



Cloud Hill Wind Farm

Technical Appendix 6.3: Visual Assessment of Visible Aviation Lighting

August 2023

Project No.: 0669769

Page intentionally left blank

CONTENTS

1.	INTRODUCTION	1
2.	REGULATIONS AND GUIDANCE.....	2
2.1	ICAO / Civil Aviation Authority (CAA) Regulations	2
2.2	Guidelines for Landscape and Visual Impact Assessment (GLVIA3)	2
2.3	Institute of Lighting Professional Guidance	3
2.4	NatureScot Guidance	3
2.4.1	Visual Representation Guidance.....	3
2.4.2	Evolving NatureScot Approaches to Turbine Lighting	4
3.	ASSESSMENT PARAMATERS.....	5
3.1	Overview	5
3.2	Worst Case Aviation Lighting Scheme.....	5
3.3	Light Intensity.....	5
3.4	Representative Night Time Viewpoints	6
4.	ASSESSMENT OF EFFECTS.....	8
4.1	Types of Effect.....	8
4.2	Baseline Lighting	8
5.	DETAILED ASSESSMENT	9
5.1	Visibility of turbine lighting from viewpoints.....	9
5.2	Viewpoint Lighting Intensity	9
6.	REPRESENTATIVE VIEWPOINTS.....	12
6.1	Viewpoint 1: A76 Sanquhar Castle	12
6.1.1	Night-Time Baseline Condition and Sensitivity	12
6.1.2	Night-Time Assessment.....	12
6.2	Viewpoint 3: Kirkconnel.....	13
6.2.1	Night-Time Baseline Condition and Sensitivity	13
6.2.2	Night-Time Assessment.....	14
6.3	Viewpoint 4: Euchan Water minor road	14
6.3.1	Night-Time Baseline Condition and Sensitivity	14
6.3.2	Night-Time Assessment.....	15
7.	CONCLUSION.....	16
8.	REFERENCES	17

List of Tables

Table 6.3.1: Intensity of Turbine Light based on the Quantec medium Intensity Obstruction Light.

Table 6.3.2: Viewpoint Lighting Intensity Summary

Page intentionally left blank

1. INTRODUCTION

This Technical Appendix has been prepared to accompany Chapter 6: LVIA in Volume 1 of the Cloud Hill Wind Farm (the Proposed Development) EIA Report. The Civil Aviation Authority (CAA) 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 the Proposed Development may need to display visible red lights 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 hubs and 32 candela red coloured light fittings located on the towers of all proposed turbines. It should be noted that all turbines would likely also include infra-red lighting on the turbine hubs which would not be visible to the human eye. The focus of this Appendix A6.3 is on the visual assessment of the visible aviation lighting requirements of the Proposed Development. For the assessment of lighting effects, the visual sensitivity and magnitude criteria described in Appendix A6.1 have been applied.

This visual assessment of turbine lighting is supported by a baseline light pollution map (Figure 6.14), ZTV of turbine hub lighting (Figures 6.15), a Lighting Intensity ZTV (Figure 6.16) and night-time photomontage visualisations from three viewpoints (See visualisation Figures 6.17 g to i, 6.19g to i, 6.20h to j).

2. REGULATIONS AND GUIDANCE

2.1 ICAO / Civil Aviation Authority (CAA) Regulations

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).

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

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 50 cd/m² or darker.

ICAO Table 6.3 (page 6-5) identifies minimum requirements and recommendations for 2,000 cd aviation lights on wind turbines at 150 m and above. In summary these are:

Minimum requirements:

- 0 to +3 ° from horizontal: 2,000 cd minimum average intensity (or 1,500 cd minimum intensity); and
- -1 degree from horizontal: 750 cd minimum intensity.

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.

Within the UK, the ICAO/ EASA requirements for lighting wind turbines are implemented through CAA publication 'CAP 764: Policy and Guidelines on Wind Turbines', and 'CAP393: Air Navigation Order 2016'. The CAA have confirmed that UK policy broadly aligns with the International standards, including insofar as the point at which lights must be switched on at 'Night' rather than 'Twilight'.

The proposed turbines, at 180 m to blade tip, would require lighting under Article 222 of the Air Navigation Order (ANO, 2016). This requires a single, medium intensity, 'steady' red aviation light (emitting 2,000 candela) to be fitted at hub level to each turbine. In addition, the CAA requires three low intensity lights to be fitted at the intermediate level on the turbine tower (CAA, 2017), to provide 360 degree visibility around the tower. The intermediate 'tower' lights will be 32 candela.

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 reduction affords valuable mitigation of light intensity and allows the minimum intensities identified above to be dimmed to 10 % of their values if meteorological conditions permit (i.e. the 2,000 cd minimum intensity may be dimmed to 10 %, or 200 cd, if visibility is greater than 5 km, i.e. in moderate to excellent or 'clear' visibility).

