15 Other Issues

Contents

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15 Other Issues

15.1 Executive Summary

15.1.1 This chapter covers the following technical disciplines:

- Telecommunications;
- Shadow Flicker; and
- Carbon Savings.

15.1.2 A review of telecommunication links and consultation with telecommunication providers showed an EE link crossing the site. Turbine 3 has the potential to cause interference with the link and therefore a 125 m micrositing buffer has been proposed. Turbines 1, 2 and 4 cause no infringements to the any telecommunication links.

15.1.3 A shadow flicker study area of ten rotor diameters (1550 m) identified 34 receptors with potential to experience shadow flicker effects. Calculations have shown that shadow flicker impacts at six of these receptors could be potentially significant. It should be noted that all six of these receptors are financially involved in the Proposed Development. The Applicant proposes that prior to the erection of the first turbine a 'Wind Farm Shadow Flicker Protocol' will be submitted to and approved in writing by Orkney Islands Council. This will set out mitigation measures to alleviate shadow flicker attributable to the Proposed Development as well as a protocol for addressing a complaint received from a receptor within the study area. Operation of the turbines would be required to take place in accordance with the approved Shadow Flicker Protocol and any mitigation measures that have been agreed through the protocol would require to be implemented as appropriate.

15.1.4 Although the Proposed Development will generate carbon free electricity, carbon will be released during the manufacturing, delivery, construction and maintenance of the wind farm. Siemens Gamesa lifecycle analysis was used to estimate the carbon released by the Proposed Development and establish the estimated carbon savings when compared to a fossil fuel source. It has been calculated that approximately 15,000 tonnes CO_2 eq would be generated by the 26.4 MW wind farm, operating for 40 years. Accounting for these CO2 emission, the estimated net carbon saving resulting from the Proposed Development is approximately 1.53 million tonnes CO_2 eq. It is clear from the analysis that the carbon emissions generated by the development are negligible in comparison to the carbon emissions that could be displaced through the Proposed Development's generation of renewable energy (less than 1%). The Proposed development would positively contribute to national objectives of reducing Greenhouse Gas (GHG) emissions and therefore, have a beneficial effect on meeting current climate change targets.

15.2 Telecommunications

Introduction

15.2.1 This section considers the potential effects of the Proposed Development on existing and planned telecommunications and television infrastructure, both within the site and in the wider area, during construction, operation, and decommissioning.

15.2.2 Wind turbines, like any other large structure, have the potential to interfere with electromagnetic signals, which are used in a variety of communications. Relevant infrastructure given consideration included telecommunication links, television reception and microwave links.

15.2.3 The Office of Communications (Ofcom) is the regulator for the UK communications industries and, under the *Wireless Telegraphy Act 2006*, is responsible for dealing with any complaints regarding interference to television, radio or telecommunications. Operators of electromagnetic links will ascribe a safeguarding buffer zone around their transmitters and line of sight pathways to ensure that they remain unobstructed. Consequently, individual telecommunication providers/operators have been consulted as part of this assessment.

15.2.4 Assessment of effects to television reception has been scoped out within the Scoping Report (refer to **Appendix 4.1**). This is because the strength of the digital signal in the area, and the inherently resilient nature of digital television broadcasting, mean that there is a low risk of interference with domestic television reception from a wind energy development at this location.

15.2.5 Any impact on aviation and radar is covered separately in **Chapter 13**.

15.2.6 This assessment has assessed the design as described in **Chapter 3**. For the purpose of this assessment, it has been assumed that the Proposed Development turbines will not exceed 180 m to blade tip. In addition, the candidate turbine that has been used to inform the assessment has a hub height of 102.5 m and blade length of 77 m. It is recognised that turbine selection will be subject to commercial tendering and availability and the specific parameters of hub height and rotor diameter may therefore vary; it is however unlikely that a change to the hub height or rotor diameter from that assessed would result in a material change in the findings of the assessment.

Legislation, Policy and Guidelines

15.2.7 The assessment has been informed by relevant legislation, policy and guidelines, details of which are noted below:

- Wireless Telegraphy Act (2006);
- The Orkney Local Development Plan (Orkney Islands Council, 2017a);
- The Orkney Local Development Plan. Supplementary Guidance: Energy (Orkney Islands Council 2017b);
- Planning Advice Note: PAN 62 Radio Telecommunications (2001); and
- Tall structures and their impact on broadcast and other wireless services (Ofcom 2009).

15.2.8 The potential impacts as a result of the Proposed Development have been assessed with reference to the above documents.

