Galileo 03 Ltd.

Mynydd Ty-talwyn Energy Park - Environmental Statement Volume III

Appendix 8.3 Night Time Lighting Assessment Methodology

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APPENDIX 8.3 – NIGHT TIME LIGHTING ASSESSMENT METHODOLOGY

8.1 Introduction

8.1.1 In accordance with Civil Aviation Authority (CAA) CAP 764 turbines taller than 150 m require visible aviation lighting. An adjusted visible aviation lighting scheme has been agreed with the CAA for the Proposed Development. In total, three turbines (T1, T5 and T6) are proposed to be fitted with visible red 2000/200 cd steady state lights on the nacelle of each turbine.

8.1.2 This Technical 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 **Environmental Statement (ES) Volume III, Appendix 8.1: Landscape and Visual Impact Assessment Criteria**. It has been guided by NatureScot's 'Guidance on Aviation Lighting Impact Assessment' (year) (Ref 1). The written assessment is supported by Zone of Theoretical Visibility (ZTV) plans showing where the lit turbines are visible from in theory (see **ES, Volume IV: Figure 8.37 Hub height ZTV for Lit Turbines T1, T5 and T6 to 20 km with Viewpoints**) and showing the theoretical intensity of the lighting at **ES Volume IV, Figure 8.38: Lighting Intensity ZTV for Lit Turbines T1, T5 and T6 to 20 km with Viewpoints**. Visualisations illustrating the proposed turbine lighting from viewpoints 4, 11 and 14 in the surrounding landscape have also been produced and are included at **ES Volume III, Appendix 8.10: Visualisations: Viewpoints 1 to 15**. The approach to the production of this supporting visual material is addressed in this appendix.

8.1.3 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 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."*

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

8.1.5 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).

8.1.6 For an assessment during daylight hours, 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.

8.1.7 For an assessment of visible aviation lighting, an understanding of light conditions after sunset and before sunrise is required:

> *"Sunrise and sunset are taken to be the times at which the apparent upper limb of the Sun is on the (astronomical) horizon." "Twilight is the interval preceding sunrise and following sunset when the sky is partially illuminated."* (Ref 2)

8.1.8 The visible aviation lights will be switched on between Evening Civil Twilight and Morning Civil Twilight in accordance with the UK Almanac.

8.1.9 Therefore, the visual assessment of the effects of visible aviation lighting has taken place at a reasonable worst-case; after the commencement of Evening Civil Twilight, within the period commonly referred to as 'dusk', when some degree of the landscape's features can be discerned.

8.1.10 However, it should be recognised that as the sun continues to dip below the horizon through the periods of civil, nautical and astronomical twilight, light levels continue to fall, and the amount of discernible landscape features rapidly decreases. Therefore, the assessment has focussed solely on the effects of the visible aviation on visual amenity. Without being able to fully appreciate landscape features and components that contribute to landscape character, it is not possible to carry out a meaningful landscape character assessment. This precedent was established in the Scottish Ministers' decision for Crystal Rig IV (WIN-140-8). (Ref 3) (Ref 4)

8.2 Description of the Proposed Turbine Lighting, Mitigation Measures and Assumptions

Description of Lighting Scheme

8.2.1 In accordance with CAA CAP 764, turbines taller than 150 m require visible aviation lighting. An adjusted visible aviation lighting scheme has been agreed with the CAA for the Proposed Development. In total three turbines (T1, T5 and T6) are proposed to be fitted with visible red 2000/200 cd lights on the nacelle of each turbine. This will include three 32cd red lights half-way up the turbine masts.

8.2.2 These will operate in the reduced 200 cd intensity where meteorological visibility is greater than 5 km, and where visibility is less than 5 km, the lights will operate at 2000 cd. The lights are required to be at maximum intensity at 3 degrees above and 1 degree below horizontal. Light intensity reduces beyond those parameters.

Mitigation and Assumptions

8.2.3 For the purpose of the figures and visualisations prepared to help inform the assessment of visible aviation lighting set out in the LVIA, the following assumptions have been made, in light of the proposed mitigation:

- Lighting is only shown on the three turbines agreed with the CAA that will be fitted with steady state visible aviation lighting;
- Three 32cd intermediate lights will be fitted halfway between the nacelle and the ground-level;
- 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 2000 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 candela lighting seen in clear conditions. This approach is consistent with NatureScot guidance on Aviation Lighting Impact Assessment;
- The reduction in the intensity of lights above and below the horizon has been illustrated on **ES Volume IV, Figure 8.38: Lighting Intensity ZTV for Lit Turbines T1, T5 and T6 to 20 km with Viewpoints**. This ZTV shows the theoretical reduction in the candela intensity of the lights at vertical angles above and below the horizon, to illustrate the reduction in the intensity of the lights at elevations below the level of the turbine lights;
- Whilst the lighting would reduce in intensity above and below the horizontal, this reduction has not been illustrated in the night-time visualisations. As such the visualisations are a worst-case. This matter has, however, been considered within the assessment judgements in the LVIA;
- The visualisations illustrate the period after the commencement of Evening Civil Twilight, when sufficient ambient light remains for the landform of the landscape on which the wind turbines are proposed, to remain partially visible. The assessment also focuses on this period, which represents a ‘worst-case’;
- Whilst the implementation of a suitable Aircraft Detection Lighting System 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 Aircraft Detection Lighting System are discussed separately in the application submission in **ES Volume III, Appendix 4.5: Aviation Lighting and Mitigation** ;

- 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 further reduce the 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 would be experienced by many of the receptors in practice; and
- The frequency in which a viewpoint is likely to be visited during the hours of darkness 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 or people star gazing.