2.2 Guidelines for Landscape and Visual Impact Assessment (GLVIA3)

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.'

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)'.

2.3 Institute of Lighting Professional Guidance

Guidance produced by the Institute of Lighting Professionals (ILP) (2011) (GN01:2011)¹ is useful in setting out some key lighting terminology that relates to potential visual effects.

'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.'

The following key guidance within the ILP GN01:2011 is noted as follows:

- '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.'

CPRE² also identifies these same broad terms as the three types of light pollution:

- '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'.

2.4 NatureScot Guidance

2.4.1 Visual Representation Guidance

In terms of how lighting is captured in visualisations, the main change in the latest version of the NatureScot guidance 'Visual Representation of Wind Farms' (Version 2.2, February 2017) is in paragraphs 174-177, which 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

¹ Institute of Lighting Professionals (ILP) - Guidance Notes for the Reduction of Obtrusive Light GN01:2011

² CPRE – 'What is Light Pollution' found at webpage - <https://www.nightblight.cpre.org.uk/what-is-light-pollution>

visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image.'

The night time photography has therefore been captured in low light conditions, when other artificial lighting (such as street lights and lights on buildings) is on, to show how the wind farm lighting would look compared to the existing baseline at night.

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 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.

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.

2.4.2 *Evolving NatureScot Approaches to Turbine Lighting*

Recent NatureScot 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 also in providing mitigation (on a project and site-specific basis).

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. NatureScot 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.

Ministers and planning authorities are using planning conditions to manage effects. It is recognised that the EIA 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.

In terms of visual effects, NatureScot'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 Appendix. NatureScot 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. NatureScot also recognises the challenges of capturing night time photography and accept that some post photographic manipulation of images to provide a good representation is acceptable.

3. ASSESSMENT PARAMETERS

3.1 Overview

A description of the proposed turbine lighting is found within Chapter 4: Description of the Proposed Development and Chapter 16: Other Issues, based on this, the following assumptions have been made with regards to visible lighting of the Proposed Development for the LVIA:

- the CAA requires that all obstacles at or above 150 m above ground level are fitted with visible medium intensity lighting (2,000 cd) located on the turbine hub;
- the CAA requires that a secondary light is fitted to the hub for use only when the primary light fails and would not be lit concurrently;
- there is an additional requirement for three lights to be provided at an intermediate level of half the hub height. These would need to be fitted around the towers to allow for 360degrees horizontal visibility; and
- The 2,000 cd medium intensity lights may be dimmed to 10 %, or 200 cd, if visibility is greater than 5 km, i.e. in moderate to excellent or 'clear' visibility.

3.2 Worst Case Aviation Lighting Scheme

In relation to the Proposed Development, the worst-case scenario for night time effects includes the following parameters:

- all turbines would have red, medium intensity visible lights mounted on the hub (105 m based on the worst case hub height candidate turbine described in Chapter 4);
- 2,000 cd and 200 cd intensity hub lights have been assessed representing two differing worst case situations. 2,000 cd represents the maximum intensity possible. 200 cd represents the maximum intensity that would be used when visibility extending from the wind farm exceeds 5 km;
- all turbines would also have low-intensity lights (32 candela) to be provided on the turbine towers at an intermediate level of half the hub height (58.5 m); and
- the steady red lighting fixed to the top of the hubs 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.

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 2,000 cd and 200 cd scenarios 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 2,000 cd during periods of poor visibility, that 2,000 cd intensity actually represents an unrealistic worst-case position, as it is unlikely to ever be experienced at that maximum illumination level.

3.3 Light Intensity

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 2,000 cd and 200 cd scenarios 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 2,000 cd during periods of poor visibility, that 2,000 cd intensity actually represents an unrealistic worst-case position, as it is unlikely to ever be experienced at that maximum illumination level.

Visible aviation obstruction warning lights are designed to emit light horizontally in 360 degrees and offer a reduced light intensity above and below the horizontal. This in line with ICAO Annex 14 which requires the intensity of emitted light to be most intense at 0° (horizontal) and lower below the horizontal. Whilst aviation lighting manufacturers must meet the minimum requirements, their products may vary in relation to recommended limits set out in ICAO standards and the lighting characteristics of different light fittings may therefore vary outside the minimum requirements stipulated by ICAO.

For this assessment data from the testing of a Quantec medium intensity obstruction light has been used to provide an example of the reduction in lighting intensity above and below the horizontal. Whilst the precise model of light to be used for the Proposed Development is not known at this time it is considered that such an example provides a useful understanding of the potential visual mitigation of the intensity of the lights for receptors viewing them from areas of the Study Area that are below the horizontal. The Quantec data has therefore been used to define the amount of light emitted at particular angles above and below the horizontal for use in the assessment, see Table 6.3.1 below.

