP including the core area is not visible and remains uninterrupted by the aviation lights.

A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium** and when combined with the **Medium-low** sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape and the partial interruption of the night-sky just above the upland skyline, from a viewpoint that is not used specifically for the purpose of viewing the night sky. Fundamentally, the core area of the DSP is not visible and the aviation lights will not impede the wider expanse of night sky to the point of being obtrusive.

| **Visual Effect of Aviation Lighting (200cd lights)** |
|---|
| The predicted view of the aviation lights at 200cd is shown in the photomontage in **Figure 6.45i**.<br>The red, medium intensity 200cd lights on the nacelle of six of the proposed turbines will be visible in clear visibility, having similar effects as described above (for 2,000 cd) but at notably reduced intensity. The effect differs due to a reduction in intensity. It is considered therefore that the 200cd lights whilst still perceptible would not form as noticeable an addition to the existing baseline as the 2,000cd lights.<br>A result of these mitigating factors, the magnitude of change on the night-time view as a result of the aviation lights is assessed as **Medium-low**, and when combined with the Medium sensitivity of the viewpoint, this results in a **Not Significant** and adverse visual effect. |
| **Potential Further Mitigation**<br>Use of lights with specific directional intensity, in order to reduce vertical downwards light impact (based on measured intensity of the 'LuxSolar Medium Intensity Obstruction Light' at different vertical angles). |
| The use of lights which allow a reduced vertical downwards effect of light would provide further mitigation. In periods of poor visibility (<5km) a 2,000cd light would be required, which at this viewpoint would be perceived as 0cd (due to the vertical angle from the horizontal plane of the light being -4.5°). In periods of clear visibility (>5km) the 2,000cd light may be dimmed to 200cd, resulting in an intensity at this viewpoint of 0cd. |

### 6.7.5 Residential Visual Amenity

112. The use of lights with a which focus the medium-intensity 2,000 cd lighting in the horizontal plane (+ or – a few degrees) will reduce the intensity of the light experienced from the three residential properties within 2km of the proposed Development (Ferter, White Clauchrie and Shallochwell). These properties all have a vertical angle from the horizontal plane of light of between -7 to -10 degrees below the horizontal plane, therefore by implementing the recommendation to attenuate the vertical downwards light using aviation lights with a directional intensity (ICAO, Annex 14) the effects of aviation lighting are predicted to be kept a level that causes only negligible visual impact on residential visual amenity.

### 6.7.6 Cumulative Assessment of Visible Turbine Lights

113. Whilst there are no turbine lights currently operating in the study area for the proposed Development, it is recognised that other planned developments within the study area have proposals for visible aviation lighting and that these lights could be seen in conjunction with the proposed lighting for the proposed Development. There are no consented windfarms within 40km with turbines above 150m blade tip requiring aviation lighting (only the consented Lethans Windfarm has turbines above this height and is located 43.3km from the proposed Development).

114. Potential cumulative effects of multiple windfarms with aviation lights arise only in the application stage scenario, as a result of application stage windfarms with turbines above 150m blade tip requiring aviation lighting. Application stage projects that are not yet approved are less certain to contribute to such a cumulative impact, as some may not achieve approval or may not ultimately be built due to other factors, or the aviation lighting technology which is conditioned and ultimately deployed, may be somewhat different than that considered in their EIAR.

115. Despite this uncertainty, application stage windfarms with potential for visible aviation lighting are locted within the main influencing distance (20km) situated within the plateau moorlands of South Ayrshire/Dumfries and Galloway - Arecleoch Extension, Kilgallioch Extension and Stranoch 2. It is considered that there is potential for the aviation lights of the proposed Development to have cumulative effects at night with the aviation lights that may be installed on these application stage projects, which are considered further.

116. There are also other application stage windfarms with potential for visible aviation lights in the wider study area, but these are located at longer distances over 25km in geographically separate landscapes, such as Windy Standard III (25.9km), Sanquhar II (34.3km) and Lethans Re-submission (43.8km), which are unlikely to have significant cumulative effects at night with the aviation lights of the proposed Development.

