Gortyrahilly Wind Farm

Collision Risk Modelling

Prepared for:

Biosphere Environmental Services

July 2022

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Document Control Sheet

Client	Biosphere Environmental
Project Title	Gortyrahilly Collision Risk Modelling
Document Title	Collision Risk Modelling
Project Number	WS0743
Document No.	GortyrahillyCRM_001

Revision	Status	Author	Review	Approved	Date
001	Draft	MCG			25/07/2022
001	FINAL		PC	PC	28/07/2022
Wetland Surveys Ireland					

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1 INTRODUCTION

Wind Farm Developments have the potential to impact bird species in a number of ways, in particular through risk of collision with wind turbines. *Wetland Surveys Ireland Ltd.* were commissioned by *Biosphere Environmental Services* to assess the collision risk for bird species at the proposed Gortyrahilly Wind Farm, Co. Cork. Collision Risk Modelling (CRM) is a method to estimate the number of birds likely to collide with turbines at a proposed wind farm site. This method uses vantage point data to calculate the risk of collision. In this case, vantage point data collected over two years (two breeding seasons and two winter seasons) at the proposed Gortyrahilly Wind Farm site was used. The vantage point surveys were undertaken from May 2017 to February 2019 at four vantage point locations (VP6, VP7, VP8, and VP9). There are three potential turbine models which may be used at the proposed wind farm, where appropriate calculations were run separately for each of the three models.

Table 1: Turbine parameters for the three proposed turbine models for Gortyrahilly Wind Farm.

Turbine Model	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Number of turbines	14	14	14
Blades per turbine rotor	3	3	3
Rotor diameter	155	149.1	150
Rotor radius	77.5	74.55	75
Hub height	102.5	110.5	105
Blade height above ground	25	35.95	30
Swept height	180	185.05	180
Mean pitch of blade (degrees)	25	25	25
Maximum chord (depth of blade)	4.5	4	4.238
Max tip speed	11.2	12.2	12.6
Circumference of blade tip	486.7	468.174	471
Rotational period (s per rotation)	5.3571	4.918	4.7619
Turbine operational time	85	85	85

2 METHODOLOGY

The vantage point surveys were carried out following Scottish Natural Heritage guidelines (SNH 2017). CRM uses a mathematical model to estimate the number of birds of a particular species that are likely to collide with the proposed turbines. The CRM method followed here is that of Scottish Natural Heritage, which is also known as the Band Model (Band et al. 2007).

Table 2: Details of four VPs at Gortyrahilly Wind Farm.

	Number of visible turbines	Viewshed area (ha)	Area of risk (ha)*	Total survey effort (hrs)
VP6	6	429.4	217.7	144
VP7	5	461.4	174.6	144
VP8	3	520.2	158.1	144
VP9	6	303.1	162.7	144

** Area of 500m turbine buffer within viewshed*

There are a number of steps involved in calculating the collision risk for bird species following SNH guidance / the Band Model, and it should be noted that CRM makes the following assumptions:

- That a bird can be modelled by a simple cruciform shape
- That a turbine blade has a width and pitch, but no thickness
- That birds fly through turbines in straight lines
- That a bird's flight will be unaffected by a near miss, despite the slipstream around a turbine blade
- That no action is taken by a bird to avoid collision and so the figures represent worst case scenarios.

The stages involved in CRM are as follows:

Stage 1: Vantage point observations of birds flying the study area are used to calculate the number of birds likely to fly through areas swept by the proposed turbine blades. There are two standard approaches that can be used here depending on species and flight behaviour.

- **Regular flights** – this approach can be taken when the bird species makes regular flights through the wind farm, perhaps in a defined direction. For example, this approach is appropriate for geese or swans undertaking daily commuting flights from roost sites to feeding areas.
- **Random flights** – this approach can be used for birds such as raptors which occupy a recognised territory and vantage point observations have led to some understanding of the distribution of flights within the study area. It is assumed that all flights recorded are randomly occurring i.e., they are as likely to occur within the wind farm site as outside it.

The flightlines recorded at Gortyrahilly wind farm from 2017-2019 did not indicate any regular flightlines through the wind farm site. Therefore, the random flight approach was used to calculate the number of birds likely to fly through the areas swept by the proposed turbine blades at Gortyrahilly.