Consultation

15.2.9 Consultation was undertaken with relevant statutory and non-statutory stakeholders to identify any fixed wireless links or scanning telemetry links in the area, and a summary of their responses is set out in Table 15.1 below.

Table 15.1 Telecommunications Consultation

Consultee	Response	Actions
Ofcom (29th April 2022)	Spectrum Licensing no longer replies to consultation on telecommunications	No further action is required.
Joint Radio Company (JRC) (3rd May 2022)	No objection	No further action required.
Atkins (3rd May 2022)	No objection	No further action required.
Arqiva (4th May 2022)	No objection	No further action required.
BT (6th May 2022)	No objection	No further action required.
Vodafone (9th May 2022)	No objection	No further action required.

Consultee	Response	Actions
EE (20th June 2022)	The Proposed Development, specifically Turbine 3, would cause a potential infringement.	An additional micrositing allowance of 125m has been incorporated into the design to ensure Turbine 3 can be sited so it does not cause unacceptable interference.
EE (30th June 2022)	Based on the additional micrositing and the new proposed turbine coordinates provided for Turbine 3, the Proposal Development is approved.	The Proposed Development layout has been revised to include micrositing and prevent interference with the EE telecommunications link.

Assessment Methodology

15.2.10 This section describes the methods by which the key baseline conditions were identified and how the potential effects of the Proposed Development on the baseline has been assessed.

15.2.11 Interference with mobile phone networks and other wireless data networks can occur through the interference of microwave and Ultra High Frequency (UHF) band fixed links. These networks are operated by or on behalf of the mobile service providers, the utility companies, the emergency services and occasionally by small private networks.

15.2.12 The impact assessment has been conducted through consultation with the operators of these networks to identify potential impacts and residual impacts, and then go on to determine appropriate mitigation measures.

Baseline Conditions

15.2.13 The baseline was established through consultation as detailed in Table 15.1 above. This process identified one link located within the site operated by EE, who are a mobile service provider.

15.2.14 The link location is shown in **Figure 15.1**.

Potential Effects

15.2.15 EE ran an interference analysis on Layout 4 (refer to **Chapter 2**) which identified potential interference to their link. Turbines 1, 2 and 4 were assessed as causing no interference, however, EE considered that the proposed location of Turbine 3 could potentially cause infringement issues.

15.2.16 EE state there is a clearance requirement of over 100m from the blade tip to a link and/or over 250m from a link end to a blade tip. Turbine 3 is situated approximately 43 m from the EE telecommunication link. Given the candidate turbine has a blade length of 77 m, infringement on the link would likely occur. Therefore, mitigation would be required.

Mitigation

15.2.17 On the assumption that the EE link continues to operate in its current form, in order to avoid infringement on the EE telecommunications link caused by turbine 3, it is proposed a 125 m micrositing buffer would be place on this turbine only. Turbine 3 would be microsited in a southerly direction to ensure an acceptable clearance distance. It is likely Turbine 3 would be located in the following location:

Table 15.2 Micrositing Location of Turbine 3

ID	X	Y
1	329811	1027366
2	330312	1026900
3	**330731**	**1027291**
4	331058	1026885

15.2.18 EE have confirmed this location would be acceptable and no infringement on the link would occur.

15.2.19 The standard 50 m micrositing buffer would remain for Turbines 1, 2 and 4.

Cumulative Effects

15.2.20 As the proposed 125 m micrositing buffer will be implemented at Turbine 3, the updated proposed location will result in the Proposed Development having no infringements on the EE telecommunications link. The Proposed Development will not have any cumulative effects on telecommunication links with other developments.

Summary

15.2.21 This section has considered the potential effects of the Proposed Development on existing and planned telecommunications infrastructure.

15.2.22 The telecommunications assessment, as informed by current guidelines and legislation, has been undertaken through consultation with the appropriate consultees, namely:

- Arqiva;
- Atkins;
- BT;
- EE;
- JRC;
- Spectrum Licensing; and
- Vodafone.

15.2.23 The consultation process identified one telecommunications link located within the site boundary operated by EE. **Figure 15.1** shows the location of the telecommunications link.

15.2.24 If the proposed mitigation of 125 m micrositing buffer at turbine 3 only is implemented, no effects on telecommunications from the construction, operation or decommissioning of the Proposed Development would be identified.

15.2.25 With the mitigation proposed, the Proposed Development will not impact any telecommunication links. Therefore, the Proposed Development will not have any cumulative effects on telecommunication links with other developments.

15.3 Shadow Flicker

Introduction

15.3.1 This section describes and assess potential shadow flicker effects resulting from the Proposed Development on neighbouring residential and commercial properties. This chapter (and its

associated figures and appendices) is not intended to be read as a standalone assessment and reference should be made to the description of the Proposed Development in **Chapter 3**.