8.3 Analysis of Aviation Lighting

8.3.1 In order to help inform the judgements made, site visits have been undertaken to the Middleton Wind Farm, East Renfrewshire, an operational commercial scale wind farm with aviation lights operating simultaneously at both 2000 candela (cd) and 200 cd. This has enabled consideration of aviation lighting in comparable low light levels, during the hours of darkness, for use as context.

8.3.2 Whilst these two sites act as an aid to the work undertaken, it should be acknowledged that the aviation lighting proposed is different and will use the latest technology to further mitigate the effect on the surrounding area.

8.3.3 Part of this additional site work also sought to consider if there would be any potential for surface illumination and therefore visibility in the wider landscape of the turbine blades, tower or nacelle as a result of the aviation lighting. 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.

8.3.4 A separate phenomenon which was experienced during the site visit to Middleton Wind Farm, 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 serve 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 south-west of the turbines where there are likely to be fewer visual receptors during the low light level period).

8.4 Assessment Criteria

8.4.1 The assessment criteria used within the assessment is set out in **ES Volume II, Chapter 8: Landscape and Visual** and further detailed in **ES Volume III, Appendix 8.1: Landscape and Visual Impact Assessment Criteria.**

8.5 Production of the Zone of Theoretical Visibility Plans

8.5.1 A 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. Two types of ZTV plans have been prepared. **ES Volume IV, Figure 8.37: Hub Height ZTV for Lit Turbines T1, T5 and T6 to 20 km with Viewpoints** shows the theoretical visibility of the turbines proposed to be lit, and illustrates the number of lit turbines theoretically visible from any point in the surrounding study area. In contrast, **ES Volume IV, Figure 8.38: Lighting Intensity ZTV for Lit Turbines T1, T5 and T6 to 20 km with Viewpoints** illustrates the theoretical intensity of the turbine lights, taking into account the difference in elevation between the lights and any point in the surrounding study area, and the resulting reduced candela. It does not, however, allow for the reduction in intensity due to distance from the turbine light.

8.5.2 Further detail on how ZTVs are generated is presented in **ES Volume III, Appendix 8.2: Visualisation Information.**

8.6 Production of Dusk Period Visualisations

Introduction

8.6.1 SNH (now NatureScot) 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."

8.6.2 The 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."

8.6.3 The following section provides background information in relation to the Dusk Period Visualisations (**ES Volume III, Appendix 8.10: Visualisations: Viewpoints 1 to 15**) 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.

Viewpoints Illustrated with Dusk Period Visualisations

8.6.4 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 hills summits and on long distance footpaths which would be unlikely to be visited after daylight hours.

Dusk Period Photography

8.6.5 SNH 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."

8.6.6 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."

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

8.6.8 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.

8.6.9 Baseline photographs of the existing view were taken using a full frame camera in accordance with NatureScot guidance.

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

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

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

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

8.6.14 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.

Stitching of Panoramas and Post-Photographic Processing

8.6.15 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.

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

8.6.17 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 NatureScot guidance.

8.6.18 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."

8.6.19 The extent of image enhancement undertaken in the production of the any photomontages is however 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).

Production of Wirelines and Photomontages

Wirelines

8.6.20 A wireline visualisation (sometimes also referred to as a wireframe visualisation) is a computer-generated 3D outline of a particular structure (in this case, the Proposed Development) 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.

8.6.21 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.

8.6.22 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 Resoft.

8.6.23 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 Proposed Development. As such, they represent a worst-case view.

8.6.24 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

8.6.25 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.

8.6.26 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.

8.6.27 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.

8.6.28 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.

8.6.29 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.

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

8.6.31 Each of the photomontages should be viewed from the stated viewing distance to give an accurate representation of what the 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

8.6.32 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 Development

8.6.33 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 500 mm when the image is curved through the same radius.

8.6.34 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 SNH 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 500 mm when the image is curved through the same radius.

Sheet E: Dusk Period Photomontage of the Proposed Development

8.6.35 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 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 500 mm when the image is curved through the same radius.

Limitations of the Visualisations

8.6.36 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 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 (260 mm by 820 mm);

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."

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

8.7 References

1. NatureScot. Guidance on Aviation Lighting Impact Assessment. (November 2024). Available at: https://www.nature.scot/doc/guidance-aviation-lighting-impact-assessment - judging-night-time-sensitivity

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4. Crystal Rig Inquiry (WIN-140-8). Core Document ELC09. SNH Photos from aviation lighting visits November 2017. Available at: https://www.dpea.scotland.gov.uk/CaseDetails.aspx?ID=120491