Kirkan Wind Farm

Environmental Impact Assessment Report
Appendix 7.2: Collision Risk Analysis

avianecology

CONTENTS

1   INTRODUCTION

1.1.1   This Appendix has been prepared to accompany Chapter 7: 'Ornithology' of the Kirkan Wind Farm (the proposed development) Environmental Impact Assessment (EIA) Report (EIAR).

1.1.2   It presents the details and result of Collision Risk Analysis, completed to inform the assessment of the proposed development.

1.1.3   Only common bird species names are referred to within this Appendix. **Appendix 7.1** of the EIAR provides a summary of all bird species referred to herein. Both common and species names, together with a summary of their conservation status as relevant is provided.

2   OVERVIEW OF FLIGHT ACTIVITY DATA

2.1.1   The following data has been used for the purposes of Collision Risk Analysis:

- Vantage Point (VP) Flight Activity Survey Data:

   o   September 2016 to August 2017 (Year 1); and,

   o   September 2017 to August 2018 (Year 2).

2.2   VP Flight Activity Data

2.2.1   Target species flight activity data has been obtained from a total of four VP locations between September 2016 and August 2018 and for which estimated viewshed visible areas are illustrated on **Figure 7.2** and summarised in **Table 2.1**. Visible areas have been calculated using an observer height of 1 m and a 20 m vertical offset above the ground.

2.2.2   **Table 2.1** also presents the visible area of each viewshed, which falls within the "wind farm areas" constructed using 200m and 500m turbine buffers for the purposes of collision risk analysis.

2.2.3   It should be noted that VP surveys were undertaken on the basis of a preliminary development area, in the absence of known turbine locations. As such for the purposes of Collision Risk Analysis, VP4 does not provide visual coverage of the "wind farm areas" and therefore flight activity recorded from this VP location has been omitted.

Table 2.1: VP locations and viewshed visible areas

VP	X	Y	Viewshed Radius (m)	Visible Area (ha)		
				Total	200 m	500 m
1	237248	867615	2000	385	152.2	304.7
2	238329	870554	2000	485.7	0	0
3	235611	867192	2000	558.6	203.4	407.4
4	235796	87060	2000	610.7	0.717	24.66

2.2.4   Survey effort completed at each VP location between September 2016 and August 2018 is summarised in **Table 2.2.** Further details of VP flight activity surveys are provided in **Appendix 7.1**.

Table 3.2: VP flight activity survey effort summary

VP	2016				2017								Year 1 Total
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
1	3	21	12	6	6	6	18	12	6	9	6	9	114
2	9	15	12	6	6	12	12	12	6	9	6	9	114
3	9	15	12	6	6	12	12	12	6	9	6	9	114
4	3	21	12	6	6	6	18	12	6	9	6	9	114
VP	2017				2018								Year 2 Total
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
1	12	12	12	6	6	6	18	12	6	12	6	6	114
2	12	12	12	6	6	12	12	12	6	9	9	6	114
3	12	12	12	6	6	12	12	12	6	6	6	12	114
4	12	12	12	6	6	6	18	12	6	9	9	6	114

3   METHODOLOGY

3.1.1   Where sufficient "at collision risk" flight activity has allowed, collision risk mortality as a result of birds colliding with rotor blades has been assessed using the SNH Collision Risk Model (CRM) as detailed in Band *et al*., (2007[1]).

3.1.2   As defined within SNH guidance (2000[2]) the Collision Risk Window (CRW) is 'equal to the width of the wind farm across the general flight direction of the birds, and of height equal to the maximum height of the highest turbine'. In accordance with this guidance (SNH, 2000) the turbine specification for the Proposed Development i.e. up to 175 m tip height and up to 142 m blade diameter, would require a minimum CRW of 142 m diameter and 33-175m height.

3.1.3   For the purposes of a precautionary assessment and in line with general industry standards, "at collision risk" flight activity (i.e. that within the CRW) is defined as that recorded at collision risk height (between 33-175 m) and within 200 m of proposed turbine locations for all target species, extended to 500 m for eagle species. As such this adopts a precautionary approach in relation to the identification of "at collision risk" flights and is considered to be in line with good practice.

3.1.4   Band *et al.* (2007) details two CRMs; one model for directional flights, and another for non-directional (or space-filling) flights. The former model is based upon the total number of birds passing through the CRW, whereas the non-directional model is based upon the total time a bird is recorded within the CRW volume. Target species have therefore been assigned to a single model based on the nature of flight activity data obtained during VP surveys.

