Appendix 4.3: Aviation Lighting Assessment

EDF Energy Renewables Ltd

Dunside Wind Farm EIA Report

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Final report
Prepared by LUC
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EDF Energy Renewables Ltd

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Introduction

4.3.1 In the interests of aviation safety, structures of 150 metres (m) or more in height, including wind turbines, require steady red visible aviation lighting, as set out in Civil Aviation Authority (CAA) guidance. The Proposed Development comprises up to 15 turbines with a maximum blade tip height of 220 m and will therefore require visible aviation lighting which may be perceptible to receptors (people) from locations across the study area.

4.3.2 The introduction of visible aviation lighting in rural locations, where there are fewer sources of artificial lighting, and where darkness or dark skies are an integral and valued aspect of the landscape, may lead to potentially significant landscape and visual effects. This appendix includes an assessment of the effects of visible lighting on landscape and visual receptors.

4.3.3 This appendix is not a technical appraisal of lighting. The EDF Energy Renewables Ltd (the Applicant) commissioned a specialist aviation consultant, Wind Power Aviation Consultants (WPAC), to develop an aviation lighting scheme for the Proposed Development that complies with the relevant guidance. This is set out in **Appendix 11.1: Wind Farm Aviation Lighting and Mitigation Report**.

4.3.4 This appendix sets out the background to the requirements for visible aviation lighting, perception of lighting, and mitigation. It presents an assessment of landscape and visual effects arising from the proposed lighting scheme, on representative receptors within the study area. This appendix should be read in conjunction with:

- **Chapter 4: Landscape and Visual Impact Assessment;**
- **Appendix 4.1: LVIA and Visualisation Methodology**; and
- Visualisations presented in Volume 3b.

4.3.5 Appendix 4.2: Residential Visual Amenity Assessment (RVAA) considers the effects of aviation lighting on residential visual amenity for each property/property group considered.

Regulatory Background

4.3.6 This section outlines the regulatory background to the requirements for visible aviation lighting on wind turbines. Further detail is provided in **Appendix 11.1**.

Aviation Lighting Requirements

4.3.7 Article 222 of the Air Navigation Order (ANO) 2016[1], sets out the statutory requirement for the lighting of 'en-route obstacles', which applies to structures of 150 m or more above ground level. The Article states: "*The person in charge of an en-route obstacle must ensure that it is fitted with medium intensity steady red lights positioned as close as possible to the top of the obstacle and at intermediate levels spaced so far as practicable equally between the top lights and ground level with an interval of not more than 52 metres*."

4.3.8 This article has been incorporated into the CAA's Policy Statement on the lighting of onshore wind turbines (June 2017)[2], which states: "*The person in charge of the wind turbine generator must ensure that it is fitted with a medium intensity (2000 candela) red light positioned as close as practicable to the top of the fixed structure. A second light serving as an alternative*

[1] The Air Navigation Order 2016 (SI 2016/765). Available at http://www.legislation.gov.uk/uksi/2016/765/contents/made [Accessed 6 June 2023].
[2] CAA Policy Statement (2017) Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150 m Above Ground Level. Available at: https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=7967 [Accessed 6 June 2023].

should be provided in case of failure of the operating light." In practice this means the installation of lights on the top surface of the turbine hub/ nacelle.

4.3.9 The CAA Policy Statement includes provision for the medium intensity 2,000 candela (cd) lights to be controlled by visibility sensors that may reduce the intensity of the light to not less than 10% of the minimum peak intensity (i.e. 200 cd) in times of clear meteorological conditions, where visibility exceeds 5 kilometres (km) (as measured on sensors on the turbine hubs).

4.3.10 Additionally, the CAA requires that "*at least three (to provide 360 degree coverage) low-intensity Type B6 lights (32 candela) lights should be provided at an intermediate level of half the nacelle height*."

Lighting Specification

4.3.11 The intensity of the light emitted from an aviation obstruction light is designed to vary with the observed angle. It aims to be at its brightest when observed from a similar level or just above (i.e. from an approaching aircraft), but less bright as the observer falls significantly below or above the level of the light. The required intensity is set out in Table 6-3 of International Civil Aviation Organization (ICAO) Annex 14[3], which is reproduced in **Appendix 11.1**.

4.3.12 **Appendix 11.1** refers to a specific model of light that meets the ICAO requirements (the 'CEL-MI-ACWGAM'[4]). The approximate maximum and minimum luminous intensity values of this light at different angles are shown in **Table 1.1**, based on information provided by the lighting supplier. Values of lights provided by other manufacturers may be different, but would be comparable in order to comply with the ICAO requirements.

