Chapter 15
Other issues

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Figure

Figure 15.1: Shadow Flicker Analysis

Technical Appendix

Technical Appendix 15.1: Carbon Calculator

Chapter 15

Other issues

15.1 Executive Summary

1. This Chapter outlines the potential for effects on or from nearby infrastructure, telecommunications and TV, aviation, carbon emissions, shadow flicker from wind turbines, population and human health, risks of disasters and waste management. The findings of these studies are summarised here.

2. Infrastructure: This study identifies that there is limited existing infrastructure on the Site which includes the adjacent A83 trunk road and Kintyre Way; commercial forestry and existing Cour Windfarm access tracks; a water main running parallel with the A83; and the Freasdail Windfarm cable route which transects the Site from north to south, east of Loch Lurach.

3. Telecommunications and TV: There is no indication as presented by consultees that the proposed Development would interfere with telecommunication links or with television reception transmission which is now served by digital transmitters.

4. Shadow Flicker: A Shadow Flicker assessment confirms that the predicted shadow flicker hours would be below the 30 hour limit and are, therefore, considered to be acceptable. No cumulative shadow flicker effects have been identified as the properties assessed in this study are located more than 10 rotor diameters in distance from all other nearby existing or proposed windfarm developments.

5. Climate and Carbon: The calculations of total carbon dioxide emission savings and payback time for the proposed Development indicates the overall payback period of a development with 19 turbines with an average (expected) installed capacity of around 6 MW each would be approximately 1.6 years, when compared to the fossil fuel mix of electricity generation. The payback will be further reduced by the proposed addition of solar arrays, although not included within the Carbon Calculator (which was solely devised for the Scottish Government to monitor onshore wind energy)

6. This means that the proposed Development is expected to take around 19 months (1.6 years) to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the wind turbines; the Site would in effect be in a net gain situation following this time period and would to contribute to national objectives.

7. Air Quality: As the nearest property is within 50 m from the existing Site entrance, effects associated with dust or vehicle emissions are possible, but these potential effects would be managed through good practice construction measures which would form part of the Construction Environmental Management Plan (CEMP).

8. Aviation: The MOD, NATS, CAA, Glasgow Prestwick Airport, Highlands and Islands Airport were consulted during the Site design phase and at the Scoping stage and no objections were raised. Following further consultation, it was concluded that the proposed Development would not have an effect on aviation as a physical obstruction. Radar modelling shows that up to 7 turbines are either in or marginally in RLoS of NERL's Lowther Hill radar which may result in radar interference. However, the Site is within an area of uncontrolled airspace where radar clutter should not be an issue and an objection from NATS is not expected. Therefore, no significant effects are predicted.

9. Population and human health: Further to the consideration of human health impacts throughout the EIAR, it is not expected that there would be any effects from the proposed Development which would have significant effects on population and human health.

10. Risks of accidents and other disasters: The vulnerability of the proposed Development to major accidents and natural disasters, such as flooding, sea level rise, or earthquakes, is considered to be low due to its geographical location and the fact that its purpose is to ameliorate some of these issues. In addition, the nature of the proposal and remoteness of the Site means there would be negligible risks on the surrounding environment.

11. With respect to potential effects on road safety, the proposed Development would create an increase to HGV traffic levels within the 25 km study area, but these levels would remain well within the design capacity of the local road network. The accident records for the study area are low, with only 54 accidents occurring over the five year study period. Therefore the level of effect is considered to be minor adverse and not significant.

12. Waste and environmental management: The outline CEMP (**Technical Appendix 3.1**) provides a general overview on how waste and other environmental issues would be managed during the construction phase. The Peat Management Plan (**Technical Appendix 10.2**) also details how excavated peat is controlled, stored, re-used and disposed of during the construction phase of the proposed Development.

13. It is expected that a site specific waste management plan for the control and disposal of waste generated onsite would be required by condition, should the proposed Development receive consent.

15.2 Introduction

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

- infrastructure;
- telecommunications;
- television reception;
- shadow flicker;
- climate and carbon balance;
- air quality;
- aviation;
- population and human health;
- risks of accidents and other disasters; and
- waste and environmental management.

15.3 Infrastructure

15. The A83 is the major trunk road serving the Kintyre peninsula between Tarbert, on the eastern shores of the Kintyre Peninsula, and Campbeltown in the south. The A83 provides access to the Site, which also runs alongside the application boundary for a distance of approximately 500 m along the north west boundary. This is the only public road which borders the Site and there are no public access roads on the Site. There is an existing access from the A83 into the Site, which provides access to several commercial forests and the operational Cour Windfarm. It is also proposed to be used for the High Constellation Windfarm which is pending Section 36 consent.

16. The application boundary to the south west runs alongside the Kintyre Way for approximately 3 km. There is no vehicle access along this part of the Kintyre Way and the proposed Development would also not use the Kintyre Way for any vehicle movements. The only exception to this would be for the installation of proposed site enhancements including bird hide, shelter and enhancement of Archaeological features.

17. There are no overhead power lines on the Site, though there is a SHETL transmission line to the north east of the application boundary which is approximately 800 m from the nearest wind turbine.

