Appendix 6.5: Aviation Lighting Impact Assessment

Loch Liath Wind Farm Ltd

Loch Liath Wind Farm EIA

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Final report
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Loch Liath Wind Farm Ltd

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Aviation Lighting Impact Assessment

Introduction

A6.5.1 In the interests of aviation safety, structures of ≥ 150m, including wind turbines, require steady red visible aviation lighting, as set out in Civil Aviation Authority (CAA) guidance[1].The Proposed Development comprises 13 turbines with a maximum blade tip height of 180-200m and will therefore require visible aviation lighting which may be perceptible to receptors (people) from locations across the Study Area.

A6.5.2 The introduction of visible aviation lighting in rural locations, where there are fewer sources of artificial lighting, and where darkness or dark skies are an integral and valued aspect of the landscape, may lead to potentially significant landscape and visual effects. This appendix includes an assessment of the effects of visible lighting on landscape and visual receptors.

A6.5.3 The requirement for visible aviation lighting is an emerging consideration for the wind energy sector, and consequently the approach to the assessment of likely environmental effects which may arise is evolving.

A6.5.4 This technical appendix sets out the background to the requirements for visible aviation lighting, followed by an assessment of landscape and visual effects arising for representative receptors within the Study Area. Receptors considered in the assessment are identified based on the Landscape and Visual Impact Assessment (LVIA) presented in **Chapter 6: Landscape and Visual Amenity**, and this appendix should be read with reference to the main assessment and the accompanying figures presented in **Volume 2** and visualisations presented in **Volume 3a-c: NatureScot LVIA Visualisations** of the EIA Report, along with **Appendix 6.1: Landscape and Visual Assessment Methodology** and **Appendix 6.2: ZTV Mapping and Visualisation Methodology.**

Regulatory Background

A6.5.5 The regulatory background to the requirements for visible aviation lighting on wind turbines is outlined in detail below.

Aviation Lighting Requirements

A6.5.6 As noted above, the UK Air Navigation Order (ANO) 2016, Article 222[2] , sets out the statutory requirement for the lighting of 'en-route obstacles', which applies to structures of 150m or more above ground level to assist their detection by aircraft. Article 222 (1) of the Civil Aviation Authority's (CAA) ANO 2016 and Regulations states:

'The person in charge of an en-route obstacle must ensure that it is fitted with medium intensity steady red lights positioned as close as possible to the top of the obstacle and at intermediate levels spaced so far as practicable equally between the top lights and ground level with an interval of not more than 52 metres.'

A6.5.7 Article 222 (8) defines an en-route obstacle as:

'an 'en-route obstacle' means any building, structure or erection, the height of which is 150 metres or more above ground level, but it does not include a building, structure or erection:

a) which is in the vicinity of a licensed aerodrome; and

b) to which section 47 of the Civil Aviation Act 1982 (warning of presence of obstructions near licensed aerodromes) applies.'

A6.5.8 For turbines of 150m or greater the exceptions listed in ANO Article 222 (8) a) and b) (set out above) would not apply, and therefore the regulations necessitate the installation of medium intensity (emitting 2,000 candela(cd)) steady red lights on all turbines.

A6.5.9 This article is incorporated into the CAA's Policy Statement[3] on the lighting of onshore wind turbines (June 2017), and states that *'The person in charge of the wind turbine generator must ensure that it is fitted with a medium intensity (2000 candela) red light positioned as close as practicable to the top of the fixed structure. A second light serving as an alternative should be provided in case of failure of the operating light.'* In practice this means the installation of lights on the top surface of the turbine hub/ nacelle.

A6.5.10 Additionally, the CAA requires that *"at least three (to provide 360 degree coverage) low-intensity Type B6 lights (32 candela) lights should be provided at an intermediate level of half the nacelle height."* However, the requirement for intermediate level lighting was scoped out in agreement with the CAA, as set out in **Appendix 14.2: Aviation Lighting and Mitigation Report**.

Lighting Specification Requirements

A6.5.11 Informed by the International Civil Aviation Organisation (ICAO) Code - Annex 14[4] which sets out the technical specification requirements for medium intensity obstacle lights (MIOL), the CAA Policy Statement details the required and recommended minimum intensity lighting settings for 2,000 candela lights (with the 200 candela rated option, for clear weather conditions, highlighted in brackets). These requirements vary at different vertical angles of elevation, relative to the lighting horizontal plane, which in this case will be the nacelle height of the wind turbines. The intensity of the light emitted from an aviation obstruction light is designed to vary with the observed angle. It aims to be at its brightest when observed from a similar level or just above, but less bright as the observer falls significantly below or above the light. Different manufacturers produce lights with slightly varying characteristics, though broadly similar in complying with the minimum requirements, and maximum recommendations, of these international standards.

A6.5.12 The Applicant commissioned a specialist aviation consultant (Wind Power Aviation Consultants (WPAC) Ltd) to design, in consultation with the CAA, the aviation lighting scheme for the Proposed Development. An Aviation Lighting Report was prepared (refer to **Appendix 14.2: Wind Farm Aviation Lighting and Mitigation Report**) which sets out the details of the lighting scheme, a candidate aviation light specification and includes information on the actual intensity experienced at different vertical angles of elevation as set out in **Appendix Table A6.5.1** below. This information is outlined in more detail in **Appendix 14.2** and **Appendix 6.2: ZTV Mapping and Visualisation Methodology**.

Table A6.5.1: Maximum and minimum luminous intensity relative to viewing angle - CEL-MI-ACWGAM light

Vertical angle of lighting from nacelle	Maximum luminous intensity (cd)	Minimum luminous intensity	Maximum luminous intensity at 10% (cd)	10% Minimum luminous intensity at 10% (cd)
Above 2°	1568cd	632cd	156cd	63cd
Between 1° to 2°	2306cd	1630cd	230cd	163cd
Between 0° to 1°	2341cd	2067cd	234cd	206cd
Between -1° to 0°	1965cd	850cd	196cd	85cd
Between -2° to -1°	832cd	356cd	83cd	35cd
Between -3 to -2°	344cd	188cd	34cd	18cd
Below -3°	≤188cd	n/a	≤18cd	n/a

A6.5.13 The ICAO sets out in Table 6.4 of Annex 14 the definitions for daylight, twilight and night based on measured background illuminance as:

[1] The Air Navigation Order 2016 (SI 2016/765). Available at http://www.legislation.gov.uk/uksi/2016/765/contents/made (Accessed: 07 July 2022).
[2] The Air Navigation Order 2016 (SI 2016/765). Available at http://www.legislation.gov.uk/uksi/2016/765/contents/made (Accessed: 07 July 2022).
[3] CAA Policy Statement (2017) Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level

[4] International Civil Aviation Organization (ICAO) (2018) Annex 14 to the Convention on International Civil Aviation – Aerodromes - Volume I Aerodrome Design and Operations

- Daylight – Above 500cd/m^2;
- Twilight – 50-500cd/m^{2}m; and
- Night – below 50cd/m^2.

A6.5.14 The perceived minimum intensity of a 2,000 candela light mounted on the turbine nacelle therefore reduces at vertical angles below the horizontal plane. This results in a reduction in visible lighting at elevations of less than -1 degree vertical angle. The light would appear less bright to an observer looking up at the nacelle from below, than it would to an observer at the same elevation as the nacelle. The intensity at angles below -1 degrees may also vary dependent on the specific obstacle lighting manufacturer's specification. Note that this does not take account of emitted light spill on to passing blades, which may be visible from all elevations as a reflected glow across the immediate surfaces of the turbine blades and nacelle.

A6.5.15 **Table A6.4.6** presented in **Annex A** provides the equivalent predicted luminous intensity of nacelle mounted aviation lighting data, informed by **Appendix 14.2: Aviation Lighting and Mitigation Report** for each of the 20 representative viewpoints considered in the LVIA.

A6.5.16 The CAA Policy Statement also includes provision for the medium intensity 2,000 candela lights to be controlled by visibility sensors that may reduce the intensity of the light to not less than 10% of the minimum peak intensity (e.g. 200 candela) in times of clear meteorological conditions where visibility exceeds 5km (as measured on sensors on the turbine hubs).

A6.5.17 In conditions of meteorological visibility less than 5km, the perceived brightness of medium intensity lights illuminated at 2,000 candela, whilst possibly still visible, is likely to be much reduced, and typically not visible at distances greater than 5km from turbines.

A6.5.18 Although the actuality of the lights remains constant, the apparent light intensity (brightness) and size of a light source as perceived by visual people will vary dependent on distance, angle of view, and atmospheric conditions. As distances increase, the light source will appear smaller. As atmospheric conditions become less clear (a reduction in clarity with increased humidity, rain, drizzle, snow, or the presence of haze, mist, fog, or a low cloud base etc) the brightness will appear reduced. Clarity varies at different levels within the sky, and across different places. Decline in brightness over distance is not uniform. The brightness at which lights are perceived also depends on the background against which they are seen. They may seem brighter because of the stronger contrast when there is no moonlight for example, or when they are seen against a dark landmass rather than against a sky where there is some residual twilight. Perception of red lights by humans is also variable from person to person and is influenced by age.

