Chapter 14

Other Issues

SCOTTISHPOWER RENEWABLES

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Other Issues

14.1 Introduction

1. This Chapter assesses the potential effects of the construction and operation of the proposed Development on the following issues:

- aviation;
- shadow flicker;
- forestry;
- climate and carbon balance;
- land use; and
- telecommunications.

2. The following aspects were scoped out of further assessment:

- Television – Since the introduction of digital television signals, effects on television reception have substantially reduced. Given the absence of residential properties in close proximity to the Site effects on television reception are considered extremely unlikely and were scoped out of further assessment within the EIAR.
- Air Quality – The only appreciable emission to air caused by the proposed Development would be emissions from construction traffic and dust generation from borrow pit excavations. Due to the distance from residential receptors and the use of industry standard measures to control potential effects on air quality during construction (e.g. dust mobilisation and construction vehicle emissions) through implementation of a Construction Environmental Management Plan (CEMP), these effects are not considered likely to be significant and were therefore scoped out of further assessment within the EIAR.
- Human Health - Properly designed and maintained wind turbines and associated infrastructure are safe technologies. The Site location, design and inbuilt buffers from sensitive receptors have minimised the risk to humans from the operation of the proposed Development. Risks associated with ice build-up, lightning strike and structural failure are removed or reduced through inbuilt turbine mechanisms in modern machines. The combination of best practice construction health and safety methods, the distance of residential receptors from the proposed Development as well as no significant effects on recreational receptors means there is minimal potential for direct effects on human health and this topic was therefore scoped out of further assessment within the EIAR.
- Major Accidents and Disasters – the proposed Development is not located within an area with a history of natural disasters such as extreme weather events, and the construction and operation of the proposed Development would be managed within the requirements of a number of health and safety regulations. Potential for any impacts has been assessed in the relevant technical assessment chapters (refer to **Chapter 7: Hydrology, Hydrogeology, Geology & Soils**, and **Chapter 12: Access, Traffic & Transport**), and any predicted effects are reported after relevant mitigation measures have been applied to the identified impact. It is considered there is minimal risk of major accidents and / or disasters occurring as a result of the proposed Development and this has therefore been scoped out of further assessment within the EIAR.

14.2 Aviation

3. The installation of wind turbines has the potential to cause a variety of adverse effects on aviation interests during turbine operation. These include, but are not limited to:

- generation of unwanted returns on Primary Surveillance Radar (PSR); and
- adverse effects on overall performance of Communications, Navigation and Surveillance (CNS) equipment, where such impacts can be shown to detrimentally impact the safe and efficient provision of air traffic services or the defence of the realm.

4. Cyrrus Limited were engaged to conduct an aviation assessment and provide guidance on aviation issues associated with the proposed Development. The full report is provided within **Technical Appendix 14.2**.

14.2.1 Legislation, Policy and Guidelines

5. The UK statutory requirements for the lighting of en-route obstacles (i.e. those away from the vicinity of a licenced aerodrome) are set out in Article 222 of the UK Air Navigation Order 2016. Article 222 requires, as a general rule, all obstacles over 150 m to be lit with medium intensity (2000 candela) steady red aviation warning lights at regular intervals (less than 52 m) up the obstacle's full height. Article 222 reflects the provision of ICAO SARPS Annex 14 paragraph 4.2.3 which states "*In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 150m or more above ground elevation should be regarded as obstacles, unless a special aeronautical study indicates that they do not constitute a hazard to aeroplanes*."

6. The Civil Aviation Authority (CAA) Policy Statement on Lighting of Onshore Wind Turbine Generators in the United Kingdom with a Maximum Blade Tip Height At or In Excess of 150 m Above Ground Level (CAA, June 2017) modifies the strict application of Article 222 to require only the hub to be lit by 2000 candela steady red lights, with a single set of intermediate steady red lights halfway down the tower at a reduced intensity of 32 candela. This CAA Policy also allows the nacelle lights to operate in a lower intensity mode "if the horizontal meteorological visibility in all directions from every wind turbine generator in a group is more than 5 km". In these circumstances the 2000 candela lights could be operated at "not less than 10% of the minimum peak intensity specified for a light of this type" (200 candela). It also remains open to a structure owner to undertake a special aeronautical study and make the case to the CAA for a further reduction in visible lighting.

14.2.2 Consultation

7. The relevant aviation stakeholders were consulted regarding the potential effects of the proposed Development as part of the scoping process. A summary of consultation is provided in **Table 14.2.1**.

Table 14.2.1 Table title

Consultee	Summary of Consultation	Applicant Response
Glasgow Prestwick Airport (GPA)	Request that appropriate radar modelling and Line of Sight analysis is carried out. The windfarm is within the operational range of the Glasgow Prestwick Airport radar, and if any turbines are visible to the radar, they may impact the performance of the radar displays in the airspace above the radar visible turbines.	An aviation assessment has been undertaken for the proposed Development. Full details included in **Appendix 14.2**.
Ministry of Defence (MOD)	No objection to the proposal. Request that in the interest of air safety the development be fitted with aviation safety lighting. Wish to be consulted and notified of any alterations to the application and the progression of submissions.	MoD onshore radar coverage maps assessed.
NATS (En Route) [NERL]	The proposed development does not conflict with safeguarding criteria and has no safeguarding objection to the proposal. Request further consultation on any changes proposed to the information supplied prior to any planning permission or any consent being granted.	NATS self-assessment maps and NATS Lowther Hill radar assessed.

14.2.3 Baseline Conditions

8. The closest NATS PSR to the proposed Development is the facility at Lowther Hill.

9. There are two PSR facilities at Glasgow Prestwick Airport (GPA):

- a Marconi S511 radar used for planning purposes; and
- a Terma Scanter 4002 radar used for approach control.

10. In addition, GPA is fed with Secondary Surveillance Radar (SSR) data from Lowther Hill radar. GPA are authorised to use SSR only in the event of the PSR failure.

14.2.4 Potential Effects

11. Analysis of NATS self-assessment maps and modelling of NATS Lowther Hill radar shows no impact on NATS infrastructure or services.

