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Llanbrynmair Wind Farm

RES Ltd

Response to BEIS

February 2019

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Revised	Owain Gabb	Partner	13 February 2019
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Issued to client	Gareth Lang	Senior Ecologist	14 February 2019

Contents

1 Introduction

Background

1.1 The Secretary of State for Business, Energy and Industrial Strategy (BEIS) is in the process of re-determining the planning application for RES Ltd's proposed thirty-turbine Llanbrynmair Wind Farm.

1.2 As part of this process, BEIS has consulted with Natural Resources Wales (NRW) and other interested parties with regard to the Habitats Regulations Assessment (HRA) for the site, along with that for Innogy Renewables Ltd's adjacent fifty-turbine Carnedd Wen wind farm planning application (which is being re-determined concurrently).

1.3 Following receipt of comments from NRW, BEIS have written to RES Ltd (on 19 December 2018) to invite any further comment on HRA matters.

Summary of Correspondence

1.4 NRW have made the following observations.

- Contrary to assertions made in correspondence from RES and Innogy in March 2018, NRW have clarified that red kite remains a listed feature of the Berwyn Special Protection Area (SPA).
- NRW are content with the conclusion of the previous HRA for the site, completed by the Secretary of State in June 2015. The HRA considered the impacts of the Llanbrynmair site in combination with Carnedd Wen, three other mid-Wales wind farms and the Llandinam Windfarm to Welshpool substation 132 kV overhead line (i.e. all of the projects considered at the mid-Wales conjoined public inquiry).
- NRW do not consider that further information supplied in relation to the application (BSG Ecology, 2018) raises any new ornithological concerns. They agree with the report recommendation that further goshawk[1] survey should be completed prior to works commencing in relation to the schemes.
- Narrative on whether it would be beneficial to run updated collision risk analysis to further inform the Environmental Statement would be beneficial.
- NRW do not have a comprehensive list of projects that should be considered in the in-combination assessment for the Berwyn SPA (completed as part of the HRA process), but Powys County Council (PCC) might be able to provide this.

1.5 BEIS have noted that the Secretary of State would welcome any comment from RES Ltd (or from Innogy) with regard to HRA for their respective schemes following NRW's representation.

1.6 Following NRW's comments, BEIS requested that PCC provide information to inform the in-combination assessment. A tabulated list of projects was provided to Chris Jackson, Senior Development Principal at RES by Gwilym Davies of PCC on 10 January 2019. This appears to be a comprehensive list of wind farms projects in Powys as opposed to a list of wind farms that have the potential to impact upon the Berwyn SPA.

Purpose of this Document

1.7 The purpose of this document is to provide further information to inform the HRA with regard to Llanbrynmair in light of comments from NRW and the list of projects provided by PCC.

1.8 As per the comments from NRW, EIA conclusions have also been considered where relevant.

[1] Goshawk is not a feature of the Berwyn SPA and therefore not relevant to the HRA being completed by BEIS.

2 Results of Survey Work in 2016-2017

Overview of Vantage Point Survey Work

2.1 In order to update the ornithological baseline for the Llanbrynmair and Carnedd Wen wind farms in a consistent manner, RES and Innogy contacted BSG Ecology to undertake survey work covering the two sites in 2016 and 2017.

2.2 Survey work included vantage-point (VP) survey from sixteen locations overlooking the combined area. Thirty-six hours of survey was completed from each of these locations between April and August 2016 (the 'breeding season'), and a further thirty-six hours of survey from each location between September 2016 and March 2017 ('winter'), resulting in over 1,150 hours of data collection. Each VP watch involved scanning a maximum arc of 180 degrees extending to 2 km from the observer.

2.3 Collision risk analysis undertaken to inform this document has focussed on Berwyn SPA qualifying species (red kite, peregrine[2], merlin and hen harrier), as comments in the BEIS correspondence largely relate to HRA.

2.4 The four SPA species were treated as a 'target species' during VP watches; all flight lines / heights of flights were mapped / estimated in the field, and the duration of each flight was recorded. All relevant data were then entered into ArcGIS and flight line maps (linked to attributes tables) generated that were included in the baseline bird report (BSG Ecology, 2018) referred to by DBEIS / NRW.