Potential Mitigation

A6.5.19 A number of potential mitigation options are currently available or are being developed by the wind energy sector in collaboration with the CAA and other stakeholders. Mitigation options which may have the potential to influence the resultant landscape and visual effects which may occur from the introduction of visible aviation lighting are outlined below.

Cardinal or Peripheral Lighting

A6.5.20 The lighting of cardinal or peripheral turbines located at the outer extremities of a wind farm development is an established mitigation option for wind farms.

A6.5.21 Current ICAO Annex 14 guidance for lighting of wind turbines states that aviation lights should be installed to identify the perimeters of the wind farm, respecting the maximum spacing between lights '*not exceeding 900m*' (paragraph 6.2.3.15) unless in situations where '*a dedicated assessment shows that a greater spacing can be used*', and also that any wind turbines of significantly higher elevation are also identified.

A6.5.22 Through consultation with the CAA, a reduced lighting scheme has been secured for the Proposed Development. Details of which turbines are proposed to be lit are described further below, with further detail provided in **Appendix 14.2**.

Lighting Design

A6.5.23 The technical specification for medium intensity obstacle lights set out in the CAA Policy Statement (CAP 764) defines the necessary requirements for both the minimum lighting intensity settings and minimum vertical angle range of medium intensity lights (as outlined above). Individual lights have slightly varying characteristics, though broadly similar in complying with international standards with sharply declining intensity when viewed from a lower level.

A6.5.24 As such, embedded mitigation within the design of the lights has the potential to much reduce the extent and perceived intensity of lights visible when viewed from different elevations (effectively the angle of view), when seen from either below (lower elevations) or above (higher elevations) the height of the turbine hub. Furthermore, embedded mitigation within the design may enable the low intensity lights installed at mid-mast level to be removed, as it the case here.

Radar Activated Lighting

A6.5.25 ICAO Annex 14 also details guidance on 'Visual Aids for Denoting Obstacles'. With specific reference to mitigation of effects on visual amenity, Note 2 outlines that *'An autonomous aircraft detection system may be installed on or near an obstacle (or group of obstacles such as wind farms), designed to operate the lighting only when the system detects an aircraft approaching the obstacle, in order to reduce light exposure to local residents.'*

A6.5.26 A number of manufacturers have developed radar activated aviation lighting systems (aviation obstruction lighting detection system), whereby the lights would only be switched on when aircraft approach within a specified airspace zone, and this technology is currently permitted by aviation authorities in EU countries (German Federal Aviation Office (LBA) and the Netherlands Aerospace Centre (NAC)) and the United States (United States Federal Aviation Authority (FAA)).

A6.5.27 This technology is not currently approved by the CAA and as such is not considered further as a potential mitigation option, at this stage. However, it may become available in the lifetime of this project, enabling the duration of visible lighting to be reduced if it were to be adopted.

Proposed Aviation Lighting

A6.5.28 Due to the height of the turbines proposed (180m-200m to turbine blade tip) visible aviation safety lighting is required. The proposed aviation lighting included in this assessment has been agreed through consultation with the CAA. The lighting design is described in more detail in the WPAC Aviation Lighting Report (refer to **Appendix 14.2**) and summarised below:

- Two medium intensity 'steady' red (2,000 candela) lights on the nacelles of each of turbines T1, T4, T7, T10, T12 and T13 (the secondary light on each turbine is fitted for use in the event of failure of the primary light, and will not be lit concurrently);
- Infrared lights to MoD specification installed on the nacelles of each turbine of the Proposed Development (thirteen in total); and,
- No low intensity red lights (32 candela) located on the intermediate level on the turbine are proposed as part of this lighting scheme.

A6.5.29 Mitigation will be implemented to dim the obstacle lights under conditions of good visibility. This is achieved with the installation of a sensor or sensors on within the wind farm. These sensors measure prevailing atmospheric conditions and visibility range. Where atmospheric conditions (as measured at the location of the sensor) limit visibility to distances of less than 5km in any direction (e.g. through the presence of low cloud cover, rain, mist, haze or fog) the lights are illuminated at the necessary medium intensity of 2,000 candela. When clear atmospheric conditions result in visibility over distances of 5km or greater from the turbines, the lights will operate in a lower intensity mode of 200 candela (the equivalent of not less than 10% of the minimum peak intensity capable illumination).

Approach to Assessment of Lighting Effects

A6.5.30 The assessment of lighting effects follows the same approach detailed in **Appendix 6.1: Landscape and Visual Assessment Methodology**. However, it is important to note that the assessment is not a technical lighting assessment based on a quantitative measurement of light levels; it relies on professional judgement of what the naked human eye can reasonably perceive in the context of the baseline situation with regard to existing sources of artificial lighting.

A6.5.31 GLVIA3 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.'* (paragraph 6.12, page 103).

A6.5.32 The WPAC Aviation Lighting and Mitigation Report (**Appendix 14.2**) provides detailed information on the candela level emitted for each turbine nacelle light, at each LVIA viewpoint, dependent on the angle of view and distance. This detailed study highlights that the maximum intensity of any nacelle light experienced at any of the night-time assessment viewpoints is as follows:

- From the lower-lying Viewpoint 1: Affric-Kintail Way, near Braefield (5.9km to the nearest lit turbine (T13)), the maximum level emitted is 145 candela during the maximum illumination mode, and 14.5 candela during the reduced intensity mode (i.e. in clear meteorological conditions);
- From the elevated Viewpoint 10: Creag Dhubh (15.1km to the nearest lit turbine (T7)), the maximum level emitted is 1721.2 candela during the maximum illumination mode, and 172.1 candela during the reduced intensity mode (i.e. in clear meteorological conditions); and
- From the elevated Viewpoint 18: Toll Creagach (18.6km to the nearest lit turbine (T7)), the maximum level emitted is 2471.1 candela during the maximum illumination mode, and 247.1 candela during the reduced intensity mode (i.e. in clear meteorological conditions).

A6.5.33 This assessment considers the effects of lights perceived under two scenarios. The assessment considers the perception of lighting, taking into account inbuilt angle intensity mitigation to reflect a more realistic account of the likely perceived brightness of aviation lighting due to the viewing angle and distance to the receptor. The reasonable maximum case candela levels (the 'Maximum candela') and reasonable minimum case candela levels (the 'Reduced (10% of Maximum) candela'), as set out in **Appendix 14.2**, are considered within the assessment and illustrated by dusk visualisations. For completeness and to enable comparisons with visualisations prepared by other consultants, the assessment also considers potential effects illustrated by dusk visualisations showing candela values at 2,000 (maximum case) and 200 (minimum case) which do not seek to represent changes in brightness as a result of viewing angle. In practice, the angle intensity mitigation will be inbuilt and so such situations would not occur. The dusk photomontage visualisations provided in Figure 6.14e-h, Figure 6.23e-h and Figure 6.31g-j reflect these scenarios.

A6.5.34 Although the assessment is based on effects arising in relation to the steady red light fixed to the top of each turbine hubs, as illustrated in the supporting visualisations, it is acknowledged that in some situations a potential flicker effect may be experienced by receptors as blades pass the stationary lights. It is not possible to represent this situation in static photomontages. Furthermore, reflected glow across the immediate surfaces of the turbine blades and hub may be evident under certain conditions.

A6.5.35 When determining the magnitude of change associated with the Proposed Development, the methodology in **Appendix 6.1** considers the duration of the change. For operational effects this is deemed to be long term (but subject to removal or change upon decommissioning, or future alteration of the Proposed Development or lighting requirements, such as the potential for adoption of transponder activated solutions). However, and with relevance to night-time effects, the frequency and duration of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness (below 500 candela/m^2) which changes with the seasons. As such, in the summer months the duration of visibility of aviation lighting will reduce. It will also be activated much later at night, when fewer people may be around to experience the lighting. In the winter the converse will be the case. The period when visibility is greater than 5km is also likely to be longer in summer, due to generally better weather conditions.

A6.5.36 The night-time baseline against which the effects of the Proposed Development are assessed, includes operational/ under construction wind farms only. Visible lighting is installed on the nacelles of the operational Corrimony Wind Farm (5 turbines, 100m tip height). A condition of the planning consent[5] for Corrimony Wind Farm required the installation of 25 candela omni-directional lighting "at the highest practicable point on the turbines". However, no information regarding the discharge of this condition is available. As noted in Appendix 14.2, "*all of the current commercially available 32cd (supposedly focused) lights are over-engineered (up to 70cd between -30deg and +40deg to fit a multitude of aviation and marine applications) they induce a disproportionately large environmental impact, often significantly more than the focused hub 2,000/200cd lights*".

A6.5.37 Several proposed wind farms are also likely to require aviation lighting, should they be constructed, as follows:

- Tomchrasky Wind Farm (14 turbines at 185m tip height);
- Bunloinn Wind Farm (10 turbines at 230m tip height); and
- Kirkan Wind Farm (17 turbines at 175m tip height).

[5] The Highland Council, Decision Notice for Planning Reference: 10/02132/FUL (18th November 2010)

A6.5.38 Whilst the scenario of illuminated proposed wind farms is not represented in the night-time visualisations (these schemes are shown in the cumulative wirelines) this is acknowledged in the assessment text, where relevant.