12. Analysis of MoD onshore radar coverage maps shows no impact on MoD radar infrastructure. While the proposed windfarm is within a red (high priority) low flying zone, the site is clear of the A714 road line feature that low flying follows.

13. The only aviation stakeholder which could be affected is GPA. Detailed radar modelling of the indicative layout against the two Primary Surveillance Radar (PSR) facilities (Terma and S511 radars) at GPA shows the following:

- Radar Line of Sight (RLoS) exists between both radars and turbines 1, 2, 4, 5, 7, 8, 9, 10, 11 and 13 and these turbines have a high probability of detection;
- In addition, further analysis shows that there is a possibility of both GPA PSRs detecting turbine 6; and
- Turbines 3, 12, 14, 15, 16, 17 and 18 are unlikely to be detected by either PSR.

14. The GPA Terma PSR is an X band radar that can distinguish between unwanted returns from wind turbines and wanted returns from aircraft and as such is considered to be windfarm tolerant. The Terma radar mitigates the effects of turbines by blanking the areas around them. Analysis of these blanked areas shows that they will have no impact on the radar's ability to track aircraft across the windfarm. The GPA S511 PSR is a legacy planning radar that it is understood will be replaced by the Terma PSR as the GPA approach radar in due course.

15. The proposed Development is situated within uncontrolled airspace. The elevation of the highest proposed turbine does not penetrate the controlled airspace, which is over 3,000ft above the highest obstacle. There is sufficient uncontrolled airspace above the proposed turbines for Visual Flight Rules military and General Aviation traffic to safely transit this area. Published Instrument Flight Procedures indicate that traffic inbound and outbound of GPA will not routinely overfly the Site. The Site is outside the GPA Air Traffic Control Surveillance Minimum Altitude Chart and will therefore not require changes to this chart. Traffic in controlled airspace should be far enough away from the Site that any 'pop up' traffic potentially hidden by turbine clutter (which should only be displayed on the legacy S511 PSR display) should be spotted by the controller in enough time to take any necessary action.

16. As a precaution and to mitigate potential effects of the Development on the Glasgow Prestwick Radar (GPR), a surveillance system may be required to be deployed within the Development Area. The requirement for this will be determined following further consultation with GPA and the Civil Aviation Authority (CAA)

14.2.5 Aviation Lighting

17. CAA guidance requires that 'en-route obstacles' at or above 150 m above ground level are lit with visible lighting to assist their detection by aircraft. As such, there is potential that parts of the proposed Development may be visible at night. The effect of the proposed Development at night would result from visible medium intensity (2,000 candela) red coloured light fittings located on the nacelles, and on the turbine towers, of all proposed turbines.

18. The proposed Development is within the Galloway Forest Dark Sky Park (DSP) buffer zone. The visual effect of turbine aviation lighting is assessed within **Chapter 6: Landscape and Visual** and specifically within **TA 6.2**. This considers the potential effect of aviation lighting on five representative viewpoints, three of which are within the DSP. The assessment predicts significant effects at two viewpoints within the DSP. Due to the relatively high sensitivity of these viewpoints, the moderate levels of change resulting from the aviation lights results in significant and adverse visual effects, occurring primarily due to the introduction of an array of new and unfamiliar visible lights in an otherwise primarily dark landscape.

19. The **TA 6.2** goes on to conclude that a series of light minimisation measures could be employed to minimise the light intrusion into the landscape.

20. The light minimisation strategies being considered include:

- allowing the lights to be dimmed from 2,000 candela (cd) to 200 cd when visibility is greater than 5km i.e. moderate to excellent visibility as permitted Air Navigation Order (ANO) 2016 (CAP393) Article 223 (8);
- an aviation detection lighting system (i.e. aviation warning lights are only activated when aircraft are detected in the vicinity of the development by a surveillance system). under Article 222 of the ANO;
- focusing the light on the horizontal plane, reducing the intensity of the light above and below the horizontal; and
- conducting a specialist aeronautical study for approval by the Civil Aviation Authority (CAA) making the case for a further reduction in visible lighting.

21. The **TA 6.2** also noted that the areas significantly affected by aviation lighting are unlikely to be locations people go to view the night sky. Further, the aviation lighting will not be visible from the 10 dark sky viewpoints promoted by the DSP, nor will the aviation lighting be visible from the low lying 'interior' (i.e. areas of highest overall darkness) of the DSP. As a result, the study concludes that aviation lighting from the proposed Development will not result in visual effects on the principal receptors within the DSP where people are likely to view and be encouraged to view the night sky.

22. In terms of the aviation detection lighting system it is noted that, given that the upper boundary of the lighting coverage volume is around 3,000ft above mean sea level (AMSL), aviation lighting will not be activated if commercial airlines overfly the proposed Development. Such aircraft ordinarily operate in controlled airspace and the base of controlled airspace over the proposed site is 5,500ft AMSL. Thus, turbine lighting is only required for non-commercial flights at night in the vicinity of proposed Development at altitudes of up to 3,000ft. Statistics on airspace usage at this low level are not available; however, it is anticipated that the lights will be rarely on in this quiet airspace.

14.2.6 Conclusion

23. In summary, through both consultation and this assessment, it is concluded that the proposed Development, will not have a significant effect on aviation infrastructure, from either physical obstruction or radar interference.

24. With regard to aviation lighting the study documented in **Chapter 6: Landscape and Visual** and within **TA 6.2** demonstrate that there are a number of potential mitigation measures being considered that will reduce the effect of aviation lighting. It also highlights that the areas potentially affected by aviation lighting are not areas where people are likely to view the proposed Development or seek views of the night sky. As a result, aviation lighting from the proposed Development is not predicted to result in visual effects on the principal receptors within the DSP.

14.3 Shadow Flicker

25. This section describes and assesses potential shadow flicker effects resulting from turbines of the proposed Development on neighbouring residential and commercial receptors.

26. Shadow flicker occurs when, *"[In] certain combinations of geographical position, time of day and time of year the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as a "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening*" (Scottish Government, 2014a, Onshore Wind Turbines).