Table 6.3.1: Intensity of Turbine Light based on the Quantec medium Intensity Obstruction Light.

Vertical Angle	Turbine Lighting Intensity (Intensity of Turbine Light shown in Candelas (cd))	
	2000cd intensity	200cd intensity
Above 6°	<100cd	<10cd
2° to 6°	775 to 100cd	77.5 to 10cd
0° to 2°	2100 to 775cd	210 to 77.5cd
0° to -1°	2100 to 750cd	210 to 75cd
-1° to -2°	750 to 75cd	75 to 7.5cd
-2° to -3°	75 to 32cd	7.5 to 3.2cd
-3° to -4°	32 to 13cd	3.2 to 1.3cd
Below -4°	<13cd	<1.3cd

On the basis of the CAA requirements, therefore, it is evident that the intensity of the visible lights of the Proposed Development will be dependent on the clarity of atmospheric visibility and the degree of negative/ positive vertical angle of view from the light to the receptor. It should also be noted that the definitions in Table 6.3.1 do not take account of the potential for some of the emitted light spilling onto the passing blades which would be visible at all negative angles, albeit as a less intense and diffuse reflected glow. Figure 6.16 shows the intensity of visible aviation lights across the extent of visibility for the hub lights for the 'Worst Case Aviation Lighting Scheme' in which all the turbines would be lit.

3.4 Representative Night Time Viewpoints

A hub height ZTV was used to identify where there could be direct line of sight from the surrounding area to the proposed turbine lights mounted on the turbine hub (Figure 6.15). This ZTV does not take account of any intervening screening that may arise as a result of forestry or woodland cover.

Guidance on night-time viewpoints is presented in NatureScot's 'Visual Representation of Wind Farms Version 2.2'³ which states that;

"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

³ Scottish Natural Heritage (February 2017). 'Visual Representation of Wind Farms Version 2.2'

*night (eg from a settlement, transport route) or where there is a particular sensitivity to lighting (eg in or near a Dark Sky Park or Wild Land Area). **Not all viewpoints will need to be illustrated in this way.***" (bold effect presented in original text).

An appropriate number of representative night-time viewpoints is considered to be three and this number is used in the majority of LVIA's produced, unless additional viewpoints are expressly requested by statutory consultees.

Night-time visualisations have been produced for three representative viewpoints. These were selected from the LVIA viewpoints and agreed with Dumfries and Galloway Council and NatureScot as follows:

- Viewpoint 1: A76 Sanquhar Castle;
- Viewpoint 3: Kirkconnel; and
- Viewpoint 4: Euchar Water minor road

Whilst 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 have been produced to show both 2,000 cd and 200 cd reduced intensity lighting, to inform the assessment of worst-case effects assessed. However, it should be noted that the night-time photography has been captured in periods of good visibility that is greater than 5 km. As a result, the night-time photomontage representations of the 2,000 cd lights are therefore an unrealistic over-representation of the likely visibility of visible aviation lighting. This is because visibility on the site (and likely at the viewpoint itself) is very likely to be much poorer (<5 km) when they operate at that intensity.

4. ASSESSMENT OF EFFECTS

4.1 Types of Effect

The visual assessment of turbine lighting is intended to determine the likely effects that the Proposed Development would have on the visual resource i.e. it is an assessment of the effects of visible aviation lighting on views experienced by people at night.

The assessment of turbine lighting in this Appendix does not consider effects of aviation lighting on landscape character (i.e. landscape effects). For visible medium intensity steady or fixed red aviation warning lights, ICAO indicates a requirement for no lighting to be switched on until 'night' has been reached, as measured at 50 cd/m² or darker. This is helpful as it does not require them to be on during 'twilight', when landscape character may be clearly discerned. It is considered that visible aviation lighting will therefore not affect the perception of landscape character, which is not readily perceived at night in darkness, particularly in rural areas. The assessment of visible lighting is solely a visual effect. While aviation lighting will be visible and result in visual effects, as assessed in this Appendix, the effects of aviation lighting on the perception of landscape character are scoped out of this assessment. This decision to scope out landscape effects reflects the Scottish Ministers' recent finding in the Crystal Rig IV Wind Farm Public Inquiry.

4.2 Baseline Lighting

The existing baseline lighting levels have been mapped for the surrounding landscape (see Figure 6.14) based on Open Source data of Light Pollution across the UK. This Open Source data has been used to help understand and illustrate the existing baseline lighting levels of the Study Area. Each pixel in the mapping shows the level of radiance (night lights) shining up into the night sky, which have been categorised into nine colour bands to distinguish between different light levels, from low level light pollution colour band one (darkest) to high level light pollution nine (brightest).