18. There is also a water main which runs parallel with the A83 and lies on the northern side of the road.

19. A cable route for the Freasdail Windfarm crosses the site in a north south direction. The proposed turbine access track crosses the cable route to the east of T14 and the recreational access track crosses the cable route between the turbine access track by T13 and T18. The cable crossing points would be constructed in a manner which protected the underground cabling. The design of the track in this location would also consider the loadings of vehicles in order to protect the cable.

15.4 Telecommunications

20. Wind turbines can potentially cause interference to telecommunication links through reflection and shadowing to electro-magnetically propagated signals including terrestrial fixed microwave links managed by telecommunications operators.

21. Telecommunications operators were consulted, and information requested for telecommunications links within close proximity of the Site. A summary of consultation is provided in **Table 15.1**

Consultee	Summary of consultation	Comment / action taken
British Telecommunications (BT)	BT has studied this proposal with respect to EMC and related problems to BT point-to-point microwave radio links. The conclusion is that, the Project indicated should not cause interference to BT's current and presently planned radio network.	No further action required
Joint Radio Company (JRC)	This proposal cleared with respect to radio link infrastructure operated by: The Local Electricity Utility & Scotia Gas Networks	No further action required
Ofcom	No response	N/A

Table 15.1: Consultee responses

23. From the consultation responses received, it is apparent that there is no indication that the proposed Development would interfere with telecommunications links. The turbines have not increased in height through the design process, therefore, this is not considered further.

15.5 Television Reception

24. Wind turbines have the potential to adversely affect analogue television reception through either physical blocking of the transmitted signal or, more commonly, by introducing multi-path interference where some of the signal is reflected through different routes. However, the proposed Development is located in an area now served by a digital transmitter. Therefore, television reception is unlikely to be affected by the proposed Development as digital signals are rarely affected. In the unlikely event that television signals are affected by the proposed Development, reasonable mitigation measures would be considered by SPR.

15.6 Shadow Flicker

15.6.1 Introduction

25. Shadow flicker may occur under certain combinations of geographical position and time of day, when the sun passes behind the rotors of a wind turbine and casts a shadow over neighbouring properties. As the blades rotate, the shadow flicks on and off, an effect known as shadow flicker. The effect can only occur inside buildings, where the flicker appears through a window opening.

26. The likelihood and duration of the effect depends upon:

- direction and aspect of the property relative to the turbine(s): in the UK, only properties within 130 degrees either side of north, relative to the turbines, can be affected, as turbines do not cast long shadows on their southern side;
- distance from turbine(s): the further the building is from the turbine, the less pronounced the effect would be, given the shadow fades with distance. Flicker effects are known to be strongest and most likely to have the potential to cause significant effects within ten rotor diameters of a turbine (refer to **Technical Appendix 4.1: Legislation, Planning Policy and Guidance** for further detail);
- turbine height and rotor diameter;
- time of year and day; and
- weather conditions (i.e. cloudy days reduce the likelihood of effects occurring).

27. If shadow flicker cannot be avoided through layout changes, then technical mitigation solutions are available, such as shutting down the turbines which cause the effect when certain conditions prevail.

28. Shadow flicker effects are only considered during the operational phase of a windfarm development.

15.6.2 Methodology

29. As noted in **Chapter 2: Site Description and Design Evolution**, the location of the proposed turbines has been carefully considered with respect to distance from residential properties.

30. An assessment has been carried out to identify whether shadow flicker would be likely to occur at properties neighbouring, and if so the predicted times of year, and the time and duration of these potential effects.

31. Shadow flicker is calculated based on the worst-case condition assuming the sun is always shining. There are no screening features such as trees, no accounting for periods of turbine shut down and also the wind is always blowing at sufficient velocity to spin the blades and in a direction which results in the blades being perpendicular to the property (maximum shadow flicker or worst-case).

15.6.3 Limitations to the assessment

32. Sunlight and wind data have not been correlated for the purposes of this assessment and specific window type (i.e. the use and level of occupation for each room) has not been incorporated into the model. Window and door opening sizes and orientations have been estimated.

33. The assumption is that large apertures through which the shadow flicker could occur are present at each property, in reality windows may be smaller than this, though this is not considered a factor in the accuracy of the assessment as it means that the modelling has been done on a worst-case scenario for window size.

34. Any screening provided by vegetation or structures has not been incorporated as the analysis has been run on bare ground terrain data.

15.6.4 Study area

35. In line with the best practice guidance (refer to **Technical Appendix 4.1**), a study area based on a distance of 10 rotor diameters from the proposed candidate wind turbines is normally employed to determine the zone of potential shadow flicker incidence. The candidate wind turbines for the proposed Development would have a rotor diameter of around 130 m; this gives a study area of 1,300 m from the turbines. In addition, to this a further 50 m area was added to the 10 rotor diameter distance in order to account for micrositing should the proposed Development receive consent.

36. The maximum study area for the proposed Development was mapped using GIS software. This was then refined to include only the areas within 130 degrees of north of proposed wind turbine locations. Properties within 10 rotor diameters (1,300 m) plus 50 m for the reasons outlined above (1,350 m) and the 130° area were identified from OS AddressBase data. A total of four properties were identified within the shadow flicker study area. **Figure 15.1** shows the location of these properties.