For random flights through the wind farm the "bird occupancy" approach is used. For this calculation, a "flight risk volume (V_w)" is first determined. This is the area of the windfarm, plus a 500m turbine buffer, multiplied by the height of the turbines. The combined volume swept by the windfarm rotors (V_r) is then calculated using the following equation:

$$V_r = N \times \pi R^2 \times (d + l)$$

Where N = number of turbines, R = rotor radius, d = rotor depth, and l = bird length

Bird occupancy within the flight risk volume (n) is then estimated. Bird occupancy is the number of birds present multiplied by the time spent flying in the flight risk volume. Data collected during VP surveys was used to determine the number of birds flying in the risk volume. Any flightlines that occurred entirely outside of the area of the windfarm plus a 500m turbine buffer were excluded from the analysis. Any flightlines that partially occurred within the windfarm and 500m turbine buffer area were included. Only data relating to the following target species was included: Kestrel, Sparrowhawk, Hen Harrier, Merlin, Peregrine, Golden Plover, Chough, and White-tailed Eagle.

The flight height bands recorded during VP surveys were 0-20m, 20-40m, 40-80m, 80-150m, and >150m. The lowest blade height above ground for any of the three turbine models is 25m. Therefore, any flightlines that were solely within the 0-20m height band were excluded from the analysis. For the remaining flightlines, the amount of time spent flying in the 20-40m, 40-80m, 80-150m, and >150m height bands was used to calculate bird occupancy within the flight risk volume. For Golden Plover bird occupancy was increased by an additional 25% to account for nocturnal activity.

VP data used in this analysis was collected during 144 hours of surveys at each VP over the entire survey period. As the amount of time spent carrying out VP surveys is only a proportion of the time that birds could potentially be active within the flight risk volume, this figure is adjusted to represent bird activity in the flight risk volume during available daylight over the two years of surveying. In addition, wind turbines are not active 100% of the time and 85% is seen as an upper limit for the amount of time that a wind turbine is typically active (Wind Europe). This was also taken into account when calculating bird occupancy.

Bird occupancy of the volume swept by the rotors is then calculated as

$$n \times (V_r / V_w)$$

Stage 2: The collision risk for an individual bird flying through a rotating turbine blade is calculated. This risk is dependant on species flight behaviour and biometrics. Bird biometrics have been obtained from the British Trust of Ornithology (BTO) and flight speeds were taken from Alerstam et al. (2007). The mean blade pitch was taken to be 25 degrees. Blade pitch varies with wind speed, season, and geographic area, with higher wind speeds typically producing higher pitch angles. The figure of 25 degrees was used as a precautionary measure and is taken from Band (2012).

For bird species that display flapping and gliding activity the average collision risk value for both flapping and gliding behaviour was used in this analysis. Figures for collision risk were calculated using an excel spreadsheet provided by SNH[1], which is available to download on their website.

Stage 3: The number of birds estimated to fly through the turbines on an annual basis (Stage 1) is multiplied by the collision risk for that species (Stage 2). The result of this calculation is taken as the "worst case scenario" assuming that birds do not display any avoidance behaviour as they approach the turbines.

Stage 4: An avoidance factor is applied to the result from Stage 3. This avoidance factor accounts for birds detecting and avoiding the turbines, thereby avoiding collision. In reality a high number of birds do take effective avoidance action. Avoidance rates from SNH (SNH 2018) were used for this calculation.

3 RESULTS

The calculations for stage 1-4 for each of the three wind turbine models can be found in Appendix I-IV. A summary of the results is provided in Table 3 - Table 6 below. Note that for Sparrowhawk the collision rate is zero, as although flightlines were recorded within the risk area, no time was spent flying >20m during these flights.

Table 3: Bird biometric data, average speed, and time observed flying >20m in risk volume during VP surveys.

	Length (m)	Wingspan (m)	Average speed (m/s)	Time observed flying >20m in risk volume (s)
Kestrel	0.34	0.76	10.1	4539
Sparrowhawk	0.33	0.62	11.3	0
Hen Harrier	0.48	1.1	9.1	70
Merlin	0.28	0.56	11.2	352
Peregrine	0.42	1.02	12.1	10
Golden Plover	0.28	0.72	17.9	152831
Chough	0.4	0.82	13.5	2732
White-tailed Eagle	0.8	2.2	13.6	180

[1] https://www.nature.scot/doc/wind-farm-impacts-birds-calculating-probability-collision

Table 4: Number of transits through rotors per year

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	212.38	191.16	198.90
Sparrowhawk	0.00	0.00	0.00
Hen Harrier	2.95	2.66	2.76
Merlin	18.26	16.44	17.10
Peregrine	0.56	0.50	0.52
Golden Plover	15841.82	14258.71	14836.25
Chough	170.86	153.79	160.02
White-tailed Eagle	11.34	10.21	10.62

Table 5: Collision probability (calculated using SNH excel spreadsheet)

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	8.15	8.05	8.65
Sparrowhawk	7.3	7.25	7.8
Hen Harrier	9.85	9.85	10.55
Merlin	7.15	7.05	7.55
Peregrine	7.4	7.35	7.85
Golden Plover	5.1	5	5.3
Chough	6.65	6.55	7.05
White-tailed Eagle	8.45	8.55	9

Table 6: 30-year collision rates for target species (assuming avoidance) for the three proposed wind turbine models.