117. When considering the representative viewpoints to assess the visual effects of aviation lighting for the proposed Development, the Arecleoch Extension, Kilgallioch Extension and Stranoch 2 application turbine aviation lights would be seen from Viewpoint 2 Minor Road to the south of Barrhill (Arecleoch Extension); and Viewpoint 24 Benyellary (Arecleoch Extension, Kilgallioch Extension and Stranoch 2).

#### 6.7.6.1 Viewpoint 2 Minor Road to the south of Barrhill

118. The application stage Arecleoch Extension Windfarm may introduce visible aviation lighting on the forested skyline to the west of the view. The difference in effect in the application stage scenario arises from the addition of the aviation lights of the proposed Development when viewed 'in succession' around the view. Whilst the scale of change predicted for the proposed Development in the application stage scenario is considered to increase slightly, the cumulative magnitude of change on the night-time view as a result of the as a result of the 2,000cd aviation lights is assessed as Medium, and 200cd lights Medium-low, and when combined with the Medium sensitivity of the viewpoint, this results in a Not Significant and adverse visual effect.

119. The additional cumulative magnitude of change arising as a result of the proposed development with application stage windfarms is assessed as Low. The additional cumulative visual effect of the proposed Development with application stage windfarms on the view experienced from this location is assessed as an in-succession cumulative effect, which is Not Significant, Long-term and Adverse, given its position relative to other windfarms and the windfarm influenced landscape context in successive views.

#### 6.7.6.2 Viewpoint 24 Benyellary

120. The Arecleoch Extension, Kilgallioch Extension and Stranoch 2 application turbine aviation lights may be viewed at distance from this location (Arecleoch Extension 21.7 km; Kilgallioch Extension 21.7km and Stranoch 2 25.9 km) and as a result would be notably less visible from this location than the lights of the proposed Development. There is a cumulative interaction in the sense that all of these lights could potentially be viewed from this location simultaneously, increasing the amount of the plateau to the west potentially populated by turbine aviation lighting at night. On balance, when considering the addition of the proposed Development lighting to a baseline that includes Arecleoch Extension, Kilgallioch Extension and Stranoch 2, the magnitude of change is considered to be broadly similar to the assessment of the visual effect of the proposed Development aviation lights due to the diminished intensity of the cumulative application scenario lights that would appear in the future baseline. As a result, no further increase in effect would occur as a result of this potential cumulative situation, with the magnitude of change on the night-time view as a result of the 2,000cd aviation lights is assessed as Medium, and 200cd lights Medium-low, and when combined with the Medium-high sensitivity of the viewpoint, this results in a Significant and adverse visual effect, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape.

#### 6.7.6.3 Other representative viewpoints

121. Arecleoch Extension, Kilgallioch Extension and Stranoch 2 application turbine aviation lights will not be visible from Viewpoint 10 (A714 near Creeside), Viewpoint 19 (B734 approach to Barr) and Viewpoint 24 (Benyellary) and will have no cumulative effects at night from these viewpoints.

## 6.8 Summary and Conclusions

122. The visual effect of the turbine aviation lighting has been considered from five representative viewpoints, three of which are within the Galloway Forest DSP and two of which are located outside the Galloway Forest DSP in areas near its transition, with low levels of lighting in the baseline. At night the proposed turbines would not in themselves be visible during times of darkness. Nevertheless, the assessment of night-time effects for the proposed Development has predicted significant effects at two viewpoints within the Galloway Forest DSP, one of which is representative of the views from the western flank of the core area of the DSP (Viewpoint 24, Benyellary) and the other being representative of the buffer area located between the proposed Development and the core area (Viewpoint 17, Kirriereoch).

123. Due to the relatively high sensitivity of these viewpoints, within the Galloway Forest DSP, the moderate levels of change resulting from the aviation lights results in significant and adverse visual effects, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape.

124. The assessment has identified that the effects of the aviation lighting of the proposed Development on the core area of the DSP may be compounded by the main 2,000cd directional intensity of the lights being likely to occur from the western flanks/range of hill summits of the core area of the DSP (the 'Awful Hand' - Benyellary, Merrick,

Kirriereoch Hill, Tarfessock and Shalloch on Minnoch), which are located between 0 to +3° from horizontal and subject to the brightest lighting intensity based on the minimum requirements of ICAO (Table 6.3 (page 6-5)) for 2,000cd aviation lights on wind turbines.