Table A4.3.1: Maximum and minimum luminous intensity relative to viewing angle - CEL-MI-ACWGAM light

Vertical angle of lighting from nacelle	Maximum luminous intensity (cd)	Minimum luminous intensity	Maximum luminous intensity at 10% (cd)	10% Minimum luminous intensity at 10% (cd)
Above 2°	1,568 cd	632 cd	156 cd	63 cd
Between 1° to 2°	2,306 cd	1,630 cd	230 cd	163 cd
Between 0° to 1°	2,341 cd	2,067 cd	234 cd	206 cd
Between -1° to 0°	1,965 cd	850 cd	196 cd	85 cd
Between -2° to -1°	832 cd	356 cd	83 cd	35 cd
Between -3 to -2°	344 cd	188 cd	34 cd	18 cd
Below -3°	≤188 cd	n/a	≤18 cd	n/a

Perception of lights

4.3.13 The figures in **Table A4.3.1** show a reduction in visible lighting at angles of less than -1 degree relative to the nacelle. That is to say, the light would appear less bright to an observer looking up at the nacelle from below than it would to an observer at the same elevation as the nacelle. Note that this does not take account of emitted light spill on to passing blades, which may be visible from all elevations as a reflected glow across the immediate surfaces of the turbine blades and nacelle.

[3] International Civil Aviation Organization (2018) Annex 14 to the Convention on International Civil Aviation – Aerodromes - Volume I Aerodrome Design and Operations.
[4] CEL Aviation Lighting (2019) Product data sheet CEL-MI-ACWGAM. Available at: CEL-MI-ACWGAM - rev6.indd (aircraftwarninglights.co.uk) [Accessed 6 June 2023].

4.3.14 In conditions of meteorological visibility of less than 5 km, the perceived brightness of medium intensity lights illuminated at 2,000 cd, whilst possibly still visible, is likely to be much reduced, and typically not visible at distances greater than 5 km from turbines.

4.3.15 Although the intensity of the emitted light remains constant, the perceived light intensity ('brightness') experienced by visual receptors (people) will also vary dependent on distance and atmospheric conditions. As distances increase, the light source will appear smaller and perceived light intensity will decrease. **Appendix 11.1** provides details of the perceived light intensity at each viewpoint, and notes that "*when considering the perception of the light from a viewpoint, in general the distance between the light and the viewpoint is the dominant factor*" (paragraph 20).

4.3.16 Atmospheric conditions such as increased humidity, rain, drizzle, snow, or the presence of haze, mist, fog, or a low cloud base, will also reduce the perceived light intensity. Lights would only be set to the 2,000 cd maximum intensity during periods with meteorological visibility of less than 5 km. The perceived light intensity in such conditions is likely to be much reduced.

4.3.17 The perceived light intensity also depends on the background against which they are seen. They may seem brighter because of the stronger contrast when there is no moonlight for example, or when they are seen against a dark landmass rather than against a sky where there is some residual twilight. Perception of red light by humans is also variable from person to person and is influenced by age.

4.3.18 **Appendix 11.1** provides further detail on perceived light intensity, including comparison with some examples such as street lights and car brake lights.

Potential Mitigation

4.3.19 A number of potential mitigation options are currently available or are being developed by the wind energy sector in collaboration with the CAA and other stakeholders. Mitigation options which may have the potential to influence the resultant landscape and visual effects which may occur from the introduction of visible aviation lighting are outlined below.

Reducing the Number of Lights

4.3.20 As an alternative to lighting all turbines, the lighting of cardinal or peripheral turbines (i.e. those located at the outer extremities of a wind farm development) is an established mitigation option for wind farms. In addition, the requirement for low intensity lights at mid-mast level can often be removed, with CAA agreement. WPAC has developed a reduced lighting scheme for the proposed wind farm development. This is set out in **Appendix 11.1** and is discussed in paragraph A.26.

Lighting Design

4.3.21 The technical specification for medium intensity obstacle lights set out in CAA guidance defines the necessary requirements for both the minimum lighting intensity settings and minimum vertical angle range of medium intensity lights (as outlined above). Individual lights have slightly varying characteristics, though are broadly similar in complying with international standards, with sharply declining intensity when viewed from a lower level.

4.3.22 As such, the embedded mitigation of the design of the lights has the potential to much reduce perceived light intensity, particularly when viewed from below the height of the turbine hub. This has the effect of reducing perceived light intensity for receptors which are near to the turbines, and which are more likely to be at a lower elevation than the nacelles. Receptors at a similar elevation to the nacelles are more likely to be those on higher ground at some distance from the proposed wind farm development.

Reducing Intensity in Clear Visibility

4.3.23 As noted above, CAA guidance includes provision for the intensity to be reduced during periods of good visibility. This can be controlled by visibility sensors fitted to the turbines, and is an established mitigation for aviation lighting. Where atmospheric conditions limit visibility to distances of less than 5 km (as measured at the location of the sensor), e.g. through the presence of low cloud cover, rain, mist, haze or fog, the lights are set to the necessary intensity (see **Table 1.1**:). Lights would only be set to this maximum intensity during periods with limited visibility, which would restrict the perceived light intensity. In clear visibility, lights would be set to 10% intensity (see **Table 1.1**), and this is therefore the most likely level of lighting that would be experienced by receptors.

Radar Activated Lighting

4.3.24 ICAO Annex 14 also details guidance on 'Visual Aids for Denoting Obstacles'. With specific reference to mitigation of effects on visual amenity, Note 2 outlines that "*An autonomous aircraft detection system may be installed on or near an obstacle (or group of obstacles such as wind farms), designed to operate the lighting only when the system detects an aircraft approaching the obstacle, in order to reduce light exposure to local residents*."

