Parc Ynni Calon y Gwynt

ENVIRONMENTAL STATEMENT

Appendix 6D: Collision Risk Modelling

62282400_APP6D_001
JULY 2026

PUBLIC

Parc Ynni Calon y Gwynt

ENVIRONMENTAL STATEMENT

Appendix 6D: Collision Risk Modelling

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PROJECT NO. 62282400

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Collision Risk Analysis

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Client	RWE Ltd
Project	Parc Ynni Calon y Gwynt Wind Farm, Collision Risk Analysis
Version	DRAFT
Project number	P25-558

	Name	**Position**	**Date**
Originated	Daniel Watson	Senior Ecologist	10 July 2026
Reviewed			Click here to enter a date.
Issued			Click here to enter a date.

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Contents

1 Introduction

1.1 NatureScot updated their guidance on collision risk modelling to assess bird collision risk at on-shore wind farms based on an updated model by Band (2024)[1,2]. In addition, the model used to inform collision risk for the ES was highly precautionary in relation to the mean rotor speed of the proposed turbines. The rotor speed used in the ES collision risk calculations was 6 seconds per revolution (or 10 revolutions per minute (rpm)).

1.2 The mean rotor speed for the candidate turbines has been considered in the model (N163 operational at 10 rpm). The parameters of the N163 are presented in Table 1, below.

Table 1. Turbine parameters for the N163

Turbine model	Nordex N163
Hub height (m)	118.5
Rotor radius (m)	82.5
No. blades	3
Rotation speed (rpm)	10
Max blade width (m)	4.68
Blade pitch	6

1.3 The Band (2024) model estimates the number of collisions through a process of five stages:

- Stage A uses bird survey data to establish the density of flying birds in the vicinity of the turbines, and the proportion flying at a risk height, between the lowest and highest points of the rotors.
- Stage B provides an estimate, based on the bird density and proportion at risk height, of the potential number of bird passages through rotors in the period in question.
- Stage C calculates the probability of collision during a single bird rotor transit.
- Stage D estimates the potential collision rate for a bird species, assuming current levels of bird use of the site, allowing for the proportion of time that turbines are not operational.
- Stage E takes account of the proportion of birds likely to avoid the wind farm or its turbines, either because they have been displaced from the site or because they take evasive action or are attracted to the wind farm, e.g. in response to changing habitats.

1.4 Stages B through E are calculated by NatureScot's Collision Risk Model Spreadsheet, which uses visual basic macros to undertake the required calculations. The workbook is locked to prevent manipulation; however, editable parameters for the proportion of operational time have been retained as default values. Stage A requires the calculation of areal bird density (in terms of bird flight seconds per km^2), which is calculated separately to the NatureScot spreadsheet.

1.5 The method to obtain areal bird density values per month is presented in detail in NatureScot's guidance[1] which states that:

"Areal bird density (DA) is the number of birds, in flight at any height at a given point in time, per unit area. DA is most often recorded in bird seconds, which is particularly appropriate where bird numbers are low, and is usually expressed per square kilometre (km2). For use in the formulae, it must be divided by 106 to yield DA in SI units, i.e. birds m-2. The spreadsheet does this division. Note that

[1]NatureScot's guidance is available at https://www.nature.scot/doc/guidance-using-updated-collision-risk-model-assess-bird-collision-risk-onshore-wind-farms [Accessed 14 March 2025]
[2] Band, W. 2024. Using a collision risk model to assess bird collision risks for onshore wind farms. NatureScot Research Report 909

areal bird density is different from the 'true density' (Dv) that is expressed in terms of bird-seconds per cubic meter (m3) of air space, and which is calculated from DA in stage B.

Vantage point survey is usually the most appropriate way to record daytime flight behaviour, location and levels of flight activity on a proposed onshore wind farm site. Such a survey records, from a set of key vantage points, all bird flights and their duration within a defined sector of the wind farm airspace, leading to a measure of bird occupancy in that airspace. We advise that all of the proposed wind farm site, plus at least a 200 m buffer, is covered by vantage point surveys. Bird occupancy is readily converted to areal bird density (bird-seconds per m2) by dividing by the area scanned from the vantage point. Where flight activity from vantage point watches is recorded in bird seconds, DA is calculated as follows:

DA = b / (t x A) bird-seconds m-2

where:

(b) is the number of flight seconds from a vantage point;

(t) is the time (in seconds) that the vantage point is watched;

(A) is the area of the vantage point view-shed (km2)."

1.6 The tables in Section 2 of this document provide the data used for each of these parameters as follows:

- Tables 2a – 2d provide the data for *(b) the number of flight seconds from a vantage point* for each of the 2020 and 2022 survey periods respectively;
- Tables 3a and 3b provide the data for *(t) the time (in seconds) that the vantage point is watched* for each of the 2020 and 2022 survey periods respectively; and
- Tables 4a and 4b provide the data for *(A) is the area of the vantage point view-shed* for each of the 2020 and 2022 survey periods respectively.

1.7 The 'weighting' of viewsheds in accordance with habitat suitability or turbine density (which are optional methods to establish mean flight density) has not been undertaken given the size of the site and homogeneity of habitats within it.

1.8 All flights recorded (irrespective of height) were entered into the model for each respective year. The proportion of flights at rotor risk height (from 40 m to 200 m above ground level; height band 'B' in Tables 2a – 2d) was calculated as 27 % for the 2020 data and 79 % for the 2022 data.

1.9 Estimates of bird size and flight speed for the four species (red kite, kestrel, curlew and golden plover) have been based on data presented in Bruderer & Boldt (2001)[3] for flight speed and Baker (2016)[4] for biometrics. It has been assumed that the proportion of upwind and downwind flights are equal for all species, and that nocturnal activity is zero.

1.10 The completed NatureScot workbook front page based each of the 2020 and 2022 data is presented at the end of this document. Stage E of the workbook presents the annual collision risk assuming avoidance action. The following avoidance rates were used for bird species as per NatureScot recommendations (updated March 2025)[5]; red kite (99%), kestrel (95%), golden plover (98%) and curlew (98%).

1.11 The model output indicates that the collision rate for red kite based on survey data collected in Year 1[6] is **0.9** and based on survey data collected in Year 2[7] is **0.5** birds per annum. The combined collision rate used for analysis is **0.7** birds per annum.

[3] Bruderer, B. & Boldt, A. (2001) Flight characteristics of birds: I. radar measurements of speeds. Ibis.143. Pp. 178-204

[4] Baker, J.K. (2016) Identification of European Non-Passerines. British Trust for Ornithology

[5] Available at https://www.nature.scot/doc/wind-farm-impacts-birds-use-avoidance-rates-naturescot-wind-farm-collision-risk-model [Accessed 14/03/2025]

[6] Year 1 is defined as covering the period April 2022 – March 2023 (inclusive)

[7] Year 2 is defined as covering the period April 2023 – March 2024 (inclusive)

1.12 The model output indicates that the collision rate for kestrel based on survey data collected in Year 1 is **0.3** and based on survey data collected in Year 2 is **1.8** birds per annum. The combined collision rate used for analysis is **1.05** birds per annum.

1.13 The model output indicates that the collision rate for curlew based on survey data collected in Year 1 is **0** and based on survey data collected in Year 2 is **0** birds per annum.