Figure 6.14 shows that the extent of baseline lighting across the Study Area is largely concentrated where settlements occur, while the majority of the Study Area remains unaffected by baseline lighting. The highest levels of baseline lighting occur in the north-wets of the Study Area where the settlements of Ayr and Kilmarnock occur and in the south-east where Dumfries occurs. The Site sits in an area classified as the lowest band of baseline lighting at <0.25 NanoWatts/cm²/sr. This area extends across the south-western sector of the Study Area with only small patches of low level lighting occurring where small scale settlement occurs within the narrow glens between the broader expanse of uplands. To the immediate north-east of the Site, there is, however, some slightly larger patches of baseline lighting ranging up to 4 to 8 NanoWatts/cm²/sr. These reflect the location of the series of settlements located along the A76, including Kirkconnel and Kelloholm, Sanquhar and Menzies. Their presence creates a baseline lighting influence within the Nithsdale valley, but also extending across the eastern edge of the Southern Uplands that lie to the west and where the Site is located. The Southern Uplands that lie to the north-east are also largely unaffected by baseline lighting with the exception of where Wanlockhead and Leadhills are situated.

5. DETAILED ASSESSMENT

5.1 Visibility of turbine lighting from viewpoints

Table 6.3.2 below provides a summary of the potential visibility of hub lights for each of the LVIA viewpoints, this is based on the hub light ZTV, and details how many lit turbines will be theoretically visible from each of the viewpoints included in the LVIA.

Table 6.3.2: Viewpoint Lighting Intensity Summary

Viewpoint	Distance to nearest turbine (km)	Number of hub aviation lights visible	Light intensity at each viewpoint relative to vertical angle (cd)		
			Vertical Angle in degrees	2,000 cd	200 cd
VP1: A76 Sanquhar Castle	5.15	11	-2 to -3	75 to 32 cd	7.5 to 3.2 cd
VP2: Sanquhar Church Road	5.15	11	-2 to -3	75 to 32 cd	7.5 to 3.2 cd
VP3: Kirkconnel	5.79	11	-2 to -3	75 to 32 cd	7.5 to 3.2 cd
VP4: Euchar Water minor road	3.76	11	-3 to -4	32 to 13 cd	3.2 to 1.3 cd
VP5: Shiel, Scour Water minor road	1.44	6	< -4	<13 cd	<1.3 cd
VP6: Mennock	6.57	4	-2 to -3	75 to 32 cd	7.5 to 3.2 cd
VP7: Southern Upland Way east of Sanquhar	6.37	11	-1 to -2	750 to 75 cd	75 to 32 cd
VP8: Polgown, Scour Water minor road	1.25	5	-3 to -4	32 to 13 cd	3.2 to 1.3 cd
VP9: Durisdeer	14.63	5	-1 to -2	750 to 75 cd	75 to 32 cd
VP10: Wauk Hill	17.35	9	0 to -1	2100 to 750 cd	210 to 75 cd
VP11: Benbrack	9.03	10	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP12: Cairnsmore of Carsphairn	14.88	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP13: Blackcraig	8.04	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP14: Corsencon Hill	10.66	11	0 to -1	2100 to 750 cd	210 to 75 cd
VP15: Todholes Hill	8.64	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP16: Lowther East Mount	13.68	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP17: Meikle Millylea	30.25	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP18: Southern Upland Way, Coupland Knowe	8.58	11	-1 to -2	750 to 75 cd	75 to 32 cd
VP19: Southern Upland Way, Glengaber Hill	12.68	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP20: Cairnkinna	5.65	11	0 to 2	2100 to 775 cd	210 to 77.5 cd
VP21: Crawick Multiverse	6.25	11	-2 to -3	75 to 32 cd	7.5 to 3.2 cd
VP22: Auchengibbert Hill	12.59	9	0 to -1	2100 to 750 cd	210 to 75 cd

5.2 Viewpoint Lighting Intensity

The Lighting Intensity ZTV in Figure 6.16 illustrates where the different intensities, relative to the different vertical angles from the hub mounted aviation light, would be visible within the surrounding

landscape in respect of the Proposed Development. Figure 6.16 also illustrates the corresponding intensity reductions for each of the 2,000 cd and 200 cd situations. It is clear from Figure 6.16 that the full intensity of the lights would only theoretically be experienced from a small proportion of the Study Area when on similar or more elevated terrain.

