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Deucheran Hill 2 Wind Farm

Appendix 14.3 Shadow Flicker Assessment

19 May 2026

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RWE Renewables UK
Onshore Wind Limited

Glossary

Term	Definition
Applicant	RWE Renewables UK Onshore Wind Limited.
Application Site Boundary	The red line boundary that encompasses the Proposed Development.
Natural Power	Natural Power Consultants Limited, the lead EIA Co-ordinator.
Proposed Development	The Proposed Development comprises the Deucheran Hill 2 repowering and extension, including up to 14 wind turbines (three with a maximum tip height of 220 m, four at 200 m and seven at 180 m), and associated ancillary infrastructure.
Proposed Wind Farm Development Area	The area within which the proposed wind farm will be located.

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1. Introduction

The Natural Power Consultants Limited (*“Natural Power”*) was commissioned by RWE Renewables (the *“Applicant”*), to conduct a shadow flicker assessment of the proposed Deucheran Hill 2 Wind Farm (the *“Proposed Development”*).

This work is to determine the extent of the worst-case shadow flicker effects on nearby residential or commercial properties, henceforth called receptors. A single receptor is considered in this assessment which was the only property within 10 rotor diameters of the Proposed Development.

This report details the inputs and assumptions made when undertaking the analysis and presents the results and findings.

1.1. Site Description

The Proposed Development is located approximately 7 km north-west of Carradale, located in Argyll and Bute, Scotland. Maps illustrating the site layout and the project location with respect to the surrounding region are shown in **Annex A: Site Layout and Receptor Locations**. The Proposed Development and surrounding area consist of undulating terrain and large areas of commercial forestry interspersed with some areas of open moorland.

The Proposed Wind Farm Development Area comprises the existing Deucheran Hill Wind Farm. The original Deucheran Hill Wind Farm, consented on the 8 June 2001 and operational in December 2001, comprises of 9 turbines with a range of 76 metres (m) to 93 m tip heights, 66 m rotor and an installed capacity of 15.75 Mega Watt (MW). A decommissioning plan for Deucheran Hill Wind Farm was submitted to Argyll and Bute Council in December 2025 and is due to be decommissioned in 2026. Therefore, it has not been included in the assessment.

The following turbine and layout scenario was used for consideration (as shown in **Volume 1, Chapter 4: Project Description**):

Table 1.1: Turbine scenario considered for the Proposed Development.

Scenario	Number of turbines	Hub height (m)	Maximum tip height (m)	Rotor diameter (m)	Elevation (m ASL)
1	7	105	180	149	153 - 303
	4	118	200	149	
	3	118	220	163	

Source: Natural Power, 2026

The Proposed Development is in an isolated area and only one dwelling has been identified which could potentially be impacted by shadow flicker. A high-level review of the area has been undertaken and no other potential receptor locations which could be impacted by shadow flicker have been identified.

The coordinates of the receptor and turbines are presented in **Annex A** and the layout of the turbines along with the receptor are illustrated in **Figure A.1: Proposed Development 14-turbine site layout with receptor (R1)**.

A worst-case scenario map detailing the areas potentially impacted by shadow flicker, represented as propagation patterns from each turbine for the Proposed Development, is presented in **Figure A.2: Proposed Development worst-case shadow flicker map**. There are a number of neighbouring projects in operation and consented in the area around the Proposed Development. Despite these neighbouring projects in the surrounding area (as shown on **Volume 2b, Figure 6.3: Cumulative Location Plan**) it has been determined that it is unlikely that there will be a cumulative shadow flicker effect on the receptor of interest (as justified below) and therefore they have not been included in this assessment. The neighbouring wind farms which are closest are Cour Wind Farm, which is operational, Clachaig Glen, which has been consented, and Killeen, which is in planning. These wind farms are approximately 3.1 km north north-east, 5.2 km south-west, and 5.2 km west of the receptor of interest respectively, and so there will not be any cumulative shadow flicker effects from these wind farms given the distances are over the shadow flicker propagation distances of approximately 10 rotor diameters.