4.3.25 A number of manufacturers have developed radar-activated aviation lighting systems, whereby the lights would only be switched on when aircraft approach within a specified airspace zone. This technology is currently permitted by aviation authorities in some EU countries and the United States. This technology is not currently approved by the CAA and as such is not considered further as a potential mitigation option. Whilst it may become available in the lifetime of this project, radar activated lighting requires comprehensive radar coverage of the airspace surrounding a wind farm which, in a landscape with hills, necessitates one or more offsite radar masts to be installed, typically at the highest point/s (hill tops) in the vicinity of a wind farm. This would give rise to its own (daytime) LVIA considerations.

Proposed Aviation Lighting

4.3.26 Due to the maximum height of the turbines proposed (220 m to turbine blade tip) visible aviation safety lighting is required. The proposed aviation lighting included in this assessment was agreed through consultation with the CAA. The lighting design is described in more detail in **Appendix 11.1** and summarised below:

- Two medium intensity 'steady' red (2,000 cd) lights on the nacelles of each of turbines T1, T3, T6, T8, T9, T14 and T15 (the secondary light on each turbine is fitted for use in the event of failure of the primary light, and will not be lit concurrently); and
- Infra-red lights to MoD specification installed on the nacelles of all 15 turbines.

4.3.27 The general requirement by the CAA for intermediate level 32 cd lights on the turbine towers was scoped out in agreement with the CAA as set out in **Appendix 11.1**, and is not considered further.

4.3.28 Infra-red lights are required for military and emergency service aircraft flying at night, and these lights are not designed to be visible to the naked eye, and are not considered further in this assessment.

4.3.29 Mitigation will be implemented through lighting design, and through reducing intensity under conditions of good visibility, as described above.

4.3.30 Lights will operate between evening civil twilight (approximately 30 minutes after sunset) and morning civil twilight (approximately 30 minute before sunrise). **Appendix 11.1** notes that this will equate to approximately 11 hours per day, on average over the year, although this will be significantly more in winter and less in summer.

Approach to Assessment of Lighting Effects

4.3.31 The assessment of lighting effects follows the same approach detailed in **Appendix 4.1**. However, it is important to note that the assessment is not a technical lighting assessment based on a quantitative measurement of light levels, but rather the assessment relies on professional judgement of what the human eye can reasonably perceive in the context of the baseline situation, with regard to existing sources of artificial lighting.

4.3.32 The Guidelines for Landscape and Visual Impact Assessment, 3rd Edition (GLVIA 3)[5] 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 dusk/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 dusk/night-time visibility*" (Paragraph 6.12, page 103).

[5] Landscape Institute and the Institute of Environmental Management and Assessment (2013) Guidelines for Landscape and Visual Impact Assessment, 3rd Edition

4.3.33 The assessment considers the potential effects associated with two potential situations: when the hub lights are illuminated at 2,000 cd; and at 200 cd. The 2,000 cd situation represents the maximum illumination or lighting intensity possible (noting that at certain angles of view the perceived brightness will exceed 2,000 cd). The 200 cd situation represents the lower intensity mode which would be activated in clear meteorological conditions, where visibility exceeds 5 km at the point of measurement.

4.3.34 As the baseline photography for each of the three representative dusk viewpoints was obtained in clear atmospheric conditions (whereby visibility exceeds distances of 5 km), the representation of 2,000 cd lighting in these conditions illustrates a potentially artificial worst-case situation. However, adopting a precautionary approach, the assessment considers the potential effects that may arise when the hub light is illuminated at both 2,000 cd and 200 cd during periods of clear visibility.

4.3.35 Although the assessment is based on effects arising in relation to the steady red light fixed to the top of each turbine hubs, as illustrated in the supporting visualisations, it is acknowledged that in some situations a potential flicker effect may be experienced by receptors as blades pass the stationary lights. In practice, the speed at which the blades pass the lights means this is unlikely to be discernible. It is not possible to represent this situation in static photomontages. Furthermore, reflected glow across the immediate surfaces of the turbine blades and hub may be evident under certain conditions.

4.3.36 When determining the magnitude of change associated with the Proposed Development, the methodology set out in **Appendix 4.1** considers the duration of the change. For operational effects this is deemed to be long term. However, and with relevance to night-time effects, the frequency of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness (below 500 lux[6]) which changes with the seasons. As such in the summer months the duration of visibility of aviation lighting will reduce, corresponding to the shorter hours of darkness.

4.3.37 The night-time baseline against which the effects of the Proposed Development are assessed includes operational / under construction wind farms only. There are currently no operational or under construction wind farms within 20 km of the Proposed Development that have or require visible aviation lighting. The consented Crystal Rig Phase 4 Wind Farm (11 turbines, 200 m to tip height) will require visible aviation lighting. Four proposed wind farms within 15 km, all at Scoping, are likely to require aviation lighting should they be consented and constructed:

- Longcroft (24 turbines at 220 m height to tip);
- Newlands Hill (17 turbines at 200 m height to tip);
- Lees Hill Energy Park (15 turbines at 200 m height to tip); and
- Back Burn (7 turbines at 200 m height to tip).