A6.5.39 The assessment of effects does not consider the potential implications of further mitigation options which may be feasibly adopted in the future to reduce the extent, frequency and perceptibility of the necessary visible aviation lighting (such as radar activated lighting). While the effects of Aircraft Detection Lighting Systems (ADLS) were not assessed in the EIA Report, the adoption of such a system would greatly reduce the incidence of night-time aviation lighting compared to the scenarios assessed here. This is illustrated, with the caveat that the circumstances may differ for the Proposed Development, by a study undertaken for a proposed wind farm located in the Highland Council area - Kirkan Wind Farm – which estimated the frequency with which the lights on the turbines would be switched on by passing aircraft if a transponder-activated lighting system was fitted to that wind farm.

A6.5.40 The study, prepared by Aviatica for Kirkan Wind Farm Limited, was reported as Appendix 4 to the Additional Information submitted for Kirkan Wind Farm in October 2021. Kirkan Wind Farm proposes 17 turbines with a maximum blade tip height of 175m, located 5.8km northwest of Garve, and is located within Allocated Region 1B East (AR1BE) in the military Night Low Flying System. The study assumed activation criteria advised by CAA (i.e. an aircraft entering a 4km radius bubble around the outer perimeter of the wind farm at an altitude less than 300m above the blade tips of the highest turbine and higher than 150m above the ground level at the lowest turbine) and reviewed flight data for military fixed wing, military helicopter, search and rescue (SAR) helicopter, air ambulance helicopter, police helicopter and other night low level aircraft traffic over the period 2016-2021. The study determined that, on worst case estimates, the transponder-activated lights would be switched on for less than 0.1% of the periods of official night (Sunset +30 minutes until Sunrise -30 minutes), or 225 minutes per year. The study referred also to comparative data for 11 wind farms with operational TALS/ADLS in Germany and Austria where lighting was activated for an average 2.31% of night-time, although five of the 11 wind farms had activation times within a similar range to Kirkan (between zero and 0.1% of night-time).

A6.5.41 At the present time the proposed manufacturer or precise model and specification of aviation light to be used is not known. Precise details of mitigation will vary according to the exact light used, but the same principles as assumed in this report will apply (i.e. decline in intensity with increased angle from the horizontal).

Zone of Theoretical Visibility Mapping

A6.5.42 The hub height (102.5m height) Zone of Theoretical Visibility (ZTV) prepared as part of the LVIA, shown on **Figures 6.3a-6.3b**, highlights the areas across the Study Area from which all turbine hubs may be apparent. This ZTV does not take account of potential screening provided by vegetation or built form, or the details of the proposed aviation lighting scheme detailed in **Appendix 14.2**, which comprises two medium intensity 'steady' red (2,000 candela) lights on the nacelles of six of the proposed turbines (T1, T4, T7, T10, T12 and T13).

A6.5.43 To illustrate the potential variability in candela levels emitted in relation to vertical viewing angle of the nacelle lighting for the six turbines noted above, a lighting intensity ZTV is shown on **Figure A6.5.1** (with a focused area to 20km radius on **Figure A6.5.2**). The ZTV does not show the reduction in the brightness of lights over distance, given it would be highly variable depending upon atmospheric conditions. As illustrated by the ZTV, visibility of the hub lights at their greatest intensity (or perceived brightness) would generally be limited to views experienced from the more elevated locations, including upland moorland areas and hill flanks facing the Proposed Development and summits found across the Study Area. These areas are less likely to be regularly frequented during the hours of darkness, given the challenging terrain. This includes Toll Creagach (VP18), Tom a Choinnich and Carn Eighe to the west, Beinn a'Bha'ach Ard (VP12) and Sgurr a' Choire Ghlais to the north, Meall Fuar-Mhonaidh (VP2) to the east, Meall Dubh (VP14) to the south-west and Carn na Saobhaidhe (VP17) to the south-east.

A6.5.44 Conversely, from lower lying settled straths and glens, which are the focus of most settlement and habitation across the LVIA Study Area, the lights (where visible) will generally be perceived at a reduced intensity due to the viewing angle being below the horizontal plane.

A6.5.45 **Figure A6.5.3** illustrates areas where Corrimony Wind Farm where the nacelle lighting of Corrimony Wind Farm is theoretically visible, areas where nacelle lighting of Corrimony and the Proposed Development will be theoretically visible, and areas where only the nacelle lighting of the Proposed Development will be theoretically visibility. As shown on **Figure A6.5.3**, areas where the Proposed Development will introduce visibility of aviation lighting are focused on elevated landform and hill summits in the centre and east of the Study Area. Other sources of artificial lighting may be visible in some views from these locations. In the west of the

Study Area, including within the Glen Affric NSA and Central Highlands WLA, areas where the Proposed Development will introduce visibility of aviation lighting are limited, given the existing visibility of the Corrimony Wind Farm nacelle lighting.

Visualisations

A6.5.46 It is important to note that visualisations represent just one source of information that informs a landscape and visual impact assessment (LVIA). Visualisations were produced for three representative assessment viewpoints, agreed through consultation with NatureScot and the Highland Council (THC) and presented in accordance with the industry standard guidance prescribed in NatureScot[6] and Landscape Institute[7] guidance. The methodology for the preparation of night-time photomontage visualisations is detailed at the end of **Appendix 6.2: ZTV and Visualisation Methodology**.

A6.5.47 The NatureScot guidance states *'The visualisation should use photographs taken in low light conditions, preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night'… 'We have found that approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image.'* (paragraphs 174 – 177, page 35 and 36).

A6.5.48 Photography taken at this time represents a relatively small window (during periods of dusk and dawn, the length of which varies with the time of year) when the landform is visible along with existing and proposed light sources, and perception of landscape character under conditions of fading light or darkness is possible. The actual night-time view, for most of the proposed hours when the turbines are lit, will usually be darker. The proposed lighting and other natural and manmade light sources will be seen against a dark sky or dark landform. In such conditions, the landscape character is harder to perceive. Bright moonlit conditions, or periods when the landscape is snow covered, may provide an exception to this. It is noted that some other light sources will be switched off when people go to bed, and that at this time people may be less susceptible to experiencing views of lighting.

A6.5.49 Baseline dusk photography was undertaken in accordance with NatureScot guidance for each of the representative viewpoints. Photography was captured at dusk in clear atmospheric conditions and sought to capture the presence of existing baseline sources of artificial lighting (e.g. lighting associated with settlement, street lighting, motor vehicles and other sources) present in the landscape as closely as is experienced by the human eye as is feasible.

A6.5.50 The representative visualisations (dusk photomontage visualisations provided in **Figure 6.14e-h**, **Figure 6.23e-h** and **Figure 6.31g-j**) are presented in V**olume 3a-b: NatureScot LVIA Visualisations** and aim to represent the appearance of the proposed visible aviation lighting at dusk during clear viewing conditions at:

- Viewpoint 1: Affric-Kintail Way, near Braefield (**Figure 6.14**, **Volume 3a: NatureScot LVIA Visualisations**);;
- Viewpoint 10: Creag Dhubh (**Figure 6.23**, **Volume 3a: NatureScot LVIA Visualisations**); and
- Viewpoint 18: Toll Creagach (**Figure 6.31**, **Volume 3b: NatureScot LVIA Visualisations**).

A6.5.51 NatureScot guidance also states that '*The developer should attempt to formally agree the lighting requirements with the aviation authorities in advance of the application. Where this is not possible the visualisations should illustrate the lighting as described in the current legislation.*' (paragraphs 177, page 36). The visualisations were created by setting the candela level at the light source within the visualisation software using the values set out for each turbine and for each night-time viewpoint in Appendix 14.2. These visualisations seek to represent the maximum case scenario candela level for the lighting, taking account of the reduction in light emitted in relation to the vertical elevation angle at which they are viewed. They do not take into account the reduction in lighting intensity over distance given this varies considerably with atmospheric distance. They show a 'maximum case' scenario and a reduced candela scenario (10% of the maximum candela value), the latter of which represents a more realistic scenario given the clear weather conditions in which photography was taken. It should be noted that the maximum case scenario is considered to be unrealistic and is unlikely to occur in practice under clear weather conditions, except infrequently for example when visibility exceeds 5km, perhaps beneath a low cloud base. For completeness, dusk visualisations are also provided showing candela values at 200 (minimum case) and 2,000 (maximum case). These do not consider changes in brightness as a result of viewing angle. In addition, as set out in Appendix 14.2, it should be noted that based on meteorological data (visibility and cloud cover) obtained for the last 30 years for the closest meteorological stations (Inverness Airport), it is expected that the lights will operate at 200 candela (or 10% brightness) for about 96% of the time, when not obscured by cloud cover.

Effects on Landscape Character at Night

A6.5.52 In terms of effects on landscape character, and as noted previously, there will usually be a relatively small window of time, at dawn and dusk, or in conditions of bright moonlight or under snow cover, during which the landform is apparent along with existing and new light sources, and when an appreciation of landscape character and associated skyscapes is perceptible. Perception of landscape character in the true darkness of night and for most of the hours when it is proposed that turbines will be lit, will be limited, albeit that the skyscape with its stars, planets, satellites etc will be seen when it is clear. Only the proposed lighting, other human light sources, and human and natural sources in the night sky will be readily apparent when it is dark. As such, the main window during which effects on landscape character, and effects on many of the associated key characteristics will be experienced will be limited to the short period of twilight (shorter in winter, and more extended in summer), or moonlight (particularly under snow). Many key characteristics, and the experience of landscape character can only readily be appreciated during the day.