Maximum tip heights were provided for each proposed turbine location, ranging from 180 m to 220 m, and these are detailed in **Table 1.1**. Both the Nordex N149 and Nordex N163 models have been modelled to give the relevant tip height restrictions at turbine locations. This assessment should be reviewed and updated should the turbine specifications change, where this will likely result in a change in turbine blade width.

2. Shadow Model

Shadow flicker may occur under certain combinations of geographical position and time of day when the sun passes behind the blades of a wind turbine and casts a shadow over the neighbouring properties. As the blades rotate, a dynamic shadow effect occurs, known as shadow flicker. The effect occurs inside buildings where the flicker appears, generally through a narrow window opening. The likelihood and duration of the effect is dependent upon several variable factors:

- Location of the property relative to the turbine. Please note that the methodology for worst case shadow flicker modelling does not take into consideration the orientation of properties or the presence of windows/openings and their dimensions/orientations. Therefore, each receptor is modelled as a worst-case (glasshouse) scenario. Equally the model assumes no sheltering from vegetation or other obstacles is present between the turbine and the receptor.
- Distance from turbine. The further an observer is from the turbine, the less pronounced the effect will be.
- Wind speed and direction. The wind speed at the turbine will need to be greater than the cut-in wind speed of the turbine (typically 3 m/s), and below the cut-out wind speed, in order for the blades to be rotating. In the worst-case scenario modelling, the turbines have been assumed to be rotating at all times. Furthermore, the shape of the shadow will be determined

by the position of the sun relative to the blades, which will be yawed to face the wind under normal turbine operation.

- Turbine height and rotor diameter.
- Time of year and day as this determines the height and angle (azimuth and zenith) of the sun in the sky.
- Weather conditions at the time – direct sunshine is required to create the flicker effect and therefore cloud cover reduces the risk of shadow flicker.

While all these factors impact the prevalence of shadow flicker effect occurring, not all factors can be effectively modelled, and a number of assumptions need to be made as part of the modelling process.

2.1. Assessment Methodology

When assessing the impact of shadow flicker on receptors, two possible conditions can be considered:

- Worst-case – this determines the maximum number theoretical hours of shadow flicker that can occur, not accounting for the likelihood of direct sunshine occurring in the region, coinciding with periods where shadow flicker is possible. This is a geometric-based calculation, dependant on the location of the sun with respect to the turbine blade, and alignment with the receptor of interest. Outside of these periods, irrespective of the cloud cover and sunshine status, flicker cannot physically occur. The outcome of this process is the maximum number of hours (per annum) at which flicker could, in theory, occur. In this assessment the topographic shadows have been taken into consideration but do not take into account the wind direction and its influence on the shadows.
- Real-case based on statistics – this takes the worst-case scenario and then adjusts the duration of the total potential flicker events by the likelihood that direct sunshine occurs in a region. Typically, this utilises sunshine data from a ground-based meteorological station to apply monthly scaling factors to the worst-case scenario results. This results in a more accurate representation of the number of hours per year, that a receptor location may experience shadow flicker. The turbines are still modelled as though they are always yawed perpendicularly to the line between the receptor and the sun, inducing maximum shadow effect. The real case does take topographic shadows into consideration but do not take into account the wind direction and its influence on the shadows.

The scope of this assessment is to determine the worst-case scenario. The model makes the following assumptions:

- The turbines are always rotating.
- The sun can be represented as a single point.
- The turbine rotor is modelled as a sphere around the hub to account for all possible turbine yaw directions relative to the line of sight with the position of the sun.
- Terrain effects are considered although this is assumed to be bare terrain and therefore surface effects from cover such as forestry or other buildings are not considered.