15.3.2 The Scottish Government Onshore wind turbines: planning advice (2014) states 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 "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening*".

15.3.3 Any receptors which may potentially be affected have been identified and the potential occurrence of shadow flicker calculated.

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

- time of day and year;
- wind 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.

15.3.5 The flickering effect caused by shadow flicker also has the potential to induce epileptic seizures in people with photosensitive epilepsy. The National Society for Epilepsy (NSE) advises that around 1 in 131 people have epilepsy and up to 5 % of these have photosensitive epilepsy (NSE, 2011). 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 in less than 3 flashes per second and are therefore unlikely to cause epileptic seizures (Harding et al., 2008: Smedley et al., 2010). Therefore, there are not considered to be any health effects associated with the Proposed Development and this assessment will address the effects of shadow flicker related only to local amenity.

15.3.6 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 semimatt finishes to reduce this effect.

15.3.7 A wind 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 taken into account within this assessment as well as the cumulative effect with other operational wind farms in the local area.

15.3.8 This section is supported by the following figures and appendices:

- Figure 15.2 Shadow Flicker Study Area
- Figure 15.3 Shadow Flicker Results (Realistic Scenario)
- Figure 15.4 Cumulative Shadow Flicker Study Area
- Appendix 15.1 Shadow Flicker Meteorological Data
- Appendix 15.2 Potential Shadow Periods

Legislation, Policy and Guidelines

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

Policy

15.3.10 **Chapter 5** of the EIA Report sets out the planning policy framework that is relevant to the EIA. The policies set out within this chapter include those from the Orkney Islands Council (OIC) Local Development Plan (LDP) and relevant supplementary guidance, those relevant aspects of Scottish Planning Policy (SPP), PANs and other relevant guidance. Of relevance to the shadow flicker assessment presented within this chapter, regard has been had to the following policies and guidance:

- The Orkney Local Development Plan (OIC, 2017a);
- The Orkney Local Development Plan. Supplementary Guidance: Energy (OIC, 2017b);
- Development Criterion 1 – Communities and Amenity, Part 4: Wind Energy: The Orkney Local Development Plan. Supplementary Guidance: Energy (OIC, 2017b); and
- Paragraph 169 of SPP (Scottish Government, 2014b).

Guidance

15.3.11 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.

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

Consultation

15.3.13 Consultation on the methodology of the shadow flicker assessment was undertaken with OIC. A summary of this consultation is shown in Table 15.3 below.

Table 15.3 Shadow Flicker Consultation

Consultee	Comment	Applicant Response
OIC (Scoping Opinion) 27th May 2022.	The potential for shadow flicker impacts will be assessed at all residential receptors within the proposed study area. This study area is proposed to include an area within a distance of 10 times the rotor diameter and 130 degrees either side of north for each turbine. The Applicant proposes to confirm the receptors that fall within the study area with Orkney Islands Council and this should be confirmed at the earliest opportunity.	A shadow flicker assessment has been conducted with an initial study area consisting of 10 times rotor blade diameter resulting in a study area of 1,550 m from each turbine location.

Assessment Methodology and Significance Criteria

Study Area

15.3.14 The Study Area is shown in **Figure 15.2** and the shadow flicker assessment has been carried out for the proposed four turbines at the locations identified in **Chapter 3**. The final turbine 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 15.4**.

Table 15.4 Details of the Turbine Model Used for the Shadow Flicker Assessment

Hub Height	102.5 m
Rotor Diameter	155 m

15.3.15 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 1.55 km from each turbine. **Figure 15.2** shows the extent of this area and those receptors that could potentially be affected by shadow flicker.

Desk Study

15.3.16 The desk study assessment identified 33 residential receptors and one commercial receptor (Hundland Gallery) within the Study Area (shown in **Figure 15.2**). Table 15.5 summarises the locations of the receptors and the distance from each property to the nearest turbine. Properties which are financially involved in the Proposed Development are denoted (FI).