A6.5.53 Informed by **Figure A6.5.1** and **Figure** A**6.5.2,** the presence of aviation lighting positioned on the hubs of six turbines will be theoretically perceptible from the plateau area surrounding the Site (though at a lower intensity where below the turbines); across site-facing hills within approximately 20km ; and in a more intermittent pattern from higher site-facing hill flanks and summits within the wider Study Area.

A6.5.54 In general terms and focusing on Landscape Character Types (LCT) within 15km where significant effects on landscape character due to aviation lighting are more likely, perception of aviation lighting from the lower-lying glens will be limited. There is some theoretical visibility of aviation lighting, though at a reduced intensity due to viewing angle, indicated from the elevated sides of Strathglass (Farmed Strath – Inverness LCT 227) to the north-west of the Site, though woodland and forestry will limit visibility. Visibility is indicated from localised extents along the northern slopes of Glen Urquhart (Wooded Glen – Inverness LCT 226) to the north of the Site, though lights will be perceived at a reduced intensity in views from this location. Visibility is also indicated from localised extents Glen Affric (Wooded Glen – Inverness LCT 226) to the west of the Site and localised areas of Loch Ness to the north-east of Drumnadrochit (Broad Steep-Sided Glen LCT 225) where lights will be perceived at a reduced intensity. In these areas, relatively dark night skies[8] are experienced, though there is some influence of artificial light sources associated with settlement and moving vehicles.

A6.5.55 From more elevated LCTs including the Rugged Massif – Inverness LCT 220, Interlocking Sweeping Peaks – Inverness LCT 230 to the north and west of the Site, Rocky Moorland Plateau – Inverness LCT 222 to the north of the Site, Rolling Uplands – Inverness LCT 221 to the east and south-east of the Site, aviation lighting will appear at maximum intensity from the most elevated locations including hill summits, though at an intervening distance of approximately 10-20km. The intensity of lighting will be slightly reduced from less elevated slopes (below approximately 600m AOD) within these LCTs. From these more remote upland landscapes, unnatural sources of light from within undeveloped areas are limited[9]. Light sources, when visible, tend to be more distant views of subdued lighting from settlements and houses, including views towards settlement at Inverness and the Black Isle, and lights from vehicles. It is recognised that the Proposed Development will introduce additional light sources into the skyscape from certain parts of these more remote upland landscapes. However, given the small number of lights and the distance over which they will be experienced, this is unlikely to significantly erode the more 'remote' and 'wild' characteristics of these LCTs, even when seen at full intensity.

A6.5.56 Overall, in summary, no significant effects on landscape character are predicted at night. Effects of lighting will primarily affect views rather than landscape character.

Effects on Designated Landscapes and Wild Land Area

A6.5.57 In terms of effects on designated landscapes and wild land areas, and as noted previously, there will be a relatively small window of time, during dawn and dusk, when the landform is apparent along with existing and new light sources, and when landscape character can still be appreciated before darkness falls. At night-time, during most of the hours when turbines will be lit, the landscape will be under darkness, with only the proposed lighting and other light man made and natural light sources being apparent. As such,

[6] Visual Representation of Wind Farms Guidance - Version 2.2. (February 2017) Scottish Natural Heritage
[7] Technical Guidance Note 06/19 Visual Representation of Development Proposals (September 2019)
[8] However, none of these lower-lying LCTs have Key Characteristics (as noted in the 2019 NatureScot Landscape Character Type Descriptions) which relate to dark skies.
[9] However, none of these upland LCTs have Key Characteristics (as noted in the 2019 NatureScot Landscape Character Type Descriptions) which relate to dark skies.

the window over which effects on designated landscapes and wild land areas, and effects on many of the associated special qualities and key attributes (which can often only be appreciated during the daytime), will be limited. As for landscape character, effects on designated landscapes and wild land will primarily be visual.

A6.5.58 Informed by **Figure A6.5.1** and **Figure** A**6.5.2** the presence of aviation lighting positioned on the hubs of six turbines will be theoretically perceptible from the Glen Affric NSA and Central Highlands WLA. There is some theoretical visibility of aviation lighting, though at a reduced intensity due to viewing angle, from localised lower-lying areas within the Glen Affric NSA. Theoretical visibility of lighting within the NSA is focused within the elevated glen sides in the north and south of the NSA, with lights occasionally appearing at maximum intensity due to viewing angle. Within the Central Highlands WLA, theoretical visibility is focused on elevated landform and summits. Aviation lighting will appear at maximum intensity from the most elevated locations including hill summits, though at an intervening distance of approximately 10-20km.

A6.5.59 Existing visible aviation lighting on the operational Corrimony Wind Farm can be viewed from the elevated slopes and localised extents of the glen floor within the Glen Affric NSA and elevated landform and hill summits of the Central Highlands WLA, as illustrated in **Figure 6.5.3**. Given this existing influence of turbine lighting, the Proposed Development will introduce additional artificial lighting into limited areas of the NSA and WLA. The Proposed Development will increase the horizontal extent and prominence of visible aviation lighting, and aviation lighting will increase the duration over which potential effects on Special Landscape Qualities (SLQs) and Wild Land Qualities (WLQs) are experienced. However, visible aviation lighting associated with the Proposed Development is not considered to result in additional significant effects on the SLQs of the NSA or WLQs of the WLA. Further information regarding the effects on the SLQs of the NSA and WLQs of the WLA are included in the **Appendix 6.3:** and **Appendix 6.4** respectively.

A6.5.60 As is the case for effects upon landscape character, effects at night-time will predominantly alter views of night skies rather than influence the landscape character of designated landscapes or wild land areas. Changes to views are described below.

Effects on Visual Amenity

Aviation Lighting Visibility from Assessment Viewpoints

A6.5.61 The table below details the predicted visibility of the proposed turbine lighting from each LVIA assessment viewpoint (informed by Appendix A of the Aviation Lighting and Mitigation Report). The table also indicates the potential influence of coniferous forestry in further screening the theoretical visibility of turbine lighting from each viewpoint location informed by the baseline photography and observations from fieldwork.

A6.5.62 As noted above the frequency of the effect should also be considered. Aviation lighting will only be apparent during hours of darkness which changes with the seasons. As such, in the summer months the length of time when visible aviation lighting will be apparent will reduce.

Table A6.5.2: Summary of Turbine Lighting Visibility

Summary of Turbine Aviation Lighting Visibility						
Hub lighting potentially visible (i.e. one medium intensity hub light)	•		Turbine hub lighting obscured from viewpoint but may be visible in the vicinity of the viewpoint		△	
Viewpoint	**T1**	**T4**	**T7**	**T10**	**T12**	**T13**
Viewpoint 1 - Affric-Kintail Way, near Braefield	n/a	n/a	n/a	n/a	•	△
Viewpoint 2 - Meall Fuar-mhonaidh	•	•	•	•	•	•
Viewpoint 3 - Balbeg	n/a	n/a	n/a	n/a	n/a	n/a
Viewpoint 4 - Affric Kintail Way, West of Cannich	n/a	n/a	n/a	n/a	n/a	•
Viewpoint 5 - Coire Loch Trail, Glen Affric	△	n/a	•	•	•	n/a
Viewpoint 6 -B862 near Whitebridge	n/a	n/a	n/a	n/a	n/a	n/a
Viewpoint 7 - A833 near Balnagrantach	n/a	n/a	n/a	•	•	•
Viewpoint 8 - B862 Suidhe Viewpoint	•	•	•	•	•	•
Viewpoint 9 - Meall Mor, above Glen Affric	•	•	•	•	•	•
Viewpoint 10 - Creag Dhubh	•	•	•	•	•	•
Viewpoint 11 - Carn na Leitire	•	•	•	•	•	•
Viewpoint 12 - Beinn a' Bha'ach Ard	•	•	•	•	•	•
Viewpoint 13 - B852 Erchite Wood, east of Loch Ness (picnic area)	•	•	•	n/a	△	n/a
Viewpoint 14 - Meall Dubh	•	•	•	•	•	•
Viewpoint 15 Core Path at Loch Affric	n/a	n/a	•	•	•	•
Viewpoint 16 - B862 South of Dores	•	•	•	•	•	•
Viewpoint 17 - Carn na Saobhaidhe	•	•	•	•	•	•
Viewpoint 18 – Toll Creagach	•	•	•	•	•	•
Viewpoint 19 - Sgurr nan Conbhairean	n/a	•	•	•	•	•
Viewpoint 20 - Carn Dearg	•	•	•	•	•	•

Representative Assessment Viewpoints

A6.5.63 Whilst the potential visibility of aviation lighting is summarised for each of the LVIA assessment viewpoints (as set out in **Appendix Table A6.5.2** above) the following assessment focuses on representative viewpoints agreed through consultation with The Highland Council (THC) and NatureScot.

A6.5.64 The three assessment viewpoints represent views from settlements and hill summits within 20km. One of the assessment viewpoints is taken from a slightly elevated section of the Affric-Kintail Way, as it passes across a minor road near residential properties on the northern slopes of Glen Urquhart. Given its proximity to areas where people live, this viewpoint is more likely to be frequented during the hours of darkness by visual receptors, including residents. The other two assessment viewpoints represent elevated views from within designated landscapes and wild land areas. These locations are less likely to be frequented during the hours of darkness.

