2019

Sheirdrim Renewable Energy Development

Appendix 9.2 - Collision Risk Modelling Report

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NATURAL RESEARCH
PROJECTS LIMITED

Sheirdrim Renewable Energy Development

Collision Risk Modelling Report

Introduction

1. This report details the results of collision risk modelling for red-throated diver (*Gavia stellata*) and hen harrier (*Circus cyaneus*), for a nineteen turbine layout at the proposed Sheirdrim Renewable Energy Development ("the proposed Development").

Collision Risk Modelling

2. The Band collision risk model (CRM) (Band *et al.*, 2007) was used to estimate the potential number of red-throated diver and hen harrier collisions likely to occur at the proposed Development. The model requires input data based on species biometrics and flight characteristics, turbine specification and data on flights observed at the site.

3. SNH guidance on collision risk modelling was used. This is a three stage process, which involves:

   1) An assessment of the probability of a collision, based on a bird flying through an operational turbine; and

   2) An estimation of the number of birds passing through the swept zone of the turbine blades.

   Multiplying stages 1 and 2 provides an estimate of collision risk with the turbines, assuming no avoidance action. After, the third stage is applied:

   3) An avoidance rate is applied (where known) to account for the fact that many species will take avoidance action.

4. The result of the model provides an estimate of the number of collisions that can be expected over a year or for the lifetime of the wind farm.

5. For the turbines proposed, the probability of a red-throated diver or hen harrier being struck by a turbine blade when passing through the rotor swept volume has been estimated at 6.0% respectively, **assuming no avoidance** (see Results). However, it is widely accepted that birds are able to avoid turbine blades in a number of ways. Birds may exercise avoidance by detecting the wind farm or turbine and modifying their flight lines to avoid the structures (Macro avoidance). At close proximity, birds may see an oncoming blade and emergency avoidance action can be taken (Micro avoidance) (SNH, 2000). As such, an avoidance rate of 99.5% and 99% (SNH, 2010 updated 2018) was applied to the model to estimate the collision risk for red-throated diver and hen harrier respectively.

Windfarm characteristics

6. The proposed scheme has nineteen turbines and the flight risk volume (Vw), in these analyses, is based on a buffer constructed with a radius of 500 m (area = 1,071 ha), centred on the turbine locations with a height that was equal to the diameter of the turbine blades (120 m). The turbines used for the collision risk modelling were based on a hub height of 90 m, giving an overall tip height of 150 m. Turbine specifications were obtained from the manufacturer and are shown where relevant.

Viewsheds

7. Flight data were obtained from a total of six Vantage Points (VPs). Viewsheds were estimated using a Digital Elevation Model (DEM) and a 20 m vertical offset above the ground surface (lowest point of rotor sweep at 30 m). Other details of the viewshed calculation are given in Table 1. Details of at-risk flights are given in Table 2. An 'at–risk' flight is one which passes into the 500 m turbine buffer with at least part of its flight at an altitude between 30 m and 150 m.

8. The total flight duration recorded during the vantage point watches was adjusted to give an estimate for the total expected over the period of occupancy by each species. The total potential flying time for each species was estimated from the sum of the day lengths of each day. Day length was estimated, for each day, using the method of Forsythe *et al.* (1995) at latitude 55.75°N.

Species-specific information

9. Table 3 summarises the species-specific information used in the collision risk calculations. Collision probability was obtained using the SNH (2000) model. Species length and wing span have been derived using a mean of the figures presented within Snow & Perrins (1998) and flight speeds were derived using Alerstam *et al.* (2007) or Provan & Whitfield (2006)(SNH, 2014).

Tables

Table 1. Vantage point survey effort and visible areas within the 500 m buffer drawn around the turbines.