As described in the LVIA baseline, the ZTV of the Proposed Development is largely contained within the local landscape by the Southern Uplands which enclose the south-western and north-eastern sides of the Nith Valley. This landform pattern ensures that the ZTV is largely contained within the first 10 km of the Proposed Development. There is a concentration of visibility across the enclosing hills on the eastern side of the Nith Valley between a range of approximately 5 and 10 km

The Lighting Intensity ZTV in Figure 6.16 shows that lighting intensity would be relatively low across the Site owing to the relative angle of the lighting being below -4° for a large part of the Site area. This equates to lighting intensities of 13 cd when considering 2,000 cd lighting and 1.3 cd when considering 200 cd lighting. This area of low level lighting intensity extends south into the Scaur Water valley and north across the Euchar Water valley. Across the rural area extending north to Kirkconnel and north-east to Sanquhar, the levels of visibility remain low owing to the -3 to -4° angle of the lighting experienced in this area, at either 32 to 13 cd, relative to 2,000 cd lighting, or 3.2 to 1.3 cd, relative to 200 cd lighting. It is then only on the more localised summits that the highest level of lighting intensity occurs, with the lights at a vertical angle of 0 to 2° at either 2,100 to 775 cd, relative to 2,000 cd lighting, or 210 to 77.5 cd, relative to 200 cd lighting.

On the north-eastern side of the River Nith, the Lighting Intensity ZTV shows a distinct pattern where bands of lighting intensity increase in level with elevation from the valley floor. The lower slopes are shown to experience the lighting at a -2 to -3° angle which would equate to a lighting intensity of 75 to 32 cd, relative to 2,000 cd lighting, or 7.5 to 3.2 cd, relative to 200 cd lighting. This steps up to 750 to 75 cd, relative to 2,000 cd lighting, or 75 to 7.5 cd, relative to 200 cd lighting, on the middle slopes where the vertical angle of the lights rises to -1 to -2° . Across the upper slopes, where the angle rises again to -1 to 0° , the lighting intensity also increases to 2,100 to 750 cd, relative to 2,000 cd lighting, or 210 to 75 cd, relative to 200 cd lighting. It is then only on the more localised summits that the highest level of lighting intensity occurs, with the lights at a vertical angle of 0 to 2° at either 2,100 to 775 cd, relative to 2,000 cd lighting, or 210 to 77.5 cd, relative to 200 cd lighting.

The pattern of visibility is more fragmented across the western and southern sectors of the first 10 km radius, where localised patches of visibility occur across summits and upper slopes facing towards the Proposed Development. The generally higher elevation of the upland landscape means that the vertical angle of the lighting is close to the horizontal and the lighting intensity levels are, therefore, typically at the higher levels. The exceptions occur through the low-lying Scaur Water valley and Euchar Water valley where typically lower levels of lighting intensity would be experienced.

Many of the representative viewpoints within the areas closest to the Proposed Development, including those found within the settled Heads of the Valley will have reduced intensity as a result of the negative vertical angle in which the hub lights would be viewed. Table 6.3.2 provides a summary of the reduced intensity for the hub lights based on the ZTV in Figure 6.16.

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

In reality, it is extremely unlikely that 2,000 cd will ever be experienced at its full intensity as it will only operate when visibility is reduced by climatic conditions. Reduced visibility will also affect someone's perception of the intensity of the light fitting. Only three of the viewpoints lie within 5 km of the Proposed Development, with the remaining 19 located beyond 5 km. Therefore, the worst case intensity experienced at the majority of the viewpoints would likely be represented by the 200 cd scenario. This is because the 2000cd intensity lights would only be in operation when visibility is less

than 5 km and in this situation they would appear far less intense due to the poor visibility surrounding the Proposed Development.

All residential properties assessed within the 2 km RVAA Study Area would have a vertical angle of below -4° resulting in an approximate range of lighting intensities of below 13 cd - when visibility <5 km and below 1.3 cd when visibility >5 km. From elevated areas to the west and south, at a range between 5 and 10 km there tends to be theoretical visibility of a higher number of the hub lights, however, the worst case intensity of the aviation lights will likely be 200 cd in 'clear' visibility because in the 2,000 cd scenario, reduced visibility will reduce the perception of the intensity of the light fitting.

In distant views, over 10km, the aviation lights are still likely to be visible, based on experience of other operational wind farm aviation lights viewed in the field, however the distance and reduced intensity are mitigating factors with increasing distance.

6. REPRESENTATIVE VIEWPOINTS

6.1 Viewpoint 1: A76 Sanquhar Castle

Nearest Visible Turbine Light: 5.15 km

6.1.1 *Night-Time Baseline Condition and Sensitivity*

The viewpoint represents a relatively close range view towards the Proposed Development from the southern boundary of Sanquhar and adjacent to the A76.

