ESB Asset Development UK Limited

Millmoor Rig Wind Farm

Environmental Impact Assessment Report (Volume 3)

Appendix 6.10 – Methodology for the Assessment of Visible Aviation Lighting on Landscape Character and Visual Amenity

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1 APPENDIX 6.10 – METHODOLOGY FOR THE ASSESSMENT OF VISIBLE AVIATION LIGHTING ON LANDSCAPE CHARACTER AND VISUAL AMENITY

1.1 Introduction

1.1.1 This appendix sets out the methodology and approach to the assessment of landscape and visual effects arising from the visible lighting of the Proposed Development set out within the **Chapter 6: LVIA**, the Viewpoint Assessment (**Appendix 6.5**) and the Residential Visual Amenity Assessment (**Appendix 6.6**). The written assessment is supported by a Zone of Theoretical Visibility (ZTV) plan of the visible turbine lighting (see **Figure 6.7** and **Figure 6.8**) and five visualisations (**Viewpoints 1**, **2**, **6**, **8** and **11**) which illustrate the proposed turbine lighting from a selection of the representative viewpoints in the surrounding landscape. The approach to the production of this supporting visual material is therefore also addressed.

1.1.2 This appendix deals with the assessment of visible aviation lighting only. Full details of the proposed aviation lighting are set out in **Chapter 13: Aviation and Radar**.

1.1.3 The primary source of best practice for Landscape and Visual Impact Assessment (LVIA) in the UK is 'The Guidelines for Landscape and Visual Impact Assessment', 3rd Edition (GLVIA3) (Landscape Institute and the Institute for Environmental Management and Assessment, 2013). The assessment criteria for the assessment of effects of visible turbine lighting has been developed in accordance with the principles established in this best practice document. It should however be acknowledged that GLVIA3 establishes guidelines not a specific methodology. The preface to GLVIA3 states:

> *"This edition concentrates on principles and processes. It does not provide a detailed or formulaic 'recipe' that can be followed in every situation – it remains the responsibility of the professional to ensure that the approach and methodology adopted are appropriate to the task in hand."*

1.1.4 The assessment criteria set out below have therefore been developed specifically for this appraisal to ensure that the methodology is fit for purpose.

1.1.5 The purpose of an LVIA when undertaken in the context of an Environmental Impact Assessment (EIA) is to identify any likely significant landscape and visual effects arising as a result of the proposals. An LVIA should consider both:

- effects on the landscape as a resource in its own right (the landscape effects); and
- effects on specific views and visual amenity more generally (the visual effects).

1.1.6 It is recognised that in some circumstances, it may be possible for turbine lighting to result in a significant effect on the character of the surrounding landscape. For example, if the proposed wind energy development is located within or in proximity to a designated dark sky area, or is remote from existing sources of visible lighting, such as residential areas, commercial or industrial sites, or major roads. For wind energy developments which are not located in such areas, it is considered that there would be no potential for significant effects on landscape character to arise from visible turbine lighting of the type proposed.

This is because in these areas the character of the landscape during low natural light levels is already in part characterised by the presence of artificial lighting. Therefore, the addition of visible turbine lighting would not have the potential bring about a fundamental change to the characteristics of the landscape.

1.1.7 For a daytime assessment, one assesses the worst case situation (i.e. clear full visibility as if a perfect day). A daytime assessment can therefore describe the full extent of that clear visibility, or lack of it, as a moment in time. For this study, it is not just the reverse. What is required is an understanding of low light level conditions which seeks to cover all the periods, both evening; dawn; gloomy winters day and after dark, in which the lights will to some degree be visible. This also seeks to cover the period just after it begins to get dark; the period just before it actually gets dark; the period in the middle as it moves from one to the other and the time after it is dark but a moonlit night affords some view of the landscape.

1.1.8 It is understood that the primary period which an assessment of visual effects should consider, is generally understood to be the period just before official sunset, when sufficient daylight remains for the landform on which the wind farm is sited, to be partially visible. This time period is known commonly as 'dusk', and whilst it is acknowledged that the formal astronomical period of dusk actually occurs after sunset, immediately prior to night, the wider time period of low light as the sun is setting and immediately after sunset is referred to hereafter in this methodology as the 'dusk period'. The timing of official sunset changes depending on the location being considered, and the date of any assessment, but is astronomically predictable. However, this does not mean that the light levels in the period just prior to official sunset are equally predictable, or consistent. In practice, these will vary due to weather conditions and also the site-specific effects of surrounding topography, vegetation and built form, including existing light sources in the landscape.