15.6.5 Modelling

37. The potential dates, times and durations of shadow flicker events have been predicted using ReSoft WindFarm software. This software creates a mathematical model of the proposed wind turbines, the surrounding area and the location of properties. The following factors are taken into account in the calculation:

- turbine location, rotor diameter and hub height;
- topography (using OS Terrain 5 digital terrain data); and
- locations of houses / buildings.

38. The software calculates the dates and times when the shadow of a wind turbine's rotor could fall onto a window. The following worst-case assumptions are made throughout the calculation:

- weather conditions are such that shadows are always cast (i.e. bright/clear/sunny at all times of day and throughout the year);
- the wind is always blowing at sufficient velocity to spin the blades;
- the turbine rotors are facing directly towards the property at all times, therefore, the shadow is always at its maximum possible size and circularity, rather than elliptical as would be the case if the turbine rotor were oriented at an angle to the property; and
- The property has a window directly facing the wind turbines.

39. Rather than modelling individual windows within the software, each façade of the receptors that contain windows facing the proposed Development have been modelled as 'windows'. This technique provides conservative results and a reduction in the amount of data, simplifying the assessment process and aiding comprehension.

40. In practice the shadow flicker effects would occur for considerably less time than the worst-case predictions, for the following reasons:

- in the UK, sunshine typically occurs for approximately 30% of daylight hours rather than 100% of daylight hours every day. At other times, the wind turbines are unlikely to cast shadows sufficiently pronounced to cause shadow flicker effects to occur;
- at times when the wind turbine rotor is not oriented directly towards the property, the duration of shadow flicker effects would be reduced due to the elliptical shape of the shadow cast; and
- the properties are located within a wooded area, predominantly coniferous tree cover. During the winter months, early mornings and late evenings, these trees could potentially provide some screening to properties from the effects of shadow flicker. However, it cannot be assumed that these trees would all be present for the full lifetime of the windfarm.

41. Only those properties within 1,350 m of the proposed turbines have been included in the calculations. The model has been run using OS terrain 5 DTM data which is the most accurate digital terrain data available for the Site.

42. The assessment has been undertaken assuming a worst-case scenario which does not take into consideration the screening effect of anything located between the wind turbines and the property and as such the actual effect would likely be even less.

15.6.6 Assessment of significance

43. No published significance criteria exist for the assessment of shadow flicker effects and there is no UK statutory limit or guidance to stipulate acceptable levels of shadow flicker.

44. Although there are no local or national UK mandatory requirements or criteria in regard to shadow effects caused by wind turbines, the Onshore Wind Energy Planning Conditions Guidance Note (Predac, 2004) observes that the amount of shadow flicker should be calculated in hours per year.

45. A review of the evidence base for shadow flicker by Parsons Brinckerhoff for the Department of Energy and Climate Change (Parsons Brinckerhoff for DECC, 2011) suggests that a maximum of 30 hours of shadow flicker in a calendar year is a threshold for consideration, ideally with no longer than 30 minutes on any single occasion.

46. The assessment has adopted a criterion of 30 hours of shadow flicker in one year as a significance threshold. Where less than 30 hours of shadow flicker is predicted to occur in one year at a particular property, this is considered to be a minor effect (not significant), with significance increasing in relation to the number of hours (over 30) of shadow flicker per year, in accordance with best practice guidance.

47. The criteria set out in paragraph 38 have been used in this assessment to represent the longest amount of time that shadow flicker effects can reasonably occur before causing, what can be considered, an unacceptable nuisance and, therefore, requiring mitigation.

48. Whilst the distance between turbine and property does not affect the calculated shadow flicker exposure times, it does mean that the actual effect (i.e. the total exposure time and flicker intensity combined) of the proposed Development would in reality be less than that calculated as a worst-case.

15.6.7 Baseline conditions

49. The defined study area includes five properties including: Housing Plot 1; Meadowview; Ardrowan; Gartnagrenach Lodge and Glebe Cottage which could theoretically be affected by shadow flicker from the proposed Development (**Figure 15.1**). Details of these properties are identified in **Table 15.2**.

No.	Property	Use	Grid reference	Distance from nearest proposed turbine (m)	Within shadow flicker zone of influence?
1	Housing Plot 1	Proposed holiday chalet	181474, 659638	1.178 km from Turbine 1	Yes
2	Meadow View	Residential	181751, 659903	1.045 from Turbine 1	Yes
3	Ardrowan	Residential	179970, 659544	1.089 from Turbine 1	Yes
4	Gartnagrenach Lodge	Residential	180039, 659623	1.105 km from Turbine 1	Yes
5	Glebe Cottage	Residential	179283,659087	1.305 km from Turbine 2	Yes

Table 15.2: Properties and shadow flicker zone of influence

15.6.8 Assessment of effects

51. **Figure 15.1** shows the potential zone of shadow flicker influence. Based on the worst case modelling technique outlined, there is predicted to be shadow flicker effects of up to 29.2 hours per year at Housing Plot 1 (show in **Table 15.3**) assuming the worst-case scenario. However, in reality this would be much less as the weather conditions are not always bright and sunny. If, as highlighted in paragraph 40, sunshine occurs for only 30% of available daylight hours the figure of 29.2 hours would reduce to a more realistic figure of 9 hours per year.