A6.5.65 Dusk/Night-time photomontage visualisations were produced for the following three assessment viewpoints:

- Viewpoint 1: Affric Kintail Way near Braefield (**Figure 6.14, Volume 3a: NatureScot LVIA Visualisations**);
- Viewpoint 10: Creag Dhubh (**Figure 6.23, Volume 3a: NatureScot LVIA Visualisations**); and

- Viewpoint 18: Toll Creagach (**Figure 6.31, Volume 3b: NatureScot LVIA Visualisations**).

A6.5.66 Photomontage visualisations illustrate the aviation lighting at both the 'maximum case' scenario and the more realistic representation of 10% of maximum emitted light during clear weather conditions (noting that this is measured at the location of the sensor). The representative visualisations take account of the potential reduction in light emitted in relation to the relevant vertical elevation angle at which they are viewed, as detailed in the WPAC Aviation Lighting Report (**Appendix 14.2**), but do not account for the reduction in light emitted over distance due to the variability of this decline with changing atmospheric conditions. The methodology for the preparation of night-time visualisations is detailed in full in **Appendix 6.2**.

Table A6.5.3: Viewpoint 1: Affric-Kintail Way, near Braefield

Viewpoint 1: Affric-Kintail Way, near Braefield				
Grid Reference	240594	830432	**Figure Number**	Figure 6.14e-h
LCT	Wooded Glen – Inverness (LCT 226)		**Landscape Designation**	None
Direction of View	South		**Distance to nearest turbine**	5.8km
Number of hubs theoretically visible	1		**Number of turbines with blades theoretically visible**	6
Maximum candela (cd) level (Annex A and Appendix A, Appendix 14.2)	T12 - 145cd (T13 – 138.4cd)		**Reduced (10% of Maximum) candela level** (Annex A and Appendix A, Appendix 14.2)	T12 - 14.5cd (T13 – 13.8cd)
Location, description of existing view and potential receptors	This viewpoint is located on the Affric Kintail Way, on a section of the route that has been recently realigned along tracks north of the A831 and passes through mixed woodland and forestry between Braefield and Buntait. The viewpoint represents views experienced by recreational receptors on the Affric Kintail Way and similar views experienced from nearby residential properties. Views south overlook Glen Urquhart with landform located along the northern site boundary, including Suidhe Ghuirmain, Carn na h-Imrich and Carn Macsna forming the background and skyline of views. Relatively dark skies are experienced at night in views from this location. Artificial lighting in the view is limited to occasional lighting associated with relatively small clusters of residential properties scattered along the floor of the glen and vehicles passing on the A831. There are no views of existing wind farm development from this location, however Corrimony Wind Farm, and its associated lighting, is visible in views from properties located approximately 1.2km further west along the minor road.			
Night-time sensitivity	Recreational and residential receptors are considered to be of high susceptibility to changes in night-time views. The viewpoint is not located within a designated landscape, and there is no specific value attached to night-time views. In the context of the settlement the value of the night-time view is judged to be medium. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **medium**.			
Assessment of visual effects – Maximum candela and Reduced (10% Maximum) candela[10] (Primary assessment)	**Figure 6.14e** illustrates the view of the Proposed Development at night with a maximum candela level of 145cd during the maximum illumination mode. When lit at maximum illumination, lighting on the hub of one of the six lit turbines will be visible just above the dark horizon in views to the south, at a distance of 5.9km from the nearest lit turbine. The lit turbine will introduce visible artificial lighting in relatively dark night skies and will be seen in the middle distance of views. The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness. Overall, the scale of change associated with visible aviation lighting is judged to be small for the maximum candela level of 145 candela, however this will only occur when atmospheric conditions such as low cloud cover and mist limit visibility to distances of less than 5km, but when the lights can still be seen for example from below the cloud base. Views of the operational lit Corrimony turbines are available within approximately 1.2km of this location. As such, the geographical extent of similar views, in which the Proposed Development is perceived to introduce artificial lighting above the horizon, is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at maximum illumination. **Figure 6.14f** illustrates the view of the Proposed Development at night with a minimum candela level of 14.5cd during the reduced intensity mode. When lit at the reduced intensity, lighting on the hub of one of the six lit turbines will be barely perceptible just above the dark horizon in views to the south, at a distance of 5.9km from the nearest lit turbine. At times of clear atmospheric conditions when the lights will appear at the reduced candela level of 14.5cd, the scale of change is judged to be small. The geographical extent of the change is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at reduced illumination.			
Assessment of visual effects – 2,000/200cd lighting[11] (Primary assessment)	The magnitude of change for 2,000 candela (maximum) illumination scenario (illustrated in **Figure 6.14g**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur. The magnitude of change for 200 candela (minimum) illumination scenario (illustrated in **Figure 6.14h**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur.			
Assessment of Cumulative Effects under alternative baselines (Scenario 1 and 2)	No other consented or proposed wind energy developments with visible aviation lighting will be perceptible in views from this location therefore no additional cumulative visual effects are predicted to occur for either cumulative assessment scenario. The level of effect will remain as assessed for the primary assessment.			

Table A6.5.4: Viewpoint 10: Creag Dhubh

Viewpoint 10: Creag Dhubh				
Grid Reference	222497	821647	**Figure Number**	Figure 6.23e-h
LCT	Rugged Massif – Inverness (LCT 220)		**Landscape Designation**	Central Highlands WLA
Direction of View	East		**Distance to nearest turbine**	15.1km
Number of hubs theoretically visible	13		**Number of turbines with blades theoretically visible**	13
Maximum candela level (Annex A and Appendix A, Appendix 14.2)	T1, T4, T13 – 1721.2cd T7, T10, T12 – 1582.1cd		**Reduced (10% of Maximum) candela level** (Annex A and Appendix A, Appendix 14.2)	T1, T4, T13 – 172.1cd T7, T10, T12 – 158.2.d
Location, description of existing view and potential receptors	This viewpoint is located on the local hill summit of Creag Dubh (539m AOD) on the southern boundary of the Glen Affric NSA and within the Central Highlands WLA 24. The viewpoint represents views experienced by recreational receptors. Relatively open and panoramic views are afforded from this elevated location. During the day, views are focused south-west towards the hill summits above Glen Affric and Kintail. Views east, towards the Proposed Development, overlook the rolling moorland summit of Creagh Dubh, with occasional rocky outcrops and small lochans. The elevated moorland ridgeline along the western Site boundary forms the background of the view. Relatively dark night skies are experienced in views from this location. However, visible lighting on the hubs of the operational Corrimony Wind Farm is barely perceptible in views east.			
Night-time sensitivity	Recreational receptors are considered to be of high susceptibility to changes in night-time views.			

[10] This scenario takes into account inbuilt angle intensity mitigation to reflect a more realistic account of the likely perceived brightness of aviation lighting due to viewing angle and distance to the receptor.

[11] This scenario does not take into account inbuilt angle intensity mitigation and would therefore not occur. The assessment and visualisations reflecting this scenario are provided for completeness and to enable comparisons with visualisations prepared by other consultants.

Viewpoint 10: Creag Dhubh	
	The viewpoint overlooks the Glen Affric NSA and is located within the Central Highlands WLA. The value of the night-time view is therefore considered to be high. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **high**.
Assessment of visual effects – Maximum candela and Reduced (10% Maximum) candela[12] (Primary assessment)	**Figure 6.23e** illustrates the view of the Proposed Development at night with a maximum candela level of 1582.1-1721.2cd during the maximum illumination mode. When lit at maximum illumination, lighting on the hubs of all six of the lit turbines will be visible just above the dark horizon in views to the east, at a distance of 15.1km from the nearest lit turbine. Lit turbines will be seen in a similar part of the view as the barely perceptible lit turbines of the operational Corrimony Wind Farm. The lighting of the Proposed Development will increase the horizontal extent of visible artificial lighting in otherwise dark night skies, however, lighting will appear as a distant feature and will not be evident in views. The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness. Overall, the scale of change associated with visible aviation lighting is judged to be small for the maximum candela level of 1582.1-1721.2cd, however this will only occur when atmospheric conditions such as low cloud cover and mist limit visibility to distances of less than 5km, but when the lights can still be seen for example from below the cloud base. The geographical extent of the change is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at maximum illumination. **Figure 6.23f** illustrates the view of the Proposed Development at night with a minimum candela level of 158.2-172.1cd during the reduced intensity mode. When lit at the reduced intensity, lighting on the hubs of all six lit turbines will be barely perceptible just above the dark horizon in views to the east, at a distance of 15.1km from the nearest lit turbine. Lighting will appear slightly brighter than that of the operational Corrimony Wind Farm. At times of clear atmospheric conditions when the lights will appear at the reduced candela level of 158.2-172.1cd, the scale of change is judged to be small. The geographical extent of the change is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at reduced illumination.
Assessment of visual effects – 2,000/200cd lighting[13] (Primary assessment)	The magnitude of change for 2,000 candela (maximum) illumination scenario (illustrated in **Figure 6.23g**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur. The magnitude of change for 200 candela (minimum) illumination scenario (illustrated in **Figure 6.23h**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur.
Assessment of Cumulative Effects under alternative baselines (Scenario 1 and 2)	Scenario 1: No other consented wind energy proposals include the implementation of visible turbine lighting therefore no additional cumulative visual effects are predicted to occur for this cumulative assessment scenario. The level of effect will remain as assessed for the primary assessment. Scenario 2: Visible aviation lighting will be seen on the hub of one turbine (T7[14]) of the proposed Tomchrasky Wind Farm in views south. This will increase the horizontal extent of artificial lighting in otherwise dark views, however, the Proposed Development will appear separately and in a different angle of the view. The magnitude of change to views will remain low and the visual effect will be **minor** (adverse) and **not significant.**