27. Any receptors which may potentially be affected have been identified and the risk of shadow flicker calculated.

28. The magnitude of shadow flicker effects varies both spatially and temporally, and depends on several environmental conditions coinciding at a point in time, which include:

- time of day and year;
- wind speed and direction;
- height of wind turbine and blade length;
- position of the sun in the sky;
- weather conditions;
- proportion of daylight hours in which the turbines operate;

- type and frequency of use of the affected space; and
- distance and direction of the wind turbine from the receptor.

29. The flickering effect caused by shadow flicker also has the potential to induce epileptic seizures in patients with photosensitive epilepsy. The National Society of Epilepsy (NSE) advises that around 1 in 100 people in the UK have epilepsy and around 3 % of these have photosensitive epilepsy (NSE, 2019). The common rate or frequency at which photosensitive epilepsy might be triggered is between 3 and 30 hertz (Hz, flashes per second). Large commercial turbines rotate at low speeds resulting less than 3 flashes per second and are therefore unlikely to cause epileptic seizures (Harding et al., 2008: Smedley et al., 2010). Therefore, photo-sensitive epilepsy is scoped out and is not considered further in this assessment as there is no likelihood of any significant effect. This assessment will focus solely on the effects of shadow flicker related to local amenity.

30. Turbines can also cause flashes of reflected light, which can be visible for some distance. It is possible to ameliorate the flashing, but it is not possible to eliminate it. Careful choice of blade colour and surface finish can help reduce the effect and all modern turbine manufacturers use light grey semi-matt finished to reduce this effect.

31. A development of more than one turbine can also result in more than one turbine affecting a specific receptor at any time, potentially increasing the overall shadow flicker intensity or frequency. This potential effect has been considered within this assessment as well as the cumulative effect with other operational windfarms in the local area.

14.3.1 Legislation, Policy and Guidelines

14.3.1.1 Legislation

32. There is no applicable legislation setting out any relevant rules or requirements for the assessment or control of shadow flicker.

14.3.1.2 Policy

33. This assessment has taken into consideration the policies contained in the Scottish Planning Policy (Scottish Government, 2014b).

14.3.1.3 Guidance

34. The Update of UK Shadow Flicker Evidence Base (DECC, 2011) reviews international legislation relating to the assessment of shadow flicker for wind turbine development and concludes that the area within 130 degrees either side of north from the turbine, and out to 10 rotor diameters, is considered acceptable for shadow flicker assessment. The DECC study also concluded that there have not been extensive issues with shadow flicker in the UK and, in circumstances where the potential for significant shadow flicker issues effects have been identified, these have been resolved using standard mitigation.

35. This assessment also takes into consideration the Scottish Government Online Renewables Planning Advice: Onshore Wind Turbines (Scottish Government, 2014a).

36. National guidance is consistent with the findings of the DECC study. Scottish Government Onshore Wind Turbines planning advice stipulates that, in most cases, where separation is provided between wind turbines and nearby dwellings (as a general rule, 10 rotor diameters), shadow flicker should not be a problem.

14.3.2 Consultation

37. The relevant stakeholders were consulted regarding the potential effects of the proposed Development as part of the scoping process. A summary of consultation is provided in **Table 14.3.1**.

Table 14.3.1 Consultation

Consultee	Summary of Consultation	Applicant Response
South Ayrshire Council (SAC) – May 2019	A suitably qualified person will be appointed to the satisfaction of the local authority, who will undertake an investigation into the incidence of shadow flicker.	A Shadow Flicker assessment has been carried out as part of the EIA and is detailed below.

14.3.3 Assessment Methodology and Significance Criteria

14.3.3.1 Study Area

38. The shadow flicker assessment has been carried out for the proposed 18 turbines at the locations identified in **Chapter 4: Development Description**. Although the turbines will have a rating of 5.6MW the final model has not been selected and this will be based on the most advanced technology available at the time. Therefore, as a precaution this assessment is based on the worst-case scenario model (i.e. that with the largest proposed rotor area) that could be installed at the site. Dimensions of the chosen model used for the purposes of the shadow flicker assessment can be found in **Table 14.3.2**.

Table 14.3.2 Details of the Turbine Model Used for the Shadow Flicker Assessment

Hub height	125 m
Rotor Diameter	150 m
Swept Area	17,671.46 m^2

39. The study area within which receptors could potentially be affected by shadow flicker has been set at a distance of 10 rotor diameters from each turbine and 130 degrees either side of north (relative to each turbine), as noted within the DECC report (DECC, 2011). In this assessment, the study area extends to 1.5 km from each turbine. **Figure 14.3.1** shows the extent of this area and those receptors that could potentially be affected by shadow flicker.

14.3.3.2 Desk Study

40. The desk-based assessment identified one residential receptor, which is the property at Ferter, within the study area (shown in **Figure 14.3.1**). Little Shalloch is also within the study area however has been omitted from this assessment on the basis that it is a derelict uninhabitable building. **Table 14.3.3** summarises the locations of the receptor and the distance from the property to the nearest turbine.

Table 14.3.3 Receptor Locations

Receptor ID	Easting	Northing	Approx. Distance to Nearest Turbine (km)	Turbine
A - Ferter	230713	587449	1.48	T6

14.3.3.3 Assessment of Potential Effect Significance

41. There are no UK statutory provisions setting out acceptable levels of shadow flicker. The DECC 2011 report identifies best practice guidelines across Europe and this assessment will adopt German quantitative guidance (Nordhein-Westfalen, 2002) which adopts two maximum limits to determine significant effects:

- an astronomic worst case scenario limit of 30 hours per year or 30 minutes on the worst affect day; and
- a realistic scenario considering meteorological parameters limited to 8 hours per year.

42. Within this assessment the sensitivity of the receptor is assumed to be high in all cases.

14.3.3.4 Assessment Modelling

43. In assessing the effect of shadow flicker, the commercial software model WindPro 3.2. was used to calculate the expected number of hours shadow flicker that could occur at each receptor. The model considers the movement of the sun relative to the time of day and time of year and predicts the time and duration of expected shadow flicker at a window of an affected receptor. The input parameters used in the model are as follows:

- the turbine locations;
- the turbine dimensions;
- the location of the receptor to be assessed; and
- the size of windows on the receptor and the direction that the windows face.