Red kite

2.5 A total of 126 red kite flights were recorded during the 2016 breeding season and 109 flights over winter 2016/17. Flights were more regularly recorded over moorland and grassland habitat than over plantation; it follows that a higher proportion of flight activity was noted over Llanbrynmair than the adjacent Carnedd Wen site, as the former is a mosaic of moorland and grasslands (of various type) with relatively limited areas of plantation (approximately 15 % coverage), whereas commercial plantation dominates the latter (in excess of 65 % coverage).

2.6 Increased levels of flight activity in red kites were often localised in terms of the survey area, being associated with animal (typically sheep) carcasses. Such carrion tended to be found in actively grazed areas, which are only commonly found within the Llanbrynmair part of the survey area. These habitats also offer other potential foraging opportunities (e.g. for invertebrates). The greater use of the airspace above Llanbrynmair than Carnedd Wen was therefore attributable to habitat suitability.

Hen harrier

2.7 Hen harrier was recorded on an occasional basis throughout the period (a total of 52 flights), with activity increasing in the autumn and in the early spring (assumedly as birds dispersed from and moved back into upland breeding areas respectively). There was no evidence of local breeding recorded during targeted work.

2.8 Flight activity during the breeding season was around the periphery of the survey area, whereas during autumn and winter birds were noted more widely within it (albeit there were very few flights within or over plantation habitats). Most flights involved quartering birds flying within a few metres of ground level.

[2] On review of survey data it was concluded that collision risk analysis was not needed for peregrine and merlin.

Peregrine and Merlin

2.9 Over the course of the survey work, only three peregrine flights at collision risk height were recorded within the entire survey area (i.e. Llanbrynmair and Carnedd Wen) that passed sufficiently close to proposed turbines for potential inclusion in modelling. The duration of these flights was 45 seconds. Modelling has not been completed for this species, as it would not be statistically valuable to undertake it.

2.10 Similarly, merlin flight activity was very limited. Merlin was not recorded from VPs during the breeding season, and on only three occasions during the autumn and winter of 2016/17. All of these flights were below collision risk height. Modelling has not been undertaken for the species.

3 Collision Risk Analysis

Collision Risk Analysis for Red Kite

Collision at Llanbrymair

3.1 In order to calculate collision risk for red kite, data were interrogated using GIS. The cross sectional area of the turbine array was measured using GIS, and a perimeter of 490 m added (245 m to each side to account for the radius of the rotor blades (45 m) and observer plotting error)[3].

3.2 Turbine parameters had been incorporated into the design of field forms used for flight line data capture. As a result, it was possible to use GIS to determine the number of flights that were entirely outside of the wind farm (as defined above), and/or which did not enter collision risk height. These flights were excluded from collision risk analysis.

3.3 Of the total of 235 red kite flights recorded over the course of the VP survey, 103 were found to have been at Collision Risk Height within the Llanbrynmair wind farm (as defined above).

3.4 In order to run the Scottish Natural Heritage (SNH) 'Band Model' (the industry standard) and generate a collision risk figure, the following information was collated and input to the model: site length, width and number of turbines in the wind farm; wind turbine dimensions and specification; bird dimensions (wingspan and length); bird flight speed; and the number of months the species is assumed to be present on site. This project specific information allows the remainder of the process to be automated (through building the model in Excel).

3.5 The output of the model assumes no avoidance action is taken. In reality, studies have demonstrated that birds have a very high rate of avoidance of wind turbines, and SNH recommends that a 99 % avoidance rate is applied for red kite based on work by Urquhart & Whitfield (2016). Applying this rate of avoidance to the model indicates that 0.08419 red kites would be killed by the Llanbrynmair wind farm each year (one bird every 11.8 years).

3.6 The model is presented in full in **Appendix 1**.

Collision Risk in combination with Carnedd Wen

3.7 Predicted collision risk for Carnedd Wen has been calculated in the same way as for Llanbrynmair. The respective outputs have then been summed.

3.8 There were 26 flights through the Carnedd Wen turbine array at collision risk height. Application of a 99 % rate of avoidance to the output of the model has resulted in a predicted collision risk of 0.01783 red kites per year (one bird every 56.1 years).

3.9 The summed total of kites predicted to be killed by the two wind farms in combination is 0.10202 (or one bird every 9.8 years).

Hen harrier

Collision Risk for Llanbrynmair

3.10 Although very low rates of flight activity at collision risk height were recorded, modelling has been undertaken for hen harrier for completeness, and so the rate of change in predicted rates of collision is apparent. From a statistical perspective the validity of running the model based on the data collected is questionable.

[3] This method of determining cross-sectional area is in line with SNH recommendations.