Table 15.5 Receptor Locations

Property	Shadow Flicker ID	Easting	Northing	Approx. Distance to Nearest Turbine (m)	Turbine which may cause flicker
Veltan *(FI)*	1	330278	1027678	550	1, 2, 3, 4
Dale *(FI)*	2	330286	1027780	590	1, 2, 3, 4
Belmont *(FI)*	3	330122	1027886	600	1, 2, 3, 4
Nisthouse *(FI)*	4	329666	1026856	540	2, 4
Mucklehouse *(FI)*	5	330034	1026607	410	None
Hundland *(FI)*	6	330018	1026575	440	None
Myres*	7	329439	1027815	590	1, 2, 3, 4
Newhouse *(FI)*	8	329570	1028108	780	1, 2, 3, 4
Stoneymilders *(FI)*	9	329903	1028121	750	1, 2, 3, 4
Lochside Cottage *(FI)*	10	330335	1028196	890	1, 2, 3, 4
The Cottage	11	329085	1027087	784	2, 4
Hundland Gallery	12	329010	1027215	840	2
Hundland Schoolhouse	13	329002	1027206	820	2
The Longhouse	14	328825	1026952	1080	2
Hunchaquoy	15	328511	1027427	1310	1, 2
Bokieha	16	329495	1028365	1050	1, 2, 3
Kelowna	17	329443	1028380	1070	1, 2, 3

Property	Shadow Flicker ID	Easting	Northing	Approx. Distance to Nearest Turbine (m)	Turbine which may cause flicker
Viewforth	18	329374	1028417	1110	1, 2, 3
Finties	19	329261	1028322	1080	1, 2, 3
Scruit Garage	20	330414	1028614	1249	1, 3
Slinghorn	21	329177	1028365	1070	1, 2, 3
Scruit	22	330407	1028626	1250	1, 2, 4
Dale Costa	23	331951	1027655	1170	2, 3, 4
Lochview	24	331958	1027169	940	2, 4
Birsay Hatcheries Caravan	25	331974	1027181	950	2, 4
Rymmon	26	332351	1027296	1360	4
Wascra	27	329323	1028595	1320	1, 2, 3
Whitemire	28	332492	1026786	1430	None
Swannay Cottage	29	329342	1028671	1380	1, 3
The Bungalow, Swannay Farm	30	329322	1028719	1430	1, 3
Wenvoe	31	329228	1028689	1440	1, 3
Neven	32	328987	1028586	1470	1
Ingsay	33	328842	1028417	1430	1
Brekkan	34	329313	1028692	1400	1, 3

Note – properties marked (FI) are considered to be Financially Involved with the Proposed Development.
**Derelict property*

Assessment of Potential Effect Significance

15.3.17 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 the generally accepted quantitative guidance which adopts two maximum limits to define significant effects:

- A worst-case scenario limit of 30 hours per year or 30 minutes on the worst affect day; and
- A realistic scenario taking account of meteorological parameters limited to 8 hours per year.

15.3.18 Within this assessment the sensitivity of the receptors is assumed to be high in all cases as all receptors are residential dwellings.

Assessment Modelling

15.3.19 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 takes into account 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 receptors to be assessed; and
- the size of windows on each receptor and the direction that the windows face.

15.3.20 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 5 m resolution.

15.3.21 Calculations were undertaken for predicted shadow hours at each of the receptors for two scenarios: a theoretical (worst-case) and a realistic scenario. For the worst-case scenario the following assumptions were made:

- all receptors have a 1 m x 1 m window facing directly towards the turbine;
- the turbine blades were assumed to be rotating for 365 days per year;
- there is a clear sky 365 days per year;
- the turbine blades were assumed to always be positioned towards each receptor;
- more than 20 % of the sun is 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 occupied at all times; and
- no screening is present.

15.3.22 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).

15.3.23 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.

15.3.24 In addition, the distance between the turbine and a window has an impact on the intensity of any shadow flicker that is experienced. The study area has been set at 10 rotor diameters as the effects of shadow flicker are shown to be greatly reduced outside this distance.

15.3.25 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.

Theoretical Scenario

15.3.26 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.

Realistic Scenario

15.3.27 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 take into account any significant shielding of receptors by buildings and vegetation between the receptor and the turbines.

15.3.28 In order to estimate the impact of cloud cover, information available from the Met Office (2020) 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 Proposed Development. In the case of the Proposed Development this is the Kirkwall Airport located approximately 25 km south-east.

15.3.29 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.

15.3.30 A 16-degree sector wind rose was calculated for 7,446 hours of wind (assuming the Proposed Development is operational for 85 % of the year) based on Open Source World Meteorological Organisation Synoptic data. The Open Source data was from Kirkwall Airport over the period between 1961 and 2021, as no meteorological mast data was available at the site for a long-term period. 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 slighting higher results; as there is a degree of correlation between bright and sunny weather conditions and low wind speeds.

Limitations to Assessment

15.3.31 All assumptions made by the WindPro 3.2 model are noted above.

15.3.32 Given the absence of UK guidance on shadow flicker, the assessment has adopted the generally accepted industry practised limit of 30 hours per year or 30 minutes per day for permanent dwellings within 10 rotor diameters of the proposed turbines.