44. The WindPro model is based upon a Zone of Theoretical Visibility (ZTV) analysis, which in this case was based upon a Digital Terrain Model (DTM) of 20 m resolution.

45. Calculations were undertaken for predicted shadow flicker hours at the receptor for two scenarios: a theoretical (worst-case) and a realistic scenario. For the worst-case scenario the following assumptions were made:

- the receptor has a 1 m x 1 m window facing directly towards the turbine;
- the turbine blades were assumed to be rotating 365 days per year;
- there is a clear sky 365 days per year;
- the turbine blades were assumed to always be positioned towards the receptor;
- more than 20 % of the sun was covered by the blade; (in practice, at a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow);
- the receptor is always occupied ; and
- no screening was present.

46. The effect of shadow flicker was not calculated where the sun lies less than 3 degrees above the horizon due to atmospheric diffusion, low radiation (intensity of the sun's rays is reduced) and high probability of natural screening. It is generally accepted that below 3 degrees shadow flicker is unlikely to occur to any significant extent (Nordhein-Westfalen, 2002).

47. These assumptions result in a highly conservative assessment for the following reasons:

- the receptor may not directly face the turbines;
- the turbine blades will not turn for 365 days of the year, and will turn to face into the direction of the wind, in order to maximise the energy generating potential from the wind, and therefore will not always face the receptor;
- it is unlikely that there will be clear skies 365 days a year;
- the receptor may not be occupied at the time that the shadow flicker impact is experienced; and
- screening, such as vegetation including the surrounding forestry, or curtains between the window and the turbine is not accounted for within the DTM and model and will prevent any shadows from being cast onto the window and therefore prevent any flickering effect.

48. The assessment carried out is limited to the effects of shadows within buildings. Moving shadows will also be apparent out of doors; however, these do not result in flicker in the same manner or to the same extent, as the light entering windows. Therefore, shadow flicker effects outdoors have been scoped out of further assessment.

14.3.3.4.1 Theoretical Scenario

49. The modelling results for the theoretical scenario are typically considered to be a theoretical worst-case estimation of the actual impacts experienced, which would not arise in practice given the assumptions listed above.

14.3.3.4.2 Realistic Scenario

50. For much of the year weather conditions will be such that shadows will not be cast or will be weak and would therefore not give rise to shadow flicker effects. WindPro calculations most likely overestimate the duration of effects as outlined in the theoretical scenario. Other factors such as the potential for screening by vegetation or structures will also reduce or prevent flicker incidence in practice. To create a more realistic scenario for the potential impact of shadow flicker on receptors, it was necessary to identify the expected meteorological conditions at the site and consider any significant shielding of receptors by buildings and vegetation between the receptor and the turbines.

51. In order to estimate the impact of cloud cover, information available from the Met Office (2019) was used to consider the likelihood of sunshine at different times of the year, and therefore allow calculations of the 'expected' values for shadow flicker occurrence. As part of the WindPro calculation it is possible to upload data from the nearest climatic station to the Site. In the case of the proposed Development this is the Girvan station located approximately 14.1 km to the west.

52. Given the largely dynamic status of the plantation forestry over the lifetime of the proposed Development and between seasons, no vegetative screening was incorporated into the model.

53. The realistic scenario represents a long-term average as it is based on long-term historic metrological data. The variation between individual years can be significant and may lead to future observations differing from the predicted results.

54. A 16-degree sector wind rose was calculated for 7,446 hours of wind (assumes the proposed Development is operational for 85 % of the year) based on meteorological mast data from the proposed Development site. The WindPro model also employs a slightly simplistic assumption that sunshine probability and turbine operational probability are independent parameters. The model is therefore expected to yield conservative results; as bright and sunny weather conditions and low wind speeds generally tend to show some degree of correlation.

14.3.3.5 Limitations to Assessment

55. All assumptions made by the WindPro 3.2 are outlined within Section 14.3.3 above.

56. Given the absence of UK guidance towards shadow flicker, the assessment has adopted the generally accepted industry practised maximum figure of 30 hours per year or 30 minutes per day for permanent dwellings and commercial properties within 10 rotor diameters of the proposed turbines.

57. The realistic scenario results represent a long-term average as they are based on long-term historic meteorological data (28 years, from 1981 to 2010). The variation between individual years can be significant and may lead to future observations differing from the predicted results.

14.3.4 Baseline Conditions

58. The receptor identified within the study area with the potential to experience shadow flicker is located to the south of the proposed Development.

59. There is mature coniferous plantation of approximately 20 m high located between the receptor and the proposed turbine locations which may act as a visual screen. For the purposes of the assessment it is assumed that the property faces the proposed Development and no local screening (vegetation and blinds/curtains) are considered.

60. Within this assessment the sensitivity of the receptor is assumed to be high.

14.3.5 Potential Effects

14.3.5.1 Construction

61. No shadow flicker will occur during construction of the proposed Development.

62. Given that any occurrence of shadow flicker during the short commissioning period would replicate itself during operation of the proposed Development, albeit more frequently, it is considered appropriate to consider the commissioning activities as part of the operational stage of the proposed Development.

14.3.5.2 Operation

14.3.5.2.1 Theoretical Modelling of Shadow Flicker Occurrence

63. The modelling results presented below represent the theoretical worst-case scenario discussed in Section 14.3.3 above. The results of the modelling are shown in **Table 14.3.4.** The theoretical duration of shadow flicker calculated is indicated to be less than 30 hours per year and less than 30 minutes per day on the worst affected day. The potential shadow flicker effects are therefore assessed as **not significant** at receptor A (Ferter) for the astronomical worst case scenario.

Table 14.3.4 Worst Case Scenario Shadow Flicker Occurrence for the Receptor

Receptor ID	Shadow Hours per Year	Max Shadow Minutes per Day
A - Ferter	23:02	26

64. **Graph A14.3** within **Technical Appendix 14.3** summaries the occurrence of shadow flicker at the receptor and illustrates the times of year and times of day when shadow flicker could theoretically occur. The graph shows that only turbine 6 would contribute to the shadow flicker experienced at the receptor, for the period May to July.