Table A6.5.5: Viewpoint 18: Toll Creagach

Viewpoint 18: Toll Creagach				
Grid Reference	219446	828294	**Figure Number**	Figure 6.31g-j
LCT	Rugged Massif - Skye & Lochalsh (LCT 365)		**Designated Landscape**	Glen Affric NSA, Strathconan, Monar and Mullardoch SLA and Central Highlands WLA
Direction of View	East		**Distance to Nearest Turbine (km)**	18.6km
Number of hubs theoretically visible	13		**Number of turbines with blades theoretically visible**	13
Maximum candela level (Annex A and Appendix A, Appendix 14.2)	T1, T7, T10, T13 – 2439.4cd T4, T12 – 2471.1cd		**Reduced (10% of Maximum) candela level** (Annex A and Appendix A, Appendix 14.2)	T1, T7, T10, T13 – 243.9cd T4, T12 – 247.1cd
Location, description of existing view and potential receptors	This viewpoint is located on the Munro hill summit of Toll Creagach (1054m AOD) within the Strathconan, Monar and Mullardoch SLA and Central Highlands WLA, and near the boundary of the Glen Affric NSA. The viewpoint is representative of views experienced by recreational receptors. Relatively open and panoramic views are afforded from this elevated location. Views east overlook descending rocky moorland and the forested slopes of Glen Affric. Layers of receding ridgelines and more distant landform forms the background of the view. Daytime views are generally focused towards the more dramatic and distinctive hill summits seen in successive views looking south to west. Some distant sources of artificial lighting exert a small influence on views from this location. Visible lighting on the operational Corrimony Wind Farm is barely perceptible in views east. Other artificial light sources in the view include distant lighting related to settlement at Inverness and the Black Isle in views north-east.			
Night-time sensitivity	Recreational receptors are considered to be of high susceptibility to changes in night-time views. The viewpoint is located within the Strathconan, Monar and Mullardoch SLA and Central Highlands WLA and overlooks the Glen Affric NSA. The value of the view is therefore considered to be high. On balance, taking account of the judgements of susceptibility and value, the overall sensitivity of receptors at this viewpoint is judged to be **high**.			
Assessment of visual effects – Maximum candela and Reduced (10% Maximum) candela[15] (Primary assessment)	**Figure 6.31g** illustrates the view of the Proposed Development at night with a maximum candela level of 2439.4-2471.1cd during the maximum illumination mode. When lit at maximum illumination, lighting on the hubs of all six of the lit turbines will be visible in front of dark landform in views to the east, at a distance of 15.1km from the nearest lit turbine. Lit turbines will appear as relatively faint and distant features, seen beyond the barely perceptible lit turbines of the operational Corrimony Wind Farm. The lighting of the Proposed Development will slightly increase the amount of visible artificial lighting in this part of the view, with further influence of artificial lighting in views looking north-east towards Inverness and the Black Isle. The visibility and perceived intensity of lighting will vary at different times dependent on viewing conditions, whilst the duration over which the visible lighting is evident will vary seasonally, in relation to the hours of relative darkness. Overall, the scale of change associated with visible aviation lighting is judged to be small for the maximum candela level of 2439.4-2471.1cd, however this will only occur when atmospheric conditions such as low cloud cover and mist limit visibility to distances of less than 5km, but when the lights can still be seen for example from below the cloud base. The geographical extent of the change is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at maximum illumination. **Figure 6.31h** illustrates the view of the Proposed Development at night with a minimum candela level of 243.9-247.1cd during the reduced intensity mode. When lit at the reduced intensity, lighting on the hubs of all six lit turbines will be barely perceptible in front of dark landform in views to the east, at a distance of 18.6km from the nearest lit turbine. Lighting will appear slightly brighter than that of the operational Corrimony Wind Farm. At times of clear atmospheric conditions			

[12] This scenario takes into account inbuilt angle intensity mitigation to reflect a more realistic account of the likely perceived brightness of aviation lighting due to viewing angle and distance to the receptor.
[13] This scenario does not take into account inbuilt angle intensity mitigation and would therefore not occur. The assessment and visualisations reflecting this scenario are provided for completeness and to enable comparisons with visualisations prepared by other consultants.

[14] Aviation lighting proposal for Tomchrasky Wind Farm detailed in Appendix 14-1: Wind Farm Aviation Lighting and Mitigation Report, November 2022 (ECU reference: ECU00004663)
[15] This scenario takes into account inbuilt angle intensity mitigation to reflect a more realistic account of the likely perceived brightness of aviation lighting due to viewing angle and distance to the receptor.

Viewpoint 18: Toll Creagach	
	when the lights will appear at the reduced candela level of 243.9-247.1cd, the scale of change is judged to be small. The geographical extent of the change is judged to be small. The overall magnitude of change is judged to be low and taking account of the high sensitivity will result in a **minor** (adverse) and **not significant** visual effect when turbines are lit at reduced illumination.
Assessment of visual effects – 2,000/200cd lighting[16] (Primary assessment)	The magnitude of change for 2,000 candela (maximum) illumination scenario (illustrated in **Figure 6.31i**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur. The magnitude of change for 200 candela (minimum) illumination scenario (illustrated in **Figure 6.31j**) would remain low, resulting in a **minor** (adverse) and **not significant** visual effect. Given the angle intensity mitigation will be inbuilt into the lights, in practice this scenario would not occur.
Assessment of Cumulative Effects under alternative baselines (Scenario 1 and 2)	Scenario 1: No other consented wind energy proposals include the implementation of visible turbine lighting therefore no additional cumulative visual effects are predicted to occur for this cumulative assessment scenario. The level of effect will remain as assessed for the primary assessment. Scenario 2: Visible aviation lighting will be seen on the hub of two turbines (T1 and T13) of the proposed Tomchrasky Wind Farm in views south-east. The proposed Tomchrasky Wind Farm will introduce artificial lighting into a relatively dark angle of the view and lit turbines will appear slightly closer in views from this location. However, the Proposed Development will appear in a separate angle of the view, with the limited influence of artificial lighting remaining relatively distant in panoramic views from this location. The cumulative magnitude of change to views will remain low and the visual effect will be **minor** (adverse) and **not significant.**

Summary of Lighting Effects

A6.5.67 Due to the reduced lighting scheme, which has been agreed through consultation with the CAA and includes medium intensity 'steady' red (2,000 candela) lights on the nacelles of six turbines only, significant landscape and visual effects associated with aviation lighting are judged to be limited.

A6.5.68 No significant effects on landscape character, designated landscapes or WLA are anticipated. Whilst dark sky qualities are not specifically recognised for any LCT, designated landscape or WLA considered in this assessment, many of these landscapes have wild, remote and naturalistic characteristics to which dark skies contribute. However, at the distances concerned, it will be infrequent for the maximum candela lighting to be seen, given this will typically be used when atmospheric visibility is below 5km (as measured at the location of the sensor). More usually, clear conditions will be required for lighting to be seen over these distances, in which case the 10% candela lighting will be activated. There will be some exceptions to this e.g. when atmospheric visibility is reduced by small or sporadic cloud at the point of measurement on the turbines, but is clear beyond this and at the location of the viewpoint, or for example when the cloud base is below the sensor, but visibility is good beneath it and at the location of viewpoints. In this instance though, there will still be some attenuation of the light by the cloud that it is within.

A6.5.69 No significant visual effects are predicted to result from the introduction of visible aviation lighting for each of the three representative assessment viewpoints. When viewing the lights from lower viewpoints, then the intensity that will be seen will be much reduced. The night-time visualisations from VP1: Affric-Kintail Way, near Braefield, and to a lesser extent VP10: Creag Dubh, illustrate the reduced lighting intensity which would be experienced due to the difference between the angle of a horizonal plane extending from hub height, and the angle of a plane extending from the elevation of the viewpoint. The representative visualisations do not take account of the influence of weather conditions which are often not as clear as when the photography was captured. In conditions of meteorological visibility of less than 5km, the perceived brightness of maximum intensity lights, whilst possibly still visible, are likely to be substantially reduced. In such conditions the lights will typically not be visible at distances much greater than 5km from turbines.

A6.5.70 Weather conditions therefore will influence the actual brightness of the lights perceived. This will include from remote mountain summits in the Glen Affric NSA and Central Highlands WLA, where the increased viewing distance will further reduce the actual brightness of the light perceived.

[16] This scenario does not take into account inbuilt angle intensity mitigation and would therefore not occur. The assessment and visualisations reflecting this scenario are provided for completeness and to enable comparisons with visualisations prepared by other consultants.