4.3.38 There are no wind farms at appeal or application stage within 20 km that are likely to include visible aviation lighting.

4.3.39 Whilst illuminated consented and proposed wind farms are not represented in the night-time visualisations, these wind farms are shown in the cumulative wirelines. This is acknowledged in the assessment text, where relevant.

4.3.40 At the present time, the proposed manufacturer or precise model and specification of aviation light to be used is not known, therefore any further potential mitigation which may be embedded into the design of the proposed lights is not considered. As such, the lighting considered under this assessment is a maximum-case situation.

Zone of Theoretical Visibility Mapping

4.3.41 A hub height (139 m height) Zone of Theoretical Visibility (ZTV) map was prepared to support this assessment (refer to **Figure A4.3.1**). This highlights the areas across the Study Area from which aviation lighting installed on the turbine hubs may be apparent. This ZTV does not take account of potential screening provided by vegetation or buildings.

4.3.42 To illustrate the potential variability in lighting intensity in relation to vertical viewing angle, a lighting intensity ZTV is provided in **Figure A4.3.2** (to 45 km) and **Figure A4.3.3** (to 10 km). This ZTV does not incorporate a reduction in lighting intensity resulting from the distance at which the lights are viewed, given the variability which would result from differing atmospheric conditions. As such it represents a worst-case scenario, assuming clear conditions. As illustrated by the ZTV, visibility of the hub lights at their greatest perceived brightness would generally be limited to views experienced from more

[6] Lux is a unit used to measure the intensity of light across a surface.

elevated locations, including upland moorland areas and site-facing hill flanks and summits found in the east, south and west of the study area, as well as locations along the distant Fife coast and in the Firth of Forth. These areas are less likely to be regularly frequented during the hours of darkness, with the exception of the Fife coast which is over 40 km away from the nearest proposed turbine. Conversely, from lower lying settled valleys and farmland, which are the focus of most settlement and habitation, the lights (where visible) will generally be perceived at substantially reduced intensity, due to the viewing angle being below the horizontal.

Wireline and Photomontage Visualisations

4.3.43 Visualisations are one source of information used to inform the LVIA. Visualisations were produced for three representative assessment viewpoints, agreed during consultation, and presented in accordance with the industry standard guidance prescribed by NatureScot and the Landscape Institute. The methodology for the preparation of night-time photomontage visualisations is detailed in **Appendix 4.1**.

4.3.44 NatureScot guidance states "*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… 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*" (Paras 174 – 177, Pages 35 and 36). Capturing photography at this time represents a relatively short period of time (during dusk and dawn) when the landform is visible along with existing and proposed light sources. The actual night-time view, for most of the time when the proposed turbines will be lit, will be darker, with the proposed lighting and other light sources (if visible) being seen against a dark landmass or against the night sky.

4.3.45 The representative visualisations are presented in **Volume 3b** as a combination of existing baseline photography and photomontages, which aim to represent the appearance of the proposed visible aviation lighting at:

- Viewpoint 3: Minor road near Wanside Rig junction (see **Figure 4.2.3g and 4.2.3h**);
- Viewpoint 7: B6456 Westruther (see **Figure 4.2.7e and 4.2.7f**); and
- Viewpoint 12: Minor road near Hen Law (see **Figure 4.2.12f and 4.2.12g**).

4.3.46 Baseline dusk photography was taken in accordance with the NatureScot guidance. Photography was taken at dusk, in clear atmospheric conditions. It sought to capture the presence of existing baseline sources of artificial lighting such as lighting associated with settlement, street lighting, and motor vehicles, as closely as seen by the human eye as was possible.

4.3.47 NatureScot guidance also states that: "*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*" (Paragraph 177, Page 36). As such, photomontage visualisations which illustrate both the 2,000 cd and 200 cd lighting intensity situations were prepared for each of the three viewpoints. The representative visualisations do not take account of the potential reduction in light intensity which may be perceived in relation to the relevant vertical elevation angle and distance at which they are viewed. The actual light perceived at these locations is likely to be less than that which is illustrated in the visualisations, as shown on **Figure A4.3.2** and **Figure A4.3.3**

Effects on Landscape Character

4.3.48 In terms of effects on landscape character, and as noted previously, there will usually be a relatively small window of time, at dawn and dusk, or in conditions of bright moonlight, during which the landform is apparent along with existing and new light sources, and when an appreciation of landscape character and associated skyscapes is perceptible. Perception of landscape character, at night, will be limited during most of the hours when it is proposed that turbines will be lit. The proposed lighting and other human light sources will be apparent against a dark landmass or night sky, along with natural sources of light. As such, the main window during which effects on landscape character, and effects on many of the associated key characteristics will be experienced, will be limited to the short period of twilight (shorter in winter, and more extended in summer), or moonlight. Many key characteristics, and the experience of landscape character can only readily be appreciated during the day.