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	25.96	23.08	25.81
Sparrowhawk	0.00	0.00	0.00
Hen Harrier	0.09	0.08	0.09
Merlin	0.78	0.70	0.77
Peregrine	0.02	0.02	0.02
Golden Plover	484.76	427.76	471.79
Chough	6.82	6.04	6.77
White-tailed Eagle	1.44	1.31	1.43

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Appendix I

Bird Parameters used in CRM

Bird length and wingspan were taken from BTO (bird facts available online), and average speed was taken from Alerstam et al. (2007)

	Length (m)	Wingspan (m)	Average speed (m/s)
Kestrel	0.34	0.76	10.1
Sparrowhawk	0.33	0.62	11.3
Hen Harrier	0.48	1.1	9.1
Merlin	0.28	0.56	11.2*
Peregrine	0.42	1.02	12.1
Golden Plover	0.28	0.72	17.9**
Chough	0.4	0.82	13.5***
White-tailed Eagle	0.8	2.2	13.6

**Average of similar species: Kestrel, Sparrowhawk, and Peregrine*

** *Value for grey plover used*

**** Value for Carrion Crow used*

Appendix II

Stage 1 Calculations

1. Calculation of risk volume (Vw)

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Windfarm area + 500m buffer (m^2)	7646000	7646000	7646000
Turbine height (m)	180	185.05	180
Flight risk volume (Vw)	1376280000	1414892300	1376280000

2. Calculation of volume swept by rotors (Vr)

$$V_r = N \times \pi R^2 \times (d + l)$$

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	1277928.19	1060334.05	1132024.95
Sparrowhawk	1275287.84	1057890.89	1129552.20
Hen Harrier	1314893.06	1094538.38	1166643.45
Merlin	1262086.11	1045675.06	1117188.45
Peregrine	1299050.97	1079879.38	1151806.95
Golden Plover	1262086.11	1045675.06	1117188.45
Chough	1293770.28	1074993.05	1146861.45
White-tailed Eagle	1399384.18	1172719.69	1245771.45

3. Calculation of bird occupancy within the risk volume (n)

	Time observed flying in flight risk volume[2]	Adjustment for available daylight hours[3]	Adjustment for nocturnal activity[4]	Adjustment for turbine operational period of 85%	n (1 year)[5]
Kestrel	4539.00	257897.73	257897.73	219213.07	109606.53
Sparrowhawk	0.00	0.00	0.00	0.00	0.00
Hen Harrier	70.00	3977.27	3977.27	3380.68	1690.34
Merlin	352.00	20000.00	20000.00	17000.00	8500.00
Peregrine	10.00	568.18	568.18	482.95	241.48
Golden Plover	152831.00	8683579.55	10854474.43	9226303.27	4613151.63
Chough	2732.00	155227.27	155227.27	131943.18	65971.59
White-tailed Eagle	180.00	10227.27	10227.27	8693.18	4346.59

4. Calculation of bird occupancy of the volume swept by the rotors (n x (V_r/ V_w))

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	101.77	82.14	90.15
Sparrowhawk	0.00	0.00	0.00
Hen Harrier	1.61	1.31	1.43
Merlin	7.79	6.28	6.90
Peregrine	0.23	0.18	0.20
Golden Plover	4230.39	3409.35	3744.70
Chough	62.02	50.12	54.97
White-tailed Eagle	4.42	3.60	3.93

[2] Observed during VP surveys.

[3] 36 hours of observations in 4 seasons = 518400 seconds. This represents 1.76% of a total of 29383131 daylight seconds during the survey period. Therefore, activity was only observed during 1.76% of the total time that it could have occurred and so the figures are adjusted to account for all available daylight hours.

[4] Only applied to Golden Plover.

[5] Observations were carried out over 2 years; final value is adjusted to be per annum.

