Hare Hill Windfarm Repowering and Extension

Appendix 6.4: Aviation Lighting Assessment

Prepared for: **ScottishPower Renewables (UK) Limited**

November 2025

MVGLA
Landscape Architecture

CONTENTS

List of Abbreviations

Abbreviation	Description
AOD	Above Ordnance Datum
CAA	Civil Aviation Authority
cd	candela, SI unit of luminous intensity
EAC	East Ayrshire Council
GLVIA3	Guidelines for Landscape and Visual Impact Assessment, Third Edition.
HH	Hare Hill Wind Farm (existing)
HHE	Hare Hill Wind Farm Extension (existing)
HHR1	Hare Hill Wind Farm Repowering and Extension (Phase 1 of the proposed Development)
HHR2	Hare Hill Wind Farm Repowering and Extension (Phase 2 of the proposed Development)
km, m, cm mm	Kilometres, metres, centimetres, millimetres
lux, microlux	SI unit of illuminance
LVIA	Landscape and Visual Impact Assessment
MOD	Ministry of Defence
T1, T2, …	Turbine 1, turbine 2 (and subsequent numbering)
VP1, VP2…	Viewpoint 1, viewpoint 2 (and subsequent numbering)
ZTV	Zone of Theoretical Visibility

1. Technical Appendix 6.4: Aviation Lighting Assessment

Introduction

1.1 This Technical Appendix sets out an evaluation of the effects of the lights of the Hare Hill Windfarm Repowering and Extension (the proposed Development) on the visual amenity of the local area during times when the turbines are lit. The assessment is supported by:

- A Zone of Theoretical Visibility (ZTV) map showing the number of turbine hubs theoretically visible across the study area (**Figure 6.2**);
- ZTVs showing the angle of views to the lights (as a downward angle of light emitted from the hubs) which can be used to indicate lighting intensity (**Figures 6.10a** and **6.10b**); and
- Night-time visualisations for three viewpoints (VPs):
    - VP4: Merkland (**Figure 6.14**);
    - VP5: A76 Kirkconnel (**Figure 6.15**); and
    - VP7: B741 Knockburnie (**Figure 6.17**).

Regulations and Guidance

1.2 As the proposed turbines would be over 150 m to blade tip, they are above the threshold for Civil Aviation Authority (CAA) regulations for lighting. The outcome of an application to the CAA for a reduced lighting scheme is not yet known, but for the purposes of the assessment it is assumed that the lighting would include:

- All turbines would have a steady visible red light on the hub, operating at 200 candela (cd) in clear visibility, but at 2000cd when visibility is less than 5km;
- There would be no tower lights; and
- The turbines would be lit between half an hour before sunset and half an hour after sunrise.

1.3 Infrared lighting on each turbine as required by the Ministry of Defence (MOD) is not visible to the naked eye and is therefore not considered further.

1.4 The use of lights designed to give a horizontal beam means there would be a reduced upward and downward spill of light, such that the brightness of the light is decreased for viewers close to the turbines viewing them from below. Data suggests that in excess of -4° below horizontal the lights should not be visible. It is assumed, however, that there may be some visibility, and it is also noted that for locations nearby, the reflection of the beam off passing blades may be visible and may appear to be flashing. Reduction in brightness above horizontal tends not to be so contained. Emittance of a typical horizontal beam light is set out in **Table 1** below.

Table 1: Intensity of light emitted based on a standard medium intensity obstruction light

Emitted angle	Light emitted	
	2000cd scenario	200cd scenario
Above 6°	<100cd	<10cd
4° to 6°	500cd to 100cd	50 to 10cd
2° to 4°	1500 to 500cd	150 to 50cd
0° to 2°	2100 to 1500cd	210 to 150cd
0° to -1	2100 to 750cd	210 to 75cd
-1° to -2°	750 to 80cd	75 to 8cd
-2° to -3°	80 to 40cd	8 to 4cd
-3° to -4°	40 to 10cd	4 to 1cd
Below -4°	<10cd	<1cd

1.5 The turbines of the proposed Development would be located at between 470m and 555m AOD (base height) and their lights on the hubs (hub heights of 82m, 105m or 119m above ground) would be at between 574m and 640m AOD.

Guidance on Assessment of Lighting Effects

1.6 This assessment follows recent guidance published by NatureScot ('Guidance on Aviation Lighting Impact Assessment' November 2024). In particular it is noted that:

- The approach to assessment follows the Guidelines for Landscape and Visual Impact Assessment (3rd edition, GLVIA3);
- The guidance notes that sensitivity of receptors at night can differ from those during daytime;
- The guidance refers to NatureScot guidance on the preparation of visualisations for wind farms, and advises that:
- Lit turbines should be marked on all 53.5° wirelines; and
- visualisations should be caveated as being 'only reasonable indicative illustrations of the lighting effects' being *'essentially artist's impressions of the light emission and do not carry the same assurance that can be drawn from a day-time photomontage'*.