1.14 The model output indicates that the collision rate for golden plover based on survey data collected in Year 1 is **0.7 and** based on survey data collected in Year 2 is **6.9** birds per annum. The combined collision rate used for analysis is **3.8** birds per annum.

2 Model Data

Table 2a: Red kite flight details (both Years)

VP number	Time	Survey date	Count of birds	Height band*	Duration (s)
1	15:42:00	10/10/2022	1	B	165
1	12:42:00	14/04/2022	1	A	35
1	13:41:00	10/10/2022	1	B	60
1	14:01:00	14/04/2022	1	A	45
1	16:57:00	20/04/2022	2	B	195
1	12:42:00	14/04/2022	1	B	40
1	12:42:00	14/04/2022	1	B	75
1	12:49:00	14/04/2022	1	B	150
1	13:16:00	14/04/2022	1	B	120
1	13:26:00	14/04/2022	1	B	30
1	13:26:00	14/04/2022	1	B	150
1	17:30:00	20/04/2022	1	B	210
1	12:49:00	14/04/2022	1	A	30
1	12:49:00	14/04/2022	1	B	45
1	13:26:00	14/04/2022	1	A	30
1	16:25:00	20/04/2022	1	B	135
1	14:51:00	18/05/2022	1	B	45
1	15:51:00	15/06/2022	1	B	165
1	17:32:00	14/07/2022	1	B	120
1	19:24:00	14/07/2022	1	B	195
1	17:17:00	12/07/2022	1	B	180
1	16:15:00	20/07/2022	1	B	195
1	17:08:00	18/05/2022	1	B	75
1	19:38:00	14/07/2022	2	B	360
1	15:38:00	12/07/2022	1	A	15
1	15:38:00	12/07/2022	1	A	30
1	15:38:00	12/07/2022	1	B	150
1	15:38:00	12/07/2022	1	B	30
1	16:01:00	20/07/2022	1	B	45
1	16:01:00	20/07/2022	1	A	75
1	18:49:00	08/05/2022	1	A	15
1	18:39:00	08/05/2022	1	B	75
1	18:39:00	08/05/2022	1	A	30
1	18:39:00	08/05/2022	1	B	285
1	18:49:00	08/05/2022	1	B	30
1	19:32:00	08/05/2022	1	B	210
1	19:32:00	08/05/2022	1	A	60
1	19:32:00	08/05/2022	1	B	90
1	18:49:00	08/05/2022	1	B	165
1	14:06:00	19/08/2022	1	B	90
1	13:47:00	25/11/2022	1	A	75

1	11:12:00	25/11/2022	1	B	60
1	12:04:00	25/11/2022	1	B	150
1	09:42:00	25/11/2022	1	A	30
1	09:42:00	25/11/2022	1	B	60
1	10:24:00	25/11/2022	1	B	60
1	10:24:00	25/11/2022	1	A	90
1	11:32:00	25/11/2022	1	B	315
1	14:10:00	09/01/2023	1	B	45
1	13:01:00	25/11/2022	1	B	195
1	13:01:00	25/11/2022	1	A	210
1	14:10:00	09/01/2023	1	A	60
1	14:10:00	09/01/2023	1	B	15
1	14:10:00	09/01/2023	1	A	30
1	10:19:00	23/09/2022	1	B	135
1	14:57:00	25/11/2022	1	A	30
1	15:02:00	25/11/2022	2	A	30
1	10:02:00	23/09/2022	1	B	195
1	14:22:00	10/10/2022	1	B	150
1	13:04:00	10/10/2022	1	B	165
1	13:18:00	10/10/2022	2	B	225
1	11:11:00	23/09/2022	1	A	45
1	13:28:00	10/10/2022	2	A	30
1	11:25:00	10/10/2022	1	A	45
1	12:25:00	10/10/2022	1	B	60
1	15:07:00	10/10/2022	1	B	135
1	15:07:00	10/10/2022	1	A	75
1	16:19:00	10/10/2022	1	A	45
1	16:19:00	10/10/2022	1	B	30
1	16:19:00	10/10/2022	1	A	45
1	15:42:00	10/10/2022	1	A	90
1	11:11:00	23/09/2022	1	B	30
1	11:11:00	23/09/2022	1	A	15
1	16:19:00	10/10/2022	1	B	315
1	11:11:00	23/09/2022	1	B	45
1	11:11:00	23/09/2022	1	A	30
1	11:11:00	10/10/2022	1	B	45
1	11:11:00	10/10/2022	1	A	60
1	11:11:00	10/10/2022	1	B	180
1	11:25:00	10/10/2022	1	B	135
1	12:25:00	10/10/2022	1	A	60
1	13:28:00	10/10/2022	2	B	180
1	13:28:00	10/10/2022	2	B	150
1	13:28:00	10/10/2022	2	A	45
1	15:14:00	10/10/2022	1	A	45
1	15:14:00	10/10/2022	1	B	315
1	15:42:00	10/10/2022	1	B	60

1	15:42:00	10/10/2022	1	A	30
1	16:29:00	10/10/2022	1	A	30
1	16:29:00	10/10/2022	1	B	30
1	16:29:00	10/10/2022	1	A	75
1	14:44:00	13/02/2023	1	B	120
1	09:17:00	13/02/2023	1	A	75
1	09:41:00	13/02/2023	1	B	135
1	10:45:00	13/02/2023	2	A	165
1	11:41:00	13/02/2023	1	B	210
1	09:28:00	13/02/2023	1	A	30
1	09:28:00	13/02/2023	1	B	45
1	09:28:00	13/02/2023	1	A	90
1	14:24:00	25/11/2022	1	B	165
1	13:33:00	31/05/2023	1	B	45
1	13:33:00	31/05/2023	1	A	79
1	15:14:00	10/10/2022	1	A	45
1	13:41:00	10/10/2022	1	A	45
1	11:11:00	23/09/2022	1	B	60
1	18:47:00	09/05/2023	1	A	44
1	15:34:00	09/05/2023	1	A	107
1	11:38:00	14/06/2023	1	A	44
1	13:26:00	05/07/2023	1	A	72
1	16:57:00	14/06/2023	1	B	94
1	18:27:00	14/06/2023	1	A	70
1	13:26:00	05/07/2023	1	B	109
1	15:54:00	05/07/2023	1	A	36
1	15:54:00	05/07/2023	1	B	97
1	15:54:00	05/07/2023	1	A	277
1	15:58:00	03/04/2023	1	A	105
1	17:21:00	03/04/2023	1	A	165
1	12:28:06	24/01/2024	1	A	57
1	13:57:00	24/01/2024	1	A	119
1	16:38:09	24/01/2024	1	A	175
1	15:11:22	28/02/2024	1	A	59
1	15:49:01	28/02/2024	1	A	116
1	13:14:24	21/09/2023	1	A	33
1	12:09:38	20/03/2024	1	A	124
1	10:49:23	21/09/2023	1	A	54
1	12:12:43	20/03/2024	1	A	107
1	13:28:55	20/03/2024	2	A	353
1	11:26:08	21/09/2023	1	B	194
1	12:34:32	21/09/2023	1	A	45
1	12:00:22	21/09/2023	2	A	202
1	12:17:15	24/11/2023	1	A	46
1	14:37:36	24/11/2023	1	A	114
1	14:48:09	24/11/2023	1	A	138