- The calculation is purely geometric and does not account for the sensitivity of perception of the observer.
- The likelihood of wind direction and speed is not taken into account.
- Shadow flicker is calculated for a height of 2 m Above Ground Level (AGL) to represent an observer at a ground floor window.
- The shadow receptors are simulated as mounted vertical plates always facing directly at each turbine simultaneously, representing the worst-case scenario (glasshouse) while real windows would be facing towards a particular, selective direction.
- The simulations have been carried out with a resolution of 1 minute.
- The shadow flicker effects have been calculated for the area within the radius of approximately 1831 m from the centre of the N149 turbines and 1797 m from the centre of the N163. This area is based on a calculated length that the shadows are likely to persist. This is calculated from the average thickness of turbine blades from a turbine specifications database.

2.2. Significance Criteria

The significance of shadow flicker is typically defined as a function of the sensitivity of a receptor with the magnitude of change. A methodology for the establishment of the magnitude of change has been derived based on professional experience and guidance¹. All the identified receptors are considered to be of high sensitivity. Where the assessment demonstrates shadow flicker to occur >30 minutes/day or >30 hours/year at a property, the magnitude of impact is considered to be high, and effects are determined to be significant. Where the assessment demonstrates shadow flicker to occur <30 hours/year and <30 minutes/day, the magnitude of impact is considered to be low, and effects are determined to be not significant. Where the assessment demonstrates that no shadow flicker will occur at a property, then there will be no effect.

2.3. Results

The results for the worst-case shadow flicker assessment are detailed in **Table B.1**. In addition, the number of days per year where any shadow flicker could occur, and the turbines which contribute to the flicker effect, are also shown in **Table B.2**.

The results indicate that for the affected receptor, the worst-case impact is a maximum of 25 minutes per day and 23.8 hours per year. Therefore, the receptor experiences shadow flicker below the maximum allowed 30 minutes/day and 30 hours/year.

Table B.2 show a list of the days that the worse-case shadow flicker on the receptor will cause shadow flicker. The assessment should be updated if the consented layout is different from the current layout used for this assessment.

¹ *Update of UK Shadow Flicker Evidence Base Final Report* [Online] Available from - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48052/1416-update-uk-shadow-flicker-evidence-base.pdf [Accessed 20/06/2026]

3. Conclusion and Recommendations

The following conclusions and recommendations are presented for consideration:

- Based on the worse-case assessment the receptor did not exceed the allowable limits on a daily or yearly basis. For this reason, a real-case assessment was not necessary as the time when shadow flicker occurs would be less.
- If any additional receptors are identified the analysis should be updated to calculate the shadow flicker effects at these locations.
- The shadow model makes a number of assumptions with respect to the shadow receptor, including the assumption that it has windows directly facing the wind farm, that the direction of the wind is aligned with the line between the receptor and the sun at all times, and that there is no screening from vegetation or buildings which would otherwise mitigate the potential shadow flicker effect. It is recommended that, as a specific dwelling is modelled, the affected dwelling is visited to confirm the conditions for shadow flicker are present, and if not, then the receptor is removed from inclusion in the calculation.
- The assessment should be updated if the consented layout is different from the current layout used for this assessment.

Annexes

A. Site Layout and Receptor Locations

Table A.1: Shadow receptor locations used in analysis

Receptor ID	Easting	Northing	Elevation (m ASL)	Distance to nearest turbine (km)
R1	178390	643986	51	1.4

Source: Natural Power, 2026

Note that coordinates are in British National Grid.

Table A.2: Proposed Development turbine locations

Turbine ID	Easting	Northing	Turbine	Modelled Hub height (m AGL)	Tip Height (m AGL)	Base Elevation (m ASL)
T01	175008	644575	N149	118	193	285
T02	175907	645497	N163	138	220	217
T03	176979	645653	N163	138	220	153
T04	177360	645197	N149	118	193	191
T05	176996	644515	N149	105	180	237
T06	177008	643886	N149	105	180	249
T07	176483	643215	N149	105	180	247
T08	176193	644941	N149	118	193	244
T09	176462	644374	N149	105	180	303
T10	175863	644244	N149	118	193	302
T11	175999	643515	N149	105	180	287
T12	175720	642904	N149	105	180	301
T13	175182	643577	N163	138	220	284
T14	174933	642873	N149	105	180	278

Source: Natural Power, 2026

Note that coordinates are in British National Grid.