1.7 NatureScot advise a proportionate and pragmatic approach to lighting assessments, with lengthy and detailed debate about the exact brightness of lights less helpful than discussion of relative brightness, with a focus on where they would be visible, and how they would change the baseline night view. However, it is considered that the perceived brightness of the lights that would be observed from each viewpoint is important to understand, including an understanding of how attenuation by distance, weather, angle of view relative to the beam of the light, and darkness adaptation affect night vision, in order to be able to make a more meaningful assessment of visual effects.

1.8 With respect to the selection of viewpoints to illustrate with dusk photomontages, health and safety must be a prime consideration. The 2024 Guidance states in Appendix 4:

> "*Assessors and consultees/stakeholders should take the practical and health and safety considerations in account when identifying and agreeing night-time viewpoint locations to best*

represent effects. This should not preclude hilltop viewpoints from being chosen, where they may provide an essential insight to the lighting effects, but an appropriate and proportionate approach should be taken to minimise risk to the assessors.

In some cases, a more accessible proxy viewpoint may be appropriate, for example where similar views from the periphery of a Wild Land Area (WLA) may be equally representative of those experienced from more inaccessible remote interior, or where the approach to a hill summit located at a lower elevation may provide opportunity to view aviation lights at closer distance and comparable relative lighting intensity". (Guidance on Aviation Lighting Impact Assessment, NatureScot, 2024)."

1.9 For the proposed Development, it was not considered necessary to ascend any hills for dusk or dawn photography.

1.10 With respect to potential cumulative effects of aviation lighting, 2024 Guidance states in Appendix 4: that "*Cumulative lighting ZTVs illustrating aviation lighting may be useful in some circumstances where more than one lit wind farm is likely to affect key receptors*".

Apparent Brightness

1.11 The intensity of light emitted is measured in candela, but the apparent brightness of light received by the eye from low intensity lights is measured in microlux (microlumens per m^2). These units can be difficult to use without translation into examples that may be familiar to viewers. Some examples include:

- Planet Venus: 140 microlux;
- Orion constellation, upper left and lower right stars: 1.5-2 microlux;
- Orion constellation, 'belt' stars: 0.3 microlux;
- Faintest light visible to a 'typical' person: 0.01 microlux;
- Car rear brake lights, although they vary, are in the order of 70-80 candela, and at 1 km may appear as 100 microlux;
- LED traffic lights can be around 400cd; and
- Standard medium intensity aviation safety lights on tall structures 200cd.

1.12 NatureScot advise that quantitative analysis is 'less useful' for the assessment of effects on the night-time experience of the lights than qualitative comparisons with existing lights that people may be familiar with. However, it is clear from the science of lighting that understanding how light intensities and brightness of lights are perceived is important to be able to carry out an assessment. It is important to note that specifications for existing lights in the landscape are not available, such that comparisons cannot be quantitative.

1.13 The apparent brightness of the light (received by the human eye) depends not only on how much light is emitted (intensity), but also on intervening atmospheric conditions (rain, fog, dust, haze, etc) that cause atmospheric dispersal of light; the lit environment of the viewer (standing in a well-lit area or a dark place); and the distance from the light source. The apparent brightness reduces with distance (attenuation) in clear weather as well as when there are poorer viewing conditions. Brightness reduces with the square of the distance ($x=1/distance^2$), such that a light observed from a distance of 10 km would have an apparent brightness only 1% of that of the same light observed from a distance of 1 km.

1.14 In good visibility, the limit of the human eye's ability to see the lights would be approximately 20 km; or the visible limit for fully dark-adapted eyes is around 0.02 microlux (with a limit of 0.4 microlux in street-lit areas). As advised in NatureScot guidance, the study area for this assessment approximately 20 km, and it is assumed that at greater distances, the lights would not be visible.

1.15 When lights are designed to give a horizontal beam with reduced upward and downward spill of light, the brightness of the light is decreased for viewers close to the turbines viewing them from below. Data suggests that in excess of -4° below horizontal the lights should not be visible. It is assumed, however, that there would be some visibility, and it is also noted that for locations nearby, the reflection of the beam off passing blades may be visible and may appear to be flashing.