1	12:15:00	24/01/2024	1	A	177
1	14:57:00	25/11/2022	1	B	405
1	15:02:00	25/11/2022	2	B	30
1	15:02:00	25/11/2022	2	A	30
1	15:02:00	25/11/2022	2	B	15
1	15:02:00	25/11/2022	2	A	90
1	12:12:36	21/09/2023	2	A	103
1	12:32:43	21/09/2023	1	A	54
1	14:51:00	04/04/2023	2	A	30
1	14:51:00	04/04/2023	2	A	30
1	14:51:00	04/04/2023	2	B	45
1	14:51:00	04/04/2023	2	A	30
1	14:51:00	04/04/2023	2	B	60
1	16:40:00	04/04/2023	1	A	30
1	16:06:00	04/04/2023	1	A	30
1	16:06:00	04/04/2023	1	A	90
1	15:27:00	04/04/2023	1	A	45
1	15:27:00	04/04/2023	1	B	30
1	15:27:00	04/04/2023	1	B	45
1	16:40:00	04/04/2023	1	A	60
1	16:40:00	04/04/2023	1	B	90
1	16:40:00	04/04/2023	1	B	45
1	16:40:00	04/04/2023	1	B	15
1	16:40:00	04/04/2023	1	A	45
1	17:02:00	04/04/2023	1	A	30
1	10:59:00	21/09/2023	1	B	19
1	10:59:00	21/09/2023	1	A	23
1	12:15:00	24/01/2024	1	B	75
1	10:59:00	21/09/2023	1	A	55
1	12:00:22	21/09/2023	2	B	117
1	12:00:22	21/09/2023	2	A	27
1	12:12:36	21/09/2023	2	B	61
1	12:32:43	21/09/2023	1	B	40
1	17:02:00	04/04/2023	1	A	15
1	17:02:00	04/04/2023	1	A	150
1	17:02:00	04/04/2023	1	B	75
1	17:02:00	04/04/2023	1	A	105
1	11:32:00	25/11/2022	1	A	60
2	15:26:00	28/06/2022	1	B	210
2	15:15:00	28/06/2022	1	A	15
2	15:15:00	28/06/2022	1	B	60
2	15:15:00	28/06/2022	1	B	30
2	15:15:00	28/06/2022	1	B	30
2	15:15:00	28/06/2022	1	A	60
2	07:17:00	29/07/2022	1	B	75
2	07:17:00	29/07/2022	1	A	60

2	11:40:00	08/03/2023	1	B	30
2	11:40:00	08/03/2023	1	A	60
2	12:41:00	29/11/2022	1	A	60
2	15:38:00	29/11/2022	1	B	45
2	12:50:00	27/01/2023	1	A	30
2	12:50:00	27/01/2023	1	A	30
2	14:59:00	12/05/2022	1	B	90
2	14:03:00	12/07/2022	1	B	60
2	15:38:00	17/05/2022	1	B	195
2	12:06:00	12/07/2022	1	A	30
2	12:06:00	12/07/2022	1	B	120
2	10:14:00	29/07/2022	1	B	90
2	10:07:00	20/04/2022	2	B	195
2	13:39:00	20/04/2022	1	B	525
2	11:41:00	20/04/2022	3	B	435
2	12:07:00	20/04/2022	1	B	165
2	13:05:00	19/08/2022	1	B	165
2	11:09:00	29/07/2022	1	B	105
2	16:02:00	14/04/2022	1	A	30
2	16:02:00	14/04/2022	1	B	75
2	16:02:00	14/04/2022	1	B	60
2	16:19:00	14/04/2022	1	B	195
2	16:19:00	14/04/2022	1	B	90
2	13:57:00	20/04/2022	1	B	135
2	07:17:00	29/07/2022	1	B	15
2	10:17:00	29/07/2022	1	B	15
2	10:17:00	29/07/2022	1	A	45
2	10:17:00	29/07/2022	1	B	60
2	07:17:00	29/07/2022	1	A	30
2	14:06:00	20/04/2022	1	A	45
2	12:00:00	16/12/2022	1	B	45
2	13:08:00	16/12/2022	1	A	45
2	12:00:00	16/12/2022	1	A	45
2	13:08:00	16/12/2022	1	B	60
2	13:08:00	16/12/2022	1	B	45
2	13:08:00	16/12/2022	1	A	60
2	11:46:00	29/11/2022	1	A	150
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2	14:16:00	22/09/2022	1	A	15
2	13:36:00	13/10/2022	1	A	30
2	13:28:00	22/09/2022	1	B	90
2	13:28:00	22/09/2022	1	A	30

2	13:28:00	22/09/2022	1	B	75
2	14:16:00	22/09/2022	1	B	120
2	14:16:00	22/09/2022	1	A	45
2	13:36:00	13/10/2022	1	B	165
2	15:38:00	29/11/2022	1	B	225
2	15:38:00	29/11/2022	1	A	30
2	09:45:00	27/01/2023	1	B	150
2	13:37:00	27/01/2023	2	B	345
2	09:52:00	27/01/2023	1	A	30
2	12:50:00	27/01/2023	1	B	210
2	09:52:00	27/01/2023	1	A	30
2	10:43:00	27/01/2023	1	B	90
2	10:43:00	27/01/2023	1	A	120
2	12:50:00	27/01/2023	1	B	75
2	12:50:00	27/01/2023	1	A	45
2	09:51:00	27/01/2023	1	A	30
2	11:40:00	08/03/2023	1	B	60
2	11:40:00	08/03/2023	1	A	45
2	12:53:00	27/01/2023	1	B	60
2	13:19:00	27/01/2023	1	A	45
2	09:51:00	27/01/2023	1	B	105
2	12:50:00	27/01/2023	1	B	165
2	12:53:00	27/01/2023	1	A	30
2	12:53:00	27/01/2023	1	B	75
2	12:53:00	27/01/2023	1	A	135
2	13:19:00	27/01/2023	1	B	165
2	16:19:00	14/04/2022	1	A	30
2	13:28:00	22/09/2022	1	A	30
2	10:43:00	29/07/2022	2	B	195
2	13:57:00	20/04/2022	1	A	15
2	09:52:00	27/01/2023	1	B	270
2	09:52:00	27/01/2023	1	B	180
2	09:52:00	27/01/2023	1	A	105
3	15:50:00	03/07/2023	1	A	207
3	12:13:00	05/04/2023	1	A	125
3	15:25:00	24/05/2023	1	A	19
3	15:39:00	03/07/2023	1	A	73
3	11:35:00	05/04/2023	1	A	67
3	16:13:00	05/04/2023	1	A	25
3	09:51:00	05/05/2023	1	A	58
3	11:42:00	05/05/2023	1	A	41
3	15:25:00	24/05/2023	1	A	45
3	16:05:00	24/05/2023	1	B	247
3	17:53:00	05/06/2023	1	B	67
3	15:54:00	24/05/2023	1	B	201
3	15:54:00	24/05/2023	1	A	45