3.1.5   Collision risk mortality has subsequently been calculated in three stages:

- Directional: calculating the total number of birds recorded to pass though the CRW. Non-directional: estimating the time an individual bird spent passing through the CRW volume.

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[1] Band, W., Madders, M. and Whitfield, D.P. (2007) Developing field and analytical methods to assess avian collision risk at windfarms. In De Lucas, M., Janss, G. and Ferrer, M. (eds) 'Birds and Wind Power'.
[2] SNH (2000) Windfarms and Birds: Calculating a theoretical collision risk assuming no avoiding action. SNH, Inverness.

- Estimating the probability that a bird will be struck by a rotor blade when passing through the area swept by the rotors.

- Applying an 'avoidance rate', whereby it is assumed that most birds will take action to avoid collision.

3.2 "At Collision Risk" Flight Activity

3.2.1 "At collision risk" flight activity recorded during VP flight activity surveys is summarised in **Tables 3.1** (Year 1) and **3.2** (Year 2) below. The total number of flights, total number of birds and total time spent at collision risk height is presented.

3.2.2 **Annex 1** provides further details of target species "at collision risk" flight activity.

Table 3.1: "At collision risk" flight activity – Year 1 (September 2016 to August 2017)

Species	Total No. of Flights	Total No. of Birds	Total Time at Collision Risk Height (s)
Pink-footed goose	2	24	335
Pink-footed/greylag goose mixed flock	1	47	120
Greylag goose	2	73	343
Red kite	1	1	244
Hen harrier	2	2	30
Golden eagle	1	1	59
Osprey	1	1	193
Peregrine	2	2	434
Golden plover	2	3	25

Table 3.2: "At collision risk" flight activity – Year 2 (September 2017 to August 2018)

Species	Total No. of Flights	Total No. of Birds	Total Time at Collision Risk Height (s)
Red-throated diver	1	1	188
Grey heron	2	2	183
Pink-footed goose	3	160	269
Red kite	1	1	375
Golden eagle	7	7	1,736
Golden plover	1	1	67

3.3 CRM Parameters

3.3.1 CRM parameters for the purposes of Collision Risk Analysis are presented in **Tables 3.3** and **3.4**.

3.3.2 Collision risk analysis has only been undertaken for golden eagle. No other species had more than three "at collision risk" flights in any survey year, none of which comprised large flocks. In addition, overall flight activity for these species was considered to be very infrequent. As such, annual collision risk mortality can reasonably be predicted to be very small and inconsequential at any population level.

3.3.3 In addition, collision risk analysis for pink-footed geese is only required where a proposal has connectivity with a protected area where this species is a qualifying interest. In the absence of any internationally designated site for the species being located within 20 km of the project area, collision risk analysis for pink-footed geese has therefore not been undertaken.

Table 3.3: Turbine parameters

Parameter	Value	Unit
No. of rotors	17	meters
No. of blades	3	meters
Height to tip	175	meters
Hub height	104	meters
Rotor diameter	142	meters
Rotor radius	71	meters
Max cord	4	meters
Pitch	15	degrees
Rotation period	6.43[3]	Seconds
Downtime	15	%

Table 3.4: Target species parameters
As per Proven & Whitfield (2007[4]), unless where otherwise specified.

Species	Length	Wingspan	Flight Speed	Collision Probability[5]	Avoidance Rate[6]	Occupancy
Golden eagle	0.85	2.12	15.0	6.6	99%	All year

3.4 Collision Probability Analysis

3.4.1 **Annex 2** presents collision probability calculations for species listed within **Table 3.4**.

4 GOLDEN EAGLE

- Wind farm area (500m): 507 ha

- Assumed daylight flying hours (potential): 4479[7] (Year Round Occupancy)

- Down time: 15%

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[3] Based upon a maximum rotational speed of 11.20 r.p.m taken from a Siemens SWT-DD-142 3.5-4.1MW, with a conservative operating speed estimate derived as 20% of the maximum. https://www.siemensgamesa.com/en-int/-/media/siemensgamesa/downloads/en/products-and-services/archive/swt-dd-142.pdf.

[4] Provan, S. & Whitfield, S. (2007) Avian flight speeds and biometrics for use in collision risk modelling. Report to SNH from Natural Research.

[5] See **Annex 2**.

[6] SNH (2017).