1.1.9 If describing a situation in detail, (e.g. just before sunset with the setting sun still illuminating part of the landscape; part going into deep shadow; a ridgeline in silhouette; the mid-ground in semi-darkness and a partially lit foreground because the street lights had just come on) this would be a snapshot in time for that viewpoint. Half an hour earlier it would have been different, as it would half an hour later, or at dawn, and that is before the matter of how it would have looked on another day earlier or later in the year is considered. Whether the description was looking east at sunset, or east at dawn would also radically change the description of what was seen and its impact. The approach taken in the LVIA therefore to try to capture a single assessment that represents a typical judgement in low light conditions, but not a specific set of conditions.

1.1.10 Such an assessment that was more specific would become very much larger, with the need to visit viewpoints at multiple times and in a range of light conditions, including dawn and dusk, to get the east - west, sunset - sunrise element. This could lead to multiple written descriptions and assessments for each location for both visual amenity and character effects. It is understood that the approach taken to the assessment of effects during the low light period in the LVIA represents a proportional approach to the low light.

2 DESCRIPTION OF THE PROPOSED TURBINE LIGHTING, MITIGATION AND THE ASSUMPTIONS MADE IN THE VISUALISATIONS AND ASSESSMENT

2.1.1 In accordance with Civil Aviation Authority (CAA) CAP 764 turbines taller than 150 m require visible aviation lighting. A reduced cardinal lighting scheme is being proposed for agreement with the CAA for the Proposed Development. Further details are set out in **Chapter 13: Aviation and Radar**.

2.1.2 In total six turbines (T01, T03, T08, T09, T11 and T12) are proposed to be fitted with medium intensity steady red (2,000 candela (cd)) lights on the nacelles of turbines.

2.1.3 The aviation lights will be capable of being dimmed to 10% of peak intensity (200 cd) when visibility at the Proposed Development is greater than 5 km. When visibility at the Proposed Development is less than 5 km the lights will operate at 2000 cd. The lights are also required to be able to shine a beam that reduces in intensity above and below the horizontal.

2.1.4 The aviation lights emit light horizontally in 360 degrees. This inherent directional intensity can be used to reduce the intensity of the lights at elevations above and below the horizon. By ensuring the lights installed comply with the International Civil Aviation Organisation (ICAO) recommendations, the intensity of the light reduces between 0° degree and - 4 ° degree vertical angle below a horizontal plane from the aviation light and between + 3 ° degree and + 8 °degree above the horizontal plane.

2.1.5 The CAA, together with the UK Wind Sector, is exploring the future use of Aircraft Detection Lighting Systems (ADLS). This can reduce the time that the obstacle lights are on. The lights are triggered by the presence of any aircraft within a defined area around the development, otherwise remaining off. Such systems are unable to be used within the current UK regulatory environment, but are widely in operation in European countries, with anticipated changes offering the potential alongside UK airspace modernisation. Whilst the Proposed Development is unable to specify ADLS, the timescale to implementation, currently anticipated to be operational in 2029, may allow for the use of ADLS and its use will be reviewed at the time of implementation.

2.1.6 For the purpose of the visualisations prepared to help inform the assessment of visible aviation lighting set out in the LVIA (see **Volume 2** of this EIA Report), the following assumptions have therefore been made in light of the proposed mitigation:

- Lighting is only shown on the six turbines, as to be formally agreed with the CAA;
- As the photography was taken in clear weather conditions when visibility was greater than 5 km, the visualisations illustrate the reduced 200 cd intensity to reflect the lighting that would arise in those conditions as a result of the mitigation proposed. It is understood that these images nonetheless represent the worst-case as should visibility be less than 5 km such that the 2,000 cd lighting was active, then these poor conditions would of themselves be such as to restrict the visibility of the lighting to no more than that of the 200 cd lighting is seen in clear conditions;
- Whilst the lighting would reduce in intensity above and below the horizontal, this reduction has not been illustrated, such that the visualisations serve as a worst-

case for any locations which are notably above or below the horizon, with the actual apparent intensity being reduced. This matter has however been considered within the assessment judgements;