52. The results shown in **Table 15.3** are based on the 'worst-case scenario' of each day being sunny and having the ability to cast shadows.

No.	Property	Grid reference	Days per year where shadow flicker potentially experienced	Max hours per day where shadow flicker potentially experienced	Total hours per year when shadow flicker potentially experienced
1	Housing Plot 1	181474, 659638	80	0.46	29.2
2	Meadow View	181751, 659903	38	0.47	9.3
3	Ardrowan	179970, 659544	62	0.48	17.7
4	Gartnagrenach Lodge	180039, 659623	28	0.47	8.4
5	Glebe Cottage	179283, 659087	28	0.41	8.0

Table 15.3: Worst Case Shadow flicker assessment outputs

54. The results confirm that the properties assessed would not experience over 30 hours of shadow flicker in a year and with a maximum of 29.2 hours predicted at any one property, that the predicted shadow flicker hours would be below the 30 hour limit and are, therefore, considered to be acceptable. This is even before considering that the modelling is based upon everyday being sunny and able to cast shadows which is very much worst case and not particularly realistic. Therefore, in reality the figures would be much lower than those presented in Table 15.3 and well within the limits of acceptability.

55. No cumulative shadow flicker effects have been identified as the properties assessed in this study is located more than 10 rotor diameters in distance from all other nearby existing or proposed windfarm developments.

15.6.9 Mitigation

56. No mitigation is currently required for the operational phase of the proposed Development as no significant shadow flicker effects are predicted to occur.

15.7 Climate and Carbon Balance

15.7.1 Introduction

57. In addition to generating electricity, the Scottish Government sees wind turbines and other renewable technologies as an important mechanism for reducing the UK's carbon dioxide (CO_2) emissions. However, such development projects can themselves create carbon emissions (e.g. use of concrete and vehicle emissions). Therefore, this Chapter estimates the CO_2 emissions associated with the manufacture and construction of the proposed Development compared to the estimated contribution the proposed Development would make to reducing CO_2 emissions. This gives an estimate of the whole life carbon balance of the proposed Development. Once the CO_2 emissions have been offset or paid back by the renewable energy development, each subsequent unit of wind or solar generated electricity would displace a unit of conventionally generated electricity, therefore, saving power station emissions and contributing to reduce CO_2 emissions.

15.7.2 Carbon and peatland

58. Renewable Energy Developments in upland areas can often be sited on peatlands which hold stocks of poorly protected carbon and so have the potential to release carbon to the atmosphere in the form of (CO_2) if disturbed. Scotland has the majority of peat soils in the UK and, therefore, has a responsibility to ensure stability of this carbon and to ensure that developments do not cause a significant loss of this carbon reservoir.

59. The carbon balance assessment must, therefore, consider the implications of any parts of the development which could lead to the release of CO_2 due to the disturbance of peat.

60. The disturbance of peat has been considered during the design process which has avoided areas of deeper peat. The Site design process is described in **Chapter 2 Site Description and Design Evolution**. Specific details on the peat depth are included in the Peat Landslide and Hazard Risk Assessment, **Technical Appendix 10.1.**

Characteristics of peatland

61. The loss of carbon from the carbon fixing potential from plants and vegetation on peat land 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.

62. When flooded, peat soils emit less carbon dioxide but more methane than when they are drained. In flooded soils, carbon emissions are usually exceeded by plant fixation, so the net exchange of carbon with the atmosphere is negative and soil stocks increase. When soils are aerated, carbon emissions usually exceed plant fixation, so the net exchange of carbon with the atmosphere is positive.

63. To calculate the carbon emissions attributable to the removal or drainage of the peat, emissions occurring if the soil had remained in situ and undrained are subtracted from the emissions occurring after removal or drainage.

64. The indirect loss of CO_2 uptake (fixation) by plants originally on the surface of the Site but eliminated by construction activity including the destruction of active bog plants on wet sites and felling, is calculated on site specific data collected as part of the EIA process and based on blanket bog.

65. 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 Site, can also be calculated from Site specific data for the Proposed Development. This figure is a worst-case scenario, as the peat would be re-used onsite to minimise carbon losses, for restoration of the renewables project and for habitat restoration including ditch blocking. Effects of carbon emissions from construction

66. Emissions arising from the fabrication of the turbines, solar panels and the associated components are based on a full life analysis of a typical turbine and include CO_2 emissions resulting from transportation, erection, operation, dismantling and removal of turbines and foundations and transmission grid connection equipment from the existing electricity grid system.

67. With respect to turbines, emissions from material production are the dominant source of CO_2. Emissions arising from construction (including transportation of components, quarrying, building foundations, access tracks and hard standings) and commissioning are also included in the calculations. The assessment has used Nayak et al (2008) default values for 'turbine life' emissions, calculated with respect to installed capacity.