1.16 An important factor for perception of light is the different ways that cameras and human eyes perceive light. Cameras are governed by lenses and settings, human eyes adapt to different light environments (for example it can seem very dark when lights are first switched off, until one's eyes become accustomed to the dark). Dark adaptation of the human eye is related to the 'rods' and 'cones', light detecting cells in the back of the eye that have different roles in low light levels, with rods taking over from cones when it is dark. Cones detect colour and are used in the light (being less sensitive in low light levels), while rods are not as good with colour but can pick up faint lights (they switch off in bright light). Dark adaptation is when the rods can fully activate and can make out faint lights in a dark environment, but as soon as a light is switched on, even briefly, cones take over again and it takes time for the rods to reactivate. Lights clearly visible to dark-adapted eyes may be imperceptible when other lights are first switched off (before dark adaptation can occur), or when in a bright place such as under streetlights or from within a dark vehicle when much of the attention is on the pool of light from the headlights. In these environments dark adaptation cannot occur in full as the rods in our eyes cannot fully take over. It is noted that most people would be close to lights after dark, either in lit houses/properties, or in vehicles with headlights on. This makes the perception of other lights more difficult.

1.17 In contrast, cameras do not have any adaptation, but light capture depends on exposure and camera settings (modern cameras may have auto-adjust or 'night mode', but this is not adaptation in the same way as the human eye). This means that images can be very different to what we experience. An issue for photographic capture and rendition of lights is that existing lights shown in photographs can appear larger and more blurred than those seen by the naked eye in the field. 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 is difficult to avoid when taking photographs of lights (particularly moving lights such as vehicle headlights). To best model the lights as if they were existing, this effect has been added to the hub lights in the viewpoint illustrations.

1.18 It is not possible to accurately model the exact brightness of the lights in visualisations, given variations in not only light specifications and camera settings, but also weather and atmospheric conditions at the time of photography, as well as the resolution and colour calibration of a computer screen, ambient light when viewing images on screen, and finally printer resolution and paper quality. However, the lights illustrated on the figures have been rendered as best possible using comparison with images of other lights in the views, and other examples of existing potentially equivalent lighting[1] observed in the study area, and other lights on wind farms in other parts of Scotland.

1.19 The duration of the light depends on when the lights are switched on and off. Sunset occurs when the sun disappears below the horizon, sunrise is the time at which the sun first appears on the horizon in the morning. The exact times of sunset and sunrise vary throughout the year. Although it is not visible, the sun still illuminates the sky with diffused light for a period of time after sunset and before sunrise, known as twilight. There are different stages of twilight:

- Civil twilight, which begins once the sun has disappeared below the horizon and continues until it descends to 6 degrees below the horizon. This translates in duration as from sunset to about half an hour after sunset, or for half an hour before sunrise. Civil twilight is still bright, such that the aviation lights are unlikely to be visible against the bright sky. Aviation lights would be switched on half an hour after sunset (and off half an hour before sunrise) because of this;

[1] Comparison with other existing lights should be done cautiously, as brightness and characteristics of other lights is not known.

- Nautical twilight, when the sun is between 6 and 12 degrees below the horizon, which is for approximately half an hour after civil twilight in the evening, or before civil twilight in the morning (landforms are still visible while the stars start to appear and so it is a valuable time for navigators at sea). During this phase the aviation lights would be on, and would become more visible as the daylight diminishes; and
- Astronomical twilight, when the sun is between 12 and 18 degrees below the horizon. Below 18 degrees below the horizon, the sun no longer illuminates the sky.

1.20 Visibility and apparent brightness of lights also depends on the background sky. It is noted that it does not necessarily get completely dark, with lingering light on short summer nights, moonlight, or the glow from settlement lights, and light reflected off clouds. In these conditions, the turbines may be partially visible over short distances at different times of night, and the apparent brightness of the lights may be affected by other lights, e.g. when seen against the late sun-lit clouds in views towards the west, or seen from well-lit areas, and contrast with background sky colour. Conversely there would be evenings and mornings that are darker due to weather conditions such as thick cloud cover.

Methodology and Approach

Assessment Methodology

1.21 The methodology and approach to the assessment of significance of lighting effects are based on the methodology of the Landscape and Visual Impact Assessment (LVIA), which is based on GLVIA3 as set out in **Technical Appendix 6.1**. It also follows the recently published guidance which supports a focussed and proportionate approach to the assessment of aviation lighting effects. The guidance sets out a three stage approach:

- Step 1: Defining the lighting proposal, to include details of the number and intensity of lights, including all mitigation that is proposed;
- Step 2: Understanding the baseline:
    - Identification and agreement of the study area (normally 10-20km in radius);
    - Selection of the representative viewpoints for night-time photomontage visualisations (normally two or three locations);
    - An evaluation of the baseline lighting environment; identifying key features, characteristics and/or qualities of the landscape that are sensitive to the introduction of aviation lighting; and
    - Identification of sensitivity of people who perceive the landscape at night (receptors), which may be very different from daytime sensitivity.
- Step 3: Assessing the effects of the aviation lighting;
    - An evaluation of the likely significant effects arising from visible aviation lights for receptors identified within the study area, taking account of proposed mitigation;
    - Evaluation of likely effects on any special qualities or wildness qualities that may arise at night; and
    - Evaluation of any likely significant cumulative effects arising from visible aviation lighting.