65. However, the duration of shadow flicker at the receptor is likely to be considerably less than that indicated above for the reasons outlined in Section 14.3.3.4

14.3.5.2.2 Realistic Modelling of Shadow Flicker Occurrence

66. The modelling results presented in **Table 14.3.5** represent the realistic scenario discussed in Section 14.3.3.4.2. the inclusion of indicative wind data and average sunshine hours into the shadow flicker calculations has greatly reduced the potential of shadow flicker occurrence at the receptor (refer to **Figure 14.3.2**).

Table 14.3.5 Realistic Scenario Shadow Flicker Occurrence for the Receptor

Receptor ID	Shadow Hours per Year	Max Shadow Minutes per Day
A - Ferter	4:39	5.2

67. The result falls within Nordheim-Westfallen's (2002) recommended limit of 8 hours per year considering meteorological parameters. The receptor falls under the 30 minute threshold for minutes (on the worst affected day).

68. The model still does not take into consideration any local screening from vegetation, blinds or curtains, or true window orientation relative to the turbines which may reduce further the potential time a receptor is likely to experience shadow flicker over the course of the year.

69. The results for the realistic scenario show a reduction in the potential shadow flicker on the receptor. The reduction has shown that for the receptor the effect is expected to be of no significance.

14.3.6 Mitigation

14.3.6.1 Construction

70. No mitigation measures are required during the construction phase of the proposed Development.

14.3.6.2 Operation

71. Although the realistic scenario takes into consideration expected operational time for the turbines and average sunshine hours for the region, the results are likely to still be conservative due to local vegetation and internal screening from blinds, curtains or furniture that are not included in the model. Additionally, while shadow flicker may potentially occur at this location it is possible that flicker will not be 'experienced' at the location due to the time of day during which it may potentially occur. As a result, no mitigation measures are proposed during operation.

14.3.7 Residual Effects

72. No significant residual effects are predicted during the operational or construction phases of the proposed Development.

14.3.8 Cumulative Assessment

73. In order to assess the potential for cumulative impact from other wind developments in the surrounding area or from turbines within the proposed Development, any turbines within 2 km of the site were noted. Shadow flicker impacts are considered to extend to 10 rotor diameters (Scottish Government, 2014) from turbine locations, a 2 km study for cumulative developments considers any potential for study area overlap between the proposed Development and a cumulative development with a blade length up to 50 m.

74. Mark Hill windfarm is located within 2 km of the proposed Development, which is an operational site of 28 turbines of 87 m rotor diameter, located approximately 1.9 km to the south west of Turbine 3.

75. There are no identified sensitive receptors within the areas of overlap between the study area of the proposed Development and that of the cumulative development, as such, there is no requirement to undertake a cumulative shadow flicker assessment with this development.

76. The cumulative shadow flicker residual effect across the study area is therefore expected to be of no significance.

14.3.9 Conclusion

77. This assessment considers whether the effect known as 'shadow flicker' is likely to be caused by the proposed Development and assesses the potential for impact on sensitive receptors. Shadow flicker is the effect of the sun passing behind the moving rotors of the turbines casting a flickering shadow through the windows and doors of neighbouring properties. This occurs in certain combinations of geographical position, time of day, time of year and specific weather conditions.

78. The study area within which properties could potentially be affected by shadow flicker covers a distance of 10 rotor diameters from each turbine and lies 130 degrees either side of north (relative to each turbine). In the case of the proposed Development, this area extends to 1,500 m from each turbine.

79. No shadow flicker impact can occur during the construction of the turbines.

80. A shadow flicker assessment was undertaken at the one identified receptor within the study area with potential to experience flicker effects. Calculations have shown that the maximum occurrence of shadow flicker within the realistic scenario at the receptor amounts to approximately 4:39 hours per year or a maximum of 5.2 minutes per day. Well within the accepted limits for realistic shadow flicker of less than 8 hours per year.

81. It is important to note, however, that these results do not consider existing screening features (structures and vegetation), dwelling orientation and local mitigation measures such as blinds or curtains which will reduce potential effects further. Receptors may also be in rooms that are not generally used at the affected times, therefore, the amount of time when shadow flicker is 'experienced' will likely be significantly less than what has been predicted.

82. The residual effect of shadow flicker is therefore expected to be not significant during the operational phase of the proposed Development.

14.4 Forestry

83. This section of the chapter provides a summary of the forestry assessment. The proposed Development lies within existing commercial forestry plantations which is owned by Scottish Ministers and managed by Forestry and Land Scotland. DGA Forestry LLP carried out an assessment of the potential effects of the proposed Development on the existing forest resource. The full assessment is detailed within **Technical Appendix 14.4.**

84. The forestry assessment describes the plans as a result of the proposed Development for felling, restocking and forest management practices; the process by which these plans were derived; and the changes to the physical structure of the forest. **TA 14.4** identifies the areas of forest which are to be removed for the construction and operation of the proposed Development and outlines the proposed management practices along with likely restocking proposals and future land management for the remaining forest.

14.4.1 Legislation, Policy and Guidelines

85. The following forestry related policies and guidance have been considered within the forestry assessment and are outlined in more detail within **TA 14.4**:

- Forestry and Land Management (Scotland) Act 2018;
- Scotland's Forestry Strategy 2019-2029;
- The Land Use Strategy for Scotland 2016-2021;
- Third National Planning Framework;
- Scottish Planning Policy;
- Control of Woodland Removal Policy;
- The Ayrshire and Arran Forestry and Woodland Strategy; and
- The Dumfries and Galloway Forestry and Woodland Strategy.

14.4.2 Consultation

The relevant forestry stakeholders were consulted regarding the potential effects of the proposed Development as part of the scoping process. A summary of consultation is provided in Table 14.4.1.