Annex A: Predicted Luminous Intensity of Nacelle Mounted Aviation Lighting

Table A6.5.6: Predicted Luminous Intensity of Nacelle Mounted Aviation Lighting – All LVIA Viewpoints

LVIA Viewpoints - Predicted Luminous Intensity (Candela/cd)							
		Legend n/a – light obscured by landform from viewpoint; Purple – light potentially obscured by landform from viewpoint as detailed in **Appendix 14.2: Aviation Lighting and Mitigation Report**[17]; and Green – light potentially obscured by woodland from viewpoint.					
		Turbine No.					
Viewpoint	**Luminous Intensity** – Full or 10% of Maximum Intensity	**T1**	**T4**	**T7**	**T10**	**T12**	**T13**
VP1: Affric Kintail Way, near Braefield	Full	n/a	n/a	n/a	n/a	145	138.4
	10%	n/a	n/a	n/a	n/a	14.5	13.8
VP2: Meall Fuar-mhonaidh	Full	2,452.1	2,428.2	2,379.4	2,379.4	2,379.4	2,428.2
	10%	245.2	242.9	237.9	237.9	237.9	242.9
VP3: Balbeg	Full	n/a	n/a	n/a	n/a	n/a	n/a
	10%	n/a	n/a	n/a	n/a	n/a	n/a
VP4: Affric Kintail Way, West of Cannich	Full	n/a	n/a	n/a	n/a	n/a	212.3
	10%	n/a	n/a	n/a	n/a	n/a	21.2
VP5: Coire Loch Trail, Glen Affric	Full	309.1	n/a	239.3	239.3	273.5	n/a
	10%	30.9	n/a	23.9	23.9	27.4	n/a
VP6: B862 near Whitebridge	Full	n/a	n/a	n/a	n/a	n/a	n/a
	10%	n/a	n/a	n/a	n/a	n/a	n/a
VP7: A833 near Balnagrantach	Full	n/a	n/a	n/a	576.0	576.0	576.0
	10%	n/a	n/a	n/a	57.6	57.6	57.6
VP8: B862 Suidhe Viewpoint	Full	982.0	902.2	902.2	982.0	982.0	1,087.1
	10%	98.2	90.2	90.2	98.2	98.2	108.7
VP9: Meall Mor, above Glen Affric	Full	2,330.0	2,257.6	2,257.6	2,257.6	2,257.6	2,330.0
	10%	233	225.8	225.8	225.8	225.8	233
VP10: Creag Dhubh	Full	1,721.2	1,721.2	1,582.1	1,582.1	1,582.1	1,721.2
	10%	172.1	172.1	158.2	158.2	158.2	172.1

[17] To take into account any limitations within the terrain model we have highlighted in purple any viewpoints where the line of sight is under 10 metres above ground level but above 1.5 metres and should therefore, still be screened by terrain but may be visible within the vicinity of the viewpoint.

VP11: Carn na Leitire	Full	1,442.9	1,317.5	1,317.5	1,317.5	1,317.5	1,317.5
	10%	144.3	131.8	131.8	131.8	131.8	131.8
VP12: Beinn a' Bha'ach Ard	Full	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8	2,452.1
	10%	242.9	242.9	242.9	242.9	242.9	245.2
VP13: B852 Erchite Wood, east of Loch Ness (picnic area)	Full	576.0	483.7	529.8	n/a	483.7	n/a
	10%	57.6	48.4	53.0	n/a	48.4	n/a
VP14: Meall Dubh	Full	2,428.8	2,379.4	2,379.4	2,379.4	2,379.4	2,379.4
	10%	242.9	237.9	237.9	237.9	237.9	237.9
VP15: Core Path at Loch Affric	Full	n/a	n/a	902.2	902.2	982.0	982.0
	10%	n/a	n/a	90.2	90.2	98.2	98.2
VP16: B862 South of Dores	Full	902.2	822.4	822.4	822.4	822.4	822.4
	10%	90.2	82.2	82.2	82.2	82.2	82.2
VP17: Carn na Saobhaidhe	Full	2,428.8	2,428.8	2,379.4	2,379.4	2,379.4	2,379.4
	10%	242.9	242.9	237.9	237.9	237.9	237.9
VP18: Toll Creagach	Full	2,439.4	2,471.1	2,439.4	2,439.4	2,471.1	2,439.4
	10%	243.9	247.1	243.9	243.9	247.1	243.9
VP19: Sgurr nan Conbhairean	Full	n/a	2,514.7	2,508.8	2,514.7	2,514.7	2,514.7
	10%	n/a	251.4	250.9	251.4	251.4	251.4
VP20: Carn Dearg	Full	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8	2,428.8
	10%	242.9	242.9	242.9	242.9	242.9	242.9

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Appendix 6.5
Figure A6.5.1: Visible Aviation Light Intensity Zone of Theoretical Visibility - 45km

- Site boundary
- Turbine with nacelle lighting
- Turbine with no nacelle lighting
- 5km intervals from outermost turbines
- LVIA study area 45km from outermost turbines
- Viewpoint

VP1: Affric-Kintail Way, near Braefield
VP2: Meall Fuar-mhonaidh
VP3: Balbeg
VP4: Affric Kintail Way, West of Cannich
VP5: Coire Loch Trail, Glen Affric
VP6: B862 near Whitebridge
VP7: A833 near Balnagrantach
VP8: B862 Suidhe Viewpoint
VP9: Meall Mor, above Glen Affric
VP10: Creag Dhubh
VP11: Carn na Leitire
VP12: Beinn a' Bha'ach Ard
VP13: B852 Erchite Wood, east of Loch Ness (picnic area)
VP14: Meall Dubh
VP15: Core Path at Loch Affric
VP16: B862 South of Dores
VP17: Carn na Saobhaidhe
VP18: Toll Creagach
VP19: Sgurr nan Conbhairean
VP20: Carn Dearg

Vertical angle of lighting from nacelle	Maximum and Minimum luminous intensity (Candela/cd)	10% of Maximum and Minimum luminous intensity (Candela/cd)
Above 2°	1568 to 632	156 to 63
1° to 2°	2306 to 1630	230 to 163
0° to 1°	2341 to 2067	234 to 206
-1° to 0°	1965 to 850	196 to 85
-2° to -1°	832 to 356	83 to 35
-3° to -2°	344 to 188	34 to 18
Below -3°	≤188cd	≤18cd

*Note: Details of data that inform the lighting intensity ZTV can be found in **Appendix 6.2: ZTV Mapping and Visualisation Methodology**'*

Notes:
Dusk viewpoints shown in blue

The ZTV is calculated to nacelle lighting height (102.5-122.5m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 1, 4, 7, 10, 12, and 13. The ZTV shows lighting intensity of a single nacelle light according to vertical angle only and does not account for distance. The terrain model assumes bare ground and is derived from OS Terrain 5 height data (obtained from Emapsite in November 2022). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcMap 10.8.1 software.

Statkraft

Map scale 1:360,000 @ A3

CB:HW EB:wingfield_h LUC Fig_A6_5_1_11057_Light_Intensity_ZTV_45km_A3L 26/04/2023
Source: Statkraft, LUC

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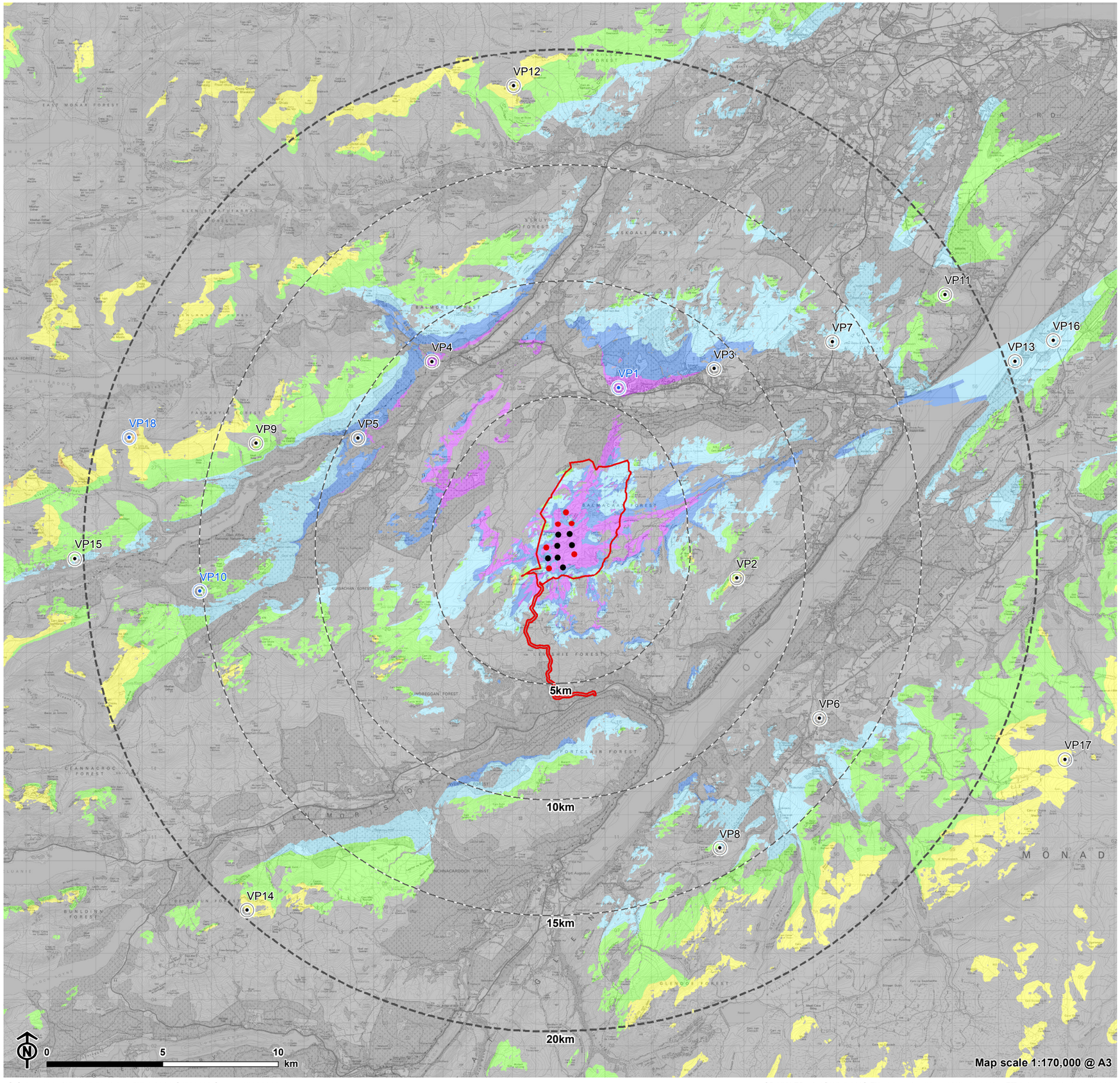
Appendix 6.5
Figure A6.5.2: Visible Aviation Light Intensity Zone of Theoretical Visibility - 20km



