Wind turbines and birds in Flanders (Belgium)

Preliminary summary of the mortality research results **19/06/2007**

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Introduction

Wind turbines can have a negative impact on birds and bats. Several field studies have shown that birds and bats can collide with the turbines during local flights and seasonal migration, or they can become disturbed in their breeding, resting and foraging areas or during migration (Langston and Pullan 2003; Kingsley and Whittam 2005).

The government of Flanders (northern part of Belgium) has the ambition to reach 6 % of the electricity supply from renewable sources like wind energy by 2010. Many wind farms are planned in the near future. In September 2000, the circular letter EME/2000.01 of the Flemish government was produced, outlining the criteria and pre-conditions for the construction of wind farms. Based on the circular letter, a "wind plan" was established for the Flemish part of Belgium (VUB & ODE Vlaanderen 2001). This wind plan can produce useful information on spatial and wind-technical feasibility of specific projects. Additionally, a bird atlas (see further) can also be used to evaluate the proposed or potential wind farm areas in relation to nature values (Everaert et al. 2003). In 2006, a new circular letter EME/2006/01 was made which replaced the older version (Vlaamse regering 2006). The authorities have the obligation by official order to strictly apply the current circular letter.

Criteria

Some criteria and pre-conditions concerning 'nature conservation' are summarised below.

- It is not allowed to build wind turbines in European Natura 2000 sites and other protected areas like nature reserves, protected landscapes, nature areas (regional zoning plan) etc.
- A study needs to be performed to determine what buffer has to be applied around protected areas. In the first circular of 2000, a buffer of 500-700m was incalculated. Actually, a buffer will be applied taking into account the precautionary principle in case of uncertainty or lack of sufficient information.
- Breeding and roosting areas and migration routes of protected, endangered or vulnerable species, and areas with high densities of birds and/or bats, have to be avoided.
- Before the construction of the wind farm can be approved , all necessary information on the presence of birds/bats throughout the annual cycle must be studied and the possible negative impact has to be determined. In case of Natura 2000 sites and other important bird area's, an "appropriate assessment" is required (within or outside an Environmental Impact Assessment (EIA)).

Most important is the prohibition of wind farms in Natura 2000 sites (SPA's, SACs) or other protected areas with recognised status (following physical planning and nature conservation legislations). Supported by the Research Institute for Nature and Forest, this prohibition was put in place as a precautionary measure in the light of evidence that had come forward from national and international studies, the problem of thoroughly assessing the impact of planned wind farms, and the failure to protect important bird areas from ongoing damage from wrongly located wind farms.

Avian mortality research in Flanders

The Research Institute for Nature and Forest currently performs a long-term project to study the impact of land-based wind turbines on birds (nature) and to act as a consultancy for proposed wind farms in Flanders. The project started in 2000, under the authority of the Flemish government. Preliminary study results of the monitoring were presented in Everaert et al. (2002), Everaert (2003), Everaert & Stienen (2006) and Everaert (2006 a, b). A 'Bird

Atlas' with important bird areas and migration routes in Flanders was also made available (Everaert et al. 2003). In 2007, a comprehensive report will be published with the monitoring results from 2002-2006 and further recommendations (Everaert 2007). A new article for a scientific journal will follow.
Also advice on the establishment of off-shore windfarms has been prepared. Next paragraph summarises preliminary monitoring results concerning the mortality research (collision).

Monitoring results

The Research Institute for Nature and Forest has been monitoring 7 wind farms (and additional limited research at some other locations). Not all collision fatalities are found during normal ground searches, for example because they end up in the water or because they are removed by scavengers or predators. Also removal from technical staff of companies concerned occurred.
The total number of collision fatalities was therefore calculated with the use of correction factors for available search area, search efficiency and scavenging by animals, deduced from the formula of Winkelman (1992a).
The mean number of collision fatalities in the Flemish wind farms varied widely between 1 and 44 birds per wind turbine per year. In some European countries, where also correction factors were applied, similar results were found (Table 1).