125. The effect of the aviation lighting on views from the core area of the DSP, is however, likely to be mitigated by the operation of the lights in accordance with Air Navigation Order 2016 (CAP393) Article 223 (8). This allows the 2,000cd aviation lights to be dimmed to 200cd, if visibility is greater than 5km, i.e. in moderate to excellent or 'clear' visibility. The core area of the DSP is located 3.9km to the east of the proposed Development at its closest point, but the range of hill summits/footpath along the ridge from where it may be viewed, is entirely over 5km away, at distances of 7.5km (at Shalloch on Minnoch) to 10.5km (at Merrick/Benyellary). The parts of the core area of the DSP where people may be, will therefore experience the aviation lights at 200cd during periods of 'clear' visibility; and only at 2,000cd in periods of poor visibility (when the influence of the lights would be reduced in poor visibility conditions).

126. Despite these assessments of significance in views from parts of the core area of the DSP (such as Viewpoint 24, Benyellary), the elevation of the upland areas and viewpoints above the proposed Development is such that the aviation lights will be located below the skyline and will not interrupt the night sky, since they are backdropped by land or sea when viewed from above. The aviation lights are not expected to result in obtrusive light that impedes the view of the night sky from the core areas of the DSP, nor result in brightening of the night sky (skyglow) that might be of detriment to the overall experience of the dark skies of the core area of the DSP.

127. Although people could feasibly be viewing the night sky from any part of the Galloway Forest DSP, these parts of the Core Zone of the DSP around the western flank and summits of the Merrick uplands (the 'Range of the Awful Hand') that offer visibility of the proposed Development are remote upland areas which are not, in all likelihood, somewhere that people often go at night to view the night sky. In general, people would tend to use the dark skies viewing locations or key routes through the DSP. The DSP information leaflet does not identify any specific locations within the core area as dark skies viewing locations, perhaps for this reason - that public access to these remote uplands areas at night is not really encouraged.

128. The parts of the core area of the DSP which demonstrate the highest overall darkness are within the lower-lying 'interior', where the assessment has found that the aviation lighting will not be visible and will have no effects on the darkness experienced from within this 'interior' of the core area of the DSP as it is entirely not visible from this interior, due to the visual and physical separation and containment provided by the mountains of the intervening 'Awful Hand'.

129. Fundamentally, aviation lighting of the proposed turbines would not be visible from any of the 10 dark skies viewing locations promoted by the Galloway Forest DSP, all of which will afford no visibility of the proposed turbines, their aviation lights and tower lights to people viewing the night sky from these locations, because they are all outside the area of theoretical visibility shown in the ZTV. Similarly, there is no visibility or effects of the aviation lights from the three scenic drives through the DSP – the Queen's Way, Carrick Forest Drive and Raider's Road; as well as the Glentrool and Clatteringshaws visitor centres, and the SUW. The aviation lighting of the proposed Development will therefore result in no visual effects on the principal 'favourite' receptors within the DSP where people are likely to be viewing/ encouraged to view the night sky.

130. The assessment has also found that although there will be a moderate level of change resulting from the aviation lights in views from parts of the transitional areas around the DSP buffer zone with relatively low levels of existing light, these effects are assessed as not significant due to the lights largely avoiding intrusion on views of the core area of the DSP, which will remain visible as a dark upland backdrop (in Viewpoint 2, for example), or due to the core area of the DSP not being visible at all (such as from Viewpoint 19 near Barr). The aviation lights will introduce new and visible features at night, but they are not expected to result in significant visual effects in these views.

131. The visual effects of the proposed Development at night would also be limited by the activity of receptors at night. Receptors that experience views at night in these areas are generally limited to residents of settlements, rural properties and motorists using the road network. Views from the road network tend to be fleeting and incidental, with reduced susceptibility, and view from within properties are likely to be restricted by the use of window coverings at night, particularly in winter. Many of the settled parts of the study area such as the Stinchar and Duisk Valleys also have no visibility, or very low levels of visibility of the aviation lights.