VP	Visible area with 500m turbine buffer (ha)	Hours of observation (hrs)
1	74.4	106.48
2	43.7	106.00
4	34.6	102.42
9	530.8	192.25
10	279.9	151.75
11	238.6	194.0

Table 2. Flight durations recorded within VP viewsheds and clipped to 500 m survey buffer. Part, or all, of these flights at a height of 30 – 150 m agl places them at risk of a collision with the turbine blades (shaded columns).

Species	Season	VP	No. Flights	No. of Birds	Total fly time (s)	Time in height category (s)					
						<10m	10-30m	30-50m	50-100m	100-150m	>150m
Red-throated diver	Apr-Aug	9	10	15	1346	32	355	395	512	52	
		10	1	1	226				226		
		11	1	1	118						118
	Sep-Mar	9	1	1	234				101	78	55
Total			**13**	**18**	**1924**	**32**	**355**	**395**	**839**	**130**	**173**
Hen harrier	Apr-Aug	1	1	1	38	28	10				
		2	2	2	36	1			35		
		9	43	43	5831	3326	907	426	441	731	
		10	2	2	180	128	52				
		11	6	6	530	530					
	Sep-Mar	9	8	8	775	678	97				
		10	13	13	1156	867	208	81			
		11	4	4	320	287	33				
Total			**79**	**79**	**8866**	**5845**	**1307**	**507**	**441**	**766**	

Table 3. Species-specific information used in the collision risk calculations.

Species	Bird length			Wingspan			Flight speed (ms⁻¹)	Collision probability (%)	Total potential flying time (hrs)
	Min (cm)	Max (cm)	Average (m)	Min (cm)	Max (cm)	Average (m)			
Red-throated diver	53	69	**0.61**	106	116	**1.11**	18	6.0%	2,442
Hen harrier	44	52	**0.48**	100	120	**1.10**	13	6.0%	4,494

Results

Red-throated diver

							Upwind:			Downwind:		
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3											
MaxChord	3.80	m	r/R	c/C	α	collide			collide			
Pitch (degrees)	15.0		radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)	
			0				1.00	0.000		1.00	0.000	
BirdLength	0.61	m	0.05	0.575	4.97	16.56	0.53	0.053	15.43	0.49	0.049	
Wingspan	1.11	m	0.1	0.622	2.48	9.04	0.29	0.058	7.81	0.25	0.050	
F: Flapping (0) or gliding (+1)	0		0.15	0.781	1.66	7.35	0.24	0.071	5.81	0.19	0.056	
			0.2	0.939	1.24	6.58	0.21	0.084	4.73	0.15	0.061	
Bird speed	18	m/sec	0.25	0.971	0.99	5.59	0.18	0.090	3.69	0.12	0.059	
RotorDiam	120	m	0.3	0.923	0.83	4.63	0.15	0.089	2.81	0.09	0.054	
RotationPeriod	5.20	sec	0.35	0.875	0.71	3.93	0.13	0.088	2.21	0.07	0.049	
			0.4	0.827	0.62	3.39	0.11	0.087	1.76	0.06	0.045	
integration interval	0.05		0.45	0.780	0.55	2.96	0.09	0.085	1.42	0.05	0.041	
			0.5	0.732	0.50	2.66	0.09	0.085	1.22	0.04	0.039	
Bird aspect ratioo: β	0.55		0.55	0.684	0.45	2.42	0.08	0.085	1.07	0.03	0.038	
			0.6	0.637	0.41	2.20	0.07	0.085	0.95	0.03	0.037	
			0.65	0.589	0.38	2.01	0.06	0.084	0.86	0.03	0.036	
			0.7	0.541	0.35	1.85	0.06	0.083	0.78	0.03	0.035	
			0.75	0.494	0.33	1.70	0.05	0.081	0.72	0.02	0.035	
			0.8	0.446	0.31	1.56	0.05	0.080	0.68	0.02	0.035	
			0.85	0.398	0.29	1.43	0.05	0.078	0.65	0.02	0.035	
			0.9	0.350	0.28	1.31	0.04	0.076	0.62	0.02	0.036	
			0.95	0.303	0.26	1.20	0.04	0.073	0.62	0.02	0.038	
			1	0.255	0.25	1.09	0.04	0.070	0.63	0.02	0.040	