- The visualisations illustrate the period just before official sunset, when sufficient daylight remains for the landform of the landscape on which the wind farm is proposed, to remain partially visible. The assessment also focuses on this period, which is understood to represent a 'worst-case' as it is acknowledged that during the period after dark, the ability to understand and appreciate much of the character of the underlying baseline landscape is diminished and the effects on landscape character may be reduced accordingly;
- Whilst the implementation of a suitable ADLS would significantly reduce the occasions when the lighting would be visible, this has not been factored into the judgements of lighting effects which focus on the 'worst-case' scenario of the period when the lighting would be visible. The benefits of a reduction in the lighting associated with the ADLS are nonetheless a matter for the wider planning balance exercise, addressed separately in the application submission for the Proposed Development;
- It is noted that the matter of darkness adaption is also a relevant consideration, with some receptors, in particular car drivers, not perceiving the lighting in the same manner as if they were in a fully dark environment, due to their vision being influenced by lighting sources in their proximity (i.e. car headlights). The same would apply to residents of residential properties who were viewing the aviation lighting from a location with existing lighting present (i.e. it is unlikely that residents would themselves be fully in a dark environment and their eyes therefore adapted to take in the full extent of the light from the turbines). This serves to potentially reduce effects compared to how they are set out in the assessment, which again can be considered to represent a 'worst-case' position compared to what may be experienced for many of the receptors in practice; and
- The frequency in which a viewpoint is likely to be visited during the dark sky period is not a factor which is considered within the assessment of magnitude or sensitivity. However, it should be noted that viewpoints at hills summits and on long distance footpaths would be unlikely to be visited after daylight hours. Any assessment of these receptors should therefore be considered a 'worst-case' scenario as in many cases the actual numbers of individuals who would be likely to experience the view would be very limited, although it is recognised that there will be a few individuals such as landscape photographers who may visit hilltops to take photographs at sunset or sunrise.

3 ANALYSIS OF AVIATION LIGHTING

3.1.1 In order to help inform the judgements made, site visits have been undertaken to the Middleton Wind Farm, East Renfrewshire, which comprises six turbines with a blade tip height of 105 m, with some turbines fitted with lights that permanently operate at 2000 candela and others that permanently operate at 200 candela lights. As well as being an operational commercial scale wind farm with aviation lighting similar to that proposed, as it features lights that permanently operate at 2000 candela or 200 candela it is useful for appreciating the difference in the intensity of the lights. This has enabled consideration of aviation lighting in comparable low light levels, during the dusk period, for use as context and an aid to the work undertaken.

3.1.2 A Photographic Record of images of the Middleton Wind Farm during low light conditions is set out at **Annex 1 to this Appendix**, along with a further supporting record of images of the Emley Moor Transmitter mast, which has also been used as a guide (Emley Moor is a 300m concrete tower and mast lit with 2,000 candela lights close to the Pegasus Office in Leeds, which has also been used as a convenient control and test location to 'ground truth' judgements).

3.1.3 Part of this additional site work also sought to consider if there would be any potential for surface illumination of the turbine blades, tower or nacelle as a result of the aviation lighting to be visible in the wider landscape surrounding a wind farm. There was no clear visibility of such phenomena in the wider landscape during the site work undertaken, however, it is understood that such events may be possible in proximity to lit turbines in locations with very low natural light. It is therefore acknowledged as part of the judgements made within the assessment that such occurrences may be possible as a worse-case scenario but that they would not be typical of the general experience of the lighting when seen from the landscape.

3.1.4 A separate phenomenon which was experienced during the site visit to Middleton, was the manner in which the turbine blades passing in front of the turbine lighting serve to cause a temporary dimming and brightening of the lights. This is something which only occurs when the turbines are viewed with the blades in front of the nacelle and therefore is dependent on the prevailing wind direction on any given day. The dimming and brightening effect serves to increase the noticeability of the turbines within the view and therefore increases their visual effect. It is therefore acknowledged as part of the judgements made within the assessment that such occurrences would periodically occur in relation to the proposed turbines (albeit the occurrence being most likely for locations to the southwest of the turbines due to the prevailing southwesterly wind direction where there are likely to be few visual receptors during the low light level period).

4 APPROACH TO SENSITIVITY

4.1 Nature (Sensitivity) of Landscape Character

4.1.1 The nature or sensitivity of landscape character reflects its susceptibility to change and the value associated with it. It is essentially an expression of a landscape's ability to accommodate a particular type of change. It varies depending on the physical and perceptual attributes of the landscape including but not necessarily limited to: scale; degree of openness; landform; existing land cover; landscape pattern and complexity; the extent of human influence in the landscape; the degree of remoteness/wildness; perception of change in the landscape; the importance of landmarks or skylines in the landscape; intervisibility with and influence on surrounding areas; condition; rarity and scenic quality of the landscape, and any values placed on the landscape including any designations that may apply. Additionally, for a consideration of landscape character during low light levels, a key further consideration is the extent to which existing artificial light sources are present in the landscape during low natural light levels.