Table 14.4.1 Consultation on Forestry Matters

Consultee	Summary of Consultation	Applicant Response
Scottish Environmental Protection Agency (SEPA) – Scoping Opinion	Advise adherence to the Forest and Water guidelines. Recommend key holing wherever possible and that clear felling may be acceptable through a Habitat Management Plan. Refer should be made to the current Forest Plan.	A detailed forestry assessment (**Technical Appendix 14.4**) has been undertaken. This details the policies and guidance that has been considered, the extent of keyholing and provides a detailed comparison of the proposed Forest Plan against the current baseline. A Habitat Management Plan is provided in **Technical Appendix 8.7**.
Scottish Forestry – Scoping Opinion	Recommend the EIA Report include a standalone chapter on "Woodland management and tree felling" describing social, economic and environmental value of the forest and woodland habitat. Should include details of proposed areas for felling, replanting and compensatory replanting with reference to the existing Forestry Land Scotland (FLS) Long-term Forest Plan.	A detailed forestry assessment is included as **Technical Appendix 14.4** to this EIA Report.

86. Consultation has been ongoing throughout the EIA process with the landowner FLS as the proposed Windfarm Forest Plan has been developed.

14.4.3 Forestry Study Area & Baseline

87. The Forestry Study area extends to approximately 11,070 hectares (ha) and contains 6 separate Forest Plans: White Clauchrie, Changue, Rowantree, Shalloch, Drumjohn and Girvan Road. The forests contain a range of woodland types and age classes due to original planting programme together with areas of unplantable land and open ground. The crops are comprised largely of commercial conifers with areas of mixed broadleaves and open ground. The woodlands are in the production phase with rotational felling and restocking underway.

88. A Forest Plan describes the woodlands, places them in context with the surrounding area, and identifies issues that are relevant to the woodland or forest. A Forest Plan typically contains felling and restock proposals covering a 10 year period in detail, with outline proposals for the remainder of the forest.

89. **TA 14.4** provides details of the baseline age class structure, species composition, and felling and restocking plans for the Forestry Study Area. The main species are commercial conifers, accounting for approximately 69.4 % of the total Forestry Study Area. The baseline felling and restocking plans show a proposed restructuring of the first rotation crops to meet current guidelines, with a decrease in Sitka Spruce in favour of broadleaved and other conifer species.

14.4.4 Development of Windfarm Forest Plan

90. Within forests and woodlands, areas of crop may require to be felled to accommodate the construction and operation of the proposed Development. In this case considering technical and environmental constraints a 2.5 ha (90 m radius) keyhole was adopted around each turbine location within woodland for construction, operation and environmental mitigation. A 10 m buffer would be applied around each item of infrastructure, in addition to the area required for the infrastructure, to accommodate area of disturbance and infrastructure required for construction. An indicative 30 m corridor has been applied to all roads to be used for turbine delivery and construction purposes.

91. For the proposed Development, felling is only required during the construction phase, which for the assessment has been anticipated to commence in 2021.

14.4.5 Windfarm Forest Plan

92. The windfarm felling plan (refer to **TA Figure 14.4**) shows which woodlands within the Forestry Study Area would be felled as a result of the proposed Development and when this felling would take place.

93. The windfarm restocking plan (refer to **TA Figure 14.4.7**) shows which woodlands would be restocked and with which species.

94. The Windfarm Felling Plan proposes advanced felling of 298.7 ha during Phase 1 of the Forest Plan, resulting from construction of the proposed Development. This is balanced by reduced felling in subsequent phases.

95. Where possible the proposed Development infrastructure will be "keyholed" into the crops. Where this is not possible the crops will be felled back to the nearest wind firm edge or management boundary and the proposed Development infrastructure will be keyholed into the restocking.

96. Under the Windfarm Forest Plan there would be a net reduction in the areas of conifer woodland by 146.5 ha and increase in broadleaf woodland by 24.9 ha and a decrease in open ground by 12.6 ha.

14.4.6 Conclusions

97. As a result of the construction of the proposed Development there would be a net loss of woodland area. The area of stocked woodland in the study area would decrease by 121.6 ha. In order to comply with the criteria of the Scottish Government's Control of Woodland Removal Policy, off-site compensation planting would be required.

98. The Applicant is committed to providing appropriate compensatory planting. The extent, location and composition of such planting to be agreed with FLS, considering any revision to the felling and restocking plans prior to the commencement of operation of the windfarm.

14.5 Climate and Carbon Balance

14.5.1 Introduction

99. This section of this Chapter details the calculations to work out carbon dioxide (CO_2) emissions from the proposed Development. In addition to generating electricity, the Scottish Government sees windfarms as an important mechanism for reducing the UK's CO_2 emissions. This Chapter estimates the CO_2 emissions associated with the manufacture and construction of the proposed Development as well as estimating the contribution the proposed Development would make to reducing CO_2 emissions, to give an estimate of the whole life carbon balance of the proposed Development. The carbon balance assessment uses the Scottish Government's web-based Carbon Calculator tool. The assessment is based on a detailed baseline description of the proposed Development and its location. All calculations are based on Site specific data, where available. Where Site specific data is not available, approved national/regional information has been used.

100. Each unit of wind generated electricity would displace a unit of conventionally generated electricity, therefore reducing traditional power station emissions. **Table 14.5.1** provides a breakdown of the estimated emissions displaced per annum and over the assumed lifespan for the proposed Development. The proposed Development is seeking in-perpetuity consent, however in order to ensure a meaningful result from the application of the carbon calculator, an operational lifespan of 40 years has been assumed. This is a timescale which can be well quantified within the assessment and effects for this timescale are well understood.

14.5.2 Legislation, Policy and Guidelines

101. A key driver for the Scottish Government's renewable targets is the Climate Change (Scotland) Act, 2009. The Act sets an interim greenhouse gas emissions target of 42 % reduction for 2020, and an 80 % reduction target for 2050. The Climate Change (Emissions Reduction Targets) (Scotland) Bill (2019) recently brought the target forward to net-zero by 2045. Decarbonisation of grid electricity through increasing the percentage of electricity generated by

renewables is identified as one of the key ways to deliver these targets, but the Climate Change (Scotland) Act also recognises the importance of carbon stores in peat and soils.

102. The Scottish Government methodology, titled 'Calculating potential carbon losses and savings from wind farms on Scottish Peat lands: a new approach' (Nayak, et al, 2008), was designed to utilise a life cycle methodology approach to estimating the wider emissions and savings of carbon associated with windfarms and for calculating how long a development will take to 'pay back' the carbon emitted during its construction. Originally an excel spreadsheet, the most recent version of the Carbon Calculator is a web-based application and central database, where all the data entered is stored in a structured manner.