3.11 A total of fifty-two hen harrier flights were noted during VP survey work. Of these, five were recorded within the combined turbine array (and perimeter area) at collision risk height. Modelling has been undertaken for completeness only.

3.12 Three of these flights were within the Llanbrynmair turbine array and perimeter area.

3.13 SNH accepts an avoidance rate of 99 % for hen harrier in Collision Risk Modelling. This is based on work by Whitfield & Madders (2006).

3.14 Applying this rate of avoidance to the model output indicates that 0.00060 hen harriers would be killed by the Llanbrynmair wind farm each year (one bird every 1,662 years).

3.15 The model is presented in **Appendix 1**.

Collision Risk in Combination with Carnedd Wen

3.16 There were two hen harrier flights through the Carnedd Wen turbine array at collision risk height. The model output with the accepted avoidance rate applied has calculated a predicted collision risk of 0.00024 hen harriers per year (one bird every 4,228 years).

3.17 The summed total of hen harriers predicted to be killed by the wind farms in combination is therefore 0.00084 birds per year (one bird every 1,190 years).

Peregrine and Merlin

3.18 Collision risk has not been calculated for these species.

3.19 Very few collision risk height flights were recorded for peregrine, and these were of very limited duration. It would not be statistically robust to extrapolate from such limited information. The likelihood of collision in the species is clearly very low.

3.20 Merlin was not recorded at collision risk height within the viewshed of either wind farm.

4 Review of Llanbrynmair ES and HRA Conclusions

4.1 Supplementary Ornithological Information (SEI) for the Llanbrynmair Wind Farm was issued in 2010 and 2013 (RES 2013, 2010).

4.2 The 2010 document updated the Ornithological Impact Assessment (OIA) within the Environmental Statement in terms of cumulative impacts and in light of research on the impacts of wind farms on upland birds (Pearce-Higgins *et al*., 2009).

4.3 The 2013 document brought together all EIA information in relation to the scheme in a single document. It was submitted ahead of the conjoined mid-Wales public inquiry (convened with regard to five Powys wind farms and the Llandinam to Welshpool substation and 132 kV overhead line).

4.4 Both the 2010 and 2013 SEI documents were principally based on data collected in 2005 and 2006. No new VP survey was completed to inform either document.

4.5 A shadow Appropriate Assessment was contained within the 2010 SEI. This considered the effects of the Llanbrynmair scheme on Berwyn SPA species alone and in combination with Carnedd Wen.

Red Kite

4.6 A collision risk for red kite at Llanbrynmair of 0.34 birds per year, and for Carnedd Wen of 0.55 birds per year (based on an avoidance rate of 99 %) is noted in the SEI information (RES Ltd, 2013; 2010[4]). The SEI states that population modelling presented in the Carnedd Wen ES stated that even if the collision risk for that site were to be doubled, this would only equate to the loss of 0.6 % of the Welsh population. It was concluded that the collision risk would not be significant for either site alone, or in combination with the other.

4.7 The shadow AA report within the SEI went on to state that

"*No red kite behaviour indicative of breeding was observed within the main study area, but there were two breeding sites in the buffer zone, over 1km from any proposed turbine locations. This species was regularly observed within the study area but the level of flight activity within the wind farm site was less than on the fringes of the study area*."

4.8 Based on a review of empirical data concerning red kite behaviour around wind farms in the UK, and evidence of mortality (from Welsh sites), the AA report stated that it was unlikely that collision risk was significant or would affect the conservation status of the local red kite population. The low levels of predicted collision at the site alone, and in combination with Carnedd Wen, were referred to in this context as supporting information.

4.9 It was also noted that red kites recorded over the site were unlikely to originate from the Berwyn SPA; rather it was likely they were more local breeders. The implication of this is that any collision of birds that does occur does not necessarily affect the Berwyn population.

4.10 It was concluded that the integrity of the SPA would not be affected by the development of the Llanbrynmair site alone or in combination with Carnedd Wen.

Hen harrier

4.11 The nature of hen harrier use of the area has changed considerably since initial baseline survey was completed at Llanbrynmair. In the mid to late 2000s the plantation at the adjacent Carnedd Wen site was far less mature, and 2-4 nests were located within it (RES Ltd, 2010). Canopy closure has since reduced opportunities, and the species does not now breed on either site.

[4] Where there is a discrepancy in figures for Llanbrynmair between the 2010 and 2013 SEI reports, the 2013 SEI has been used as the source of data.