4.3.49 Informed by **Figure A4.3.1**, aviation lighting positioned on the hubs of up to seven turbines is theoretically visible from areas of upland moorland including within the Site, including the summits of Twin Law, Hunt Law and Hogs Law. Theoretical

visibility reduces along the narrow valleys which dissect the moorland plateau. Within 20 km, there is theoretical visibility of aviation lighting on the hubs of up to seven turbines from summits and site-facing slopes in the Lammermuir moorland plateau to the east and west of the Site, and from the farmed plateau to the south. There is very limited theoretical visibility from the settled East Lothian lowlands in the north of the study area.

4.3.50 Nacelle lights are theoretically visible across the host Dissected Plateau Moorland LCT and neighbouring Plateau Moorland – Lothians LCT to the north, particularly within around 5 km. These LCTs possess qualities of naturalness and wildness, with few artificial light sources in the baseline apart from occasional scattered farmsteads. None of the operational wind farms within the LCT have aviation lighting, as they are all below 150 m height to tip. However, given the small number of proposed nacelle lights, and the presence of artificial light sources at farmsteads along the Dye Water valley within the Site, nacelle lights would be unlikely to significantly affect the key characteristics of the Dissected Plateau Moorland LCT or Plateau Moorland – Lothians LCT. Views from this area are represented by Viewpoint 3: Minor road near Wanside Rig junction (see **Figure 4.2.3g and 4.2.3h**).

4.3.51 There is theoretical visibility of up to seven nacelle lights from parts of the settled Rolling Farmland - Borders LCT to the south of the Site. This LCT is moderately densely settled, with baseline artificial light sources associated with scattered farmsteads, small settlements (including Westruther and Houndslow) and occasional vehicle lights from road users on the network of roads which crosses the LCT, including the A697. Despite these light sources, a dark, rural outlook is generally available from the LCT. The number of nacelle lights which are theoretically visible is limited by the rolling landform, with Twin Law also providing some screening. When apparent, nacelle lights experienced in views to the north beyond forested horizons would be unlikely to significantly alter the key characteristics of the LCT, which include its wide horizons and skyscapes. Furthermore, due to the viewing angle from the LCT generally being below the horizontal, the intensity of aviation lighting experienced from the LCT would be reduced (see **Figure A4.3.3**). Views from this area are represented by Viewpoint 7: B6456 Westruther (see **Figure 4.2.7e and 4.2.7f**).

4.3.52 There would be theoretical visibility of up to seven nacelle lights from parts of the Upland Fringe Moorland with Hills LCT which includes Dirrington Great Law and Dirrington Little Law. This LCT has open views and a well-defined visual identity, which are described as key characteristics. Artificial light sources within the LCT are limited to scattered farmsteads and occasional vehicle lights on the road network, and a dark rural outlook is generally available from the LCT. When apparent, nacelle lights experienced in views to the north-west would be unlikely to significantly alter the key characteristics of the LCT, including its open views and well-defined visual identity. Furthermore, due to the viewing angle from the LCT generally being below the horizontal, the intensity of aviation lighting experienced from the LCT would be reduced (see **Figure A4.3.3**). Views across this area are represented by Viewpoint 12: Minor road near Hen Law (see **Figure 4.2.12f and 4.2.12g**).

4.3.53 Effects of lighting will primarily affect views rather than landscape character. Given that the Proposed Development will not affect the key characteristics of the underlying landscape, no significant effects are predicted on landscape character.

Effects on Designated Landscapes

4.3.54 The Proposed Development is located within the Lammermuir Hills Special Landscape Area (SLA), which is coincident with the Lammermuir Moorland SLA in the East Lothian local authority area, to the immediate north of the Site. Other SLAs lie further to the north. One of the special qualities of the Lammermuir Moorland SLA refers to "*both peacefulness and wildness in particular deriving from the areas openness to the elements, remoteness, and limited built development, roads or plantation forestry, as well as limited light pollution.*" Dark skies are not specifically recognised as a special quality within the Lammermuir Hills SLA, although this landscape has remote and natural characteristics to which dark skies contribute. Artificial light sources are limited to scattered farmsteads and the headlights of occasional passing traffic on the minor road network.

4.3.55 As noted above, there would be theoretical visibility of up to seven nacelle lights from areas of upland moorland around the Site, particularly within 5 km but also extending to Spartleton Edge to the north-east (within the Whiteadder SLA) and Dirrington Great and Little Law to the south-east (within the Lammermuir Hills SLA). Theoretical visibility is reduced within the steep sided valleys which dissect the plateau moorland and there is very little theoretical visibility from the settled East Lothian farmland to the north. When apparent, nacelle lights would typically be seen on the skyline. Given the small number of lights visible, and other occasional light sources including properties and car headlights in the baseline, no significant effects on the special qualities of these designated landscapes are anticipated to occur.

Effects on Visual Amenity

4.3.56 **Table A4.3.2** below details the predicted visibility of the proposed turbine lighting from each LVIA assessment viewpoint (informed by **Appendix 11.1**). The table also indicates the potential influence of coniferous forestry in further screening the theoretical visibility of turbine lighting from each viewpoint location, informed by the baseline photography and observations from fieldwork.