15.3.33 The realistic scenario results represent an average as they are based on historic metrological data from Kirkwall Airport (48 years, from 1973 to 2021 for wind and 60 years, from 1961 to 2021 for sunshine). The variation between individual years can be significant and may lead to future observations differing from the predicted results.

15.3.34 As noted above, the historic meteorological data was also taken from Kirkwall Airport and is not site-specific. Kirkwall Airport is situated approximately 25km south and there may be slight variations in the historical data used.

Baseline Conditions

15.3.35 35 receptors have been identified within the Study Area with the potential to experience shadow flicker (refer to Figure 15.2 and Table 15.5) and are located from north, east and west of the Proposed Development turbine locations.

15.3.36 For the purpose of the assessment, it is assumed that the properties face the Proposed Development and no local screening (vegetation and blinds/curtains) are considered.

15.3.37 Within this assessment the sensitivity of receptors is assumed to be high in all cases.

Potential Effects

Construction

15.3.38 No shadow flicker will occur during construction of the Proposed Development.

15.3.39 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.

Operation

Theoretical Modelling of Shadow Flicker Occurrence

15.3.40 The modelling results presented below represent the theoretical worst-case scenario discussed in the previous section. The results of the modelling are shown in Table 15.6. The theoretical duration of shadow flicker calculated is indicated to be significant at 17 receptors (greater than 30 hours per year). It should be noted that this is the theoretical modelling and in reality the duration of shadow flicker at each location is likely to be considerably less than that indicated below for the reasons outlined in the Assessment Modelling section above.

Table 15.6 Worst-Case Scenario Shadow Flicker Occurrence at each Receptor

Property	Shadow Flicker ID	Shadow Flicker hours per year	Max Shadow Flicker hours per day	Significance
Veltan (FI)	1	214.07	2:07	Significant
Dale (FI)	2	185:28	1:57	Significant
Belmont (FI)	3	178:20	1:29	Significant
Nisthouse (FI)	4	6:26	0:10	Not Significant
Mucklehouse (FI)	5	0:00	0:00	Not Significant
Hundland (FI)	6	0:00	0:00	Not Significant
Myres*	7	90:59	1:18	Significant
Newhouse (FI)	8	101:43	1:16	Significant
Stoneymilders (FI)	9	94:52	1:21	Significant
Lochside Cottage (FI)	10	115:20	1:29	Significant
The Cottage	11	15:58	0:39	Not Significant
Hundland Gallery	12	11:35	0:27	Not Significant
Hundland Schoolhouse	13	11:37	0:27	Not Significant
The Longhouse	14	7:03	0:20	Not Significant
Hunchaquoy	15	13:42	0:24	Not Significant
Bokieha	16	60:07	0:59	Significant
Kelowna	17	58:11	0:57	Significant
Viewforth	18	53:37	0:55	Significant
Finties	19	52:03	0:57	Significant
Scruit Garage	20	48:47	1:09	Significant
Slinghorn	21	38:06	0:49	Significant
Scruit	22	46:40	1:08	Significant
Dale Costa	23	33:37	0:32	Significant
Lochview	24	27:50	0:53	Not Significant
Birsay Hatcheries Caravan	25	26:44	0:52	Not Significant
Rymmon	26	7:21	0:25	Not Significant
Wascra	27	41:53	0:48	Significant
Whitemire	28	0:00	0:00	Not Significant
Swanny Cottage	29	24:25	0:28	Not Significant

Property	Shadow Flicker ID	Shadow Flicker hours per year	Max Shadow Flicker hours per day	Significance
The Bungalow, Swannay Farm	30	22:06	0:27	Not Significant
Wenvoe	31	25:02	0:27	Not Significant
Neven	32	14:13	0:26	Not Significant
Ingsay	33	11:39	0:26	Not Significant
Brekkan	34	23:49	0:28	Not Significant

Note – properties marked (FI) are considered to be Financially Involved with the Proposed Development.
**Derelict property*

15.3.41 Graphs 15.2.1 to 15.2.34 within **Appendix 15.2** summarise the occurrence of shadow flicker at the receptors and illustrate the times of year and times of day when shadow flicker could theoretically occur and by which turbine.

Realistic Modelling of Shadow Flicker Occurrence

15.3.42 The modelling results presented in Table 15.7, **Appendix 15.2** and **Figure 15.3** represent the realistic scenario. 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 all of the receptors, such that none are predicted to experience flicker for more than 30 hours per year.