132. The duration of the effect of the lights on receptors is likely to be over a relatively short period, more commonly experienced during evening and morning hours of darkness, after dusk and before sunrise, when people are not sleeping. The ICAO standard requires for 2,000 candela medium intensity red lights, to be switched on when 'Night' has been reached, as measured at 50cd/m2 or darker, removing the likelihood of visible lighting during twilight.

133. One of the key findings of the visual assessment of the aviation lights is that they are considered unlikely to result in 'obtrusive' light, nor impede the expanse of night sky to the point of being obtrusive. Generally this is because the aviation lights will be viewed relatively near the horizon, or even below the skyline from elevated parts of the core area of the DSP, so while they may have significant effects by breaking into the darkness as point features of light, appearing unusual and surprising in an otherwise dark landscape, they are not expected to result in obtrusive light that would harm the enjoyment of the night-skies or change the fundamental perception of the site and its surrounds as a rural and essentially dark landscape.

## 6.9 References

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- CAP393, The Air Navigation Order 2016 (SI 2016 No.765).
- LuxSolar Medium Intensity Obstruction Light CAP 168 MIOL-C: Data Sheet, January 2018.
- Civil Aviation Authority, Safety & Airspace Regulation Group (2017). Policy Statement: 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.
- Institute of Lighting Professionals (2011). Guidance Notes for the Reduction of Obtrusive Light (GN01:2011)
- Institute of Lighting Professionals (2019). Night-time Photography.
- Annex 14 to the Convention on International Civil Aviation - Volume I Aerodrome Design and Operations (ICAO, Eighth Edition, July 2018).
- CAP 764: Policy and Guidelines on Wind Turbines (CAA).
- England's Light Pollution and Dark Skies (LUC/CPRE, 2016)
- South Ayrshire Council (2016) Supplementary Guidance: Dark Sky Lighting
- South Ayrshire Council (2014) Adopted Local Development Plan.

## Legend

- Application Boundary
- Clauchrie Wind Turbines
- LVIA Night-time Viewpoint
- Dark Skies Viewing Location
- Southern Upland Way
- National Cycle Network
- A Road
- The Queen‘s Way
- Carrick Forest Drive
- Raiders‘ Road Forest Drive
- 10 km Radii
- Dark Skies Park Core Area
- Dark Skies Park Buffer

Light Pollution

(NanoWatts / cm$^2$ / sr)

- >32 (high)
- 16 - 32
- 8 - 16
- 4 - 8
- 2 - 4
- 1 - 2
- 0.5 - 1
- 0.25 - 0.5
- < 0.25 (low)

**LVIA Night-time Viewpoint**
2 - Minor road to the south of Barrhill
10 - A714, Creeside
17 - Kirriereoch Picnic Site
19 - B734 Approach to Barr
24 - Benyellary

**Dark Skies Viewing Location**
1 - Galloway Red Deer range
2 - Clatteringshaws Visitor Centre
3 - Glentrool Visitor Centre
4 - Bruce’s stone
5 - Caldons woodlands
6 - Kirroughtree Visitor Centre
7 - Loch Braden
8 - Loch Doon south end
9 - Talnotry
10 - Raiders road west end

| Rev | Date | By | Comment |
|---|---|---|---|
| B | 10/12/19 | JM | Second Issue. |
| A | 22/11/19 | JM | First Issue. |