4.3.57 As noted above the frequency and duration of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness (below 500 lux), which changes with the seasons. As such, in the summer months when nights are shorter, the length of time subject to visible aviation lighting will reduce.

Table A4.3.2: Summary of Turbine Lighting Visibility

Summary of Turbine Lighting Visibility								
Table Key:								
Hub lighting potentially visible (i.e. one medium intensity 2,000 cd nacelle light)	•	Turbine hub lighting obscured from viewpoint but may be visible in the vicinity of the viewpoint	△	Turbine hub lighting potentially screened by forestry	✘			
Summary of Turbine Lighting Visibility								
Hub light		Turbine 1	Turbine 3	Turbine 6	Turbine 8	Turbine 9	Turbine 14	Turbine 15
1	Twin Law Cairns, Southern Upland Way		•	•	•	•	•	•
2	Nun Rig, Southern Upland Way	•		•	•	•	•	•
3	Minor road near Wanside Rig junction	•	•	•	•	•	•	•
4	Watch Water Reservoir, Southern Upland Way						•	•
5	Minor road near Wrunk Law	•	•	•	•	•	•	•
6	Spartleton Hill	•	•	•	•	•	•	•
7	B6456, Westruther					•	•	•

Summary of Turbine Lighting Visibility					
Table Key:					
Hub lighting potentially visible (i.e. one medium intensity 2,000 cd nacelle light)	•	Turbine hub lighting obscured from viewpoint but may be visible in the vicinity of the viewpoint	△	Turbine hub lighting potentially screened by forestry	✘

Summary of Turbine Lighting Visibility								
Hub light		Turbine 1	Turbine 3	Turbine 6	Turbine 8	Turbine 9	Turbine 14	Turbine 15
8	B6456 near Bedshiel	•	•	•	•	•	•	•
9	Dirrington Great Law	•	•	•	•	•	•	•
10	Lammer Law	•	•	•	•	•	•	•
11	Edgarhope Wood, Southern Upland Way	•	•	•	•	•	•	•
12	Minor road near Hen Law	•	•	•	•			
13	A6015 near Greenlaw	•	•	•	•	•	•	•
14	B6362 above Lauder	•	•	•		•	•	•
15	Traprain Law	•	•	•	△	•	•	
16	Park Lane, Haddington							
17	Barney Hill, Garleton Hills	•	•					
18	A6112 near Fawcett Wood	•	•	• ✘	△	•	△	△
19	A697 near Coldstream	△ ✘	• ✘	△	△	•	•	•
20	B6371 near Tranent							

Summary of Turbine Lighting Visibility							
Table Key:							
Hub lighting potentially visible (i.e. one medium intensity 2,000 cd nacelle light)	•	Turbine hub lighting obscured from viewpoint but may be visible in the vicinity of the viewpoint	△	Turbine hub lighting potentially screened by forestry	✘		

Summary of Turbine Lighting Visibility								
Hub light		Turbine 1	Turbine 3	Turbine 6	Turbine 8	Turbine 9	Turbine 14	Turbine 15
21	Eildon North Hill	•	•	•	•	•	•	•
22	North Berwick Law	•	•	•	•	•	•	•
23	A198 near Dirleton	•	•	•				
24	Torfichen Hill	•	•	•	•	•	•	•

Representative Assessment Viewpoints

4.3.58 Whilst the potential visibility of aviation lighting is summarised for each of the LVIA assessment viewpoints (as set out in **Table A4.3.2**), the following assessment focuses on representative viewpoints, agreed through consultation.

4.3.59 The three assessment viewpoints represent views from settlements and roads within approximately 10 km, which are more likely to be frequented during the hours of darkness by higher sensitivity receptors, and are within a viewing distance over which significant visual effects are more likely to occur. Night-time photomontage visualisations were produced for the following assessment viewpoints:

- Viewpoint 3: Minor road near Wanside Rig junction (see **Figure 4.2.3g, 4.2.3h**);
- Viewpoint 7: B6456 Westruther (see **Figure 4.2.7e, 4.2.7f**); and
- Viewpoint 12: Minor road near Hen Law (see **Figure 4.2.12f, 4.2.12g**).

4.3.60 Photomontage visualisations illustrate the aviation lighting at both the 'maximum reasonable worst case' situation, and the more likely representation with 10% of maximum emitted light during clear weather conditions, noting the need for it to be clear for 5 km at all points of measurement. The methodology for the preparation of night-time visualisations is detailed in full in **Appendix 4.1**.