103. Other guidance which has been referred to while completing the carbon balance assessment is the following:

- Assessment of Peat Volumes, Reuse of Excavated Peat and Minimisation of Waste: Guidance. Scottish Government (2014); and
- Peatland Survey. Guidance on Developments on Peatland. SNH, SEPA, Scottish Government (2017).

14.5.3 Carbon and Peatland

104. Windfarms in upland areas tend to be sited on peatlands which hold stocks of carbon and so have the potential to release carbon into the atmosphere in the form of CO_2 if the peat is disturbed.

105. In order to minimise the requirement for the extraction of peat, the Site design process has avoided areas of deeper peat (greater than 1m). Where areas of deep peat cannot be avoided floating tracks are proposed rather than new excavated track construction. The Site design process is described in **Chapter 3: Site Selection and Design**. Specific details on the peat depths of the Site are included in the Peat Landslide and Hazard Risk Assessment, included as **Technical Appendix 7.2.**

14.5.3.1 Effects of Carbon Emission from Construction

106. Emissions arising from the fabrication and manufacture of turbines and the associated components are based on a full life analysis of a typical turbine and include CO_2 emissions resulting from fabrication, transportation, erection, operation, dismantling and removal of turbines and foundations and transmission grid connection equipment from the existing electricity grid system. The assessment has used Nayak *et al.* (2008) default values for 'turbine life' emissions, calculated with respect to the Site's installed capacity (in the region of 100 MW).

14.5.3.2 Characteristics of Peatland

107. The loss of carbon from the carbon fixing potential from plants and vegetation on peatland is small but is calculated for the area from which peat is removed and the area affected by drainage. The carbon stored in the peat itself represents a much larger potential source of carbon loss.

108. To calculate the carbon emissions attributable to the removal or drainage of peat from the Site as a result of the proposed Development, emissions occurring if the soil had remained in situ and undisturbed are subtracted from the carbon emissions occurring after removal or development-related drainage.

109. The indirect loss of CO_2 uptake (fixing) by plants originally on the surface of the Site but eliminated by construction activity, is calculated on Site specific data collected as part of the EIA process and for the purpose of the carbon calculator is based on blanket bog as identified as the key habitat on Site during the Phase 1 Habitat Survey (as included in **Technical Appendix 8.1**).

110. Emissions due to the indirect, long term liberation of CO_2 from carbon stored in peat due to drying and oxidation processes caused by construction of the proposed Development on the Site, can also be calculated from Site specific data (the habitat loss calculations are included in **Technical Appendix 8.1**) for the proposed Development. This figure is a worst-case scenario, as the peat would be re-used where possible onsite to minimise carbon losses.

14.5.4 Assessment Methodology

111. The purpose of the 'carbon calculator' is to assess, in a comprehensive and consistent way, the carbon impact of windfarm developments. This is undertaken by comparing the carbon costs of windfarm developments with the carbon savings attributable to the windfarm.

112. Carbon emissions and savings are both ultimately part of a global 'pool' and therefore this assessment is not restricted solely to those emissions or savings that occur within the site boundary of the proposed Development. Land-based emissions from peat and habitat losses are based on the site boundary but other activities, for example, emissions resulting from the extraction and production of steel are likely to occur in other parts of the world but are still attributable to the proposed Development.

14.5.4.1 Input Parameters

113. To undertake the assessment of carbon balance the following parameters were considered, which encompass a full life cycle analysis of the proposed Development. These parameters include:

- Emissions arising from the fabrication of the turbines and all the associated components;
- Emissions arising from construction (including transportation of components; quarrying; building foundations, access tracks and hard standings; and commissioning);
- The indirect loss of CO2 uptake (fixation) by plants originally on the surface of the Site but eliminated by construction activity (including the destruction of active bog plants) and felling;
- Emissions due to the indirect, long term liberation of CO2 from carbon stored in peat due to drying and oxidation processed caused by construction; and
- Loss of carbon due to drainage of the site and rom forestry clearance.

114. As part of their methodology, Nayak et al (2010) have provided a spreadsheet 'Scottish Government Windfarm Carbon Assessment Tool' to calculate whole life carbon balance assessments for windfarms on peatlands. The calculator has progressed to an online tool. Version 1.6.0 of the carbon calculator is the current model and was used in this assessment. The online calculation tool[1] (project reference MHEA-39DJ-9PFR) allows a range of data to be input in order to address the expected, minimum and maximum values as a result of the proposed Development. However, it should be noted that if several parameters are varied together, this can have the effect of 'cancelling out' a single parameter change. For this reason, the approach for this assessment has been to include 'maximum values' as those values which would result in the longest (maximum) payback period; and 'minimum values' as those values which would result in the shortest (minimum) payback period.

115. This tool provides generic values for CO_2 emissions associated with some components (such as turbine manufacture) and requires Site specific information for other components (such as habitat type, extent of peat disturbance and groundwater levels, these were collected or inferred during the Phase 1 Habitat and Peat surveys of the Site and can be found in **Technical Appendix 8.1** and **Technical Appendix 7.2** respectively.

116. This assessment draws on information detailed in the EIA Report, **Chapter 4: Development Description, Chapter 7: Hydrology, Hydrogeology, Geology and Soils** and **Chapter 8: Ecology.** For the purpose of the assessment, it is assumed that all embedded good practice measures outlined in **Chapter 7: Hydrology, Hydrogeology, Geology and Soils** and **Chapter 8: Ecology**, would be employed.

117. The final wind turbine choice is not yet known, but would likely be a 5.6 MW generating machine, and the proposed Development would consist of 18 turbines with a total installed capacity in the region of 100 MW. The greenhouse gas savings and carbon payback are based on these input parameters. Figures are based on currently available turbine specifications and assume a consistent supplier for all turbine locations (i.e. turbine types are chosen by manufacturer).

118. The input parameters for the Scottish Government online calculation tool are detailed in **Technical Appendix 14.5.1**. The choice of methodology for calculating the emission factors uses the 'Site Specific Methodology' defined within the online calculation tool.