3	12:04:29	05/01/2024	1	A	327
3	12:12:39	05/01/2024	1	A	64
3	12:29:58	05/01/2024	1	A	130
3	12:47:43	05/01/2024	1	A	354
3	11:51:19	20/02/2024	2	A	309
3	15:19:54	16/11/2023	1	A	5
3	12:10:01	20/02/2024	2	A	32
3	12:43:25	20/02/2024	1	B	71
3	11:37:50	12/03/2024	2	A	233
3	13:19:55	12/03/2024	1	A	318
3	13:53:00	21/09/2023	4	A	159
3	13:19:31	20/02/2024	1	B	252
3	12:46:00	12/10/2023	2	B	207
3	16:27:14	12/10/2023	1	A	126
3	13:26:00	16/11/2023	1	A	65
3	16:01:01	16/11/2023	2	B	94
3	10:46:00	20/02/2024	1	A	58
3	11:28:17	20/02/2024	2	B	68
3	11:28:17	20/02/2024	2	A	15
3	15:19:54	16/11/2023	1	B	66
3	13:19:31	20/02/2024	1	A	66
3	14:38:11	20/02/2024	1	A	278
3	11:47:00	05/01/2024	2	B	348
3	11:47:00	05/01/2024	2	A	478
3	10:46:00	20/02/2024	1	B	24
3	14:38:11	20/02/2024	1	B	158

Table 2b: Kestrel flight details (both Years)

VP number	Time	Survey date	Count of birds	Height band*	Duration (s)
1	14:32:00	05/07/2023	1	B	116
1	17:05:00	08/05/2022	1	B	30
1	14:56:00	25/11/2022	1	B	165
1	15:13:00	25/11/2022	1	A	90
1	14:29:00	10/10/2022	1	B	120
1	16:23:00	10/10/2022	1	A	15
1	14:22:00	10/10/2022	1	A	90
1	14:25:00	10/10/2022	1	A	45
1	14:22:00	10/10/2022	1	B	75
1	14:25:00	10/10/2022	1	B	135
1	14:25:00	10/10/2022	1	B	165
1	14:25:00	10/10/2022	1	B	30
1	16:23:00	10/10/2022	1	B	180
1	11:55:00	13/02/2023	1	B	105
1	16:23:00	10/10/2022	1	A	30

1	13:04:00	05/07/2023	1	A	176
1	14:32:00	05/07/2023	1	A	17
1	13:48:00	05/07/2023	1	A	68
1	13:48:00	05/07/2023	1	B	111
1	20:16:00	05/07/2023	1	A	41
1	20:16:00	05/07/2023	1	B	27
1	20:16:00	05/07/2023	1	A	39
1	14:17:00	09/05/2023	1	B	54
1	14:17:00	09/05/2023	1	C	85
1	15:52:59	20/03/2024	1	A	27
1	16:08:00	04/04/2023	1	A	75
1	16:08:00	04/04/2023	1	A	45
1	17:40:00	19/10/2023	1	A	32
1	15:52:59	20/03/2024	1	A	34
1	14:14:00	28/02/2024	1	A	68
1	11:15:00	21/09/2023	1	A	127
1	12:24:38	21/09/2023	1	A	32
1	17:40:00	19/10/2023	1	B	42
1	17:40:00	19/10/2023	1	A	20
1	15:52:59	20/03/2024	1	B	44
1	10:46:00	25/11/2022	2	B	45
1	10:46:00	25/11/2022	2	A	75
1	10:46:00	25/11/2022	2	B	60
2	13:15:00	19/08/2022	1	A	30
2	16:41:00	12/05/2022	1	B	195
2	16:37:00	14/06/2022	1	B	300
2	17:39:00	14/06/2022	1	B	60
2	12:04:00	19/08/2022	1	B	120
2	13:15:00	19/08/2022	1	B	15
2	13:36:00	20/04/2022	1	B	120
2	13:36:00	20/04/2022	1	A	60
2	12:31:00	20/04/2022	1	B	75
2	12:31:00	20/04/2022	1	A	30
2	12:31:00	20/04/2022	1	B	105
2	12:01:00	19/08/2022	1	A	30
2	12:01:00	19/08/2022	1	B	15
2	12:01:00	19/08/2022	1	A	45
2	13:15:00	19/08/2022	1	B	150
2	16:30:00	14/04/2022	1	B	210
2	16:20:00	14/04/2022	1	B	120
2	16:20:00	14/04/2022	1	A	30
2	14:47:00	29/11/2022	1	B	90
2	16:55:00	13/10/2022	1	B	135
2	14:47:00	29/11/2022	1	B	165
2	14:04:00	22/09/2022	1	B	165
2	15:24:00	23/09/2022	1	B	165

2	13:39:00	13/10/2022	1	B	105
2	13:08:00	13/10/2022	1	A	45
2	13:08:00	13/10/2022	1	B	105
2	13:26:00	13/10/2022	1	A	150
2	13:26:00	13/10/2022	1	A	15
2	13:26:00	13/10/2022	1	A	30
2	13:13:00	22/09/2022	1	B	105
2	13:13:00	22/09/2022	1	A	15
2	13:13:00	22/09/2022	1	B	45
2	13:13:00	22/09/2022	1	A	30
2	12:01:00	27/01/2023	1	B	135
2	12:44:00	19/08/2022	1	B	90
2	12:44:00	19/08/2022	1	A	30
2	12:44:00	19/08/2022	1	B	45
2	12:44:00	19/08/2022	1	A	30
2	12:44:00	19/08/2022	1	B	150
2	05:36:00	29/07/2022	2	B	75
2	17:30:00	13/10/2022	11	B	105
3	16:35:00	24/05/2023	1	B	131
3	20:42:00	05/06/2023	1	A	47
3	15:34:00	24/05/2023	1	A	15
3	15:34:00	24/05/2023	1	B	7
3	16:35:00	24/05/2023	1	A	15
3	16:35:00	24/05/2023	1	A	7
3	14:52:45	12/10/2023	1	B	94
3	12:18:19	20/02/2024	1	B	54
3	14:52:45	12/10/2023	1	A	62
3	14:52:45	12/10/2023	1	A	16

Table 2c: Curlew flight details (both Years)

VP number	Time	Survey date	Count of birds	Height band*	Duration (s)
2	17:16:00	12/05/2022	1	B	30
2	17:16:00	12/05/2022	1	A	15
2	17:16:00	12/05/2022	1	A	45
3	05:43:00	05/05/2023	1	A	33
3	06:53:00	05/05/2023	1	A	21
3	06:06:00	05/05/2023	1	B	6
3	06:06:00	05/05/2023	1	A	5
3	06:06:00	05/05/2023	1	A	19
3	13:31:00	05/05/2023	2	B	39
3	13:31:00	05/05/2023	2	A	22
3	14:15:00	05/05/2023	2	B	25
3	14:15:00	05/05/2023	2	B	48

Table 2d: Golden plover flight details (both Years)