Table A4.3.3: Viewpoint 3: Minor road near Wanside Rig junction

Viewpoint 3: Minor road near Wanside Rig junction			
Grid Reference (NGR)	360689, 664164	Figure Number	4.2.3g, 4.2.3h
LCT	LCT 90	Designated Landscape	Lammermuir Moorland SLA
Direction of View	South-west	Distance to Nearest Lit Turbine (km)	4.1

Viewpoint 3: Minor road near Wanside Rig junction			
Number of Turbines with Nacelle Lighting Visible	7	Nearest Lit Turbine	T1
Location, Description of Existing Night-time View and Potential Receptors			
This viewpoint is located on a minor road just south of the B6355, following the ridge above Faseny Water. The viewpoint represents road users and the local community from the junction between the B6355 and the minor road which crosses the Lammermuir Hills, providing access to dispersed properties north-east of the Site. Views in all directions from this location look out over wide stretches of rough grassland and undulating moorland, bound by post and wire fencing. At night, the silhouettes of Fallago Rig Wind Farm are perceptible on the skyline to the south-west, although none are equipped with aviation lighting. There are no artificial light sources visible in night-time views from this location, with the exception of car headlights from occasional passing traffic, although this is infrequent at night.			
Night-Time Sensitivity			
Road users are considered to be of **medium** susceptibility to changes in night-time views. The viewpoint is located within the Lammermuir Moorland SLA. The value of the view is considered to be **medium**. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **medium**.			
Assessment of Night-Time Visual Effects			
Figures 4.2.3g and 4.2.3h illustrate the view of the Proposed Development at night at 2,000 and 200 cd, respectively. Lighting on the nacelles of up to seven turbines would be visible on the skyline in views to the south-west. The visible lighting would be seen in the context of a dark rural outlook, with no other artificial light sources except occasional car headlights. Given the visibility of all seven nacelle lights, proximity and the lack of other artificial light sources, the scale of visual change at night would be medium for the 2,000 cd situation. The geographical extent would be medium as similar views are afforded from along the minor road and from the B6355 to the north. The magnitude of change would be medium, resulting in a **Moderate and Significant** effect for road users at this viewpoint. During the more likely situation for clear weather conditions (10% brightness) the magnitude of change would fall to low, resulting in a **Minor and Not Significant** effect.			
Assessment of visual effects under future baseline scenarios			
Scenario 1: The nacelle lights on the consented Crystal Rig – Phase 4 Wind Farm would be perceptible on the skyline above open moorland in views to the east, at a distance of around 6 km. Only four nacelles are visible, with the remainder screened by the intervening landform. Given this limited visibility there would not be a notable change to the existing night-time baseline views, and effects would therefore remain the same as the primary assessment. **Scenario 2**: The nacelle lights on the proposed Newlands Hill Wind Farm (at Scoping stage) would be visible on the skyline above the viewer, in very close views to the north and west. The addition of the Proposed Development would introduce visibility of lighting on the skyline in views to the south, albeit further from the viewer than Newlands Hill. The nacelle lights on the turbines of Newlands Hill would be dominant in views, and those of the Proposed Development and would be seen behind them at distance. The scale of change would therefore be small, resulting in a **Minor and Not Significant** effect.			

Table A4.3.4: Viewpoint 7: B6456 Westruther

Viewpoint 7: B6456 Westruther			
Grid Reference (NGR)	363868, 650100	Figure Number	4.2.7e, 4.2.7f
LCT	99 Rolling Farmland – Borders	Designated Landscape	None
Direction of View	North	Distance to Nearest Lit Turbine (km)	6.9 km

Viewpoint 7: B6456 Westruther			
Number of Turbines with Nacelle Lighting Visible	3	Nearest Lit Turbine	T14
Location, Description of Existing Night-time View and Potential Receptors			
This viewpoint is located along the B6456, near Westruther, approximately 7 km south of the Site. The viewpoint is representative of road users and residents within and in proximity to Westruther. Views north look out over undulating pastoral and arable fields bound by occasionally gappy drystone walls and scrubby verges, towards the southern slopes of the Lammermuir Hills. Blocks of forestry are scattered throughout, and form dark blocks against the lighter hues of underlying landcover. Further north the large scale Harecleugh Forest is seen on the rising slopes of Flass Hill, as a dark band. To the west along the B6456, the residential facades of Westruther are seen along the roadway, situated within forestry and garden vegetation. Occasional artificial lighting is seen from this location from properties within the settlement. There are also car headlights from occasional passing traffic, although this is infrequent at night.			
Night-Time Sensitivity			
Road users are considered to be of **medium** susceptibility to changes in night-time views. Residents are considered to be of **high** susceptibility to changes in night-time views. The viewpoint is not located within a designated landscape. The value of the view is considered to be **medium**. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **medium-high**.			
Assessment of Night-Time Visual Effects			
Figures 4.2.7e and 4.2.7f illustrate the view of the Proposed Development at night at 2,000 and 200 cd, respectively. Lighting on the nacelles of up to three turbines would be visible on the skyline, beyond a forested horizon. The remainder would be screened by the intervening landform. The visible lighting would be seen in the context of a dark rural outlook, with a small number of other artificial light sources including properties in Westruther to the west of the viewpoint, and occasional car headlights to the east and west. Given the small number of nacelle lights visible and presence of other light sources, the scale of visual change at night would be small for the 2,000 cd situation. The geographic extent would be medium, as similar views may be obtained along a short section of the B6456. The magnitude of change would be low, resulting in a **Minor and Not Significant** effect for residents and road users at this viewpoint. During the more likely situation for clear weather conditions (10% brightness) the magnitude of change would remain low, resulting in a **Minor and Not Significant** effect.			
Assessment of visual effects under future baseline scenarios			
Scenario 1: No consented wind farms would be visible. As the existing baseline would not change, effects would therefore remain the same as the primary assessment. **Scenario 2**: No proposed wind farms would be visible. As the existing baseline would not change, effects would therefore remain the same as the primary assessment.			