1:100,000
Scale @ A1

0 2.5 5 10 Km



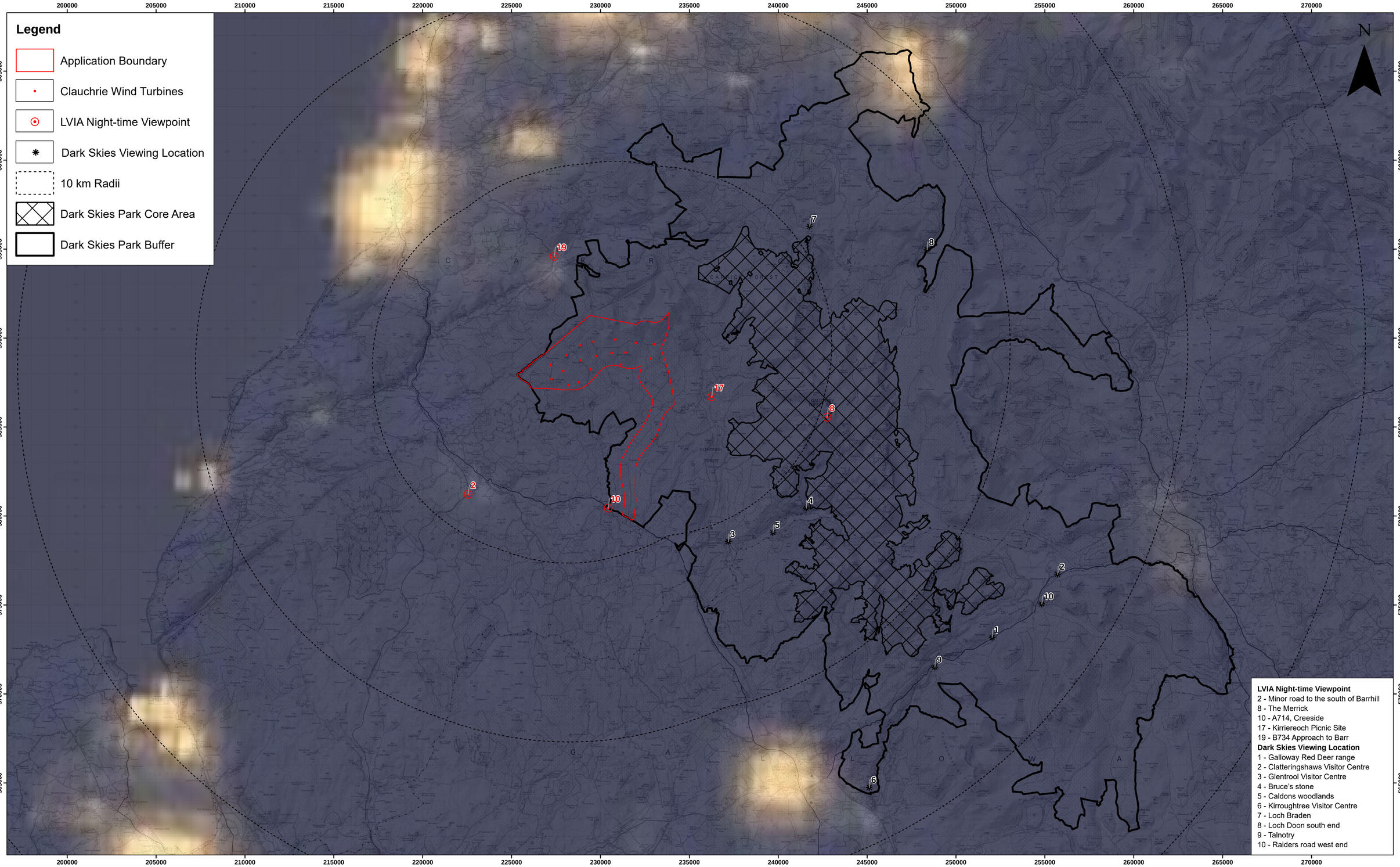
# Clauchrie Windfarm

Technical Appendix

Study Area - Baseline Lighting

| | |
|---|---|
| Drg No | EDI_1263_EIAR |
| Rev | B |
| Date | 10/12/19 |
| Figure | TA6.2.-1a |

Datum: OSGB36
Projection: TM




**LVIA Night-time Viewpoint**
2 - Minor road to the south of Barrhill
8 - The Merrick
10 - A714, Creeside
17 - Kirriereoch Picnic Site
19 - B734 Approach to Barr

**Dark Skies Viewing Location**
1 - Galloway Red Deer range
2 - Clatteringshaws Visitor Centre
3 - Glentrool Visitor Centre
4 - Bruce's stone
5 - Caldons woodlands
6 - Kirroughtree Visitor Centre
7 - Loch Braden
8 - Loch Doon south end
9 - Talnotry
10 - Raiders road west end

SCOTTISHPOWER RENEWABLES

| Rev | Date | By | Comment |
|---|---|---|---|
| | | | |
| | | | |
| A | 10/12/19 | JM | First Issue. |