[1] https://informatics.sepa.org.uk/CarbonCalculator/index.jsp

14.5.5 Results

119. This section presents a summary of the carbon assessment which has been undertaken in respect of the proposed Development. An assessment has been undertaken to calculate the carbon emissions which would be generated during the construction, operation and decommissioning (i.e. assumed to be after 40 years for the purpose of the calculator) of the proposed Development as well as the carbon payback period resulting from the operation of the proposed Development.

120. The carbon calculations results are provided in **Technical Appendix 14.5.2** and can be viewed online (using the project reference code MHEA-39DJ-9PFR)**.** A summary of the anticipated carbon emissions and carbon payback period of the proposed Development are provided in **Table 14.5.1** below.

Table 14.5.1 Anticipated Carbon Emissions

Results	Expected	Minimum	Maximum
Net emissions of carbon dioxide (t CO_2 eq.)	291,086	221,604	333,904
Carbon Payback Period of proposed Development Comparison			
Displacing Coal-fired electricity generation (years)	1.3	0.9	1.7
Displacing Grid-mix of electricity generation (years)	4.9	3.4	6.2
Displacing Fossil fuel - mix of electricity generation (years)	2.8	1.9	3.5

14.5.5.1 Interpretation of Results

121. The calculations of total CO_2 emission savings and payback time for the proposed Development indicates the overall payback period of a windfarm with 18 turbines with an average (expected) installed capacity in the region of 100 MW per turbine would be approximately 2.8 years, when compared to the fossil fuel mix (the existing energy mix within the UK) of electricity generation.

122. The potential savings in CO_2 emissions due to the proposed Development replacing other electricity sources over the lifetime of the proposed Development (assumed to be 40 years for the purposes of the carbon calculator) are approximately:

- 216,000 tonnes of CO_2 per year over coal-fired electricity (8.64 million tonnes assuming a 40 year lifetime for the purposes of the carbon calculator);
- 60,000 tonnes of CO_2 per year over grid-mix of electricity (2.4 million tonnes assuming a 40 year lifetime for the purposes of the carbon calculator); or
- 106,000 tonnes of CO_2 per year over a fossil fuel mix of electricity (4.24 million tonnes assuming a 40 year lifetime for the purpose of the calculator).

14.5.6 Conclusions

123. The proposed Development is expected to take around 34 months (2.8 years) to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the windfarm. There are no current guidelines about what payback time constitutes a significant impact, however, this is a relatively small percentage (9.75 %) of the 40 year lifespan of the proposed Development (based on the conservative lifespan used in the carbon calculator). Compared to fossil fuel electricity generation projects, which also produce embodied emissions during the construction phase and significant emissions during operation due to combustion of fossil fuels, the proposed Development has a very low carbon footprint and after 2.8 years, the electricity generated is estimated to be carbon neutral and will displace grid electricity generated from fossil fuel sources. The Site would, in effect, be in a net gain situation following this time period and will then be contributing to national objectives of reducing greenhouse gas emissions and meeting the 'net zero' carbon targets by 2050, therefore the Proposed Development is evaluated to have an overall **beneficial** effect on climate change mitigation.

14.6 Telecommunications

124. Wind turbines can potentially cause interference to telecommunication links through reflection and shadowing to electromagnetically propagated signals including terrestrial fixed microwave links managed by telecommunication operators.

125. Telecommunications operators were consulted, and information requested for telecommunications links within proximity of the Site. A summary of consultation is provided in **Table 14.6.1** and copies of the correspondence provided in **Technical Appendix 14.6.**

126. Ofcom's Spectrum Information System (SIS) online portal was checked for any Fixed Links within 2 km of the proposed Development site. The portal showed no transmitters within the 2 km study area or links crossing the Site.

Table 14.6.1 Table title

Consultee	Summary of Consultation	Applicant Response
Joint Radio Company (JRC) Ltd. (March 2019 & October 2019)	No concerns. This proposal cleared with respect to radio link infrastructure operated by Scottish Power and Scotia Gas Networks.	No further action required
BT (Openreach) (March 2019)	No concerns. Proposed Development should not cause interference to BT's current and presently planned radio network.	No further action required.
Arqiva (October 2019)	No concern. Development is 13 km south east of nearest SHF link site.	No further action required.
Atkins (October 2019)	No objection.	No further action required.

127. From the consultation responses received, it is concluded that the proposed Development would have no effect on any telecommunication links.

14.7 Summary

128. Table 14.7.1 below provides a summary of the residual effects presented within this chapter.

Table 14.7.1 Summary Table

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial / Adverse		Significance	Beneficial / Adverse
During Construction					
Aviation – effects on aviation (obstruction)	Negligible	Neutral	None	Negligible	Neutral
Aviation – effects on aviation and radar interests (interference)	Negligible	Neutral	None	Negligible	Neutral

Description of Effect	Significance of Potential Effect		Mitigation Measure	Significance of Residual Effect	
	Significance	Beneficial / Adverse		Significance	Beneficial / Adverse
Shadow Flicker	Negligible	Neutral	None	Negligible	Neutral
Forestry	Not regarded as a receptor for EIA purposes. Commercial forests are dynamic regardless of the proposed Development therefore not considered under EIA regulations terms of significance.				
Telecommunication Interests	None	Neutral	None	None	Neutral
During Operation					
Aviation – effects on aviation (obstruction)	Minor	Adverse	None	Negligible	Neutral
Aviation – effects on aviation and radar interests (interference)	Negligible	Neutral	A surveillance system may be deployed as a precaution.	Negligible	Neutral
Shadow Flicker	Negligible	Neutral	None	Negligible	Neutral
Forestry	Not regarded as a receptor for EIA purposes. Commercial forests are dynamic regardless of the proposed Development therefore not considered under EIA regulations terms of significance.				
Telecommunication Interests	None	Neutral	None	None	Neutral
Cumulative Effects					
Aviation Interests	Minor	Adverse	Aviation lighting will be installed on erected turbines, in line with CAA requirements	Negligible	Neutral
Shadow Flicker	None	Neutral	None	None	Neutral
Telecommunication Interests	None	Neutral	None	None	Neutral

14.8 References

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