[7] Potentially active hours for golden eagle has been calculated using a latitude of 57.671665 as per Forsythe, W. C., Rykiel, Jr., E. J., Stahl, R. S., Wu, H and Schoolfield, R. M. (1995) "A Model Comparison for Daylength as a Function of Latitude and Day of the Year. *Ecological modelling*, **80**, pp. 87-95. Hours exclude 29th February as field surveys were not undertaken over a leap year.

Year 1 (2016/2017 Non-breeding – 2017 Breeding)

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr^-1	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	304.70	114.0	34735.80	0.00	0.0000000000	0.413567512	0.0000000000
3	407.40	114.0	46443.60	158.81	0.0000009498	0.552961616	0.0000005252
4	24.66	114.0	2811.24	0.00	0.0000000000	0.033470872	0.0000000000
Totals	736.76	342.0	83990.6	159	0.0000009498	1.0000000000	0.0000005252

Mean activity hr^-1 in wind farm				WIND FARM DATA				
Risk height	0.00027	0.0266%		Wind farm area (ha)		507.00		
Daylight hours		4479						
Downtime		15	0.85			D	142.0	
Vw =		719940000				L + d	4.85	
Vr =		1305080	No. of turbines		17	R	71	
Vr/Vw =		0.0018128						
Speed		15						
Vw Occupancy =		1.1927	4293.7					
Vr Occupancy =		0.0022	7.8					
Transit time =		0.3233						
Transits =		24.073						
Collision probability from SNH sheet		0.066						
Collisions with no avoidance		1.589						
Collisions with 99% avoidance		0.016						
Collisions with 99% avoidance & downtime		0.014						
30 year mortality		0.477						
30 year mortality with 15% downtime etc		0.405						
Years for 1 death		74.05						

Year 2 (2017/2018 Non-breeding – 2018 Breeding)

VP	Watch data			Flying time (s)	Flying time hahr-1	Weighted flying time ha hr^-1	
	Area (ha)	Time (hrs)	HaHr	Risk height	Risk height	Weighting	Risk height
1	304.70	114.0	34735.80	118.16	0.0000009449	0.413567512	0.0000003908
3	407.40	114.0	46443.60	138.46	0.0000008281	0.552961616	0.0000004579
4	24.66	114.0	2811.24	567.93	0.0000561169	0.033470872	0.0000018783
Totals	736.76	342.0	83990.6	825	0.0000578899	1.0000000000	0.0000027270

Mean activity hr^-1 in wind farm				WIND FARM DATA				
Risk height	0.00138	0.1383%		Wind farm area (ha)	507.00			
Daylight hours			4479					
Downtime			15	0.85			D	142.0
Vw =			719940000				L + d	4.85
Vr =			1305080	No. of turbines		17	R	71
Vr/Vw =			0.0018128					
Speed			15					
Vw Occupancy =			6.1926	22293.3				
Vr Occupancy =			0.0112	40.4				
Transit time =			0.3233					
Transits =			124.987					
Collision probability from SNH sheet			0.066					
Collisions with no avoidance			8.249					
Collisions with 99% avoidance			0.082					
Collisions with 99% avoidance & downtime			0.070					
30 year mortality			2.475					
30 year mortality with 15% downtime etc			2.104					
Years for 1 death			14.26					

ANNEX 1 – "AT COLLISION RISK" FLIGHT ACTIVITY

Tables **A1-1** and **A1-2** present "at collision risk" flight activity for target species recorded between September 2016 and August 2018; the number of birds, total flight duration and time spent below (HT1), at (HT2) and above (HT3) collision risk height is presented.

Table A1-1: Target species (excl. eagle species) "at collision risk" flight activity (Wind Farm Area: 200m).
HT1 (0-25m); HT2 (25-175m); HT3 (>175m)

Date	VP	Species	No. of Birds	Start Time	Total Flight Duration (s)	Total Time Spent (s)		
						HT1	HT2	HT3
20160928	3	Pink-footed / greylag goose mixed flock	47	10:22	120	0	120	0
20160930	3	Red kite	1	13:02	244	0	244	0
20160930	3	Pink-footed goose	22	13:04	130	0	130	0
20161017	1	Pink-footed goose	2	12:17	205	0	205	0
20161017	1	Greylag goose	9	12:17	205	0	205	0
20161018	3	Peregrine	1	09:51	257	0	257	0
20161018	3	Greylag goose	64	13:56	138	0	138	0
20161028	1	Peregrine	1	10:16	177	0	177	0
20161111	1	Hen harrier	1	12:27	136	121	15	0
20161213	3	Hen harrier	1	12:58	60	45	15	0
20170420	3	Golden plover	1	13:31	10	0	10	0
20170420	3	Golden plover	2	11:46	30	15	15	0
20170430	3	Osprey	1	08:11	193	0	193	0
20180406	1	Pink-footed goose	35	13:15	122	0	122	0
20180406	1	Pink-footed goose	55	15:20	129	0	129	0
20180409	3	Golden plover	1	13:52	67	0	67	0
20180410	4	Pink-footed goose	70	10:56	138	0	18	120