1.22 The guidance recommends the production of a range of supporting graphics, including:

- A ZTV indicating theoretical visibility of lights (i.e. a hub height ZTV);
- An Aviation Lighting Intensity ZTV if vertical directional intensity mitigation is used (a horizontal beam of light with reduced intensity above and below);

- Notes on all wirelines (those of 53.5° included angle) indicating which turbines are to be lit;
- Dusk photomontages for 2-3 locations agreed with statutory consultees, indicating potential appearance of the lights; and
- Cumulative ZTVs for lighting as required.

1.23 Dusk photomontages are recognised in the guidance as "*artistic impressions*" of what the aviation lighting may look like, given the variation of weather and atmospheric conditions, distance attenuation, angle attenuation, and differences between the camera image and what the human eye experiences. The guidance recommends that visualisations aim to show the lights at 200cd, rather than at reduced intensity due to downward angle (if a horizontal beam lamp is used).

1.24 In considering sensitivity of receptors and magnitude of change to arrive at a judgement of significance of effects, it is noted that:

- Sensitivity is generally considered in guidance to relate to daytime views, and night-time sensitivity is very different. At night, viewpoints that of high value and susceptibility may be of low sensitivity at night because people do not go there to see the dark. Locations within Dark Skies Parks are an exception to this as people go to experience the dark and observe the stars, but for most places' sensitivity is low as people move through or between lit spaces (turning lights on or using headlights as necessary) and usually view darker landscapes from better lit locations; and
- The change to night views includes consideration of baseline lighting in the view and the proposed lights, including intensity and position in the view in relation to existing lights, as well as colour, nature (steady or flashing) and duration.

1.25 The likely brightness of the lights seen from each viewpoint is a function of emitted light and angle of view (reduced downward light spill from a horizontal beam design), as well as distance attenuation and atmospheric conditions. The assessment below considers potential brightness of the lights in clear conditions.

Fieldwork

1.26 Field visits undertaken for the LVIA between September 2022 and March 2025 included observations made after dark. Fieldwork and photography specific to the nighttime lighting assessment was undertaken between May 2024 and February 2025.

ZTV modelling

1.27 ZTV mapping has been carried out to identify the theoretical visibility of the hub lights. It is noted that the ZTV uses a bare ground model and does not account for local screening by woodlands or buildings. The ZTV on **Figure 6.2** is calculated to show theoretical visibility of all hubs to 45km. **Figures 6.10a** and **6.10b** show the visibility of the aviation lights of Phases 1 and 2 and are coloured to illustrate the downward angle of view (from the light to the viewer) and therefore represent the brightness emitted at that angle. These ZTVs do not include attenuation by distance, nor do they take account of variations in atmospheric conditions. **Figure 6.10c** shows the cumulative lighting of the proposed Development plus Sanquhar II Windfarm which is under construction and will have turbines of 200 m to blade tip that will be lit[2].

Production of visualisations

1.28 Photography for night-time photomontages to illustrate potential effects of aviation lighting was carried out in the evening or in early morning. A set of photographs was taken prior to sunset to ensure that the camera was correctly set up, and to allow cross reference between lights caught on dark photographs and buildings caught on daytime photographs. A series of photograph sets were taken over a period of

[2] Not all turbines of Sanquhar II are to be 200 m, those under 150 m are not modelled in Figure 6.10c.

about an hour and a half from sunset into nautical twilight. This enabled the photographer to take multiple sets as the sky darkened, with varied camera settings. Downloaded sets were then reviewed to select a set that best matched NatureScot advice on having the sky relatively dark and other lights in the landscape on, but the form of the landscape still visible.

1.29 Photomontages prepared for night-time views using photography taken during twilight were produced using the same method as for daylight photomontages (methodology as set out in **Technical Appendix 6.1**), with turbines rendered in black as silhouettes. Images of aviation lights are provided for indicative illustration only. They have been modelled on the basis of approximately 200 cd.