Table 15.7 Realistic Scenario Shadow Flicker Occurrence at each Receptor

Property	Shadow Flicker ID	Shadow Flicker hours per year	Max Shadow Flicker hours per day	Significance
Veltan (FI)	1	24:42	0:32	Significant
Dale (FI)	2	20:38	0:25	Significant
Belmont (FI)	3	17:01	0:19	Significant
Nisthouse (FI)	4	0:58	0:03	Not Significant
Mucklehouse (FI)	5	0:00	0:00	Not Significant
Hundland (FI)	6	0:00	0:00	Not Significant
Myres*	7	11:28	0:18	Significant
Newhouse (FI)	8	8:45	0:10	Significant
Stoneymilders (FI)	9	7:47	0:08	Not Significant
Lochside Cottage (FI)	10	9:19	0:12	Significant
The Cottage	11	2:17	0:09	Not Significant
Hundland Gallery	12	1:39	0:07	Not Significant
Hundland Schoolhouse	13	1:39	0:07	Not Significant
The Longhouse	14	1:01	0:05	Not Significant
Hunchaquoy	15	1:57	0:06	Not Significant
Bokieha	16	4:46	0:08	Not Significant
Kelowna	17	4:41	0:08	Not Significant

Property	Shadow Flicker ID	Shadow Flicker hours per year	Max Shadow Flicker hours per day	Significance
Viewforth	18	4:22	0:07	Not Significant
Finties	19	4:31	0:08	Not Significant
Scruit Garage	20	3:27	0:07	Not Significant
Slinghorn	21	3:24	0:07	Not Significant
Scruit	22	3:17	0:07	Not Significant
Dale Costa	23	4:07	0:05	Not Significant
Lochview	24	3:42	0:12	Not Significant
Birsay Hatcheries Caravan	25	3:32	0:12	Not Significant
Rymmon	26	0:57	0:05	Not Significant
Wascra	27	3:16	0:06	Not Significant
Whitemire	28	0:00	0:00	Not Significant
Swanny Cottage	29	1:54	0:03	Not Significant
The Bungalow, Swannay Farm	30	1:43	0:03	Not Significant
Wenvoe	31	1:57	0:04	Not Significant
Neven	32	1:12	0:04	Not Significant
Ingsay	33	1:11	0:04	Not Significant
Brekkan	34	1:51	0:03	Not Significant

Note – properties marked (FI) are considered to be Financially Involved with the Proposed Development.
**Derelict property*

15.3.43 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 in reality will reduce further the potential time receptors are likely to experience shadow flicker over the course of the year.

15.3.44 The realistic scenario model does indicate potential for shadow flicker to occur for at least short periods at all receptors except receptors 5, 6 and 28. The realistic duration of shadow flicker calculated is indicated to be at **significant** levels at receptors 1, 2, 3, 7, 8 and 10, with a duration greater than 8 hours per year. Receptors 1, 2, 3, 8 and 10 are financially involved with the Proposed Development and receptor 7 is currently an unoccupied derelict property.

15.3.45 It is important to stress the theoretical and conservative nature of the model, and the absence of any consideration of screening in the model as explained in paragraph 15.7.42. For these reasons it is unlikely the number of hours predicted in the 'realistic' scenario would actually occur at the sensitive receptors. In reality the expected total shadow hours will be less than modelled. Notwithstanding these points and the financial involvement of receptors, the Applicant is committed to providing a Shadow Flicker Mitigation Protocol to be engaged should any concerns in relation to shadow flicker effects be raised and shadow flicker subsequently be found to be causing nuisance in certain atmospheric conditions.

15.3.46 The realistic duration of shadow flicker calculated is indicated to be at non-significant levels at the remaining 28 receptors, with a duration less than 8 hours per year

Decommissioning

15.3.47 Given that any occurrence of shadow flicker during the short decommissioning period would replicate that which would occur during operation of the Proposed Development, it is considered

appropriate to consider the decommissioning activities as part of the operational stage of the Proposed Development.

15.3.48 No shadow flicker impact can occur post-decommissioning of the Proposed Development.

Mitigation

Construction

7.1.1 No mitigation measures are required during the construction phase of the Proposed Development.

Operation

7.1.2 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, dwelling orientation and internal screening from blinds, curtains or furniture that are not included in the model. Additionally, while shadow flicker may potentially occur at these locations it is possible that flicker will not be 'experienced' at all locations due to the time of day during which it may potentially occur.