The A76 is the main road connecting Dumfries in the south with Kilmarnock in the north. The viewpoint is representative of the views of road-users on the A76. As the road passes through Sanquhar, the views of road-users are largely screened by the enclosure of buildings on either side of the road. The two sections from which more open views are experienced by road-users, occur to the south of the town, where the viewpoint is located, and in the northern part of the town, where there are sports fields associated with Sanquhar Academy and open fields on the western side of the road. The open views extend from the southern edge of the town towards Mennock, albeit with intermittent and/or partial screening of the Site by tree cover and landform. To the north, the open views occur towards Kirkconnel, although again intermittent and/or partial visibility occurring as a result of intermittent tree cover and buildings.

In respect of most residents of Sanquhar, the enclosed nature of the traditional street pattern means that views from properties are typically enclosed by other surrounding properties. Exceptions to this occur where properties are located on the western or southern edges of the town, or in elevated parts, where more open views occur.

During the day, south-westerly views from the A76 and from edge or elevated properties in Sanquhar, extend across a landscape which is simple in pattern with fields of improved grassland in the foreground and rougher moorland grassland and coniferous forestry closer to the horizon. The focal features include Sanquhar Castle offset approximately 200 m from the A76, as well as Castle Mains farmhouse and associated farm sheds, some of which are dilapidated. Operational wind farms are visible from this viewpoint, with the nine turbines of Twentyshilling visible on the skyline to the south and the nine turbines of Whiteside Hill visible on the skyline and behind the forestry to the south-west, albeit that none of these operational turbines have aviation lighting.

At night, however, individual landscape elements that create different landscape patterns in the view are difficult to discern, including the operational wind farms. The baseline night photography is captured at a time where the shape of the upland ridgeline can be distinguished against the sky. The night time view presents a contrast between the relative darkness of the rural area and the artificially lit character of the urban area. There are street lights along the A76 through Sanquhar and lighting emanating from the petrol filling station to the rear of the viewpoint. Lighting from properties also occurs although this typically lower in intensity levels.

The value and visual susceptibility of receptors at night differs when compared to the assessment carried out for daytime conditions. During the night the landscape has a diminished scenic quality and receptors would not have the same appreciation of the landscape which is dark and muted compared to what is evident during the day. Taking these factors into account, the night-time sensitivity of residential receptors is considered to be **medium-high** and the sensitivity of road-users is considered to be **medium**.

6.1.2 *Night-Time Assessment*

2,000 cd Light Intensity

All 11 of the hub lights would be readily visible from this location. The location of the viewpoint relative to the prevailing south-westerly wind would mean that the lights on the hubs would at most times be seen behind the rotors and would therefore be intermittently obscured by intervening blades. On this

basis they would appear to flicker as the turbine blades pass the hub lights. The intensity of the hub lights in the 2,000cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be below 75 to 32 cd.

The aviation lights would be seen as an introduction of lights into the rural area, where they would be seen set above the south-western horizon and in a part of the view where there are very few other visible lights. The separation distance of 5.15 km and the containment of the turbines within 10 to 20 degrees of the wider 360 degree view would reduce the effect that the lighting would have on residents and road-users represented by this viewpoint. Furthermore, the lights would be seen to be added to a context where baseline lighting is evident along this section of the A76 through Sanquhar and this comparison would moderate the effect.

Taking these factors into account, it is considered that these lights would form a relatively moderate addition to the existing baseline view and the magnitude of change is assessed as **medium-low**. The effect on residential and road-user receptors at this viewpoint is considered to be **moderate** and **not significant**.

200 cd Light Intensity

The description of lights visible for 2,000cd also applies to the 200cd reduced intensity scenario. The intensity of the hub lights in the 200cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be below 7.5 to 3.2 cd. The effect of the 200 cd lighting therefore differs, with a reduced intensity of light experienced. Taking this into account the magnitude of change is assessed as **low** resulting in a **moderate-minor** and **not significant** effect.

6.2 Viewpoint 3: Kirkconnel

Nearest Visible Turbine Light: 5.79 km

6.2.1 Night-Time Baseline Condition and Sensitivity

This viewpoint represents the views from Kirkconnel at night, and from the relatively close range of 5.79 km to the nearest turbine. The original settlement of Kirkconnel is set between the Glasgow to Carlisle train line to the north and the River Nith to the south, with the A76 forming the main street through the centre. Kelloholm, which forms an extension to the original settlement extends onto the southern side of the river. The river valley location of the settlement means that it is mostly low lying and contained by the surrounding hills. The viewpoint is located adjacent to the A76 on the eastern edge of the original settlement and is representative of the views of residents and road-users. Within the settlement of Kirkconnel, the views of residents are largely contained by the enclosure of the built form, and it is only on the southern and eastern edges and from more elevated properties towards the train line that open views towards the Site occur. While the views of road-users are also largely contained within the settlement, there is intermittent visibility towards the Site from the section of the A76 that extends south-eastwards towards Sanquhar, with tree cover interrupting the continuity of these views.