68. A number of technical papers (detailed in Nayak et al, 2008) have reported a wide range of emissions values from windfarms, these being between 6 and 34 tonnes CO_2 GWh-1. From this a calculation of additional CO_2 payback time due to production, transportation, erection and operation of the proposed Development that this represents can be compared. The additional CO_2 payback time for the best case scenario would be 8 months (0.7 years) assuming replacement of coal fired power generation and 31 months (2.6 years) assuming a replacement of grid mix (the combination of electricity suppliers, including coal, gas and oil generation, used for grid balancing and the type of power generation most likely to be replaced by wind generated power). For the worst-case scenario this would increase to 10 months (0.8 years) and 35 months (2.9 years) additional CO_2 payback respectively. For solar panels, there is limited technical research but the solar industry reports around a 3 year payback period to offset the CO_2 produced during the construction and installation of solar farms.

69. These increases are considerable and so it is essential that they are considered for the calculation of CO_2 payback time. However, it should be noted that this may still compare very favourably with the life cycle analysis of other means of non fossil fuel based power generation, such as nuclear, particularly when the full energy costs of construction, operation, maintenance and decommissioning, uranium mining and transportation and long term waste management are taken into account.

15.7.3 Carbon Payback Methodology

70. The assessment of the carbon payback 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.

71. The methodology to calculate carbon emissions is based on 'Calculating carbon savings from windfarms on Scottish peat lands - A New Approach' (Nayak et al, 2008), prepared for the Scottish Government Science, Policy and Co-ordination Division. This was superseded in 2011 by the document 'Calculating Carbon Savings from Wind Farms on Scottish Peatlands - A New Approach', (Nayak et al, 2008 and 2010) and (Smith et al, 2011). In terms of carbon footprint, the 'carbon calculator' is the Scottish Government's tool provided to support the process of determining the carbon impact of windfarm developments in Scotland. It is noted that this methodology is specifically designed for windfarms and not renewable energy developments like this proposed Development. Therefore, the assessment only considers the wind turbine element of the proposed Development.

72. The proposed Development is seeking consent without a limit to operational lifetime, however in order to ensure a meaningful result from the application of the calculator, an operational lifespan of 40 years has been assumed.

Input parameters

73. To undertake this assessment 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 CO_2 uptake (fixation) by plants originally on surface of the Site but eliminated by construction activity (including the destruction of active bog plants on wet sites) and felling;
- 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; and
- loss of carbon due to drainage and from forestry clearance.

74. As part of their methodology, Nayak et al have provided a spreadsheet called 'Scottish Government Windfarm Carbon Assessment Tool' to calculate whole life carbon balance assessments for windfarms on peat lands. The calculation spreadsheet (Version 2.9.0 and online version V8 reference number 3G17-2RPY-IEN5 V.6) allows a range of data to be input in order to address expected, minimum and maximum values. However, 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.

75. This spreadsheet 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 ground water levels).

76. This assessment draws on information detailed in the EIA Report, **Chapter 8 Ecology** and **Chapter 10 Hydrology**, **Hydrogeology**, **Geology and Soils**. For the purpose of this assessment, it is assumed that all the embedded good practice measures outlined in **Chapter 8 Ecology**, and **Chapter 10 Hydrology, Hydrogeology**, **Geology and Soils**, would be employed.

77. The final wind turbine choice is not yet known but would likely be around 6 MW and the greenhouse gas savings and carbon payback are based on the input parameters of the proposed 19 turbines. Figures are based on currently available turbines and assume a consistent supplier for all turbine locations (i.e. turbine types are chosen by manufacturer). Note that, within the calculation spreadsheet, the expected, maximum and minimum values have been adjusted to suit the input parameter.

78. The recommended capacity factor within the calculation spreadsheet is based on 35.8% which is the average of the figures used in the carbon calculator assessment.

79. The input parameters for the Scottish Government calculation spreadsheet are detailed in **Technical Appendix 15.1**. The choice of methodology for calculating the emission factors uses the 'Site Specific methodology' defined within the calculation spreadsheet.

15.7.4 Results

80. This section presents a summary of the carbon assessment which has been undertaken in respect of the proposed Development. 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 a windfarm. An assessment has been undertaken to calculate the carbon emissions which would be generated in the construction, operation and possible decommissioning of the proposed Development after 40 years.

81. The carbon calculations spreadsheet is provided in **Technical Appendix 15.1.** A summary of the anticipated carbon emissions and carbon payback of the proposed Development are provided in **Table 15.4.**

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO_2 eq.)	235,752	228,538	242,782
Carbon payback time			
Coal-fired electricity generation (years)	0.7	0.6	0.8
Grid-mix of electricity generation (years)	2. 6	2.3	2.9
Fossil fuel - mix of electricity generation (years	1.5	1.3	1.6
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	25	13	43
Ratio of CO_2 eq. emissions to power generation (g / kWh)	16	15	18
(TARGET ratio by 2030 (electricity generation) < 50 g /kWh)			

Table 15.4: Anticipated carbon emissions

15.7.5 Interpretation of results

82. The calculations of total carbon dioxide emission savings and payback time for the proposed Development indicates the overall payback period of a development with 19 wind turbines with an average (expected) installed capacity of around 6 MW each would be approximately 1.5 years, when compared to the fossil fuel mix of electricity generation.