7.1.3 Nevertheless, in the event of consent in order to ensure that potential shadow flicker effects do not exceed acceptable limits at any property, the Applicant proposes that prior to the erection of the first turbine a written scheme (known as the 'Wind Farm Shadow Flicker Protocol') will be submitted to and approved in writing by OIC. This will set out mitigation measures to alleviate shadow flicker attributable to the Proposed Development as well as a protocol for addressing a complaint received from a receptor within the study area. Operation of the turbines would be required to take place in accordance with the approved Shadow Flicker Protocol and any mitigation measures that have been agreed through the protocol would require to be implemented as appropriate.

7.1.4 The most effective mitigation measure to mitigate shadow flicker is by selective automatic turbine shutdown during the times of year when shadow flicker is predicted if the weather conditions are correct. The relevant technology which will allow for the automatic shutdown of the turbine will be fitted to the Proposed Development turbines and details included within the 'Wind Farm Shadow Flicker Protocol'. It is proposed that this is secured through a mitigation scheme requirement condition attached to the permission.

Residual Effects

15.3.49 On the basis that potential shadow flicker effects can be mitigated through matters secured through the agreement of the Wind Farm Shadow Flicker Protocol, no significant residual effects are predicted during the operational, construction or decommissioning phases of the Proposed Development.

Cumulative Assessment

15.3.50 In order to assess the potential for cumulative impact from other wind developments in the surrounding area, any turbines within 3 km of the proposed turbine locations were noted. Shadow flicker impacts are considered to extend to 10 rotor diameters (Scottish Government, 2014a) from turbine locations, therefore a 10 rotor diameter study area has been placed around all turbines in the vicinity of the Proposed Development. **Figure 15.4** shows the cumulative shadow flicker study area.

15.3.51 No receptors were identified within the overlap between the shadow flicker study areas (refer to **Figure 15.4**), and as such there is no potential for cumulative shadow flicker effects.

Summary

15.3.52 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.

15.3.53 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 1550m from each turbine.

15.3.54 No shadow flicker impact can occur during the construction or the decommissioning of the turbines.

15.3.55 A shadow flicker assessment was undertaken at 34 identified receptors within the Study Area. Calculations have shown that effects from shadow flicker have the potential to be significant.

15.3.56 It is important, however, to note that these results do not take into account 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 actually 'experienced' will likely be significantly less than what has been predicted.

15.3.57 The Applicant proposes that prior to the erection of the first turbine a 'Wind Farm Shadow Flicker Protocol' will be submitted to and approved in writing by OIC. This will set out mitigation measures to alleviate shadow flicker attributable to the Proposed Development as well as a protocol for addressing a complaint received from a receptor within the study area. Operation of the turbines would be required to take place in accordance with the approved Shadow Flicker Protocol and any mitigation measures that have been agreed through the protocol would require to be implemented as appropriate.

15.3.58 The residual effect of shadow flicker is, therefore, expected to be not significant for all receptors during the operational phase of the Proposed Development.

15.3.59 A cumulative assessment shows there are no receptors located within the Study Area which are also located within the relevant shadow flicker study area for any operational or proposed wind farms.

15.4 Carbon Savings

Climate Change and Carbon Considerations

15.4.1 Increasing atmospheric concentrations of greenhouse gases (GHGs), including carbon dioxide (CO_2) - also referred to as carbon emissions - are resulting in climate change. A major contributor to this increase in GHG emissions is the burning of fossil fuels. With concern growing over climate change, reducing its cause is of utmost importance. The replacement of traditional fossil fuel power generation with renewable energy sources provides high potential for the reduction of GHG emissions. This is reflected in UK and Scottish Government climate change and renewable energy policy and commitments. The relevant aspects of such policies are summarised in **Chapter 5**.

Energy Life Cycle Assessment

15.4.2 A technical review of energy displacement by the UK Energy Research Centre (UKERC) considered over two hundred studies and papers from all round the world for the UK Government and concluded that "it is unambiguously the case that wind energy can displace fossil fuel-based generation, reducing both fuel use and carbon dioxide emissions" (UKERC, 2006).

15.4.3 Whilst the Proposed Development will reduce carbon emissions by replacing the need to burn fossil fuels for power, carbon emissions will result from the component manufacturing, transportation and installation processes associated with the Proposed Development.

15.4.4 For wind farm developments, there is also the potential for carbon fixers and sinks to be lost through the clearing of vegetation during construction and excavation of peat during construction. There must therefore be a sufficient balance between the carbon reduced and that which is produced and lost through associated processes.

15.4.5 At the Proposed Development site, very little vegetation is found at the proposed turbine locations and indicative access routes, with no forestry present on-site. Minimal peat has been recorded at the proposed infrastructure locations, and the relatively minor volume of peat that will require to

be excavated will all be reused locally on-site for restoration and landscaping. Therefore, the carbon emissions from the loss of carbon storage materials are considered to be negligible.