During the day, views to the south are across a foreground comprising the River Nith valley where fields of pasture and semi-mature tree planting create a green corridor. Beyond the river and fields, the extension of Kelloholm can be seen as a band of housing with a larger light industry building to the right. Beyond these rooftops a horizontal section of the upland landscape can be seen with operational Sanquhar Wind Farm visible to the right at approximately 5.1 km and Whiteside Hill Wind Farm visible to the left at approximately 6.1 km.

At night, however, individual landscape elements that create different landscape patterns in the view are difficult to discern. The baseline night photography is captured at a time when the distant ridgeline of hills is discernible against the skyline, however, the intervening landscape is not readily visible. Baseline lighting in this view is not readily visible although it is anticipated that low level domestic lighting associated with the properties at Kelloholm would normally be evident. Other lights can also

be seen in the wider view, with vehicle lights and street lights relating to the busy A76 road corridor and domestic lights of properties on the northern side of Main Street and on both sides leading into the town.

During the night the landscape has a diminished scenic quality and receptors would not have the same appreciation of the landscape which is dark and muted compared with the landscape scenery evident during the day and particularly in muted contrast to the closer context of lighting within the settlement itself. Taking these factors into account, the night-time sensitivity of this location is considered to be **medium-high** for residents and **medium** for road-users.

6.2.2 Night-Time Assessment

2,000 cd Light Intensity

Nine of the eleven hub lights would be visible from this location. The location of the viewpoint relative to the prevailing south-westerly wind would mean that the lights on the hubs would at times when the wind is more southerly in direction be intermittently obscured by intervening blades, so that they would appear to flicker as the turbine blades pass the hub lights. On this basis they would at times appear to flicker as the turbine blades pass the hub lights. The intensity of the hub lights in the 2,000 cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be below 75 to 32 cd.

As the aviation lights would be seen in the southerly sector where there is existing residential and light industrial development, they will not be introducing lighting into a completely dark view. They will, however, be adding red lights at a higher elevation than the baseline lights that will increase the vertical extent and variation of lighting in this sector of the view. The effect of the aviation lighting would also be moderated by the influence of baseline lighting in the other sectors of the view. This includes street lighting extending along the A76 into Kirkconnel and evident also in surrounding streets, the lights of vehicles on the busy A76, and the domestic lighting associated with the residential properties in the town. While all these sources are relatively low level, their proximity to the viewpoint means that they would create a context in respect of which the aviation lights would not make such a notable change.

Taking these factors into account, it is considered that these lights would form a relatively moderate addition to the existing baseline view and the magnitude of change is assessed as **medium-low**. The effect on residential and road-user receptors at this viewpoint is considered to be **moderate/minor** and **not significant**.

200 cd Light Intensity

The description of lights visible for 2,000cd also applies to the 200cd reduced intensity scenario. The intensity of the hub lights in the 200cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be below 7.5 to 3.2 cd. The effect differs therefore, reducing the intensity of light experienced. Taking this into account the magnitude of change is assessed as **low** resulting in a **minor** and **not significant** effect.

6.3 Viewpoint 4: Euchan Water minor road

Nearest Visible Turbine Light: 3.76 km

6.3.1 Night-Time Baseline Condition and Sensitivity

This viewpoint is located at the junction of the minor road that runs along the Euchan Water valley and an access road to properties at 'Barr'. The viewpoint is representative of users of the minor road and local residents in scattered properties to the south of Sanquhar. Residential dwellings within this rural landscape tend to be slightly elevated within the undulating landscape. There is no specific focus to this view, but it offers an open, wide-ranging vantage to the upland landscape to the south.

The view looks south across an undulating landscape of pastoral agriculture that occupies the fore-to-midground. The view presents a contrast between the settled valley and the large-scale landscape of the Southern Uplands, which enclose the southern side of the Upper Nithsdale Valley. The majority of the upland landscape is characterised by open moorland, covering the steep hill sides, and rounded summits. The hills interlock to form an extensive undulating ridgeline, cut by incised river valleys. The operational Whiteside Hill Wind Farm at 5.3 km and Sanquhar Wind Farm at 5.9 km, spread across the ridgelines to the south-west, making wind farm development a notable feature in views towards the Site. The blades and rotors of the Twentyshilling Wind Farm are visible along the skyline to the south.