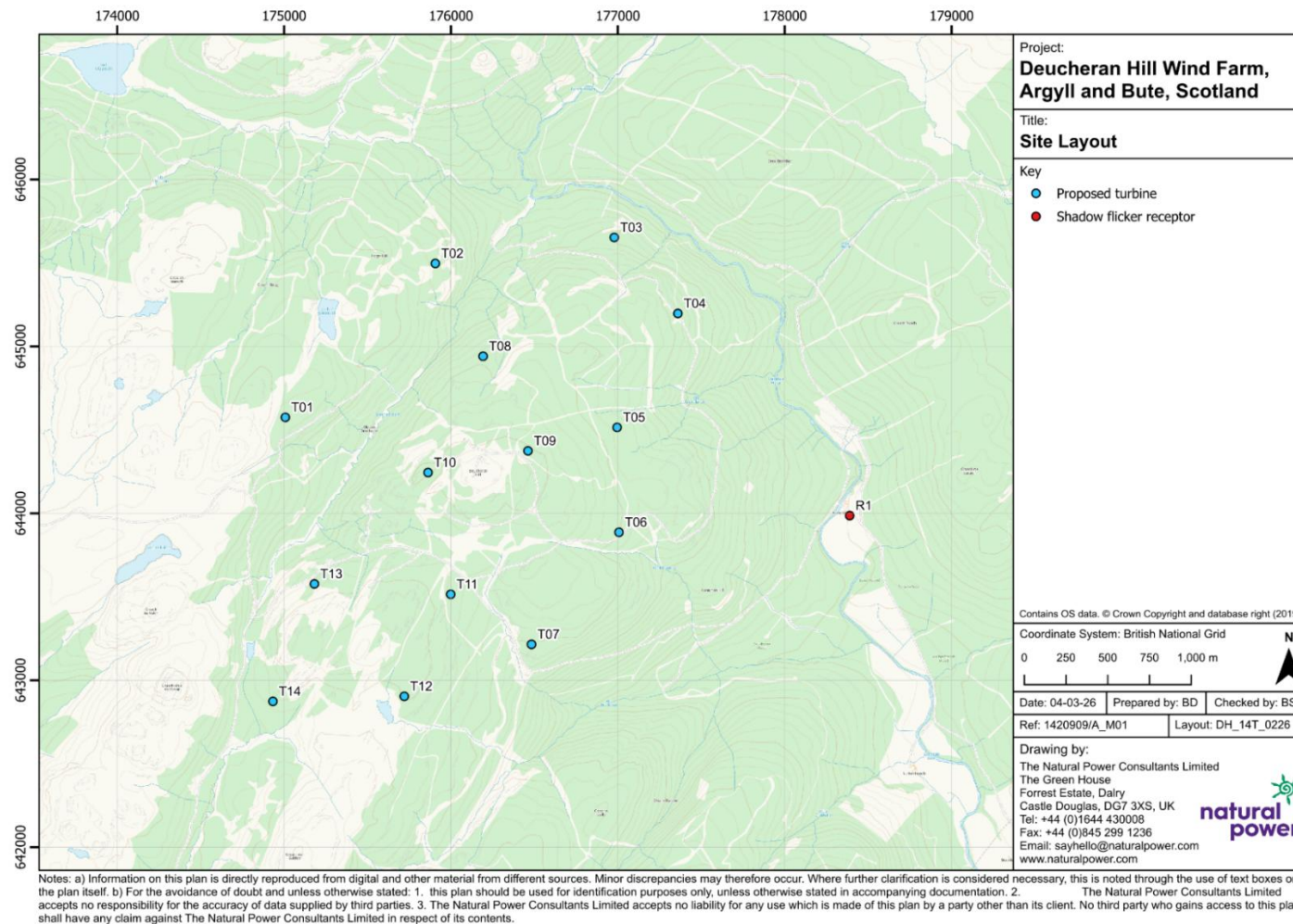