Table A4.3.5: Viewpoint 12: Minor road near Hen Law

Viewpoint 12: Minor road near Hen Law			
Grid Reference (NGR)	372386,654338	Figure Number	4.2.12f, 4.2.12g
LCT	99 Rolling Farmland -Borders	Designated Landscape	None
Direction of View	North-east	Distance to Nearest Lit Turbine (km)	10.6 km

Viewpoint 12: Minor road near Hen Law			
Number of Turbines with Nacelle Lighting Visible	4	Nearest Lit Turbine	T15
Location, Description of Existing Night-time View and Potential Receptors			
This viewpoint is located along a minor road in between Longformacus and Duns, and represents road users and local community members accessing dispersed properties along the route. Located just off the minor road, this viewpoint looks out north-west across rolling moorland. Rough grassland with wire post fencing comprises the foreground of the view. Wood electrical poles follow along the minor road as it winds down the slopes to the north-east. The conical form of Dirrington Great Law forms a notable feature in the middle distance in the north-west. In the distant north, the gradually rising upland forms of the Lammermuir Hills can be seen, across which Fallago Rig is perceptible. There are no artificial light sources in this view with the exception of car headlights from occasional passing traffic, although this is infrequent at night.			
Night-Time Sensitivity			
Road users are considered to be of **medium** susceptibility to changes in night-time views. The viewpoint is not located within a designated landscape. The value of the view is considered to be **medium**. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **medium**.			
Assessment of Night-Time Visual Effects			
Figures 4.2.12f and 4.2.12g illustrate the view of the Proposed Development at night at 2,000 and 200 cd, respectively. Lighting on the nacelles of up to four turbines would be visible on the skyline. The remainder would be screened by Dirrington Great Law, although noting that they may become visible as the viewer travels north on this minor road around Dirrington Great Law. The visible lighting would be seen in the context of a dark rural outlook, with very few other artificial light sources except occasional car headlights. Given the intervening distance and limited number of nacelle lights visible, the scale of visual change at night would be small for the 2,000 cd situation. The geographical extent would be medium, as similar views will be gained intermittently along the road to the north and south. The magnitude of change would be low, resulting in a **Minor** and **Not Significant** effect for road users at this viewpoint. During the more likely situation for clear weather conditions (10% brightness), the magnitude of change would remain low, resulting in a **Minor and Not Significant** effect.			
Assessment of visual effects under future baseline scenarios			
Scenario 1: The nacelle lights on the consented Crystal Rig – Phase 4 Wind Farm would be perceptible on the skyline above rolling farmland in views to the north, at a distance of around 12 km. At this distance there would not be a notable change to the existing night-time baseline views, and effects would therefore remain the same as the primary assessment. **Scenario 2**: The nacelle lights on the proposed Newlands Hill Wind Farm (at Scoping stage) would be perceptible on the skyline above open moorland in views to the north-west, at a distance of around 16 km. At this distance there would not be a notable change to the existing night-time baseline views, and effects would therefore remain the same as the primary assessment.			

Summary of Lighting Effects

4.3.61 No significant effects on landscape character or designated landscapes are anticipated. Whilst dark sky qualities are not specifically recognised for all the LCTs considered in this assessment, some of these areas of landscape have remote and natural characteristics to which dark skies contribute. Dark sky qualities are not specifically recognised across all the designated landscapes considered in this assessment, although the Lammermuir Moorland SLA refers to limited light pollution as a contributing factor to the qualities of peacefulness and wildness.

4.3.62 When visible, the Proposed Development would tend to be seen in closer proximity views from the minor roads which cross the Lammermuir moorland plateau to the east of the Site, or from the rolling farmland to the south, beyond forested horizons. In terms of visual effects, significant visual effects are predicted for one assessment viewpoint, but under the 2,000 cd situation only.

4.3.63 It is important to note that the representative visualisations do not take account of the potential reduction in light intensity which may be perceived in relation to the relevant vertical elevation angle (refer to **Figure A4.3.2** and **Figure A4.3.3**) or the influence of weather conditions which are not as clear as when the photography was captured. These factors would influence the actual brightness of the lights perceived, both from the elevated plateau moorland and lower-lying settled rolling farmland in closer proximity to the Proposed Development.

4.3.64 In conditions of meteorological visibility of less than 5 km at the point of measurement, the perceived brightness of medium intensity lights illuminated at 2,000 cd, whilst possibly still visible, is likely to be substantially reduced. In such conditions, the lights would typically not be visible at distances greater than 5 km from turbines, and therefore this represents a less likely situation. In the 200 cd situation, which is more likely to be experienced by people at these viewpoints, no significant effects are predicted.