At night, the individual landscape elements that create these contrasting landscapes are difficult to discern. Baseline lighting is especially low level, typically emanating from the dispersed rural properties within the Euchar Water valley. This ensures a relatively dark outlook towards the southern uplands whilst in contrast there is a glow across the Nith valley to the east. The contrast between land and sky on the southern skyline can be seen beyond dusk as the setting sun maintains a low glow against the skyline for a sustained period with objects on the skyline, such as the Whiteside Hill turbines, silhouetted in this dusky light.

The value and visual susceptibility of residents and road-users at this location differs at night when compared to the assessment carried out for daytime conditions. During the night the landscape has a diminished scenic quality and residents and road-users would not have the same appreciation of the landscape which is dark and muted compared with the landscape scenery evident during the day. It is also the case that very few people would be walking in darkness in this remote area. Taking these factors into account, the sensitivity of residents would be **medium-high** while the sensitivity of road-users would be **medium**.

6.3.2 Night-Time Assessment

2,000 cd Light Intensity

All 11 of the hub aviation lights would be visible from this location. The location of the viewpoint relative to the prevailing south-westerly wind would mean that the lights on the hubs would be intermittently obscured by intervening blades and so would appear to flicker due to turbine blades passing the hub lights.

The intensity of the hub lights in the 2,000cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be 32 to 13 cd. The hub aviation lights would be seen to introduce lighting to a part of the upland horizon to the south-west of the viewpoint at a distance of 3.76 km. Their effect would be accentuated by the very limited presence of baseline lighting in this south-westerly sector of the view, and where relatively high levels of darkness on this eastern edge of the Southern Uplands occur. The effects would, however, also be moderated by the presence of low level lighting associated with the dispersed rural properties in the Euchar Water valley, which would mean the hub aviation lights would not be seen from a completely dark context.

Taking all these factors into account, the magnitude of change is assessed as **medium** resulting in a **moderate** and **significant** effect.

200 cd Light Intensity

The description of lights visible for 2,000cd also applies to the 200cd reduced intensity scenario. The intensity of the hub lights in the 200cd scenario, allowing for the vertical angle between this viewpoint and the closest hub is calculated to be 3.2 to 1.3 cd. The effect differs therefore, reducing the intensity of light experienced. Taking this into account the magnitude of change is assessed as **medium-low** resulting in a **moderate** and **not significant** effect.

7. CONCLUSION

At night the turbines would not in themselves be conspicuous during times of darkness. Nevertheless, the assessment of night-time effects for the Proposed Development has predicted a significant effect for one of the three representative night-time viewpoints, namely at Viewpoint 4: Euchar Water minor road as a result of the 2000 cd scenario. For the other representative viewpoints, the effect is assessed as not significant.

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, around dusk and sunrise. The ICAO standard requires the lights to be switched on 30 minutes after sunset, and 30 minutes before sunrise, removing the likelihood of visible lighting during twilight. 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 are generally limited to residents of on the closest edge or elevated parts of settlements, residents of rural properties and road-users. Views from within properties are likely to be restricted by the use of window coverings, particularly in winter. Views from remote uplands and hills, rural farmland and footpaths etc. are visited infrequently at night therefore numbers of receptors affected will be low.

The assessment of night-time effects is also based on clear night time viewing conditions. At dusk and sunrise, it may be possible to identify the formation of the turbines with the lighting switched on, but only in conditions of good and excellent visibility. At sunrise it may also be possible, in views from the west, to see the turbines with lights switched on whilst backlit by the rising sun.

8. REFERENCES

- Civil Aviation Authority (2016). CAP393: The Air Navigation Order 2016 (SI 2016 No.765).
- Civil Aviation Authority (2016) CAP 764: Policy and Guidelines on Wind Turbines.
- 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.
- Council for the Protection of Rural England (CPRE) (2016). England's Light Pollution and Dark Skies.
- ICAO (2018). Annex 14 to the Convention on International Civil Aviation - Volume I Aerodrome Design and Operations (ICAO, Eighth Edition).
- Institute of Lighting Professionals (2011). Guidance Notes for the Reduction of Obtrusive Light (GN01:2011).
- Institute of Lighting Professionals (2019). Night-time Photography.
- Landscape Institute with the Institute of Environmental Management and Assessment (2013). Guidelines for Landscape and Visual Impact Assessment, Third Edition (GLVIA3).
- Landscape Institute (2019). Visual representation of Development Proposals: Landscape Institute Technical Guidance Note 06/19.
- NatureScot (2017). Visual Representation of Wind Farms, Version 2.2.

**ERM has over 160 offices across more 40
countries and territories worldwide**

ERM's Edinburgh Office

6th Floor

102 West Port

EH3 9DN Edinburgh

T: +44 (0)20 3206 5200

F: +44 (0)20 3206 5440

www.erm.com