4.1.2 In this assessment, the nature or sensitivity of landscape character is considered with reference to published landscape character areas/types. Information regarding the key characteristics of these character areas/types is extrapolated from relevant published studies. Together with on-site appraisal, an assessment of landscape sensitivity to visible wind turbine aviation lighting has been undertaken, employing professional judgement.

4.1.3 The nature or sensitivity of landscape character shall be described as 'very high', 'high', 'medium', 'low, or 'very low'.

4.2 Nature (Sensitivity) of Visual Receptors

4.2.1 The nature or sensitivity of a visual receptor group reflects their susceptibility to change and the value associated with the specific view in question. It varies depending on a number of factors such as the occupation of the viewer, their viewing expectations, duration of view and the angle or direction in which they would see the site. Whilst most views are valued by someone, certain viewpoints are particularly highly valued for either their cultural or historical associations and this can increase the sensitivity of the view. The following criteria are provided for guidance only and are not exclusive:

- Very Low Sensitivity – People engaged in industrial and commercial activities, or military activities, who would be unlikely to have any particular expectation of their wider night time view.
- Low Sensitivity - People at their place of work (e.g. offices); shoppers; users of trunk/major roads and passengers on commercial railway lines (except where these form part of a recognised and promoted scenic route). The primary interest of such receptors would not generally be on the dusk/night time view.
- Medium Sensitivity - Users of public rights of way and minor roads which do not appear to be used primarily for recreational activities or the specific enjoyment of the landscape; recreational activities not specifically focused on the landscape (e.g. football). Such receptors may have some interest in their dusk/night time view of the wider landscape, but generally their primary concern would be their immediate landscape context;
- High Sensitivity – Residents at home; users of caravan parks, campsites and 'destination' hotels; tourist attractions open after daylight hours with opportunities

for views of the landscape (but not specifically focused on a particular vista); users of public rights of way or minor roads which appear to be used for recreational purposes or the specific enjoyment of the landscape during dusk/night time (often likely to be in close proximity to residential areas).

- Very High Sensitivity - People at recognised vantage points (often with interpretation boards) which are designed to take in a dusk/ night time view, people at tourist attractions with a focus on a specific view which is available at dusk/ night time, visitors to historic features/estates where the setting is important to an appreciation and understanding of cultural value and can be visited and appreciated during dusk/night time.

4.2.2 It is important to appreciate that it is the visual receptor (i.e. the person) that has a sensitivity and not a property, public right of way or road. Therefore, a large number of people may use a motorway during dusk/ night time, for example, but this does not increase the sensitivity of the receptors using it. Conversely, a residential property may only have one person living in it, but this does not reduce the sensitivity of that one receptor.

4.2.3 Where judgements are made about the sensitivity of assessment viewpoints, the sensitivity rating provided shall be an evaluation of the sensitivity of the receptor represented by the viewpoint and not a reflection of the number of people who may experience the view.

4.2.4 It is also important not to confuse the concept of visual sensitivity with the perception of wind turbines. It is acknowledged that some people consider wind turbines to be unattractive, but many people also enjoy the sight of them. This matter is therefore not a factor when determining sensitivity.

5 APPROACH TO NATURE (MAGNITUDE) OF EFFECTS

5.1 Nature (Magnitude) of effects on Landscape Character

5.1.1 The magnitude of effect on landscape character from visible lighting during low light periods is influenced by the resulting alteration to the physical and perceptual characteristics of the landscape. Professional judgement is used as appropriate to determine the magnitude using the following criteria as guidance only. In doing so, it is recognised that usually the landscape components in the immediate surroundings, including any visible lighting, have a stronger influence on the sense of landscape character than distant features whilst acknowledging the fact that more distant features can have an influence on landscape character as well.

- Very Low Magnitude of Change – No notable introduction of new visible lighting into the landscape; resulting in negligible change to the key physical and/or perceptual attributes of the landscape during the low light period.
- Low Magnitude of Change - Introduction of a minor new extent of visible lighting into the landscape; resulting in a minor alteration to the key physical and/or perceptual attributes of the landscape during the low light period.
- Medium Magnitude of Change - Introduction of some notable new visible lighting into the landscape; resulting in some notable change to the key physical and/or perceptual attributes of the landscape during the low light period.
- High Magnitude of Change - Introduction of major new visible lighting into the landscape; resulting in a major change to the key physical and/or perceptual attributes of the landscape during the low light period.
- Very High Magnitude of Change - Introduction of dominant new visible lighting into the landscape; resulting in a profound change to the key physical and/or perceptual attributes of the landscape during the low light period.