Overall p(collision) =   Upwind   7.7%   Downwind   4.2%

Average   6.0%

WIND FARM PARAMETERS

Size of windfarm envelope	1071	ha
Number of turbines	19	
Rotor diameter	120	m
Hub height	90.0	m
Max. rotor depth in metres	4.2	m
Max. chord	3.80	m
Pitch	15.0	degrees
Rotation period	5.20	s
Turbine operation time	85	%

BIRD PARAMETERS

Length	0.61	m
Wingspan	1.11	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	18	ms^-1
Number of hours birds potentially present	2442	hrs
Assumed avoidance rate	99.5	%

BAND USED TO DEFINE 'RISK HEIGHT'

Max height	150 m
Min height	30 m

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	74.4	76.83	0.0	0.0
2	43.7	75.00	0.0	0.0
4	34.6	74.42	0.0	0.0
9	530.8	114.25	1580.0	1138.0
10	279.9	74.00	226.0	226.0
11	238.6	114.0	118.0	0.0
Totals	1202.0	528.5	1924.0	1364.0

VP	Flight Activity Per Unit Time & Area		Weighted By Observation Effort		
	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	VP	Weighting	Adjusted time at 'risk height' (Hahr^-1)
1	5716.15	0.0000000	1	0.070	0.0000000
2	3277.50	0.0000000	2	0.040	0.0000000
4	2574.93	0.0000000	4	0.032	0.0000000
9	2574.93	0.0000000	9	0.032	0.0000000
10	20712.60	0.0000030	10	0.255	0.0000008
11	46288.40	0.0000000	11	0.570	0.0000000
Totals	81144.52	0.000000505	Totals	1.000	0.0000007737

Mean activity hr^-1 in wind farm	
Risk height	0.08286%
Rotor height	0.08286%

MORTALITY ESTIMATE

Flight risk volume (Vw)	1285200000	m^3
Rotor radius^2	3600	m
Combined rotor swept area (Va)	214885	m^2
Vr = Va * (d + l)	1033597	m^3
Bird occupancy (n)	2.02	hrs / yr
Bird occupancy of rotor swept vol (b)	5.86	bird-secs
Bird transit time (t)	0.27	secs
No. of transits through rotors	21.92	per year
Estimated no. of collisions	1.12	per year
After allowing for avoidance	0.006	per year
i.e. equivalent to one bird every	**179.1 years**	

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R E S E A R C H

Hen harrier

						Upwind:			Downwind:	
K: [1D or [3D] (0 or 1)	1	**Calculation of alpha and p(collision) as a function of radius**								
NoBlades	3									
MaxChord	3.80 m	r/R	c/C	α	collide			collide		
Pitch (degrees)	15.0	radius	chord	alpha	length	p(collision)	y(x)	length	p(collision)	y(x)
		0				1.00	0.000		1.00	0.000
BirdLength	0.48 m	0.05	0.575	3.59	10.65	0.47	0.047	9.51	0.42	0.042
Wingspan	1.1 m	0.1	0.622	1.79	5.96	0.26	0.053	4.74	0.21	0.042
F: Flapping (0) or gliding (+1)	1	0.15	0.781	1.20	5.03	0.22	0.067	3.50	0.16	0.047
		0.2	0.939	0.90	4.64	0.21	0.082	2.80	0.12	0.050
Bird speed	13 m/sec	0.25	0.971	0.72	4.01	0.18	0.089	2.10	0.09	0.047
RotorDiam	120 m	0.3	0.923	0.60	3.35	0.15	0.089	1.54	0.07	0.041
RotationPeriod	5.20 sec	0.35	0.875	0.51	2.87	0.13	0.089	1.14	0.05	0.036
		0.4	0.827	0.45	2.49	0.11	0.088	0.86	0.04	0.031
integration interval	0.05	0.45	0.780	0.40	2.39	0.11	0.095	0.85	0.04	0.034
		0.5	0.732	0.36	2.16	0.10	0.096	0.72	0.03	0.032
Bird aspect ratioo: β	0.44	0.55	0.684	0.33	1.97	0.09	0.096	0.63	0.03	0.031
		0.6	0.637	0.30	1.80	0.08	0.096	0.55	0.02	0.029
		0.65	0.589	0.28	1.66	0.07	0.096	0.50	0.02	0.029
		0.7	0.541	0.26	1.52	0.07	0.095	0.50	0.02	0.031
		0.75	0.494	0.24	1.40	0.06	0.093	0.53	0.02	0.035
		0.8	0.446	0.22	1.29	0.06	0.091	0.55	0.02	0.039
		0.85	0.398	0.21	1.18	0.05	0.089	0.56	0.02	0.042
		0.9	0.350	0.20	1.08	0.05	0.086	0.57	0.03	0.045
		0.95	0.303	0.19	0.99	0.04	0.083	0.57	0.03	0.048
		1	0.255	0.18	0.90	0.04	0.080	0.56	0.02	0.050