15.4.6 There must, however, be a sufficient balance between the energy generation associated with renewable energy development and that which is consumed over the life cycle of the development.

15.4.7 Calculations are presented below, providing an estimate of the energy that could be generated by the Proposed Development over its lifetime, and comparing that with the estimated energy consumed over the development life cycle.

15.4.8 The maximum electrical power output from the Proposed Development is assumed to be up to 26.4 MW, comprising four turbines. Currently available turbine models within the 180 m tip height threshold have a maximum capacity of approximately 6.6 MW.

15.4.9 As noted in **Chapter 3**, using a capacity factor of approximately 40.0 %, based on wind energy performance data for Orkney specifically (OREF, 2016), the annual electrical power output of the Proposed Development, taking account of an estimated 3% downtime, would be approximately 89.7 GWh per year (based on the assumed total site capacity of 26.4 MW).

15.4.10 Although future wind yields cannot be guaranteed, if the Proposed Development continued to generate, on average, at this load factor over its proposed 40 year lifespan, it is expected that a total of approximately 3,600 GWh of renewable energy could be generated.

15.4.11 Based on an average carbon savings of 0.43 tonnes/MWh over all non-renewable energy sources[1], it is therefore estimated that the Proposed Development would displace approximately 1.54 million tonnes of CO_2 eq over its lifetime.

15.4.12 The above figure does not account for any carbon emissions that would be generated in the development of the wind farm. This has therefore been considered as set out below.

15.4.13 Data has been sought on energy consumption over the life cycle of wind turbines of the scale relevant to the Proposed Development. Siemens Gamesa has undertaken a life cycle assessment for the SG 6.6-155 wind turbines (Environmental Product Declaration, 2022)[2].

15.4.14 The Siemens Gamesa life cycle assessment for the SG 6.6-155 is based on a scenario involving a 99 MW wind farm in medium wind conditions, with various assumptions relating to an 'average' European site. The figures can be used to extrapolate down to the Proposed Development capacity of 26.4 MW.

15.4.15 Siemens Gamesa estimates that a 99 MW wind farm of SG-155 turbines (6.6 MW capacity), operating for 25 years at an 'average' European site in medium wind conditions, would generate carbon emissions of 5.13 g CO_2 eq over the project life cycle. This would equate to approximately 51,080 tonnes CO_2 eq in total, for the 99MW plant. Based on a direct scaling down from 99 MW to 26.4 MW, it is estimated that approximately 13,620 tonnes CO_2 eq emissions would be generated by a 26.4 MW capacity wind farm operating for 25 years.

15.4.16 The Siemens Gamesa life cycle assessment indicates that 86% of the carbon emissions associated with the wind farm development derive from raw materials and manufacturing, and construction. Therefore, operation of the wind farm for 40 years instead of the assumed 25 years would be expected to have little impact on the total carbon emissions generated by the development. However, for conservatism as part of this assessment, 10% has been added to the estimated total emissions, resulting in a total estimate of approximately 15,000 tonnes CO_2 eq generated by the 26.4 MW wind farm, operating for 40 years.

15.4.17 Therefore, subtracting the estimated 15,000 tonnes CO_2 eq estimated to be generated by the development, from the 1.54 million tonnes CO_2 eq estimated to be displaced by the renewable energy produced by the development, the estimated net carbon saving resulting from the Proposed Development is approximately 1.53 million tonnes CO_2 eq.

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[1] *Digest of UK Energy Statistics (DUKES): electricity. Department for Business, Energy and Industrial Strategy (July 2022).*

[2] *EDP (2021) Electricity from a European onshore wind farm using SG 6.6-155 wind Turbines* https://api.environdec.com/api/v1/EPDLibrary/Files/b789cb39-ca79-46ef-e5fc-08da53492d7b/Data

15.4.18 It is clear from the above analysis that the carbon emissions generated by the development are negligible in comparison to the carbon emissions that could be displaced through the Proposed Development's generation of renewable energy (less than 1%).

15.4.19 Therefore, it is considered reasonable to estimate that the total electricity that could be generated by the Proposed Development is over 3,550 GWh over its 40 year lifetime.

15.4.20 Based on an average household consumption of 3.748 MWh/yr [3]and the net generation calculations above, the Proposed Development would be expected to generate enough electricity to power at least 23,500 average UK households.

[3] *Department for Business, Energy and Industrial Strategy (BEIS) (2021) National Electricity and Gas Consumption Statistics. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1079141/subnational_electricity_and_gas_consumption_summary_report_2020.pdf*