5.2 Nature (Magnitude) of effects on Views and Visual Amenity

5.2.1 Visual effects are caused by the introduction of new elements into the views of a landscape, or the removal of elements from the existing view. In this case the effects would be brought about by the addition of visible lighting.

5.2.2 Professional judgement shall be used to determine the magnitude of impacts using the following criteria as guidance only:

- Very Low Magnitude of Change - No change or negligible change in views;
- Low Magnitude of Change - Some change in the view that is not prominent but visible to some visual receptors;
- Medium Magnitude of Change - Some change in the view that is clearly notable in the view and forms an easily identifiable component in the view;
- High Magnitude of Change - A major change in the view that is highly prominent and has a strong influence on the overall view; and
- Very High Magnitude of Change – A change in the view that has a dominating or overbearing influence on the overall view.

5.2.3 Using this set of criteria, determining levels of magnitude is primarily dependant on how prominent the lighting associated with the development would be in the landscape, and what may be judged to flow from that prominence or otherwise.

5.2.4 For clarification, the use of the term 'prominent' relates to how noticeable the lighting associated with the development would be. This is affected by how close the viewpoint is to the development but not entirely dependent on this factor. Other modifying factors include: the focus of the view, visual screening and the nature and scale of other landscape features and visible lighting within the view. Rather than specifying crude bands of distance at which the turbines will be dominant, prominent or incidental to the view etc, the prominence of the turbines in each view is described in detail for each viewpoint or receptor group taking all the relevant variables into consideration.

5.3 Consideration of the Duration and Reversibility of effect

5.3.1 Prior to the publication of GLVIA3, LVIA practice had evolved over time in tandem with most other environmental disciplines to consider significance principally as a function of two factors, namely: the sensitivity of the receptor and the magnitude of the effect (the term 'magnitude' being a word most commonly used in LVIA and most other environmental disciplines to describe the size or scale of an effect).

5.3.2 The flow diagram on page 39 of GLVIA3 now suggests that the magnitude of effect is a function of three factors (the size/scale of the effect, the duration of the effect and the reversibility of the effect). This however, is somewhat problematic in the context of assessing wind energy development. This is because wind energy developments are generally consented for a time limited period and are largely reversible at the end of their operational period. Whilst this is a material consideration in the planning balance it does not however, reduce the scale of the effect during the period in which the scheme is operational (i.e. the 'magnitude' of the effect in the traditional and commonly understood sense of the word). In this regard, it would be incorrect to report a lesser magnitude of change to the view during the operational phase as a result of the time limited period of the effect, or the relative reversibility of the effect.

5.3.3 The approach proposed to be taken in this assessment is therefore, to consider magnitude of effect solely as the scale or size of the effect in the traditional sense of the term 'magnitude'.

6 APPROACH TO LEVEL OF EFFECT

6.1.1 The purpose of an LVIA when produced in the context of an EIA is to identify any significant effects on landscape and visual amenity arising from the Proposed Development.

6.1.2 The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 do not define a threshold at which an effect may be determined to be significant. In certain other environmental disciplines, there are regulatory thresholds or quantitative standards which help to determine the threshold of what constitutes a significant effect. However, in LVIA, any judgement about what constitutes a significant effect is the judgement of a competent and appropriately qualified professional assessor.

6.1.3 The level (relative significance) of the landscape and visual effects is determined by combining judgements regarding sensitivity of the landscape or the viewer, the magnitude of change, duration of effect and the reversibility of the effect. In determining the level of residual effects, all mitigation measures are taken into account.

6.1.4 The level (relative significance) of effect shall be described as **Major**, **Moderate major**, **Moderate**, **Minor moderate**, **Minor**, **Minor to no effect**. No Effect may also be recorded as appropriate where the effect is so negligible it is not even noteworthy.

6.1.5 In the assessment, those effects described as **Major**, **Moderate major** and in some cases **Moderate** may be regarded as significant effects as required by the EIA Regulations. These are the effects which the authors of the LVIA consider to be most material in the decision making process.

7 PRODUCTION OF THE ZONE OF THEORETICAL VISIBILITY (ZTV) PLAN

7.1.1 A Zone of Theoretical Visibility (ZTV) illustrates the extents from which a feature (in this case the visible lighting from a number of wind turbines) would theoretically be visible within a defined study area.

7.1.2 ZTVs are generated assuming a 'bare ground' terrain model. This means that the ZTVs presented are generated from topographical data only and they do not take any account of vegetation or the built environment, which may screen views of the development. They are, as such, a 'worst case' zone of visual influence and considerably over-emphasises the actual visibility of the scheme. In reality trees, hedges and buildings may restrict views of the Proposed Development from many of the areas rendered as within the ZTV.