83. This means that the proposed Development is expected to take around 1.6 years or 19 months to repay the carbon exchange to the atmosphere (the CO_2 debt) through construction of the wind turbines; the Site would in effect be in a net gain situation following this time period and would contribute to national CO_2 reduction targets.

15.8 Air Quality

84. Construction activities can result in short term temporary effects from dust if unmanaged. This can result in nuisance effects, such as soiling of buildings and, if present over a long period of time, can affect human health. As the nearest property is adjacent to the application boundary and the existing access to the Site, effects associated with dust or vehicle emissions are considered to be likely. Mitigation measures as part of the CEMP (**Technical Appendix 3.1**) would be implemented based on good construction practice to reduce the potential for dust emissions. In addition, SPR is also proposing to construct a new access which would reduce further the likelihood of dust impacts at the existing Site entrance.

15.9 Aviation and Defence

85. The potential impacts of wind turbines on aviation interests have been widely publicised. There are two dominant scenarios:

- physical obstruction: turbines can present a physical obstruction at, or close to, an aerodrome or other aviation activity site; and
- radar / Air Traffic Services: turbines can produce spurious / false returns known as "clutter", particularly from primary surveillance radar (PSR). Turbine clutter appearing on a radar display can affect the safe and efficient provision of air traffic services as it can mask unidentified aircraft from the air traffic controller and / or prevent him from accurately identifying aircraft under his control and / or cause the track of the aircraft under control to be incorrectly reported. In some cases, radar reflections from the turbines can affect the performance of the radar itself.

15.9.1 Baseline conditions

86. The Site is approximately 62 km north west of Glasgow Prestwick Airport and 65 km west of Glasgow Airport, the two major airports in the west of Scotland. Initial assessments have established that the proposed Development is not within radar line of sight (RLOS) of the PSRs at either airport and beyond both airports' wind turbine consultation zones.

87. NATS published radar line of sight safeguarding maps show that the Site is visible to NATS (En Route) plc (NERL) radars and may conflict with NERL safeguarding criteria. Further modelling confirms that 5 turbines (turbines 1, 7, 14, 15 and 16) are in RLoS of Lowther Hill. Additionally, turbines 8 and 17 are marginally in RLoS and may be detected. Notwithstanding this, the Site is within an area of uncontrolled airspace, as detailed below, where radar clutter should not be an issue.

88. The proposed Site is situated within Class G (uncontrolled) airspace which extends from the ground to Flight Level 195 (approximately 19,500ft above mean sea level [amsl]). In uncontrolled airspace the responsibility to see and avoid other traffic and obstacles rests with the pilots in command of civilian and military aircraft - any Air Traffic Services provided are essentially advisory. Above FL195 the airspace is Class C controlled airspace. The elevation of the highest proposed turbine (turbine 13) extends to 398m (approximately 1,310ft) amsl, and as such does not penetrate any controlled airspace. The Site is well clear of any of the airspace structures that are in the vicinity. The Site is within the Glasgow Airport Air Traffic Control Surveillance

Minimum Altitude Chart; however, as the obstacles on the Isle of Arran are far higher, it will not require any changes to this chart. In addition to the commercial aircraft operating to and from Glasgow Prestwick Airport and Glasgow Airport, the military and General Aviation communities must be considered. Volumes of controlled and restricted airspace can result in the channelling or funnelling of such traffic around said volumes. In this instance, there are no such volumes in the Site vicinity to create this funnelling effect.

89. The proposed Development's turbines are located within a Ministry of Defence (MOD) "blue" low flying consultation zone. The MOD class such zones as low priority military low flying areas that are less likely to raise concerns. The MOD was consulted during the Site design phase and at the Scoping stage and no objection was raised. However, Defence Infrastructure Organisation Safeguarding requested to be consulted and notified of the progression of the consent application to verify that it would not adversely affect defence interests. In particular, it requested details of the construction programme, height of equipment, co-ordinates of wind turbines ahead of construction. The purpose of requesting this information was to enable flying charts to be updated and to make sure that military aircraft avoid the area.

90. The MOD also requested that the cardinal turbines are fitted with MOD accredited 25 candela omni-directional red lighting and infrared combination lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point. The remaining perimeter turbines should be fitted with 25 candela omni-direction red lighting or infrared lighting to the same specification. However, as highlighted at Gatecheck Report to the ECU, SPR would be willing to install the infrared lighting on the perimeter turbines but wishes to discuss further the need for 25 candela omni-direction red lighting on other turbines. As the area is a low priority low fly area and as the turbines would be mapped on charts, SPR is of the view that the lighting is not needed, especially as Freasdail Windfarm directly adjacent does not have any red lighting.

91. It is understood that the MOD has recently agreed that either red lighting or infrared lighting can be installed for the Kennoxhead windfarm and SPR would seek to agree a similar condition for this proposed Development.

92. In addition, as turbines would be less than 150 m to blade tip and, therefore, would not require aviation lighting to comply with CAA requirement in accordance with Article 219 of the Air Navigation Order which comes into effect at 150 m.