**1:100,000**
**Scale @ A1**

0 2.5 5 10 Km



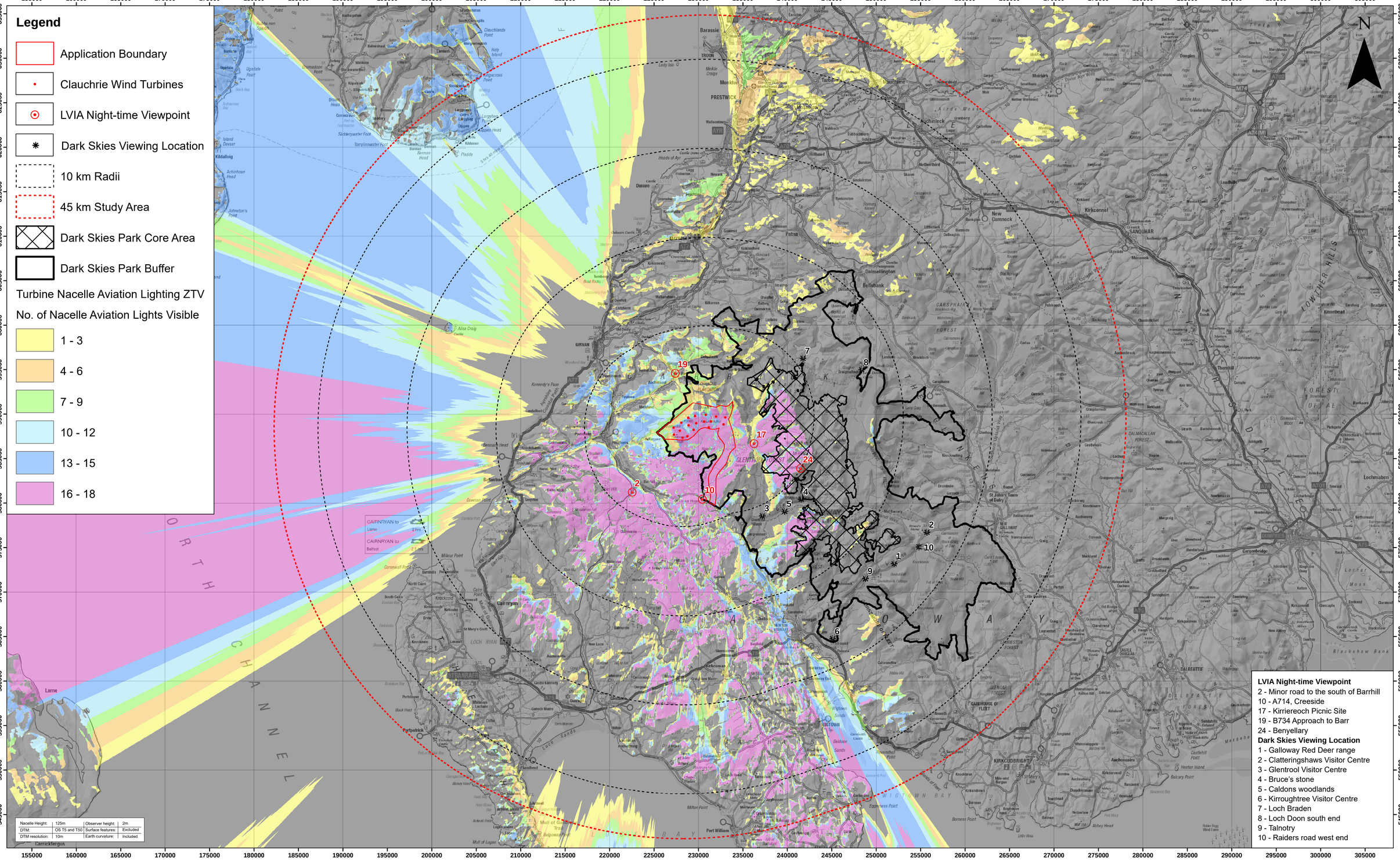
# Clauchrie Windfarm

Technical Appendix

Earth at Night 2012

| | |
|---|---|
| **Drg No** | EDI_1263_EIAR |
| **Rev** | A |
| **Date** | 10/12/19 |
| **Figure** | TA6.2.-1b |