1.30 The 53.5° wireline (as part of the NatureScot visualisation set) for each viewpoint is marked to indicate which of the proposed turbines would be lit, using a red dot above the turbine number.

Scope of the Assessment

1.31 Recent guidance sets out that a normal study area for aviation lighting assessment is of approximately 10-20km radius, beyond which the lights are too distant and are likely to go unnoticed. Much of the study area with theoretical visibility is off-road, with likely viewers limited to walkers on descent paths close to settlements, with the potential for some walkers to be out on the Southern Upland Way (SUW) at dusk.

1.32 Routes pass through dark areas between settlements, and although drivers' and passengers' attention is most likely to be on the road ahead corresponding with the area lit by the vehicle headlights, other lights in the landscape can be noticeable. The assessment of effects of aviation lighting at night considers each of the routes used in the daytime LVIA. Routes can be considered by using representative viewpoints and knowledge of roadside screening by vegetation and buildings.

1.33 Settlements are places where people are most likely to be at night but are also where there is abundant lighting. From well-lit areas, faint lights are more difficult to see. With lights nearby, although the lights of the proposed Development may be visible from settlements, there would be no likelihood of significant effects. Settlements are therefore not considered further.

1.34 The assessment of effects of aviation lighting at night briefly considers each of the viewpoints used in the LVIA. Illustrative dark photomontages have been provided for three viewpoints:

- VP4: Merkland (**Figure 6.14**);
- VP5: A76 Kirkconnel (**Figure 6.15**); and
- VP7: B741 Knockburnie (**Figure 6.17**).

1.35 During the times when the lights would be on, the perception of the character of the landscape is reduced to nothing in darkness, such that whilst the lighting may be seen in views when the outlines of landforms and horizons would still be visible, the likelihood of significant effects on the perception of landscape character decreases rapidly with the onset of darkness. As such, an assessment of effects of aviation lighting on landscape character has been scoped out.

Baseline Lighting

1.36 The proposed Development site itself is currently unlit, and the hills are dark. Farms and residential properties scattered across the study area have lights, and settlements such as New Cumnock, Kirkconnel etc have clustered lights. Settlements of New Cumnock, Sanquhar and Kirkconnel create a slight glow in the sky ('skyglow') in some atmospheric conditions. Roads are a source of moving lights with vehicle headlights and rear lights seen frequently along roads, in particular on the A76.

1.37 Existing windfarms with turbines of over 150m within the study area include Middle Muir, Cumberhead, Kennoxhead Phase 1 and Kype Muir Extension. These are located over 20km away to the

north. Windfarms under construction of over 150m include Sanquhar II, Windy Standard Phase 3, as well as more distant Douglas West Extension, Cumberhead West and Hagshaw Hill Repowering. Of those, Sanquhar II is closest and will be seen in many views with the proposed Development. A cumulative lighting ZTV with Sanquhar II is provided in **Figure 6.10c**.

1.38 No ready comparison can be made between the lights that would be installed at the proposed Development and other lights currently in the landscape because their technical specifications are not known. The perceived brightness of a light at any given distance depends fundamentally on this specification. Additionally, the specifications of lights of the type required for windfarms are developing in response to the issues which may arise for visual amenity and may be different by the time of construction. For the purposes of this assessment it is assumed, however, that the lights on the Proposed Development will be similar to those to be added to Sanquhar II turbines.

Assessment of Visual Effects of Aviation Lighting

1.39 As stated above, it is assumed that all turbines would be lit with a 2000/200cd steady red light on the top of the hub (a second light on the hub would be installed as backup but would not be lit when the primary light is functional). The lights would come on at half an hour after sunset and would be switched off at half an hour before sunrise (to be on during nautical twilight).

Analysis of the ZTV

1.40 The hub ZTV (for all turbines) shown on **Figure 6.2** illustrates where hubs would be visible. The aviation lighting ZTVs in **Figures 6.10a** and **6.10b** were modelled for Phases 1 & 2 (HHR1 and HHR2). The ZTVs are calculated to show the minimum vertical viewing angle for the lights visible at each point, i.e. the angle closest to the horizontal for the brightest light, which is not necessarily the closest turbine or the same turbine at each point. Whilst the ZTV does not indicate which turbine would be the brightest, it indicates the least amount of downward reduction in intensity. It should be noted that the ZTVs in **Figures 6.10a** and **6.10b** do not illustrate the brightness of light that may be received in any one place, which needs to take account of distance attenuation and technical specifications for a candidate light unit.

1.41 The CZTV in **Figure 6.10c** with the lights of Sanquhar II turbines illustrates where lights of both schemes would be visible within 20km of each, but does not indicate downward reduction in intensity, or attenuation by distance. It illustrates that for most locations where the proposed Development lights would be visible, there would be visibility of Sanquhar II lights.