7.1.3 A further assumption of ZTVs is that climatic visibility is 100% (i.e., visibility is not impeded by moisture or pollution in the air). In reality, such atmospheric conditions are relatively rare. Mist, fog, rain and snow are all common weather occurrences, which would regularly restrict visibility of the lighting associated with the Proposed Development from some of the areas within the ZTV; this being an incrementally more significant factor with distance from the site. Atmospheric pollution is not as significant as it is in other parts of the country but is still present and would also restrict actual visibility on some occasions, again more so with distance from the site.

7.1.4 The ZTV is generated using GIS software and is based on topographical height data (OS Terrain 5). The programme then renders the model using a square grid to illustrate whether the turbine lighting would be visible in each 50m x 50m square on the grid for a specified distance in every direction from the site.

7.1.5 A digital ZTV has been prepared to illustrate the theoretical visibility of the turbine lighting for a radius of up to 35km around the site. It should be noted that when light travels from its source it diminishes in intensity, limiting the area that its source can illuminate, a process known as 'light attenuation' or 'fall-off'. Therefore, whilst the ZTV would not illustrate any reduction in intensity it should be recognised that the aviation lighting would diminish in intensity with distance from the wind farm.

7.1.6 It should be noted that there are several limitations to the use of ZTVs. For a discussion of these limitations please refer to Visual Representation of Wind farms – Version 2.2 (SNH February 2017). In particular, it should be noted that the ZTV plan shall simply illustrate theoretical visibility and will not imply or assign any level of significance to those areas identified as being within the ZTV. A ZTV is a tool to assist the Landscape Architect to identify where the turbine lighting would potentially be visible from, however, the assessment of landscape and visual effects shall not rely solely on the ZTV and in all cases professional judgement shall be used to evaluate the significance of effects.

8 PRODUCTION OF THE DUSK PERIOD VISUALISATIONS

8.1 Introduction

8.1.1 NatureScot (formerly SNH) Guidance, Visual Representation of Wind Farms, Version 2.2, February 2017, considers the matter of visible turbine lighting at paragraphs 174 to 177. This highlights 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'.*

8.1.2 The NatureScot Guidance goes on to note that:

> *'This is only likely to be required in particular situations where the wind farm is likely to be regularly viewed at night (e.g. from a settlement, transport route) or where there is a particular sensitivity to lighting (e.g. in or near a Dark Sky Park or Wild Land Area)'. It is also clear that '**Not all viewpoints will need to be illustrated in this way**'.*

8.1.3 The following section provides background information in relation to the Dusk Period Visualisations which have been prepared to illustrate the visible lighting proposed as part of the Proposed Development. The text explains how the photography was taken and how the visualisations were prepared and presented. It includes instructions for how the visualisations should be viewed and explains the limitations of the visualisation material.

8.2 Viewpoints Illustrated with Dusk Period Visualisations

8.2.1 The starting point for consideration for which locations should be illustrated with dusk period visualisations was the locations proposed as assessment viewpoints for the main daytime period visual assessment. Of these viewpoints a review was then undertaken in order to establish which were likely to be representative of visual receptors during low light conditions. In this regard, viewpoints at distances of beyond 10km from the site were discounted, along with viewpoints at hills summits and on long distance footpaths which would be unlikely to be visited after daylight hours.

8.3 Dusk Period Photography

8.3.1 NatureScot advises that:

> *'The visualisation should use photographs taken in low light conditions, preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night. It is only necessary to illustrate visible lighting, not infrared or other alternative lighting requirements'. It goes on to note that 'We have found that approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image. It is important that the photographs represent the levels of darkness as seen by the naked eye at the time and the camera exposure does not make the image appear artificially brighter than it is in reality. It can also be helpful to note the intensity of other lights in*

the area to enable comparison (e.g. television transmitters) as this can aid the assessment process'.

8.3.2 In this context, the following text explains how the baseline photography was taken for each viewpoint illustrated with a visualisation.

8.3.3 Each viewpoint illustrated with a visualisation was visited during the 'dusk period' and photographs taken at regular intervals as the light levels decreased across the dusk period. In particular, it was sought to gather photographs during the period where street lighting and other light sources of visible light in the baseline are illuminated, but the landform remains partially visible. The ambient light conditions were recorded during each round of photography with a light meter to seek to ensure consistency across the visualisations prepared.

8.3.4 Baseline photographs of the existing view were taken using a high quality Canon 5D Mark II digital camera with a Canon EF 50mm f/1.4 USM lens. In accordance with NatureScot guidance, this camera has a full frame digital sensor.