93. 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 15.5.**

Consultee	Summary of consultation	Comment/Action taken
Defence Infrastructure Organisation	Email dated 11/04/2019 The MOD has no objection to the application The MOD requests that the cardinal turbines are fitted with MOD accredited 25 candela omni-directional red lighting and infrared combination lighting with an optimised flash pattern of 60 flashes per minute of 200ms to 500ms duration at the highest practicable point. The remaining perimeter turbines should be fitted with 25 candela omni-direction red lighting or infrared lighting to the same specification. Defence Infrastructure Organisation Safeguarding wishes to be consulted and notified of the progression of planning applications and submissions relating to this proposal to verify that it will not adversely affect defence interests. If planning permission is granted we would like to be advised of the following prior to commencement of construction; • the date construction starts and ends; • the maximum height of construction equipment; • the latitude and longitude of every turbine. This information is vital as it will be plotted on flying charts to make sure that military aircraft avoid this area	SPR would consult with MOD/DIO prior to the commencement of construction so that details of the scheme can be provided. The need for any specific red lighting and infrared lighting would also be discussed and agreed prior to commencement
NATS Safeguarding	Email dated 08/04/19 NATS provided generic guidance which the Applicant could refer to in order to ascertain whether an impact might be anticipated	NATS RLoS safeguarding maps indicate Site visibility to NERL radars. Modelling confirms 5 turbines in RLoS of Lowther Hill radar. However, no NATS objection is expected as the Site is within uncontrolled airspace.
Civil Aviation Authority	No response	N/A
Glasgow Prestwick Airport (GPA)	Email dated 07/05/2019 GPA consider the scope of the proposed assessments appropriate. Preliminary Line of Sight (LOS) analysis suggests that some of the turbines may be visible to GPA's primary radar – and thus require mitigation	Modelling shows the proposed Development is not within RLoS of either of the GPA PSRs.
Highlands and Islands Airports Ltd (HIAL)	Email dated 09/05/2019 With reference to the above, our calculations show that, at the given position and height, this development would not infringe the safeguarding surfaces for Campbeltown Airport. However, due to the height of the turbines an omnidirectional steady red aviation warning lights may be required to be fitted at the hub height of some of the turbines. As a minimum the Civil Aviation Authority (CAA) recommends that all proposed developments over 90m in height should be notified to the CAA.	Turbines would be less than 150 m to blade tip and do not require aviation lighting in accordance with CAA requirements, however, MOD require lighting of perimeter turbines.

Table 15.5: Consultee responses

15.9.2 Assessment of effects

95. From the consultation undertaken, it is concluded that the proposed Development, would not have an effect on aviation, as a physical obstruction. Radar modelling shows that up to 7 turbines are either in or marginally in RLoS of NERL's Lowther Hill radar which may result in radar interference. However, the Site is within an area of uncontrolled airspace where radar clutter should not be an issue and an objection from NATS is not expected. Therefore, aviation is not considered further.

15.10 Population and human health

96. **Chapter 7 Landscape and Visual Impact Assessment**, **Chapter 10 Hydrology, Hydrogeology, Geology and Soils**, **Chapter 12 Access, Traffic and Transport**, **Chapter 13 Noise** and **Chapter 14 Socio-Economics Recreation and Tourism**, contain assessments which relate to the health and wellbeing of the local population. These Chapters assess the effects of the proposed Development, both positive and negative, provide an analysis of the significance of these effects and also put forward measures to mitigate against negative effects on people and their health.

97. **Chapter 16 Summary of Mitigation**, provides an overview of the mitigation put forward as part of these assessments in order to reduce any negative effects of the proposed Development to an acceptable level.

98. Further to the topics covered in **Chapters 7 to 15**, it is not expected that there will be any other effects from the proposed Development which would have significant effects on population and human health.

15.11 Risk of Accidents and Other Disasters

15.11.1 Introduction

99. The vulnerability of the proposed Development to major accidents and natural disasters, such as flooding, sea level rise, or earthquakes, is considered to be low due to its geographical location and the fact that its purpose is to ameliorate some of these issues.

100. In addition, the nature of the proposals and remoteness of the Site means there would be negligible risks on the factors identified by the EIA Regulations. For example:

- population and human health – the Site is remote with low population density and the required safety clearances around turbines has been a key consideration throughout the design process;
- biodiversity – receptors and resources would be unaffected as there would be little risk of polluting substances released or loss of habitat in a turbine failure scenario (highly unlikely);
- land, soil, water, air and climate – there would be little risk of polluting substances released or loss of habitat in a turbine failure scenario (highly unlikely); and
- material assets, cultural heritage and the landscape – there would be no adverse effects on these features in a turbine failure scenario (highly unlikely).

15.11.2 Public Safety and Access

101. The RenewableUK Onshore Wind Health and Safety Guidelines (2015) note that wind turbine development and operation can give rise to a range of risks to public safety including:

- traffic (especially lorries during construction, and abnormal loads for the transport of wind turbine components; including beyond the application boundary);
- construction site hazards (particularly to any people entering the Site without the knowledge or consent of the site management);
- effects of catastrophic wind turbine failures, which may on rare occasions result in blade throw, tower topple or fire; and
- ice throw, if the wind turbine is operated with ice build-up on the blades.