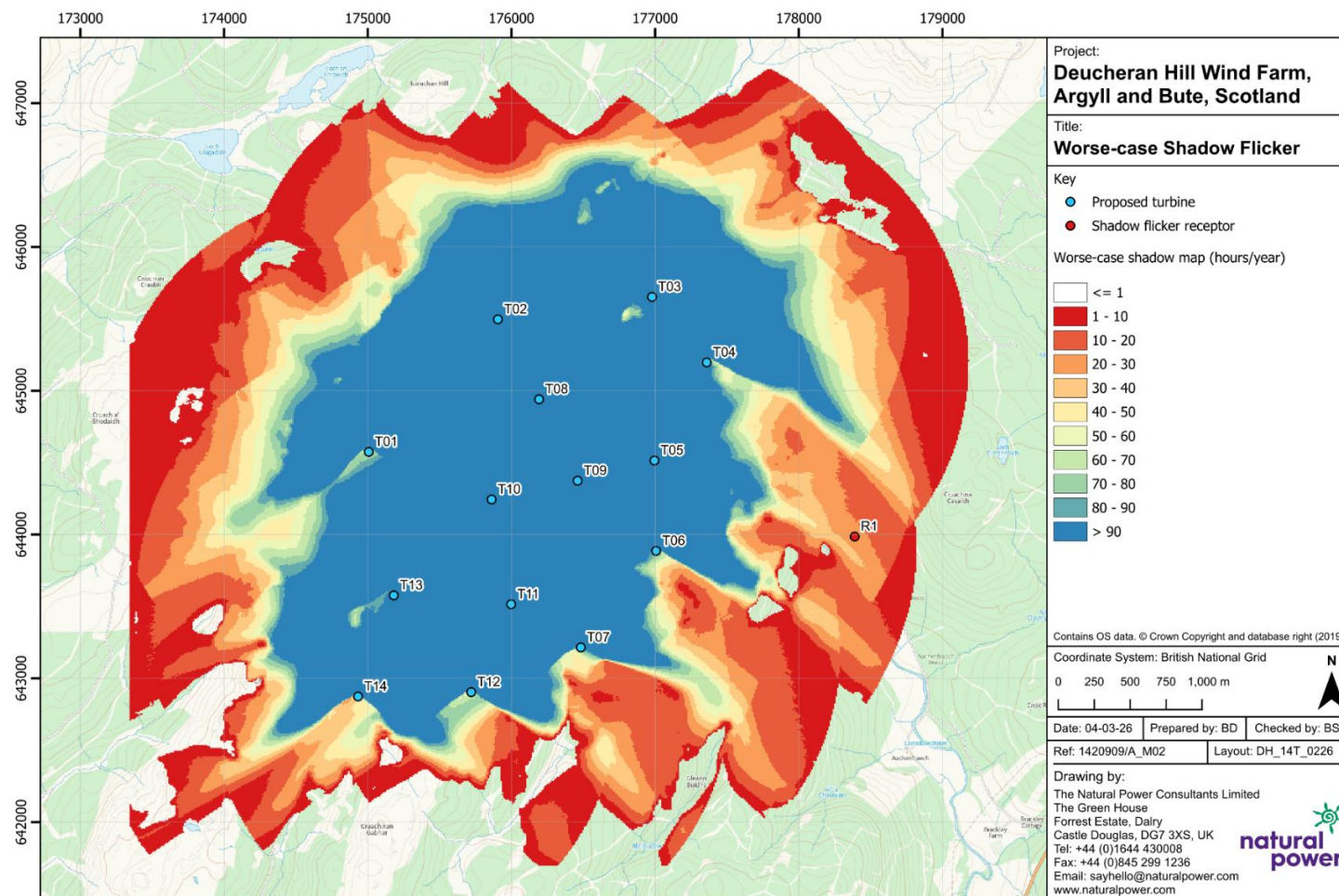