VP number	Time	Survey date	Count of birds	Height band*	Duration (s)
1	12:16:11	24/01/2024	2	B	60
1	14:27:00	20/03/2024	4	B	36
1	17:52:25	19/10/2023	7	B	36
1	15:58:42	24/11/2023	27	C	56
2	14:56:00	29/11/2022	12	B	90
2	07:38:00	08/03/2023	27	B	105
3	11:27:00	05/04/2023	36	B	131
3	11:55:00	05/04/2023	36	B	77
3	09:03:51	05/01/2024	6	B	39
3	13:01:47	05/01/2024	70	B	194
3	12:57:00	12/10/2023	22	B	181
3	13:24:06	12/10/2023	125	B	255
3	10:45:11	12/10/2023	2	B	53
3	10:55:17	12/10/2023	6	B	141
3	13:24:06	12/10/2023	125	A	14
3	14:04:00	12/10/2023	52	B	233
3	12:05:46	12/10/2023	5	B	170
3	12:15:30	12/10/2023	48	B	133
3	14:40:44	12/10/2023	22	B	101
3	14:40:44	12/10/2023	22	B	98
3	10:44:32	05/01/2024	18	A	117
3	11:27:40	12/10/2023	18	B	139
3	11:27:40	12/10/2023	18	A	20
3	12:57:00	12/10/2023	22	A	27
3	14:04:00	12/10/2023	52	A	34
3	14:40:44	12/10/2023	22	A	15
3	14:40:44	12/10/2023	22	A	17
3	10:44:32	05/01/2024	18	B	77
3	14:40:44	12/10/2023	22	A	34
3	14:40:44	12/10/2023	22	B	76

Height bands: A = <40 m; B = 40-200 m; C = >200 M

Table 3a: VP visit details (Year 1)

VP Number	Survey Date	Start Time	Finish Time	Month	Duration
1	14/04/2022	11:55:00	14:55:00	April	03:00:00
2	14/04/2022	15:35:00	17:05:00	April	01:30:00
1	20/04/2022	15:25:00	18:25:00	April	03:00:00
2	20/04/2022	10:00:00	13:00:00	April	03:00:00
2	20/04/2022	13:30:00	15:00:00	April	01:30:00
1	08/05/2022	18:30:00	21:30:00	May	03:00:00
1	08/05/2022	15:00:00	18:00:00	May	03:00:00
2	12/05/2022	14:20:00	17:20:00	May	03:00:00
2	17/05/2022	14:00:00	17:00:00	May	03:00:00
2	17/05/2022	17:30:00	20:30:00	May	03:00:00
1	18/05/2022	14:30:00	17:30:00	May	03:00:00
1	04/06/2022	08:50:00	11:50:00	June	03:00:00
1	05/06/2022	04:40:00	07:40:00	June	03:00:00
2	14/06/2022	15:15:00	18:15:00	June	03:00:00
2	14/06/2022	18:45:00	21:45:00	June	03:00:00
1	15/06/2022	15:40:00	18:40:00	June	03:00:00
2	28/06/2022	12:50:00	15:50:00	June	03:00:00
1	12/07/2022	14:45:00	17:45:00	July	03:00:00
2	12/07/2022	11:10:00	14:10:00	July	03:00:00
1	14/07/2022	17:30:00	20:30:00	July	03:00:00
1	20/07/2022	16:00:00	19:00:00	July	03:00:00
2	29/07/2022	08:50:00	11:50:00	July	03:00:00
2	29/07/2022	05:20:00	08:20:00	July	03:00:00
1	19/08/2022	13:50:00	16:50:00	August	03:00:00
2	19/08/2022	10:20:00	13:20:00	August	03:00:00
2	22/09/2022	12:30:00	15:30:00	September	03:00:00
1	22/09/2022	08:50:00	11:50:00	September	03:00:00
1	23/09/2022	09:05:00	12:05:00	September	03:00:00
2	23/09/2022	13:00:00	16:00:00	September	03:00:00
1	10/10/2022	10:50:00	13:50:00	October	03:00:00
1	10/10/2022	14:20:00	17:20:00	October	03:00:00
2	13/10/2022	12:05:00	15:05:00	October	03:00:00
2	13/10/2022	15:35:00	18:35:00	October	03:00:00
1	25/11/2022	13:00:00	16:00:00	November	03:00:00
1	25/11/2022	09:30:00	12:30:00	November	03:00:00
2	29/11/2022	09:55:00	12:55:00	November	03:00:00
2	29/11/2022	13:25:00	16:25:00	November	03:00:00
1	14/12/2022	12:40:00	15:40:00	December	03:00:00
1	14/12/2022	09:10:00	12:10:00	December	03:00:00
2	16/12/2022	11:30:00	14:30:00	December	03:00:00
2	16/12/2022	08:00:00	11:00:00	December	03:00:00
1	09/01/2023	13:20:00	16:20:00	January	03:00:00
1	09/01/2023	09:50:00	12:50:00	January	03:00:00

2	27/01/2023	11:15:00	14:15:00	January	03:00:00
2	27/01/2023	07:45:00	10:45:00	January	03:00:00
1	13/02/2023	12:30:00	15:30:00	February	03:00:00
1	13/02/2023	09:00:00	12:00:00	February	03:00:00
2	08/03/2023	10:00:00	13:00:00	March	03:00:00
2	08/03/2023	06:30:00	09:30:00	March	03:00:00

Table 3b: VP visit details (2022)

VP Number	Survey Date	Start Time	Finish Time	Month	Duration
1	03/04/2023	14:40:00	17:40:00	April	03:00:00
1	04/04/2023	14:45:00	17:45:00	April	03:00:00
2	05/04/2023	09:45:00	12:45:00	April	03:00:00
2	05/04/2023	13:15:00	16:15:00	April	03:00:00
2	27/04/2023	13:00:00	16:00:00	April	03:00:00
2	05/05/2023	05:15:00	08:15:00	May	03:00:00
2	05/05/2023	08:45:00	11:45:00	May	03:00:00
2	05/05/2023	12:15:00	15:15:00	May	03:00:00
1	09/05/2023	13:00:00	16:00:00	May	03:00:00
1	09/05/2023	16:30:00	19:30:00	May	03:00:00
2	24/05/2023	13:50:00	16:50:00	May	03:00:00
1	31/05/2023	10:40:00	13:40:00	May	03:00:00
2	05/06/2023	14:55:00	17:55:00	June	03:00:00
2	05/06/2023	18:45:00	21:45:00	June	03:00:00
1	14/06/2023	09:05:00	12:05:00	June	03:00:00
1	14/06/2023	12:35:00	15:35:00	June	03:00:00
1	14/06/2023	16:05:00	19:05:00	June	03:00:00
2	03/07/2023	14:00:00	17:00:00	July	03:00:00
2	03/07/2023	17:30:00	20:30:00	July	03:00:00
1	05/07/2023	11:40:00	15:40:00	July	04:00:00
1	05/07/2023	15:10:00	18:10:00	July	03:00:00
1	05/07/2023	18:40:00	21:40:00	July	03:00:00
1	14/08/2023	11:05:00	14:05:00	August	03:00:00
2	14/08/2023	14:40:00	17:40:00	August	03:00:00
1	21/09/2023	10:15:00	13:15:00	September	03:00:00
2	21/09/2023	13:49:00	16:49:00	September	03:00:00
2	12/10/2023	10:30:00	13:30:00	October	03:00:00
2	12/10/2023	14:00:00	17:00:00	October	03:00:00
1	19/10/2023	12:00:00	15:00:00	October	03:00:00
1	19/10/2023	15:30:00	18:30:00	October	03:00:00
2	16/11/2023	09:55:00	12:55:00	November	03:00:00
2	16/11/2023	13:25:00	16:25:00	November	03:00:00
1	24/11/2023	09:55:00	12:55:00	November	03:00:00
1	24/11/2023	13:25:00	16:25:00	November	03:00:00
2	05/01/2024	11:30:00	14:30:00	January	03:00:00
2	05/01/2024	07:59:00	10:59:00	January	03:00:00
1	24/01/2024	10:25:00	13:25:00	January	03:00:00
1	24/01/2024	13:55:00	16:55:00	January	03:00:00
2	20/02/2024	10:40:00	13:40:00	February	03:00:00
2	20/02/2024	14:10:00	17:10:00	February	03:00:00
1	28/02/2024	11:15:00	14:15:00	February	03:00:00
1	28/02/2024	14:45:00	17:45:00	February	03:00:00
2	12/03/2024	10:31:00	13:31:00	March	03:00:00