Datum: OSGB36
Projection: TM




| Rev | Date | By | Comment |
|---|---|---|---|
| B | 10/12/19 | JM | Second Issue. |
| A | 22/11/19 | JM | First Issue. |

1:200,000
Scale @ A1

0 5 10 20 Km



# Clauchrie Windfarm

Technical Appendix

Nacelle Aviation Lighting ZTV (45km)

| | |
|---|---|
| Drg No | EDI_1263_EIAR |
| Rev | B |
| Date | 10/12/19 |
| Figure | TA6.2.-2 |

Datum: OSGB36
Projection: TM

## Legend

- Application Boundary
- Clauchrie Wind Turbines
- LVIA Night-time Viewpoint
- Dark Skies Viewing Location
- 10 km Radii
- Dark Skies Park Core Area
- Dark Skies Park Buffer

Turbine Nacelle Aviation Lighting ZTV

No. of Nacelle Aviation Lights Visible

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 18

| | | | |
|---|---|---|---|
| Nacelle Height: | 125m | Observer height: | 2m |
| DTM: | OS T5 and T50 | Surface features: | Excluded |
| DTM resolution: | 10m | Earth curvature: | Included |

**LVIA Night-time Viewpoint**
2 - Minor road to the south of Barrhill
10 - A714, Creeside
17 - Kirriereoch Picnic Site
19 - B734 Approach to Barr
24 - Benyellary

**Dark Skies Viewing Location**
1 - Galloway Red Deer range
2 - Clatteringshaws Visitor Centre
3 - Glentrool Visitor Centre
4 - Bruce's stone
5 - Caldons woodlands
6 - Kirroughtree Visitor Centre
7 - Loch Braden
8 - Loch Doon south end
9 - Talnotry
10 - Raiders road west end

SCOTTISHPOWER RENEWABLES

| Rev | Date | By | Comment |
|---|---|---|---|
| B | 10/12/19 | JM | Second Issue. |
| A | 22/11/19 | JM | First Issue. |

**1:100,000**
**Scale @ A1**

0 2.5 5 10 Km



# Clauchrie Windfarm

Technical Appendix

Nacelle Aviation Lighting ZTV (Dark Skies Park)

| | |
|---|---|
| **Drg No** | EDI_1263_EIAR |
| **Rev** | B |
| **Date** | 10/12/19 |
| **Figure** | TA6.2.-3 |

Datum: OSGB36
Projection: TM

## Legend

- Application Boundary
- Clauchrie Wind Turbines
- Dark Skies Viewing Location
- LVIA Night-time Viewpoint
- 10 km Radii
- Dark Skies Park Core Area
- Dark Skies Park Buffer

Turbine Tower Aviation Lighting ZTV

No. of Turbine Tower Lights Visible

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 18

| | | | |
|---|---|---|---|
| Light Height: | 62.5m | Observer height: | 2m |
| DTM: | OS T5 and T50 | Surface features: | Excluded |
| DTM resolution: | 10m | Earth curvature: | Included |

**LVIA Night-time Viewpoint**
2 - Minor road to the south of Barrhill
10 - A714, Creeside
17 - Kirriereoch Picnic Site
19 - B734 Approach to Barr
24 - Benyellary

**Dark Skies Viewing Location**
1 - Galloway Red Deer range
2 - Clatteringshaws Visitor Centre
3 - Glentrool Visitor Centre
4 - Bruce's stone
5 - Caldons woodlands
6 - Kirroughtree Visitor Centre
7 - Loch Braden
8 - Loch Doon south end
9 - Talnotry
10 - Raiders road west end

SCOTTISHPOWER RENEWABLES

| Rev | Date | By | Comment |
|---|---|---|---|
| B | 10/12/19 | JM | Second Issue. |
| A | 22/11/19 | JM | First Issue. |

1:100,000
Scale @ A1

0 2.5 5 10 Km



# Clauchrie Windfarm

Technical Appendix

Tower Aviation Lighting ZTV (Dark Skies Park)

| | |
|---|---|
| Drg No | EDI_1263_EIAR |
| Rev | B |
| Date | 10/12/19 |
| Figure | TA6.2.-4 |