Site boundary
Turbine with nacelle lighting
Turbine with no nacelle lighting
5km intervals from outermost turbines
LVIA study area 20km from outermost turbines
Viewpoint

VP1: Affric-Kintail Way, near Braefield
VP2: Meall Fuar-mhonaidh
VP3: Balbeg
VP4: Affric Kintail Way, West of Cannich
VP5: Coire Loch Trail, Glen Affric
VP6: B862 near Whitebridge
VP7: A833 near Balnagrantach
VP8: B862 Suidhe Viewpoint
VP9: Meall Mor, above Glen Affric
VP10: Creag Dhubh
VP11: Carn na Leitire
VP12: Beinn a' Bha'ach Ard
VP13: B852 Erchite Wood, east of Loch Ness (picnic area)
VP14: Meall Dubh
VP15: Core Path at Loch Affric
VP16: B862 South of Dores
VP17: Carn na Saobhaidhe
VP18: Toll Creagach

Vertical angle of lighting from nacelle	Maximum and Minimum luminous intensity (Candela/cd)	10% of Maximum and Minimum luminous intensity (Candela/cd)
Above 2°	1568 to 632	156 to 63
1° to 2°	2306 to 1630	230 to 163
0° to 1°	2341 to 2067	234 to 206
-1° to 0°	1965 to 850	196 to 85
-2° to -1°	832 to 356	83 to 35
-3° to -2°	344 to 188	34 to 18
Below -3°	≤188cd	≤18cd

*Note: Details of data that inform the lighting intensity ZTV can be found in **Appendix 6.2: ZTV Mapping and Visualisation Methodology**'*

Notes:
Dusk viewpoints shown in blue

The ZTV is calculated to nacelle lighting height (102.5-122.5m) from a viewing height of 2m above ground level. The turbines that are proposed to have nacelle lighting are turbines 1, 4, 7, 10, 12, and 13. The ZTV shows lighting intensity of a single nacelle light according to vertical angle only and does not account for distance. The terrain model assumes bare ground and is derived from OS Terrain 5 height data (obtained from Emapsite in November 2022). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcMap 10.8.1 software.

Statkraft

CB:HW EB:wingfield_h LUC Fig_A6_5_2_11057_Light_Intensity_ZTV_20km_A3L 26/04/2023
Source: Statkraft, LUC

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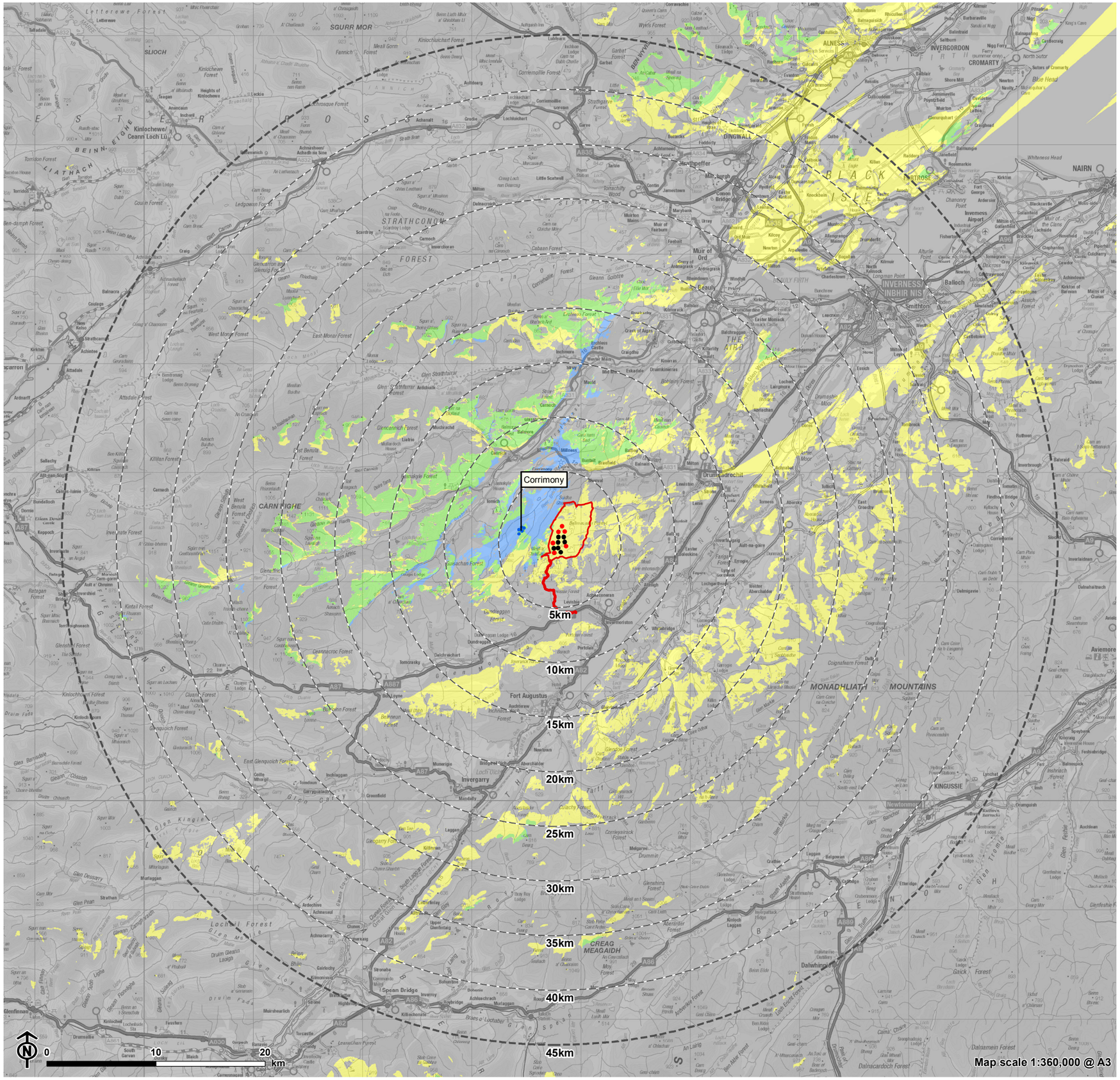
Appendix 6.5
Figure A6.5.3: CZTV (Hub Height) - Loch Liath and Corrimony Wind Farm



- Site boundary
- Turbine with nacelle lighting
- Turbine with no nacelle lighting
- 5km intervals from outermost turbines
- LVIA study area 45km from outermost turbines
- Only Corrimony wind farm visible
- Only Loch Liath's lit turbine hubs visible
- Corrimony wind farm and Loch Liath's lit hubs visible

Wind farm developments (by status)

- Operational

Notes:
The ZTV compares the lit turbines hubs of Loch Liath (102.5-122.5m) with all turbine hubs of Corrimony (59m) from a viewing height of 2m above ground level.The turbines that are proposed to have nacelle lighting are turbines 1, 4, 7, 10, 12 and 13. The terrain model assumes bare ground and is derived from OS Terrain 5 height data (obtained from Emapsite in November 2022). Earth curvature and atmospheric refraction have been taken into account. The ZTV was calculated using ArcMap 10.8.1 software.

Statkraft

CB:HW EB:wingfield_h LUC Fig_A6_5_3_11057_r0_Comparative_Hub_ZTV_LochLiath_Corry_A3L 24/04/2023
Source: Statkraft, LUC