2	12/03/2024	14:01:00	17:01:00	March	03:00:00
1	20/03/2024	14:05:00	17:05:00	March	03:00:00
1	20/03/2024	10:35:00	13:35:00	March	03:00:00

Table 4a: VP Viewshed area[!] (All Years)

VP Number	Area of viewshed (km^2)
1	1.7505
2	3.4846

[!] The extent of the visible area from VP locations has been calculated using QGIS (using LiDAR Digital Surface Model (DSM) data obtained from the DataMapsWales[8] website) and is based on the area visible at 40 m above ground level from the VP locations. The DSM data allows consideration of tree heights (based on 2022 to 2024 heights) to model the actual visibility from each VP location.

[8] Available at: https://datamap.gov.wales/maps/lidar-viewer/ [Accessed 28/11/2023]

3 Collision Risk Model Output

(Overleaf)

Kestrel (Year 1)

COLLISION RISK MODEL																									
		Required input data is in		orange	boxes																				
		Calculated output is in		blue	boxes																				
				green	boxes are for information only, to show variables used at each stage																				
		Value	Units					Value	Units									Value	Units						
Bird data					**Windfarm data**									**Turbine data**											
Species name		**Kestrel**			Site name		**Calon Y Gwynt**							Model		**Nordex N163**									
Bird length	L	0.34	m		Latitude		52.572	degrees						Hub height		118.5	m								
Wingspan	W	0.76	m		No of turbines	T	11							Rotor radius	R	82.5	m								
Bird flight speed	v	8	m s^{-1}		Width of windfarm	w	2.2677	km						No of blades	b	3									
Flight type, flapping or gliding		flapping												Rotation speed	Ω	10	rpm								
% of flights upwind/downwind		50%	50%											Max blade width	C	4.68	m								
Nocturnal activity ranking 1-5		1												Blade pitch	λ	6	degrees								
Nocturnal activity factor	f_{night}	0%												Risk height range		36-201	m								
normal approach		Set to 'normal approach' to use survey data on bird density																							
		Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A																							
Stage A						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge							
Daytime bird density	D_R		birds/km^2			0.0009	0.0028	0	0.005	0.0011	0.0016	0.0007	0.01	0.0035	0.0233	0.0038	0	0.0049							
Proportion at rotor risk height	Q_{ER}	84.76%																							
At latitude 52.6		**Daylight hours per month**				255.5	275.6	366.6	416.9	487.6	502.4	505.7	456.4	382.0	331.0	264.2	240.2	4484.1							
		Nighttime hours per month				488.5	468.4	377.4	327.1	256.4	241.6	238.3	287.6	362.0	413.0	479.8	503.8	4443.9							
Stage B																									
No of turbines	T	11																							
Rotor radius	R	82.5	m																						
		Total rotor frontal a		235207																					
Nocturnal activity factor	f_{night}	0%																							
Bird flight speed	v	8	m s^{-1}			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total							
		Projected number of rotor transits				8.0	26.6	0.0	72.3	19.1	27.3	11.7	158.2	46.4	267.3	90.3	0.0	**728**							
Stage C																									
No of blades	b	3				Bird length	l	0.34	m																
Rotation speed	Ω	10	rpm			Wingspan	w	0.76	m																
Rotor radius	R	82.5	m			Bird flight speed	v	8	m s^{-1}																
Max blade width	C	4.68	m			Flight type		flapping																	
Pitch	λ	6	degrees		% of flights upwind/downwind			50%	50%																
Blade profile		see Blade profile sheet																							
		Single transit risk		**upwind**	7.31%																				
				downwind	4.03%																				
				weighted mean	**5.67%**																				
Stage D						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge							
Proportion of time operational	Q_{op}					87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%							
						Collision rates before avoidance												year total							
						0.40	1.35	0.00	3.47	0.74	1.09	0.46	6.94	2.25	13.86	4.48	0.00	**35**							
Stage E																									
Allow for large array correction?		No																							
Width of windfarm	w	2.267719	km																						
			large corrections			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year							
						Collision rates allowing for avoidance																			
Avoidance rates modelled		95.00%	100.00%			0.02	0.07	0.00	0.17	0.04	0.05	0.02	0.35	0.11	0.69	0.22	0.00	**1.8**							
		98.00%	100.00%			0.01	0.03	0.00	0.07	0.01	0.02	0.01	0.14	0.05	0.28	0.09	0.00	**0.7**							
		99.00%	100.00%			0.00	0.01	0.00	0.03	0.01	0.01	0.00	0.07	0.02	0.14	0.04	0.00	**0.4**							
		99.50%	100.00%			0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.03	0.01	0.07	0.02	0.00	**0.2**							

Kestrel (Year 2)