Figure A.1: Proposed Development 14-turbine site layout with receptor (R1)



Notes: a) Information on this plan is directly reproduced from digital and other material from different sources. Minor discrepancies may therefore occur. Where further clarification is considered necessary, this is noted through the use of text boxes on the plan itself. b) For the avoidance of doubt and unless otherwise stated: 1. this plan should be used for identification purposes only, unless otherwise stated in accompanying documentation. 2. The Natural Power Consultants Limited accepts no responsibility for the accuracy of data supplied by third parties. 3. The Natural Power Consultants Limited accepts no liability for any use which is made of this plan by a party other than its client. No third party who gains access to this plan shall have any claim against The Natural Power Consultants Limited in respect of its contents.

Figure A.2: Proposed Development worst-case shadow flicker map

B. Shadow Flicker Results

Table B.1: Results of shadow flicker assessment at each receptor

ID	No. of days with shadow flicker occurrences	Worst-case maximum shadow flicker (mins/day)	Worst-case shadow flicker (hours/annum)
R1	83	25	23.8

Source: Natural Power, 2026

Table B.2: List of days of shadow flicker exceeding maximum hourly limit for Receptor R1

Day	Minutes of Shadow Flicker	Turbines causing flicker
29-Mar	1	T06
30-Mar	6	T06
31-Mar	10	T06
01-Apr	13	T06
02-Apr	16	T06
03-Apr	18	T06
04-Apr	20	T06
05-Apr	23	T06
06-Apr	25	T06
07-Apr	24	T06
08-Apr	24	T06
09-Apr	22	T06
10-Apr	21	T05
11-Apr	18	T05
12-Apr	14	T05
13-Apr	9	T05
06-May	1	T05
07-May	5	T05
08-May	9	T05
09-May	13	T05
10-May	16	T05
11-May	20	T05
12-May	22	T05
13-May	23	T05
14-May	24	T05
15-May	24	T05

Day	Minutes of Shadow Flicker	Turbines causing flicker
16-May	24	T05
17-May	24	T05
18-May	24	T05
19-May	23	T05
20-May	23	T05
21-May	23	T05
22-May	22	T05
23-May	21	T05
24-May	20	T05
25-May	18	T05
26-May	17	T05
27-May	15	T05
28-May	14	T05
29-May	11	T05
30-May	9	T05
31-May	3	T05
13-Jul	6	T05
14-Jul	10	T05
15-Jul	13	T05
16-Jul	15	T05
17-Jul	16	T05
18-Jul	18	T05
19-Jul	19	T05
20-Jul	20	T05
21-Jul	21	T05
22-Jul	22	T05
23-Jul	23	T05
24-Jul	23	T05
25-Jul	24	T05
26-Jul	24	T05
27-Jul	24	T05
28-Jul	24	T05
29-Jul	24	T05
30-Jul	23	T05
31-Jul	23	T05

Day	Minutes of Shadow Flicker	Turbines causing flicker
01-Aug	22	T05
02-Aug	18	T05
03-Aug	15	T05
04-Aug	11	T05
05-Aug	8	T05
06-Aug	4	T05
30-Aug	10	T06
31-Aug	14	T06
01-Sep	18	T06
02-Sep	21	T06
03-Sep	22	T06
04-Sep	24	T06
05-Sep	24	T06
06-Sep	25	T06
07-Sep	23	T06
08-Sep	21	T06
09-Sep	18	T06
10-Sep	15	T06
11-Sep	13	T06
12-Sep	10	T06
13-Sep	6	T06
14-Sep	2	T06

Source: Natural Power, 2026



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