Datum: OSGB36
Projection: TM

## Legend

- Application Boundary
- Clauchrie Wind Turbines
- Dark Skies Viewing Location
- LVIA Night-time Viewpoint
- 10 km Radii
- Dark Skies Park Core Area
- Dark Skies Park Buffer

**LVIA Night-time Viewpoint**
2 - Minor road to the south of Barrhill
10 - A714, Creeside
17 - Kirriereoch Picnic Site
19 - B734 Approach to Barr
24 - Benyellary

**Dark Skies Viewing Location**
1 - Galloway Red Deer range
2 - Clatteringshaws Visitor Centre
3 - Glentrool Visitor Centre
4 - Bruce's stone
5 - Caldons woodlands
6 - Kirroughtree Visitor Centre
7 - Loch Braden
8 - Loch Doon south end
9 - Talnotry
10 - Raiders road west end

Intensity of Turbine Light shown in Candelas (cd)

| Vertical Angle | Turbine Lighting Intensity | |
|---|---|---|
| | 2000cd light | 200cd light |
| 0° to 3° | 2000cd | 200cd |
| 0° to -1° | 2000cd to 750cd | 200cd to 75cd |
| -1° to -2° | 750cd to 80cd | 75cd to 8cd |
| -2° to -3° | 80cd to 40cd | 8cd to 4cd |
| -3° to -4° | 40cd to 10cd | 4cd to 1cd |
| Below -4° | Below 10cd | Below 1cd |

**Notes**

1. Reduced intensity turbine lighting (200cd) based on 'Air Navigation Order 2016 (CAP393) Article 223 (8)' which allows the 2000cd turbine light to be 'reduced to not less than 10% of the minimum peak intensity specified' i.e. 200cd 'if visibility in all directions from every wind turbine generator in a group is more than 5km'.

2. The lighting intensity for each of the vertical angles shown is based on information provided by an aviation warning light bulb manufacturer. See Appendix 6.2.

3. Perception of theoretical candela intensity does not take account of distance.

4. ZTV calculations do not take into account surface features such as forestry or buildings.

5. ZTV calculations for turbine lighting intensity based on visible aviation lighting mounted on the turbine hub.

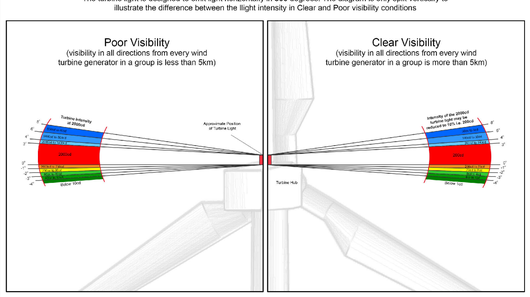
6. The ZTV calculates the degree of vertical angle from the study area shown to each of the proposed Development turbines.

7. ZTV calculations represent a worst case situation where predicted lighting intensity may be as a result of only one turbine in the layout.

8. Whilst there are small patches of landform close to the proposed Development site above 3° from the height of some of the turbine lights, other lights in the layout would be experienced at between 0° - 3° on these same patches of landform. Taking this into account, the light Intensity shown represents this worst case higher lighting intensity calculation of 2000cd or 200cd on these small patches of landform.

Diagram illustrating the Light Intensity Variation from the proposed turbine light

The turbine light is designed to emit light horizontally in 360 degrees. The diagram is only split vertically to illustrate the difference between the light intensity in Clear and Poor visibility conditions




| Nacelle Height: | 125m | Observer height: | 2m |
|---|---|---|---|
| DTM: | OS T5 and T50 | Surface features: | Excluded |
| DTM resolution: | 10m | Earth curvature: | Included |

| Rev | Date | By | Comment |
|---|---|---|---|
| B | 10/12/19 | JM | Second Issue. |
| A | 22/11/19 | JM | First Issue. |

1:100,000
Scale @ A1

0 2.5 5 10 Km



# Clauchrie Windfarm

Technical Appendix

Nacelle Lighting Intensity (Dark Skies Park)

| | |
|---|---|
| Drg No | EDI_1263_EIAR |
| Rev | B |
| Date | 10/12/19 |
| Figure | TA6.2.-5 |

Datum: OSGB36
Projection: TM

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