8.3.5 As far as possible, photographs were taken in good weather and clear visibility conditions.

8.3.6 Photographs are captured in high resolution JPEG format and as RAW metadata files.

8.3.7 At each viewpoint the camera is mounted on a levelled tripod at a height of approximately 1.5m above ground level (providing an approximation of average adult eye level).

8.3.8 The camera is set up on a panoramic rotating head and photographs taken at 30 degree increments of rotation from left to right.

8.3.9 In each case the camera focus is locked on the distant horizon (infinity). In doing so the photographs are in each case focussed on the development site whilst very close objects in the foreground may in some cases be out of focus. This approach is in line with best practice photography techniques. The exposure is set correctly for the centre of the development site and then locked off so that it remained constant as the camera is rotated through the panorama.

8.4 Stitching of Panoramas and Post-Photographic Processing

8.4.1 Each of the panoramic images presented for the Photographic Record and used for the Visualisations is comprised of three single frame photographs stitched together and then cropped down to a particular horizontal and vertical field of view.

8.4.2 The panoramic baseline photographs which illustrate a 90 degree horizontal angle of view are stitched in cylindrical projection as per the NatureScot guidance.

8.4.3 The photomontages which show a 53.5 degree horizontal field of view are based on the same single frame panoramic photographs but stitched in planar projection in accordance with the SNH guidance.

8.4.4 In some cases a degree of post photography processing of the raw image files may be undertaken to enhance the quality of the baseline photographs. As stated in the NatureScot guidance:

'Photographic processing involves judgements - there is no process by which a 'pure' photograph can be produced without the application of human decision-making, from

exposure timing to the specification of the camera, and whether this is applied manually or automatically.....'

'In reality there is no way to avoid a photograph being enhanced as this is an integral part of photography and photomontage production.'

8.4.5 The extent of image enhancement undertaken in the production of the any photomontages is however be limited to that which would conventionally occur in a darkroom to improve the clarity of an image and does not in any case change the essential character of the image. Overall, a minimum of post-photography image enhancement takes place and during the stitching process none of the photographs are distorted in terms of scaling (other than that which is an inherent and unavoidable product of stitching photography in planar projection).

8.5 Production of Wirelines and Photomontages

Wirelines

8.5.1 A wireline visualisation (sometimes also referred to as a wireframe visualisation) is a computer generated 3D outline of a particular structure (in this case a wind farm) placed on top of a 3D ground terrain model, which again is represented by a wireline. No rendering is given to any of the surfaces.

8.5.2 The wireline images of the proposed turbines (as well as any other cumulative turbines modelled) is generated utilising the actual dimensions of the proposed turbines and a model of the structures placed in position over a ground terrain model generated from Ordnance Survey Terrain 50 DTM data.

8.5.3 The coordinates of the viewpoints are recorded using a Global Positioning System (GPS) in the field. Checks on these coordinates are made with reference to Google Earth. These coordinates are then used to set up viewpoints in the model from which to view the turbines. The wirelines are generated using specialist computer software package 'WindFarm' by ReSoft Ltd.

8.5.4 The wireline images are generated on a bare ground model and therefore do not take account of any vegetation or the built environment between the viewpoint and the development. As such, they represent a worst case view.

8.5.5 For each of the viewpoints which are illustrated with a Visualisation, a wireline is presented to scale beneath a baseline photograph to illustrate the view. The wireline images illustrate the anticipated scale and position of the turbines in relation to the terrain. Each of the lit turbines is identified on the wireline as set out in best practice guidance.

Dusk Period Photomontages

8.5.6 In simple terms, a photomontage is the superimposition of a rendered, photorealistic, computer generated model of a development (in this case a wind farm with visible lighting) on to a baseline photograph to illustrate how it will appear in the surrounding landscape context.

8.5.7 The production of the photomontages begins with the generation of a 3D digital ground terrain model and wireline images of the turbines, using ReSoft Ltd WindFarm software

(as described above). The model of the structures is then rendered, and the lighting levels set appropriate to the date, time and orientation on which the photograph was taken.

8.5.8 Using world coordinates in the computer modelling programme, the photographic viewpoints for which a photomontage is to be prepared is replicated such that a view is set up looking at the structures from exactly the same location as where the baseline photograph was taken from. The view from the model is then superimposed over the original photograph and edited as necessary in Adobe Photoshop to give a final photomontage. Several known landmarks in the far distance of the baseline photographs are recorded on site using a GPS and used to check that the positioning and scale of the structures is correct.