Assessment of Visibility of Lights from Viewpoints

1.42 **Table 2** sets out data relating to the theoretical visibility of turbine lights from viewpoints. It is noted that several of these viewpoints are beyond the 20km range that is considered the extent to which lighting may be noticeable.

Table 2: Visibility of Aviation Lights from Viewpoints

Viewpoint	Distance (km) to the nearest lit hub visible	Number of lights visible: Phase 1 + Phase 2	Emitted angle in Phase 1 (see Figure 6.10a)	Phase 2 (see Figure 6.10b)
VP1 Auchinleck	14.7km	10 + 4	-1° to -2°	as Phase 1
VP2 Glaisnock Road	8.4km	10 + 3	-1° to -2°	as Phase 1
VP3 A76 New Cumnock	5.0km	9 + 0	-3° to -4°	as Phase 1
VP4 Merkland	4.0km	8 + 2	<-4°and below	as Phase 1
VP5 A76 Kirkconnel	5.4km	8 + 5	-3° to -4°	as Phase 1

Viewpoint	Distance (km) to the nearest lit hub visible	Number of lights visible: Phase 1 + Phase 2	Emitted angle in Phase 1 (see Figure 6.10a)	Phase 2 (see Figure 6.10b)
VP6 Crawick Multiverse Park	10.4km	15 + 8	-2° to -3°	as Phase 1
VP7 B741 Knockburnie	8.8km	5 + 8	-2° to -3°	-1° to -2°
VP8 Glen Afton	2.3km	3 + 0	<-4°and below	as Phase 1
VP9 Kelloholm	3 km	8 + 8	-2° to -3°	as Phase 1
VP10 SUW Benbrack	8.6km	14 + 8	0 to +1°	as Phase 1
VP11 SUW Whing Head	7.3km	15 + 8	0 to -1°	as Phase 1
VP12 SUW below Conrig Hill	14.7km	15 + 8	0 to -1°	as Phase 1
VP13 Lowther Hill	21.2km	-	-	-
VP14 Blackcraig Hill	1.2km	15 + 8	+2° to +3°	as Phase 1
VP15 Cairn Table	14.4km	15 + 8	0 to +1°	as Phase 1
VP16 Limmerhaugh Muir	17.1km	11 + 7	-1° to -2°	as Phase 1
VP17 Cairnsmore of Carsphairn	10.0km	11 + 6	0 to +1°	as Phase 1

1.43 It is noted that brightness reduces with distance, as well as with atmospheric conditions and weather. The visibility shown on **Figures 6.10a** and **6.10b** and the data above is theoretical for emitted light only and does not account for attenuation of brightness by distance. It is assumed that in conditions of poor visibility, the lights would be strongly attenuated by weather conditions, even at 2000cd.

Lighting in the Cumulative Scenarios

1.44 As noted above, there are existing or under construction windfarms with lit turbines of over 150m within the study area yet most are distant from the Site. The exception is Sanquhar II Windfarm which is of 200m turbines under construction. As these turbines will be close to the site, lights on them are considered through the assessment below.

1.45 Most of the consented windfarms within 25km would be of over 150m turbines, and lighting would be required. Of note, Windy Standard 1 Repower, Lethans and Lethans Extension would be the closest windfarms to the site that would be lit. There would therefore be lights on the hills above Nithsdale to the north and south.

1.46 Most of the windfarm proposals in planning within 25km would be of over 150m turbines, and lighting would be required. The closest windfarms to the site that would be lit would be Cloud Hill, Greenburn Variation, Euchanhead and Lorg. There would therefore be more lights on the hills south of Nithsdale.

Assessment of Visibility of Lights

A76 corridor, including the Railway

1.47 The A76 runs through the Ayrshire lowlands with agricultural landscapes with lights at properties and farms, and through settlements along the road. It bypasses Auchinleck and Cumnock but goes through New Cumnock, Kirkconnel and Sanquhar. The railway follows this route, and minor roads run parallel to it passing properties and farms. At night, these routes are used by people in cars, people in trains will be in lit carriages. Dark adaptation is therefore not normally reached, with occasional dog-walkers on the nearby

minor roads most likely to see additional lights in the landscape. Sensitivity is judged to be low at night. Current lighting is seen at properties, and on vehicles along the road. The lights on Sanquhar II turbines will be visible from around Auchinleck (see **Figure 6.10c** and VP1, **Figure 6.11**), and from around Kirkconnel to Sanquhar (see Viewpoints VP5, **Figure 6.15** and VP6, **Figure 5.16**) but not around New Cumnock (see VP3, **Figure 6.13**).