Date	VP	Species	No. of Birds	Start Time	Total Flight Duration (s)	Total Time Spent (s)		
						HT1	HT2	HT3
20180525	1	Grey heron	1	05:32	68	0	68	0
20180525	1	Grey heron	1	09:25	115	0	115	0
20180617	3	Red-throated diver	1	12:41	188	0	188	0
20180701	1	Red kite	1	09:49	375	0	375	0

Table A1-2: Eagle species "at collision risk" flight activity (Wind Farm Area: 500m)
HT1 (0-25m); HT2 (25-175m); HT3 (>175m)

Date	VP	Species	No. of Birds	Start Time	Total Flight Duration (s)	Total Time Spent (s)		
						HT1	HT2	HT3
20161125	3	Golden eagle	1	11:23	59	0	59	0
20170911	1	Golden eagle	1	16:30	100	0	100	0
20171018	4	Golden eagle	1	10:46	178	0	178	0
20180225	3	Golden eagle	1	12:24	127	2	125	0
20180226	3	Golden eagle	1	11:58	235	0	210	25
20180325	4	Golden eagle	1	11:34	278	0	278	0
20180325	4	Golden eagle	1	11:41	700	0	700	0
20180416	1	Golden eagle	1	13:15	145	0	145	0

ANNEX 2 – COLLISION PROBABILITY CALCULATIONS

Golden Eagle

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA											
K: [1D or [3D] (0 or 1)	1		Calculation of alpha and p(collision) as a function of radius								
No. Blades	3					Upwind:			Downwind:		
Max Chord	4	m	r/R	c/C	a	collide		contribution	collide		contribution
Pitch (degrees)	15		radius	chord	alpha	length	p (collision)	from radius r	length	p (collision)	from radius r
Bird Length	0.85	m	0.025	0.575	8.65	38.14	1.00	0.00125	36.95	1.00	0.00125
Wingspan	2.12	m	0.075	0.575	2.88	13.11	0.41	0.00306	11.92	0.37	0.00278
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.73	9.08	0.28	0.00353	7.63	0.24	0.00297
			0.175	0.860	1.24	7.62	0.24	0.00415	5.83	0.18	0.00318
Bird speed	15	m/sec	0.225	0.994	0.96	6.76	0.21	0.00473	4.70	0.15	0.00329
Rotor Diam	142	m	0.275	0.947	0.79	5.52	0.17	0.00472	3.56	0.11	0.00305
Rotation Period	6.43	sec	0.325	0.899	0.67	4.65	0.14	0.00470	2.79	0.09	0.00282
			0.375	0.851	0.58	4.00	0.12	0.00467	2.24	0.07	0.00261
			0.425	0.804	0.51	3.49	0.11	0.00461	1.83	0.06	0.00241
			0.475	0.756	0.46	3.08	0.10	0.00455	1.51	0.05	0.00223
Bird aspect ratio: b	0.40		0.525	0.708	0.41	2.73	0.09	0.00446	1.27	0.04	0.00207
			0.575	0.660	0.38	2.49	0.08	0.00446	1.13	0.04	0.00201
			0.625	0.613	0.35	2.30	0.07	0.00448	1.03	0.03	0.00201
			0.675	0.565	0.32	2.13	0.07	0.00448	0.96	0.03	0.00202
			0.725	0.517	0.30	1.98	0.06	0.00447	0.91	0.03	0.00205
			0.775	0.470	0.28	1.84	0.06	0.00444	0.87	0.03	0.00210
			0.825	0.422	0.26	1.71	0.05	0.00440	0.86	0.03	0.00221
			0.875	0.374	0.25	1.59	0.05	0.00434	0.88	0.03	0.00240
			0.925	0.327	0.23	1.48	0.05	0.00427	0.89	0.03	0.00257
			0.975	0.279	0.22	1.38	0.04	0.00418	0.90	0.03	0.00273
				Overall p(collision) =			Upwind	8.4%		Downwind	4.9%
								Average	6.6%		