COLLISION RISK MODEL		Required input data is in	orange	boxes														
		Calculated output is in	blue	boxes														
			green	boxes are for information only, to show variables used at each stage														
		Value	Units				Value	Units							Value	Units		
Bird data				**Windfarm data**						**Turbine data**								
Species name		**Kestrel**		Site name	**Calon Y Gwynt**					Model	**Nordex N163**							
Bird length	L	0.34	m	Latitude		52.572	degrees			Hub height		118.5	m					
Wingspan	W	0.76	m	No of turbines	T	11				Rotor radius	R	82.5	m					
Bird flight speed	v	8	$m\,s^{-1}$	Width of windfarm	w	2.2677	km			No of blades	b	3						
Flight type, flapping or gliding		flapping								Rotation speed	Ω	10	rpm					
% of flights upwind/downwind		50%	50%							Max blade width	C	4.68	m					
Nocturnal activity ranking 1-5		1								Blade pitch	λ	6	degrees					
Nocturnal activity factor	f_{night}	0%								Risk height range		36-201	m					
normal approach		Set to 'normal approach' to use survey data on bird density																
		Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A																
Stage A					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge	
Daytime bird density	D_R		$birds/km^2$		0	0.0012	0.0014	0.0016	0.0017	0.0003	0.0048	0	0.0043	0.0022	0	0	0.0015	
Proportion at rotor risk height	Q_{ER}	39.70%																
At latitude 52.6		**Daylight hours per month**			255.5	275.6	366.6	416.9	487.6	502.4	505.7	456.4	382.0	331.0	264.2	0.0	4243.8	
		Nighttime hours per month			488.5	468.4	377.4	327.1	256.4	241.6	238.3	287.6	362.0	413.0	479.8	0.0	3340.7	
Stage B																		
No of turbines	T	11																
Rotor radius	R	82.5	m															
		Total rotor frontal a	235207															
Nocturnal activity factor	f_{night}	0%																
Bird flight speed	v	8	$m\,s^{-1}$		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year tota	
		Projected number of rotor transits			0.0	5.5	8.5	11.1	13.5	2.1	39.9	0.0	26.9	12.0	0.0	0.0	**119**	
Stage C																		
No of blades	b	3			Bird length	l	0.34	m										
Rotation speed	Ω	10	rpm		Wingspan	w	0.76	m										
Rotor radius	R	82.5	m		Bird flight speed	v	8	$m\,s^{-1}$										
Max blade width	C	4.68	m		Flight type		flapping											
Pitch	λ	6	degrees	% of flights upwind/downwind			50%	50%										
Blade profile		see Blade profile sheet																
		Single transit risk	**upwind**	7.31%														
			downwind	4.03%														
			weighted mean	**5.67%**														
Stage D					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge	
Proportion of time operational	Q_{op}				87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%	
				Collision rates before avoidance													year tota	
					0.00	0.28	0.42	0.53	0.52	0.08	1.56	0.00	1.30	0.62	0.00	0.00	**5**	
Stage E																		
Allow for large array correction?		No																
Width of windfarm	w	2.267719	km															
			large correction		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year	
				Collision rates allowing for avoidance														
Avoidance rates modelled		95.00%	100.00%		0.00	0.01	0.02	0.03	0.03	0.00	0.08	0.00	0.07	0.03	0.00	0.00	**0.3**	
		98.00%	100.00%		0.00	0.01	0.01	0.01	0.01	0.00	0.03	0.00	0.03	0.01	0.00	0.00	**0.1**	
		99.00%	100.00%		0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.00	0.00	**0.1**	
		99.50%	100.00%		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	**0.0**	

Red kite (Year 1)

COLLISION RISK MODEL

Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Unit
Species name		Red kite	
Bird length	L	0.63	m
Wingspan	W	1.85	m
Bird flight speed	v	13	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Unit
Site name		Calon Y Gwynt	
Latitude		52.572	degrees
No of turbines	T	11	
Width of windfarm	w	2.2677	km

Turbine data		Value	Unit
Model		Nordex N163	
Hub height		118.5	m
Rotor radius	R	82.5	m
No of blades	b	3	
Rotation speed	Ω	10	rpm
Max blade width	C	4.68	m
Blade pitch	λ	6	degrees
Risk height range		36-201	m

normal approach

Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_R	birds/km^2	0	0	0	0.04	0.0108	0.0032	0.0203	0.0046	0	0	0	0	0.0066
Proportion at rotor risk height	Q_{2R}	80.66%													
At latitude 52.6		Daylight hours per month	0.0	0.0	0.0	416.9	487.6	502.4	505.7	456.4	0.0	0.0	0.0	0.0	2369.0
		Nighttime hours per month	0.0	0.0	0.0	327.1	256.4	241.6	238.3	287.6	0.0	0.0	0.0	0.0	1351.0

Stage B

No of turbines	T	11													
Rotor radius	R	82.5	m												
		Total rotor frontal a	235207												
Nocturnal activity factor	f_{night}	0%													
Bird flight speed	v	13	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits		0.0	0.0	0.0	896.5	283.0	87.8	553.0	112.3	0.0	0.0	0.0	0.0	**1933**

Stage C

No of blades	b	3		Bird length	l	0.63	m
Rotation speed	Ω	10	rpm	Wingspan	w	1.85	m
Rotor radius	R	82.5	m	Bird flight speed	v	13	m s^{-1}
Max blade width	C	4.68	m	Flight type		flapping	
Pitch	λ	6	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					

Single transit risk	upwind	7.33%
	downwind	5.30%
	weighted mean	**6.32%**

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Stage D														
Proportion of time operational	Q_{op}	87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%
		Collision rates before avoidance												year total
		0.00	0.00	0.00	47.90	12.15	3.82	24.06	5.48	0.00	0.00	0.00	0.00	**93**

Stage E

Allow for large array correction? No
Width of windfarm w 2.267719 km

Avoidance rates modelled	large correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
		Collision rates allowing for avoidance												
95.00%	100.00%	0.00	0.00	0.00	2.40	0.61	0.19	1.20	0.27	0.00	0.00	0.00	0.00	**4.7**
98.00%	100.00%	0.00	0.00	0.00	0.96	0.24	0.08	0.48	0.11	0.00	0.00	0.00	0.00	**1.9**
99.00%	100.00%	0.00	0.00	0.00	0.48	0.12	0.04	0.24	0.05	0.00	0.00	0.00	0.00	**0.9**
99.50%	100.00%	0.00	0.00	0.00	0.24	0.06	0.02	0.12	0.03	0.00	0.00	0.00	0.00	**0.5**

Red kite (Year 2)

COLLISION RISK MODEL Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

		Value	Unitr
Bird data			
Species name		**Red kite**	
Bird length	l	0.63	m
Wingspan	w	1.85	m
Bird flight speed	v	13	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

		Value	Unitr
Windfarm data			
Site name		**Calon Y Gwynt**	
Latitude		52.572	degrees
No of turbines	T	11	
Width of windfarm	w	2.2677	km

		Value	Unitr
Turbine data			
Model		**Nordex N163**	
Hub height		118.5	m
Rotor radius	R	82.5	m
No of blades	b	3	
Rotation speed	Ω	10	rpm
Max blade width	C	4.68	m
Blade pitch	λ	6	degrees
Risk height range		36-201	m

normal approach
Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_R		birds/km^2	0.022	0.012	0.017	0.022	0.0043	0.0022	0.0063	0	0.0487	0.003	0.0058	0	0.0119
Proportion at rotor risk height	Q_{ER}	29.07%														
At latitude 52.6		**Daylight hours per month**		255.5	275.6	366.6	416.3	487.6	502.4	505.7	456.4	382.0	331.0	264.2	0.0	4243.9
		Nighttime hours per month		488.5	468.4	377.4	327.1	256.4	241.6	238.3	287.6	362.0	413.0	479.8	0.0	3940.1

Stage B

No of turbines	T	11														
Rotor radius	R	82.5	m													
		Total rotor frontal a		235207												
Nocturnal activity factor	f_{night}	0%														
Bird flight speed	v	13	m s^{-1}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
		Projected number of rotor transits		109.0	64.0	120.9	177.6	40.5	21.9	62.2	0.0	360.6	19.0	29.7	0.0	**1005**

Stage C

No of blades	b	3		Bird length	l	0.63	m	
Rotation speed	Ω	10	rpm	Wingspan	w	1.85	m	
Rotor radius	R	82.5	m	Bird flight speed	v	13	m s^{-1}	
Max blade width	C	4.68	m	Flight type		flapping		
Pitch	λ	6	degrees	% of flights upwind/downwind		50%	50%	
Blade profile		see Blade profile sheet						

Single transit risk	**upwind**	7.33%
	downwind	5.30%
	weighted mean	**6.32%**

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{op}	87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%
		Collision rates before avoidance												year total
		6.02	3.61	6.67	3.49	1.74	0.95	2.71	0.00	13.49	1.09	1.64	0.00	**53**