4.12 The presence of breeding hen harriers in the area during initial work, and their tendency to sometimes fly above the canopy of plantation coupes when commuting, resulted in far higher collision risk than is predicted by current modelling. A cumulative risk of 0.36 birds per year was reported for the schemes, albeit it was noted that habitat management (deforestation) at Carnedd Wen would be predicted to reduce this risk to 0.13 birds per year (as birds typically commute within a few metres of the ground when crossing moorland / grassland habitats) (RES, 2010). Collision risk for Llanbrynmair alone was noted as being 0.07 birds per year in the 2013 SEI (one bird every 14 years).

4.13 The shadow AA report within the SEI concluded that habitat management within the Llanbrynmair and adjacent Carnedd Wen sites would result in a cumulative benefit for the species.

Peregrine and Merlin

4.14 Peregrine and merlin flight activity in the vicinity of Llanbrynmair (and Carnedd Wen) were very low. A collision risk of one bird every 50 years was predicted for Llanbrynmair and one bird every 33.3 years for the project in combination with Carnedd Wen.

4.15 It was concluded that due to the minimal likelihood of collision, and the design of the schemes (to avoid historic nest locations), effects on the species would be negligible in both EIA and HRA terms.

5 DECC HRA

5.1 The Department of Energy and Climate Change (DECC) completed a Habitats Regulations Assessment of the Llanbrynmair Wind Farm in June 2015.

5.2 Section 3.11 of the HRA stated:

"*The other development in SSA B, the Llanbrynmair project, will not have a likely significant effect upon any European sites. The Berwyn SPA is approximately 5 km from the Llanbrynmair project, a likely significant effect upon the Berwyn SPA was screened out because SPA bird species are unlikely to forage within or be functionally linked to the project site. On this basis, the SoS is satisfied that the Llanbrynmair project would not have a likely significant effect on the Berwyn SPA. This conclusion is supported by NRW (RES UK and NRW: Statement of Common Ground: Ornithology (27 March 2009))*."

6 Conclusions

6.1 Red kite and hen harrier flight activity at collision risk height over the Llanbrynmair site has declined since work was undertaken to inform the ES and HRA for the scheme. This may be due to plantation with the Carnedd Wen site (to the north) maturing and becoming less attractive to these species as a foraging and breeding resource (the latter with regard to hen harrier only).

6.2 SEI (RES, 2013) for the site predicted (approximately) one red kite collision every three years. Work completed in 2016/17 results in a predicted rate of fatality of one bird every 11.8 years. In combination with the adjacent Carnedd Wen scheme, this would increase to one bird every 9.8 years. In the context of a Welsh red kite population that has grown to over 2,000 breeding pairs, with a substantial additional non-breeding population, this level of predicted fatality is likely to have a negligible impact.

6.3 In HRA terms, it is highly questionable whether red kites using the Llanbrynmair site are from the Berwyn SPA population or are of importance in maintaining this population through recruitment to it. This is due to the distance between the site and the SPA (in excess of five kilometres), the abundance of the species in Powys and its wide occurrence as a breeding species outside of SPAs (in valley woodlands and shelter belts in particular).

6.4 For hen harrier the level of collision risk from the site alone and in combination with Carnedd Wen is predicted to be negligible. Peregrine and merlin use of the site was so limited that a collision risk has not been generated for either species.

6.5 It is concluded that effects on hen harrier, peregrine and merlin are likely to be negligible. If both the Llanbrynmair site and Carnedd Wen are consented, however, and habitat management is implemented as planned, this is likely to deliver conservation gain through improved foraging and nesting potential for hen harrier and merlin.

6.6 The conclusion reached by DECC in 2015, in agreement with NRW) therefore appears reasonable; the collision risk analysis completed in relation to work undertaken in 2016 and 2017 does not suggest this conclusion needs to be reappraised.

7 References

BSG Ecology. (2018). Llanbrynmair and Carnedd Wen bird survey report 2016/17. Report to RES Ltd and Innogy Renewables.

DECC. (2015). Habitats Regulations Assessment for the mid-Wales wind farms and for the Llandinam to Welshpool substation and 132 kV overhead line.

Pearce-Higgins, J., Stephen, R., Langston, R., Bainbridge, I & Bullman, R. (2009). The distribution of breeding birds around upland wind farms. Journal of Applied Ecology

RES Ltd (2013). Llanbrynmair supplementary environmental information. Volume 1.