1.48 Phase 1: **Figure 6.10a** indicates that the relative elevation of the site above the route within the Nithsdale valley is such that for the section of this route corridor closest to the site (within approximately 5km), the lights would be emitting a reduced intensity at -3° or steeper, and the lights would therefore not be bright, if visible. The lights, although high on the hilltop in a part of the view currently without lights (although lights on the taller Sanquhar II turbines will be visible from approximately 3 km east of Kirkconnel), would not affect the overall experience of travelling along the settled valley and would not have significant effects on night-time views. In conditions of poor visibility when lights are operated at 2000cd, they may be brighter (if local fog conditions mean they are visible), but would not have significant effects on the routes. From sections further way (over 5km from the proposed Development), the lights would be affected by distance attenuation and would also be seen in the context of more closer lights in the landscape.

1.49 Phase 1 + consented: Lethans and Lethans Extension would be lit, with Overhill lights visible further west. Although HHR1 turbines would be the closest to the route, the strong downward angle of view (see **Figure 6.10a**) would mean that the lights would not be bright. Significant effects on the experience of the route, given existing lights of settlements and farms, are considered to be unlikely.

1.50 Phase 2 + consented: HHR2 would introduce a small number of additional lights over the horizon to the south of Nithsdale. These would not be numerous or bright and would not have significant effects on views in this context.

1.51 Phase 2 + in planning: In this scenario, Cloud Hill and Greenburn Variation would be lit, and lights may be visible from the route corridor through New Cumnock and along Nithsdale. HHR2 would introduce a small number of additional lights over the horizon to the south of Nithsdale. These would not be numerous or bright and would not have significant effects on views in this context.

1.52 Full proposed Development: The introduction of the full proposed Development (as if un-phased) would be similar to Phase 1 but with the additional lights of HHR2 at the same time. As set out above, the downward angle would mean that emitted light is less bright and would not have a significant effect on the experience of the route corridor.

B741 New Cumnock to Dalmellington and Straiton

1.53 For this route, there would be theoretical visibility of lights along the north facing slopes south of Nithsdale when descending from Maneight east bound. From this section of the route, between 10km and 5km, the lights would be visible at the periphery of the panorama northwards across the settled lowland around New Cumnock, including the lights of New Cumnock and surrounding farms. Sanquhar II turbine lights would not be visible from this section. Lower down the road to the east, the angle from the lights would be steeper and the lights although closer would not be bright. Sanquhar II lights would be visible from further down the road as indicated by **Figure 6.10c**. In addition, the experience of the route is more affected by lights on properties of Burnside, Blankglen, Connel Park and New Cumnock, with street lighting in sections. It is therefore unlikely that significant effects would occur as a result of lighting on the proposed Development.

Minor road along Glen Afton

1.54 This road runs along the foot of the deep Afton Water valley. It also forms C14 Glen Afton core path. The route is dark except for lights on occasional properties along the valley floor. Sanquhar II turbines (under construction) will have lights that will be visible from sections of the valley. For this route, there would be theoretical visibility of lights but the relative elevation of the route to the hubs would mean that

downward angles would prevent the lights from being bright, if visible. In spite of the proximity to the site, it is therefore unlikely that significant effects would occur as a result of lighting on the proposed Development.

Southern Upland Way

1.55 The SUW runs over hills and along valleys within the study area, and although most walkers will not be out after dark there may be some people descending at dusk or on the route looking at the dark skies. Sensitivity is judged to be medium at night. The lights of Sanquhar II (under construction) will be visible on turbines either side of the SUW south of Sanquhar, for those who are on that sections of the route after dark. From the descent into Sanquhar on the north side of Nithsdale, the lights on Sanquhar II turbines will be visible on the hill horizon albeit over 10km away (see VP12 below Conrig Hill, **Figure 6.22**). Windy Standard Phase 3 (also under construction) will be lit, with visibility from some upland sections of the route (see VP 10 Benbrack, **Figure 6.20**).

1.56 Phase 1: **Figure 6.10a** indicates that the lights would be visible at angles of 0 to -3° from the slopes to the north and south of Nithsdale, and at 0 to +1° from the highest sections at Benbrack. Lowther Hill is over 20km from the Site such that lights are unlikely to be visible. From Benbrack, the lights would be approximately 8.6km away (VP10, see **Table 2** above) and would be reduced in brightness by distance. From VP10 Windy Standard 3 lights will be over 10km away (once construction is complete) and also affected by distance attenuation. Although visible, the lights on the proposed turbines would not have a significant effect on the experience of being on the hill at night. From the slopes of Nithsdale, the lights would be between 15km and 7km away (at Whing Head), and although visible would be seen in the context of lights in Nithsdale – at Sanquhar, Kirkconnel, New Cumnock and scattered farms and properties, as well as in the context of lights on Sanquhar II turbines. Given the distance to the proposed turbines, it is judged that significant effects are unlikely to occur.