Stage E

Allow for large array correction?		No														
Width of windfarm	w	2.267719	km													
			large correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
				Collision rates allowing for avoidance												
Avoidance rates modelled		95.00%	100.00%	0.30	0.18	0.33	0.47	0.09	0.05	0.14	0.00	0.97	0.05	0.08	0.00	**2.7**
		98.00%	100.00%	0.12	0.07	0.13	0.19	0.03	0.02	0.05	0.00	0.39	0.02	0.03	0.00	**1.1**
		99.00%	100.00%	0.06	0.04	0.07	0.09	0.02	0.01	0.03	0.00	0.19	0.01	0.02	0.00	**0.5**
		99.50%	100.00%	0.03	0.02	0.03	0.05	0.01	0.00	0.01	0.00	0.10	0.01	0.01	0.00	**0.3**

Golden plover (Year 1)

COLLISION RISK MODEL Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

Bird data		Value	Units
Species name		Golden plover	
Bird length	l	0.28	m
Wingspan	w	0.72	m
Bird flight speed	v	10	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

Windfarm data		Value	Units
Site name		Calon Y Gwynt	
Latitude		52.572	degrees
No of turbines	T	11	
Width of windfarm	w	2.2677	km

Turbine data		Value	Units
Model		Nordex N163	
Hub height		118.5	m
Rotor radius	R	82.5	m
No of blades	b	3	
Rotation speed	Ω	10	rpm
Max blade width	C	4.68	m
Blade pitch	λ	6	degrees
Risk height range		36-201	m

normal approach
Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_R		birds/km^2	0	0	0.0377	0	0	0	0	0	0	0	0.0072	0	0.0037
Proportion at rotor risk height	Q_{ZR}	100.00%														
At latitude 52.6		Daylight hours per month		255.5	275.6	366.6	416.3	487.6	502.4	505.7	456.4	382.0	331.0	264.2	240.2	4484.1
		Nighttime hours per month		488.5	468.4	377.4	327.1	256.4	241.6	238.3	287.6	362.0	413.0	479.8	503.8	4443.9

Stage B

					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year total
No of turbines	T	11															
Rotor radius	R	82.5	m														
		Total rotor frontal a		235207													
Nocturnal activity factor	f_{night}	0%															
Bird flight speed	v	10	m s^{-1}														
		Projected number of rotor transits			0.0	0.0	708.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.3	0.0	**806**

Stage C

No of blades	b	3		Bird length	l	0.28	m	
Rotation speed	Ω	10	rpm	Wingspan	w	0.72	m	
Rotor radius	R	82.5	m	Bird flight speed	v	10	m s^{-1}	
Max blade width	C	4.68	m	Flight type		flapping		
Pitch	λ	6	degrees	% of flights upwind/downwind		50%	50%	
Blade profile		see Blade profile sheet						
		Single transit risk	upwind	6.29%				
			downwind	3.66%				
			weighted mean	**4.98%**				

Stage D

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Proportion of time operational	Q_{op}	87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%

	Collision rates before avoidance												year total
	0.00	0.00	30.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.23	0.00	**35**

Stage E

Allow for large array correction? No
Width of windfarm w 2.267719 km

		large correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
Avoidance rates modelled	95.00%	100.00%	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	**1.8**
	98.00%	100.00%	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	**0.7**
	99.00%	100.00%	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	**0.4**
	99.50%	100.00%	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	**0.2**

Golden plover (Year 2)

COLLISION RISK MODEL Required input data is in orange boxes
Calculated output is in blue boxes
green boxes are for information only, to show variables used at each stage

		Value	Unit
Bird data			
Species name		Golden plover	
Bird length	L	0.28	m
Wingspan	W	0.72	m
Bird flight speed	v	10	m s^{-1}
Flight type, flapping or gliding		flapping	
% of flights upwind/downwind		50%	50%
Nocturnal activity ranking 1-5		1	
Nocturnal activity factor	f_{night}	0%	

		Value	Unit
Windfarm data			
Site name		Calon Y Gwynt	
Latitude		52.572	degrees
No of turbines	T	11	
Width of windfarm	w	2.2677	km

		Value	Unit
Turbine data			
Model		Nordex N163	
Hub height		118.5	m
Rotor radius	R	82.5	m
No of blades	b	3	
Rotation speed	Ω	10	rpm
Max blade width	C	4.68	m
Blade pitch	λ	6	degrees
Risk height range		36-201	m

normal approach
Set to 'normal approach' to use survey data on bird density
Set to 'birds on migration' to use 'Migrant collision risk' sheet in place of Stage A

Stage A

				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Daytime bird density	D_A		birds/km^2	0.0963	0	0.002	0.0273	0	0	0	0	0	0.3898	0.0205	0	0.0441
Proportion at rotor risk height	Q_{ER}	90.21%														
At latitude 52.6		Daylight hours per month		255.5	275.6	366.6	416.3	487.6	502.4	505.7	456.4	382.0	331.0	264.2	0.0	4243.8
		Nighttime hours per month		488.5	468.4	377.4	327.1	256.4	241.6	238.3	287.6	362.0	413.0	479.8	0.0	3940.7

Stage B

No of turbines	T	11		
Rotor radius	R	82.5	m	
		Total rotor frontal a		235207
Nocturnal activity factor	f_{night}	0%		
Bird flight speed	v	10	m s^{-1}	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year tota
Projected number of rotor transits	1139.0	0.0	33.2	527.0	0.0	0.0	0.0	0.0	0.0	5973.7	251.0	0.0	**7924**

Stage C

No of blades	b	3		Bird length	l	0.28	m
Rotation speed	Ω	10	rpm	Wingspan	w	0.72	m
Rotor radius	R	82.5	m	Bird flight speed	v	10	m s^{-1}
Max blade width	C	4.68	m	Flight type		flapping	
Pitch	λ	6	degrees	% of flights upwind/downwind		50%	50%
Blade profile		see Blade profile sheet					
Single transit risk			upwind	6.29%			
			downwind	3.66%			
			weighted mean	**4.98%**			

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year avge
Stage D														
Proportion of time operational	Q_{op}	87.4%	89.3%	87.4%	84.6%	68.0%	68.9%	68.9%	77.3%	85.6%	91.2%	87.4%	86.5%	81.9%
Collision rates before avoidance		49.53	0.00	1.44	22.18	0.00	0.00	0.00	0.00	0.00	271.07	10.91	0.00	year tota **355**

Stage E

Allow for large array correction?		No		
Width of windfarm	w	2.267719	km	

Avoidance rates modelled		large correction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	per year
			Collision rates allowing for avoidance												
95.00%	95.00%	100.00%	2.48	0.00	0.07	1.11	0.00	0.00	0.00	0.00	0.00	13.55	0.55	0.00	**17.8**
98.00%	98.00%	100.00%	0.99	0.00	0.03	0.44	0.00	0.00	0.00	0.00	0.00	5.42	0.22	0.00	**7.1**
99.00%	99.00%	100.00%	0.50	0.00	0.01	0.22	0.00	0.00	0.00	0.00	0.00	2.71	0.11	0.00	**3.6**
99.50%	99.50%	100.00%	0.25	0.00	0.01	0.11	0.00	0.00	0.00	0.00	0.00	1.36	0.05	0.00	**1.8**