RES Ltd. (2010). Llanbrynmair supplementary environmental information. Volume 2.

SNH. (Undated). Avoidance rates for the onshore SNH wind farm collision risk model. SNH, Inverness.

Urquhart, B. & Whitfield, D.P. (2016) Derivation of an avoidance rate for red kite *Milvus milvus* suitable for onshore wind farm collision risk modelling. Natural Research Information Note 7. Natural Research Ltd, Banchory, UK.

Whitfield, D.P. & Madders, M. (2006) A review of the impacts of wind farms on hen harriers *Circus cyaneus* and an estimation of collision avoidance rates. Natural Research Information Note 1 (revised). Natural Research Ltd, Banchory, UK.

Appendix 1: Collision Risk Analysis

Site Name **Llanbrynmair**

Bird Dimensions

Species	**Red kite**
length (m)	0.63
wing span (m)	1.85
speed (m/sec)	8

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); BTO Bird Facts

Turbine Dimensions

Height of tower (m)	90
Blade length (m)	45
Max blade height (m)	135
Min blade height (m)	45
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	30
Site width (m)	2430
Site length (m)	7300

Both width and length include a 490m 'extension' to allow for the sweep of the blades and margin for flight line plotting error

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1)	1

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours)	576

Period when Red kite likely to be on site.

Type in the number of days in each month where the target species is present within the site

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Red kite **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume
13/04/2016	150	1	150
18/04/2016	60	1	60
03/05/2016	100	1	100
03/05/2016	15	1	15
03/05/2016	15	1	15
05/05/2016	105	2	210
16/05/2016	45	1	45
16/05/2016	60	1	60
16/05/2016	60	1	60
16/05/2016	30	1	30
16/05/2016	30	1	30
16/05/2016	15	1	15
16/05/2016	75	1	75
16/05/2016	45	1	45
16/05/2016	15	1	15
16/05/2016	150	1	150
16/05/2016	30	1	30
16/05/2016	15	1	15
16/05/2016	15	1	15
16/05/2016	30	1	30
16/05/2016	30	1	30
16/05/2016	15	1	15
18/05/2016	195	1	195
18/05/2016	75	1	75
18/05/2016	60	1	60
24/05/2016	270	1	270
07/06/2016	15	1	15
07/06/2016	60	1	60
07/06/2016	75	1	75
23/06/2016	150	1	150
23/06/2016	75	1	75
23/06/2016	75	2	150
23/06/2016	45	1	45
23/06/2016	45	1	45
23/06/2016	225	1	225

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume
29/06/2016	105	1	105
30/06/2016	15	1	15
30/06/2016	60	1	60
30/06/2016	45	1	45
27/07/2016	45	1	45
19/09/2016	75	1	75
13/10/2016	60	2	120
13/10/2016	210	1	210
13/10/2016	255	1	255
18/10/2016	45	1	45
18/10/2016	60	1	60
08/11/2016	60	1	60
08/11/2016	30	1	30
08/11/2016	75	1	75
08/11/2016	300	1	300
28/11/2016	75	1	75
28/11/2016	15	1	15
28/11/2016	165	1	165
28/11/2016	90	1	90
14/12/2016	45	1	45
14/12/2016	60	1	60
14/12/2016	90	1	90
15/12/2016	375	1	375
15/12/2016	15	1	15
15/12/2016	60	1	60
15/12/2016	15	1	15
15/12/2016	30	1	30
15/12/2016	60	1	60
15/12/2016	60	1	60
15/12/2016	195	2	390
15/12/2016	90	2	180
15/12/2016	210	2	420
15/12/2016	270	2	540
15/12/2016	90	1	90
15/12/2016	150	1	150
15/12/2016	270	2	540
22/12/2016	45	1	45
22/12/2016	30	1	30
22/12/2016	45	1	45

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume
25/01/2017	60	1	60
01/02/2017	90	1	90
16/02/2017	30	1	30
16/02/2017	15	1	15
16/02/2017	30	1	30
17/02/2017	105	1	105
17/02/2017	165	2	330
27/02/2017	135	1	135
08/03/2017	75	1	75
08/03/2017	120	1	120
08/03/2017	105	1	105
08/03/2017	90	1	90
08/03/2017	105	1	105
23/03/2017	90	1	90
23/03/2017	195	1	195
23/03/2017	105	1	105
27/03/2017	60	1	60
27/03/2017	45	1	45
27/03/2017	30	1	30
27/03/2017	60	1	60
Total	**8170**	**103**	**9610**