1.57 Phase 1 + consented: In this context, Windy Standard 1 Repower turbine will be lit. Lethans and Lethans Extension would also be lit and may be visible from sections of the SUW (see VP11 Whing Head **Figure 6.21** and VP12 below Conrig Hill, **Figure 6.22**). Significant effects on the experience of the route remain unlikely.

1.58 Phase 2 + consented: HHR2 would introduce a small number of additional lights amongst those of HHR1. These would not have significant effects on views in this context.

1.59 Phase 2 + in planning: In this scenario, walkers on the SUW would pass Cloud Hill with lit turbines. Significant effects of lights on HHR2 turbines are unlikely.

1.60 Full Proposed Development: The introduction of the full proposed Development (as if un-phased) would be similar to Phase 1 but with the additional lights of HHR2 at the same time. As set out above, the distance to the route would mean that there would be attenuation of brightness, and the lights would not have a significant effect on the experience of the route.

Local Paths and Core Paths

1.61 Walkers on local and core paths may include people out walking dogs at dusk, although they are more likely to be on sections of the paths closer to settlement. It is less likely that people would be out on high ground after dark, except on the SUW (considered above).

1.62 As indicated on **Figures 6.10a** and **6.10b**, for valley routes within 5km there would be strong downward angles of emitted light such that the lights, if visible, would not be bright. Figure 6.10c illustrates that visibility of lights of Sanquhar II will also occur for some routes. At no point along the local routes considered would there be significant effects as a result of lighting on the hubs of the turbines of the proposed Development.

Crawick Multiverse Park

1.63 This park is closed during the winter and at night such that there are normally no viewers after dark.

Summary

1.64 All of the turbines of the proposed Development would be lit with a 2000cd steady red light on the hub which would be reduced to 200cd in clear conditions where visibility extends beyond 5km. The assessment of the effects of the lighting on views after dark considered the appearance of the proposed lighting relative to existing lights in the views, lighting on Sanquhar II turbines (currently under construction), and the change to the night time viewing experience along key routes through the study area.

1.65 The proposed Development Site is unlit, although Sanquhar II Windfarm will have aviation lighting on all but two turbines (those furthest north-east which are to be under 150m to blade tip) and nearby properties within Nithsdale and Glen Afton have lights on and within buildings. Moving lights are common on roads, with vehicle headlights and rear lights.

1.66 Closer locations would experience the lights at a greater downward angle and therefore at reduced brightness. More distant locations would experience the lights with greater attenuation by distance, and locations on higher ground are less likely to be visited during dark hours. Viewers at most locations are unlikely to have eyes that are dark adapted, and the proposed lights would be seen in the context of other lights in the landscape. Off-road or hilltop locations are unlikely to have viewers at night, although there may be a few people on the SUW or on local paths at dusk. People out in dark places at night carry lights with them, which would affect dark adaptation.

1.67 No significant effects would occur as a result of aviation lighting. During times of poor weather conditions, when visibility is reduced to 5km, the lights would be operated at 2000cd. Readily accessible viewpoints within 5km tend to be at notably lower elevation than the site, with strong downward mitigation of brightness because of the use of a horizontal beam light design. At no locations would there be significant effects as a result of aviation lighting during times of lower visibility.

References

- CAA publications CAP 764 Policy and Guidance relating to Wind Turbines and Aviation. Available at: https://www.caa.co.uk/safety-initiatives-and-resources/windfarms/windfarms/ Accessed in January 2025.
- CAP 393 Air Navigation Order 2016. Available at: https://www.caa.co.uk/general-aviation/the-ga-unit/air-navigation-order-2016/ Accessed in January 2025.
- Landscape Institute and Institute of Environmental Management and Assessment. (2013) Guidelines for Landscape and Visual Impact Assessment, Third Edition. London. Routledge.
- NatureScot. (2024) Guidance on Aviation Lighting Impact Assessment. Available at: https://www.nature.scot/doc/guidance-aviation-lighting-impact-assessment Accessed in January 2025.
- Scottish Natural Heritage. (2017) Visual Representation of Wind Farms: Guidance. Available at: https://www.nature.scot/doc/visual-representation-wind-farms-guidance Accessed in January 2025.