102. The RenewableUK guidance (2015) states that "*Developers should ensure that risks to public safety are considered and managed effectively over the project lifecycle, and should be prepared to share their plans for managing these risks with stakeholders and regulators; effective engagement can both build trust, and help to reduce the level of public safety risk by taking account of local knowledge.*"

103. Site security and access during the construction period would be governed under Health and Safety at Work Act 1974 and associated legislation. There would be no public access to the Site during construction. However, the Land Reform (Scotland) Act (2003) which came into effect in February 2005 establishes statutory rights of responsible access on and over most land. The legislation offers a general framework of responsible conduct for both those exercising rights of access and for landowners. Once the construction period and commissioning of the windfarm is complete, no special restriction on access is proposed.

104. Informal recreational access within the Site, which is being promoted by the proposed Development, would benefit from the presence of the proposed Development by providing a feature of interest and enhancing access through site infrastructure. Appropriate warning signs would be installed concerning restricted areas such as the substation compound, transformers, switchgear and metering systems. All onsite electrical cables would be buried underground with relevant signage.

15.11.3 Traffic

105. Accident data for the roads local to the Site (A83 between the Site and Campbeltown Harbour to the south and north to Lochgilphead) has been reviewed and is presented in **Chapter 12 Access, Traffic and Transport**. An assessment of the potential effects on road safety has been undertaken. In summary, the proposed Development would create an increase to HGV traffic levels within the study area, but these levels would remain well within the design capacity of the local road network. The accident records for the 25 km study area are low, with only 54 accidents occurring over the five year study period. Therefore, the level of effect is considered to be minor adverse and not significant.

15.11.4 Construction

106. With regard to risks and accidents during the construction phase, the construction works for the proposed Development would be undertaken in accordance with primary health and safety legislation, including the Health and Safety at Work Act 1974 and the Construction (Design and Management) (CDM) Regulations 2015 which will include a requirement to produce emergency procedures in a Construction Phase (Health & Safety) Plan in accordance with the Regulations.

107. Nonetheless, the risk of accidents and other disasters is covered where relevant in individual topic Chapters, for instance, the potential for environmental incidents and accidents such as spillages are considered in **Chapter 8 Ecology**, **Chapter 9 Ornithology** and **Chapter 10 Hydrology, Hydrogeology, Geology and Soils**. Flood risk is also assessed with **Chapter 10**.

15.11.5 Extreme weather

108. As far as the risk of turbine failure during high winds is concerned, the turbines would cut-out and automatically stop as a safety precaution in wind speeds over 25 m/s. The solar mounting panels would also be designed to with stand high winds. Failure of the solar panel arrays during high winds, whilst not expected, would be unlikely to result in any significant environmental effects.

109. Wind turbines can be susceptible to lightning strike due to their height and appropriate measures are taken into account in the design of turbines to conduct lightning strikes down to earth and minimise the risk of damage to turbines. However, occasionally lightning can strike and damage a wind turbine blade. Modern wind turbine blades are manufactured from a glass-fibre or wood-epoxy composite in a mould, such that the reinforcement runs predominantly along the length of the blade. This means that blades will usually stay attached to the turbine if damaged by lightning and in all cases turbines will automatically shut down if damaged by lightning. Solar panels can also be susceptible to lightning strikes and they would be installed with lightning protection systems to reduce risks of lightning damage.

110. Ice build-up on blade surfaces occurs in cold weather conditions. Wind turbines can continue to operate with a very thin accumulation of snow or ice, but will shut down automatically as soon as there is a sufficient build up to cause aerodynamic or physical imbalance of the rotor assembly. Potential icing conditions affecting turbines can be expected two to seven days per year (light icing) in Scotland (WECO, 1999). The potential for ice throw to occur after start up following a turbine shut down during conditions suitable for ice formation is high. There are monitoring systems and protocols in place to ensure that turbines that have been stationary during icing conditions are restarted in a controlled manner to ensure public safety. The risk to public safety is considered to be very low due to the few likely occurrences of these conditions along with the particular circumstances that can cause ice throw.

15.11.6 Seismic activity

111. No fault lines are present on or in the immediate vicinity of the Site (Figure 10.4), and there are no records of any earthquakes occurring in the vicinity of the Site within the last 130 years (BGS GeoIndex, viewed 09/10/2019). Earthquakes in Scotland are typically no greater than 3 on the Richter Scale and, therefore, minor and unlikely to cause significant damage to buildings and infrastructure.

112. It is very unlikely that an earthquake would occur on the vicinity of the Site resulting in any damage to the proposed Development. Should a wind turbine or solar array be damaged, the risk to public safety is considered to be negligible due to the remote location and careful design layout of the infrastructure.

15.12 Waste and Environmental Management

113. **Chapters 7 to 14** put forward suggestions on how to mitigate any negative impacts from the proposed Development with regards to waste and environmental management. These are summarised in **Chapter 16 Summary of Mitigation**.

114. The outline CEMP (**Technical Appendix 3.1**) provides a general overview on how waste and other environmental issues would be managed during the construction phase. The Peat Management Plan **(Technical Appendix 10.2)** also details how excavated peat is controlled, stored, re-used and disposed of during the construction phase of the Proposed Development.

115. It is expected that a site specific waste management plan for the control and disposal of waste generated onsite would be required by condition, should the Proposed Development receive consent.

15.13 References

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