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Llanbrynmair

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Red kite
length (m)	0.63
wing span (m)	1.85
speed (m/sec)	8

Bird Flight Data

No of birds	103
Time spent in V_w (sec)	73619.11

Turbine Dimensions

Height of tower (m)	90
Blade length (m)	45
Max blade height (m)	135
Min blade height (m)	45
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	30
Site width (m)	2430
Site length (m)	7300
Area (m^2)	17739000

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation		Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	2394765000	m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the rotor front to back, and l is the bird length	V_r =	817083.28	m^3	
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	73619.11	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r $n \times (V_r / V_w)$ bird-seconds	occupancy =	25.12	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors $t = (d + l) / v$ where v is bird speed (m/sec)	t =	0.54	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = $n \times (V_r / V_w) / t$	transits =	46.93	bird transits per annum	

Number of bird transits through the rotors per annum = 46.93

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 14/02/2019

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.63	m
Wingspan	1.85	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	8	m/sec
RotorDiam	90	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.34	

Calculation of alpha and p(collision) as a function of radius

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	3.40	12.12	1.00	0.00125	10.55	1.00	0.00125
0.075	0.575	1.13	4.57	0.57	0.00428	2.99	0.37	0.00281
0.125	0.702	0.68	3.55	0.44	0.00555	1.63	0.20	0.00255
0.175	0.860	0.49	3.32	0.41	0.00725	0.96	0.12	0.00211
0.225	0.994	0.38	3.21	0.40	0.00904	0.49	0.06	0.00139
0.275	0.947	0.31	3.02	0.38	0.01039	0.83	0.10	0.00284
0.325	0.899	0.26	2.74	0.34	0.01114	0.98	0.12	0.00397
0.375	0.851	0.23	2.52	0.31	0.01181	1.07	0.13	0.00502
0.425	0.804	0.20	2.33	0.29	0.01239	1.13	0.14	0.00598
0.475	0.756	0.18	2.17	0.27	0.01289	1.16	0.14	0.00687
0.525	0.708	0.16	2.03	0.25	0.01332	1.17	0.15	0.00767
0.575	0.660	0.15	1.90	0.24	0.01366	1.17	0.15	0.00839
0.625	0.613	0.14	1.78	0.22	0.01391	1.16	0.14	0.00903
0.675	0.565	0.13	1.67	0.21	0.01409	1.14	0.14	0.00958
0.725	0.517	0.12	1.57	0.20	0.01419	1.11	0.14	0.01006
0.775	0.470	0.11	1.47	0.18	0.01420	1.08	0.13	0.01045
0.825	0.422	0.10	1.37	0.17	0.01413	1.04	0.13	0.01077
0.875	0.374	0.10	1.28	0.16	0.01398	1.01	0.13	0.01100
0.925	0.327	0.09	1.19	0.15	0.01375	0.96	0.12	0.01115
0.975	0.279	0.09	1.10	0.14	0.01344	0.92	0.12	0.01122

Overall p(collision) = Upwind 22.5% Downwind 13.4%

Average 17.9%

Bird survey data

Date	Time observed (seconds)		Number of birds	Bird Occupancy in flight risk volume
TOTAL	8170		103	9610

TOTAL SURVEY TIME 576 hours or 2073600 seconds

Period when Red kite likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Red kite likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)

Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.

Assumption 2:

Assumption 3:

Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Red kite flight time = 9610 seconds in 2073600 seconds survey time

Therefore in 12 months = 73619.11 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours birds are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours	8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs* 5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean	8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present	31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month	**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year	**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	46.93
Average collision risk for bird passing through rotor =	17.9%
Number of birds potentially killed by rotors per annum =	8.42

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.420925**
1 bird killed every	**2.375718 years**

Correcting for 98% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.168370**
1 bird killed every	**5.939295 years**

Correcting for 99% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.08419**
1 bird killed every	**11.878591 years**

Site Name **Llanbrynmair**

Bird Dimensions

Species	**Hen harrier**
length (m)	0.48
wing span (m)	1.1
speed (m/sec)	10

= data input required
= model calculates value

Sources of speed and dimension information: Whitfield & Madders (2006); BTO Bird Facts

Turbine Dimensions

Height of tower (m)	90
Blade length (m)	45
Max blade height (m)	135
Min blade height (m)	45
Depth of rotor (m)	3.651781003

Wind Farm Dimensions

No of turbines	30
Site width (m)	2430
Site length (m)	7300

Both width and length include a 490m 'extension' to allow for the sweep of the blades and margin for flight line plotting error

Turbine Specifications

K: [1D or [3D] (0 or 1)	1
NoBlades	3
MaxChord	4 *
Pitch (degrees)	20 *
Rotation period	3 *

Flight Characteristics

Flapping (0) or gliding (+1) 1

Night adjustment

What percentage of the night is the target species active? 5 **%**

Survey Data

Total survey time (hours) 576

Period when Hen harrier likely to be on site.