5. Calculation of time taken for a bird to make a transit through the rotor and completely clear the rotors

(t=(d + l) / v)

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	0.48	0.43	0.45
Sparrowhawk	0.43	0.38	0.40
Hen Harrier	0.55	0.49	0.52
Merlin	0.43	0.38	0.40
Peregrine	0.41	0.37	0.38
Golden Plover	0.27	0.24	0.25
Chough	0.36	0.33	0.34
White-tailed Eagle	0.39	0.35	0.37

6. Calculation of number of transits through the rotors per year

(n x (V_r/ V_w) / t)

	SG 6.6 -155 (Siemens Gamesa)	N149/5.X (Nordex)	V150 (Vestas)
Kestrel	212.38	191.16	198.90
Sparrowhawk	0.00	0.00	0.00
Hen Harrier	2.95	2.66	2.76
Merlin	18.26	16.44	17.10
Peregrine	0.56	0.50	0.52
Golden Plover	15841.82	14258.71	14836.25
Chough	170.86	153.79	160.02
White-tailed Eagle	11.34	10.21	10.62

Appendix III

Collision probability

Calculated using excel spreadsheet provided by SNH

	SG 6.6 -155 (Siemens Gamesa)			N149/5.X (Nordex)			V150 (Vestas)		
	Flapping	**Gliding**	**Average**	**Flapping**	**Gliding**	**Average**	**Flapping**	**Gliding**	**Average**
Kestrel	8.2	8.1	8.15	8.1	8	8.05	8.7	8.6	8.65
Sparrowhawk	7.3	7.3	7.3	7.3	7.2	7.25	7.8	7.8	7.8
Hen Harrier	9.9	9.8	9.85	9.9	9.8	9.85	10.6	10.5	10.55
Merlin	7.2	7.1	7.15	7.1	7	7.05	7.6	7.5	7.55
Peregrine	7.5	7.3	7.4	7.4	7.3	7.35	7.9	7.8	7.85
Golden Plover	5.1		5.1	5		5	5.3		5.3
Chough	6.7	6.6	6.65	6.6	6.5	6.55	7.1	7	7.05
White-tailed Eagle	8.6	8.3	8.45	8.7	8.4	8.55	9.2	8.8	9

Appendix IV

Stage 2-4 Calculations

Calculation of collision rates for Siemens model (SG 6.6 -155 (Siemens Gamesa))

	Number of transits through rotors of wind farm	Collison probability (see Appendix III)	Collisions per year - no avoidance	Avoidance rate (%)	Annual theoretical collision rate assuming avoidance	30-year collision rate assuming avoidance
Kestrel	212.38	8.15	17.31	95	0.87	25.96
Sparrowhawk	0.00	7.30	0.00	98	0.00	0.00
Hen Harrier	2.95	9.85	0.29	99	0.00	0.09
Merlin	18.26	7.15	1.31	98	0.03	0.78
Peregrine	0.56	7.40	0.04	98	0.00	0.02
Golden Plover	15,841.82	5.10	807.93	98	16.16	484.76
Chough	170.86	6.65	11.36	98	0.23	6.82
White-tailed Eagle	11.34	8.45	0.96	95	0.05	1.44

Calculation of collision rates for Nordex model (N149/5.X)

	Number of transits through rotors of wind farm	Collison probability (see Appendix III)	Collisions per year - no avoidance	Avoidance rate (%)	Annual theoretical collision rate assuming avoidance	30-year collision rate assuming avoidance
Kestrel	191.16	8.05	15.39	95	0.77	23.08
Sparrowhawk	0.00	7.25	0.00	98	0.00	0.00
Hen Harrier	2.66	9.85	0.26	99	0.00	0.08
Merlin	16.44	7.05	1.16	98	0.02	0.70
Peregrine	0.50	7.35	0.04	98	0.00	0.02
Golden Plover	14258.71	5.00	712.94	98	14.26	427.76
Chough	153.79	6.55	10.07	98	0.20	6.04
White-tailed Eagle	10.21	8.55	0.87	95	0.04	1.31

Calculation of collision rates for Vestas model (V150)

	Number of transits through rotors of wind farm	Collison probability (see Appendix III)	Collisions per year - no avoidance	Avoidance rate (%)	Annual theoretical collision rate assuming avoidance	30-year collision rate assuming avoidance
Kestrel	198.90	8.65	17.20	95	0.86	25.81
Sparrowhawk	0.00	7.80	0.00	98	0.00	0.00
Hen Harrier	2.76	10.55	0.29	99	0.00	0.09
Merlin	17.10	7.55	1.29	98	0.03	0.77
Peregrine	0.52	7.85	0.04	98	0.00	0.02
Golden Plover	14836.25	5.30	786.32	98	15.73	471.79
Chough	160.02	7.05	11.28	98	0.23	6.77
White-tailed Eagle	10.62	9.00	0.96	95	0.05	1.43