8.5.9 Whilst every effort is made to ensure the accuracy of the photomontages, it must be appreciated that no photomontage could ever claim to be 100% accurate as there are a number of technical limitations in the model relating to the accuracy of information available from Ordnance Survey and from the GPS. In particular, it should be recognised that baseline photographs on which photomontages are based can, at best, only ever be a 'flattened' 2D representation of what the eye sees in 3D on site. A photograph will never capture as much detail as the eye would see in the field, it therefore follows that a photomontage can never truly capture the sense of perspective and detail which would be possible in reality.

8.5.10 Additionally, it has been established during the field work undertaken for previous similar studies that dusk period photographs of visible lighting do not always capture the extent to which the eye perceives light sources during the dusk period. Often photography will appear to show the lighting to be more recessive than it is actually perceived in the field. The photomontages therefore do not seek to replicate the manner in which a dusk period photograph would capture the aviation lighting, rather they seek to replicate the manner in which the lighting is perceived when it is viewed in the field.

8.5.11 In some cases, the visibility of the turbines may also be slightly digitally enhanced to ensure that they are visible when printed out.

8.5.12 Each of the photomontages should be viewed from the stated viewing distance to give an accurate representation of what the Proposed Development will look like. However, the photomontages are simply a tool to assist the Landscape Architect in their assessment of effects. The assessment of visual effects does not rely solely on the photomontages as it is ultimately professional judgement which is used to evaluate the significance of effects.

Presentation of the Visualisation Sheets

8.5.13 For each Dusk Period Viewpoint Visualisation, the following additional visualisation sheets are presented after the daytime visualisations

Sheet D: Baseline Photograph of the Existing Dusk Period View and Wireline of the Proposed Scheme

8.5.14 The baseline photograph is an unedited existing dusk period view from the viewpoint. The image illustrates a 90 degree horizontal field of view and a 25 degree vertical field of view. This image is presented in cylindrical projection and the principal viewing distance

(the distance at which one should view the image to obtain a geometrically accurate impression) is 500mm when the image is curved through the same radius.

8.5.15 A cumulative wireline image of the proposed development with the lit turbines annotated, and all other operational and proposed wind farms is set out directly beneath the corresponding baseline view. This image also presents a 90 degree horizontal field of view. This sheet presents the information required of the 'Baseline Panorama and Wireline' as set out in Annex C of the NatureScot guidance. Both of these images are presented in cylindrical projection and the principal viewing distance (the distance at which one should view the image to obtain a geometrically accurate impression) is 500mm when the image is curved through the same radius.

Sheet E: Dusk Period Photomontage of the Proposed Scheme

8.5.16 This sheet provides a dusk period photomontage of the proposed development below the existing dusk period baseline photograph. The image also illustrates a 90 degree horizontal field of view and an 25 degree vertical field of view. This image is presented in cylindrical projection and the principal viewing distance (the distance at which one should view the image to obtain a geometrically accurate impression) is 500mm when the image is curved through the same radius.

8.6 Limitations of the Visualisations

8.6.1 Annex A of 'Visual Representation of Wind Farms, Version 2.2 (SNH, February 2017) sets out a summary of the key limitations of visualisations and recommends that these are set out for each windfarm application. The following text is therefore reproduced from Annex A of the aforementioned NatureScot guidance:

'Visualisations of wind farms have a number of limitations which you should be aware of when using them to form a judgement on a wind farm proposal. These include:

- A visualisation **can never show exactly** what the wind farm will look like in reality due to factors such as: different lighting, weather and seasonal conditions which vary through time and the resolution of the image;
- The images provided give a reasonable impression of the scale of the turbines and the distance to the turbines, but **can never be 100% accurate**;
- A static image cannot convey turbine movement, or flicker or reflection from the sun on the turbine blades as they move;
- The viewpoints illustrated are representative of views in the area, but cannot represent visibility at all locations;
- To form the best impression of the impacts of the wind farm proposal these images **are best viewed at the viewpoint location shown**;
- The images **must be printed at the right size to be viewed properly** (260mm by 820mm);
- You should **hold the images flat at a comfortable arm's length**. If viewing these images on a wall or board at an exhibition, you should stand at arm's length from the image presented to gain the best impression.
- It is preferable to view printed images rather than view images on screen. If you do view images on screen you should do so using a normal PC screen with the image enlarged to the full screen height to give a realistic impression. Do not use a tablet or other device with a smaller screen to view the visualisations described in this guidance'.

8.6.2 It should also be noted that the quality of all printed visualisations is also dependent on the printing methods, paper and ink used.