Type in the number of days in each month where the target species is present within the site

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total number of months when Hen harrier **likely to be present:** 12

Enter the date of each record, the time the bird(s) was recorded in the collision risk area and the number of birds on a separate
Bird occupancy is automatically calculated.

Date	Time observed (seconds)	Number of birds	Bird Occupancy in flight risk volume
13/10/2016	15	2	30
17/02/2017	15	2	30
08/03/2017	15	1	15
Total	**45**	**5**	**75**

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

= data input required
= model calculates value

Step 1 **Go to Data Input**

Input data about the species that is being assessed - body length, wing span and flight speed
Input data on turbine dimensions
Input data on wind farm area
Input data on turbine dimensions and specification
Input all vantage point data for the species that is being assessed - number of birds and flight time within the study area
Input the number of days for each month where the species is likely to be present within the site
Input days for those months where the species is likely to be present within the site
Input the appropriate night time correction factor for the species being assessed, e.g. a 25% nocturnal flight time correction was proposed by Band et al for geese. This correction cannot be applied to all species, for example raptors.

Step 2 **Go to Collision Risk**

Final collision risk estimates are highlighted
Only use the collision risk estimate for the method that has been used

Scottish Natural Heritage: Calculating a theoretical collision risk assuming no avoiding action

Site Name: Llanbrynmair

= data input required
= model calculates value

Stage 1: Number of birds flying through rotors

Input Parameters

Bird Dimensions

Species	Hen harrier
length (m)	0.48
wing span (m)	1.1
speed (m/sec)	10

Bird Flight Data

No of birds	5
Time spent in V_w (sec)	574.55

Turbine Dimensions

Height of tower (m)	90
Blade length (m)	45
Max blade height (m)	135
Min blade height (m)	45
Depth of rotor (m)	3.651781

Wind Farm Dimensions

No of turbines	30
Site width (m)	2430
Site length (m)	7300
Area (m^2)	17739000

Method 1 - Birds using the windfarm airspace

(to be used for birds that fly across the site using a variety of different flight paths)

Step No	Description of Calculation		Calculation		Comments
1	Identify 'flight risk volume' V_w' which is the area of the wind farm multiplied by the height of the turbines	V_w =	2394765000	m^3	Area is equivalent to survey area and should include minimum of 500m buffer around turbines
2	Calculate the combined volume swept out by the rotors $V_r = N \times \pi R^2 \times (d + l)$ where N is the number of turbines, d is the depth of the rotor front to back, and l is the bird length	V_r =	788459.09	m^3	
3	Estimate bird occupancy n within V_w This is the number of birds multiplied by the time spent within V_w (per season/year)	n =	574.55	secs per yr	Bird occupancy is based on observations of birds flying through rotor-swept area
4	Bird occupancy of V_r $n \times (V_r / V_w)$ bird-seconds	occupancy =	0.19	bird-seconds	
5	Time taken for a bird to make transit through and completely clear the rotors $t = (d + l) / v$ where v is bird speed (m/sec)	t =	0.41	seconds	Speed should be assessed in the field but published values are available
6	Calculate number of bird transits through the rotors = $n \times (V_r / V_w) / t$	transits =	0.46	bird transits per annum	

Number of bird transits through the rotors per annum = 0.46

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA

Input parameters regarding the turbine specification will need to be obtained from the design engineers or manufacturers.