Overall p(collision) =   Upwind   8.3%   Downwind   3.8%

Average   6.0%

WIND FARM PARAMETERS

Size of windfarm envelope	1071	ha
Number of turbines	19	
Rotor diameter	120	m
Hub height	90.0	m
Max. rotor depth in metres	4.2	m
Max. chord	3.80	m
Pitch	15.0	degrees
Rotation period	5.20	s
Turbine operation time	85	%

BIRD PARAMETERS

Length	0.48	m
Wingspan	1.10	m
Flapping (0) or gliding (+1)	1	
Assumed flight speed	13	ms^-1
Number of hours birds potentially present	4497	hrs
Assumed avoidance rate	99	%

BAND USED TO DEFINE 'RISK HEIGHT'

Max height	150 m
Min height	30 m

VP	Watch Data		Bird Flight Data	
	Area (ha)	Time (hrs)	Total (s)	'Risk height' (s)
1	74.4	106.48	38.0	0.0
2	43.7	106.00	36.0	35.0
4	34.6	102.42	0.0	0.0
9	530.8	192.25	6606.0	1598.0
10	279.9	151.75	1336.0	81.0
11	238.6	194.0	850.0	0.0
Totals	1202.0	852.9	8866.0	1714.0

Flight Activity Per Unit Time & Area / Weighted By Observation Effort

VP	Observation effort (HaHr)	Flying time at 'risk height' (Hahr^-1)	VP	Weighting	Adjusted time at 'risk height' (Hahr^-1)
1	7922.11	0.0000000	1	0.038	0.0000000
2	4632.20	0.0000021	2	0.022	0.0000000
4	3543.73	0.0000000	4	0.017	0.0000000
9	102046.30	0.0000043	9	0.493	0.0000021
10	42474.83	0.0000005	10	0.205	0.0000001
11	46288.40	0.0000000	11	0.224	0.0000000
Totals	206907.57	0.0000012	Totals	1.000	0.0000023011

Mean activity hr^-1 in wind farm	
Risk height	0.24645%
Rotor height	0.24645%

MORTALITY ESTIMATE

Flight risk volume (Vw)	1285200000	m^3
Rotor radius^2	3600	m
Combined rotor swept area (Va)	214885	m^2
Vr = Va * (d + l)	1005662	m^3
Bird occupancy (n)	11.08	hrs / yr
Bird occupancy of rotor swept vol (b)	31.22	bird-secs
Bird transit time (t)	0.36	secs
No. of transits through rotors	86.72	per year
Estimated no. of collisions	4.45	per year
After allowing for avoidance	0.045	per year
i.e. equivalent to one bird every	**22.4 years**	

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R E S E A R C H

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