W Band 14/02/2019

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	4	m
Pitch (degrees)	20	
BirdLength	0.48	m
Wingspan	1.1	m
F: Flapping (0) or gliding (+1)	1	
Bird speed	10	m/sec
RotorDiam	90	m
RotationPeriod	3.00	sec
Bird aspect ratioo: β	0.44	

Calculation of alpha and p(collision) as a function of radius

				Upwind:			Downwind:		
r/R	c/C	α	collide		contribution	collide		contribution
radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
0.025	0.575	4.24	12.93	1.00	0.00125	11.36	1.00	0.00125
0.075	0.575	1.41	4.83	0.48	0.00363	3.26	0.33	0.00245
0.125	0.702	0.85	3.79	0.38	0.00474	1.87	0.19	0.00234
0.175	0.860	0.61	3.56	0.36	0.00623	1.21	0.12	0.00211
0.225	0.994	0.47	3.45	0.35	0.00777	0.73	0.07	0.00165
0.275	0.947	0.39	3.15	0.31	0.00866	0.56	0.06	0.00153
0.325	0.899	0.33	2.81	0.28	0.00914	0.61	0.06	0.00197
0.375	0.851	0.28	2.55	0.25	0.00956	0.74	0.07	0.00277
0.425	0.804	0.25	2.33	0.23	0.00992	0.83	0.08	0.00351
0.475	0.756	0.22	2.15	0.21	0.01021	0.88	0.09	0.00418
0.525	0.708	0.20	1.99	0.20	0.01043	0.91	0.09	0.00478
0.575	0.660	0.18	1.84	0.18	0.01059	0.93	0.09	0.00532
0.625	0.613	0.17	1.71	0.17	0.01068	0.93	0.09	0.00580
0.675	0.565	0.16	1.59	0.16	0.01071	0.92	0.09	0.00620
0.725	0.517	0.15	1.47	0.15	0.01067	0.90	0.09	0.00655
0.775	0.470	0.14	1.36	0.14	0.01057	0.88	0.09	0.00683
0.825	0.422	0.13	1.26	0.13	0.01041	0.85	0.09	0.00704
0.875	0.374	0.12	1.16	0.12	0.01017	0.82	0.08	0.00719
0.925	0.327	0.11	1.07	0.11	0.00987	0.79	0.08	0.00727
0.975	0.279	0.11	0.98	0.10	0.00951	0.75	0.07	0.00729

Overall p(collision) = Upwind 17.5% Downwind 8.8%

Average 13.1%

Bird survey data

Date	Time observed (seconds)		Number of birds	Bird Occupancy in flight risk volume
TOTAL	45		5	75

TOTAL SURVEY TIME 576 hours or 2073600 seconds

Period when Hen harrier likely to be on site (see below) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	30	30	31	31	30	31	30	31

Total days = 364 Total hours (corrected - see below) = 4412.55

Period when Hen harrier likely to be on site = 15885180 seconds (in each year)

Assumptions (write in any assumptions that have been included in the model)

Assumption 1: The flying period extends from dawn to dusk and includes 25% of night.

Assumption 2:

Assumption 3:

Assumption 4:

Proportion of time during which a collision may occur = 15885180 (in each year)

Hen harrier flight time = 75 seconds in 2073600 seconds survey time

Therefore in 12 months = 574.55 seconds

Note: This table is only relevant when calculating collision risk for goose species. It provides an adjustment for nocturnal flight behaviour for these species.

Number of hours birds are potentially active during winter (from Band et al, in press)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nox	Dec	
Mean Daylight hours	8	10	12	13	14	15	14	13	12	11	9	7	
Mean Nocturnal hrs* 5	0.8	0.7	0.6	0.55	0.5	0.45	0.5	0.55	0.6	0.65	0.75	0.85	
Combined Daily Mean	8.8	10.7	12.6	13.55	14.5	15.45	14.5	13.55	12.6	11.65	9.75	7.85	
No of days birds present	31	28	31	30	30	30	31	31	30	31	30	31	
Total hours each month	**272.8**	**299.6**	**390.6**	**406.5**	**435**	**463.5**	**449.5**	**420.05**	**378**	**361.15**	**292.5**	**243.35**	**4412.55**
Total hours per year	**4412.55**												

Method 1 - Birds using the windfarm airspace (to be used for birds that fly across the site using a variety of different flight paths)

Number of bird transits through the rotors per annum =	0.46
Average collision risk for bird passing through rotor =	13.1%
Number of birds potentially killed by rotors per annum =	0.06

NB: The above calculation assumes no avoidance

Correcting for 95% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.003007**
1 bird killed every	**332.510020 years**

Correcting for 98% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.001203**
1 bird killed every	**831.275051 years**

Correcting for 99% avoidance rate:

Number of birds potentially killed by rotors per annum =	**0.00060**
1 bird killed every	**1662.550102 years**