Location	Number of turbines	Type of turbines (kW)	Number of birds/turbine/year	Study-period (year)	Reference
Flanders, Belgium (Schelle)	3	1500	7-18 (mean: 12)	3	Everaert et al. 2002 Everaert 2003 Everaert 2006 a, b Everaert 2007 in prep.
" (Zeebrugge)	25	200/400/600	16-24 (mean: 21)	6	
" (Brugge)	14	600	21-35 (mean: 26)	5	
" (Brugge)	7	1800	41-44 (mean: 43)	2	
" (Gent)	11	2000	6-8 (mean: 7)	2	
" (Gent)	2	2000	2	1	
" (Nieuwkapelle)	2	600	1	1	
Spain (Salajones)	33	660	22	1	Lekuona 2001
" (Izco)	75	660	23	1	
" (Alaiz)	75	660	4	1	
" (Guerinda)	145	660	8	1	
" (El Perdón)	40	500-600	64	1	
Spain (Basque Country)	40	650-850	5-7	3	Onrubia et al. 2002
Spain (Tarifa)	190	100-150	0.45 (a)	1	SEO/Birdlife 1995
" (Tarifa)	66	150-180	0.05 (a)	1	
England (Blyth)	9	300	1.34	2	Still et al. 1996
The Netherlands (Zeeland)	5	250	2-7	1	Musters et al. 1996
" (Oosterbierum)	18	300	22-33 (b)	1	Winkelman 1995
" (Urk)	25	300	15-18 (b)	1	"
" (Almere)	10	1650	9	1	Akershoek et al. 2005
" (Waterkaaptocht)	8	1650	34	1	"
" (Groettocht)	7	1650	19	1	"

Table 1. Mean avian mortality rates from collision at some wind farms in Europe. These studies used some correction factors (search area, scavenging removal and/or search efficiency rates) to adjust the figures. (a) This is only the number of large sized birds. Small sized birds are not included because they weren't surveyed. (b) These rates were calculated mainly from several days in spring and autumn, originally expressed as birds per turbine per day; the rates over a year long period can be lower.

With exception of terns in Zeebrugge (see further), most collision fatalities in Flanders concern common birds, mainly Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus* and Black-headed Gull *Larus ridibundus*. In the wind farms of Zeebrugge (25 turbines) and Brugge (7+14 turbines) each year about 800 gulls collide with the turbines (Everaert 2006a). Some other quite common species are Mallard *Anas platyrhynchos*, Common Pochard *Aythya ferina*, Eurasian Wigeon *Anas penelope*, Common Teal *Anas crecca*, Coot *Fulica atra*, Wood Pigeon *Columba palumbus*, Song Thrush *Turdus philomelos* and Meadow Pipit *Anthus pratensis*. But there were also rarer species as Grey Heron *Ardea cinerea*, Sparrowhawk *Accipiter nisus*, Common Kestrel *Falco tinnunculus*, Peregrine Falcon *Falco peregrinus*, Redshank *Tringa totanus*, Oystercatcher *Haematopus ostralegus*, Black-tailed Godwit *Limosa limosa*, Mediterranean Gull *Larus melanocephalus*, Kittiwake *Rissa tridactyla* and Swift *Apus apus*.

However, in the wind farm at the eastern breakwater in the port of Zeebrugge, since 2004, a high number (161-177 per breeding season) of Common Tern *Sterna hirundo*, Sandwich Tern *Sterna sandvicensis* and Little Tern *Sterna albifrons* collided with some of the turbines, causing a significant negative impact on the internationally important breeding population of terns in Zeebrugge (see detailed information in Everaert & Stienen (2006)). This shows that significant effects can occur even in relatively short time-periods. So far, there have been no measures to reduce the number of collisions in Zeebrugge, despite recommendations to temporary shut down some of the most deadly turbines. However, the wind farm operator is now planning to replace the existing wind turbines by larger ones and with greater distance between the turbines, which could result in a significant reduction of the collision fatalities.

The number of collision fatalities of birds on the Flemish locations seems to be particularly dependent on the number of (flying) birds and probably in much less degree on the type of wind turbine (Figures 1-3). Some small groups or individual turbines seem to have less impact than long lines of turbines, but no conclusions can be made yet.

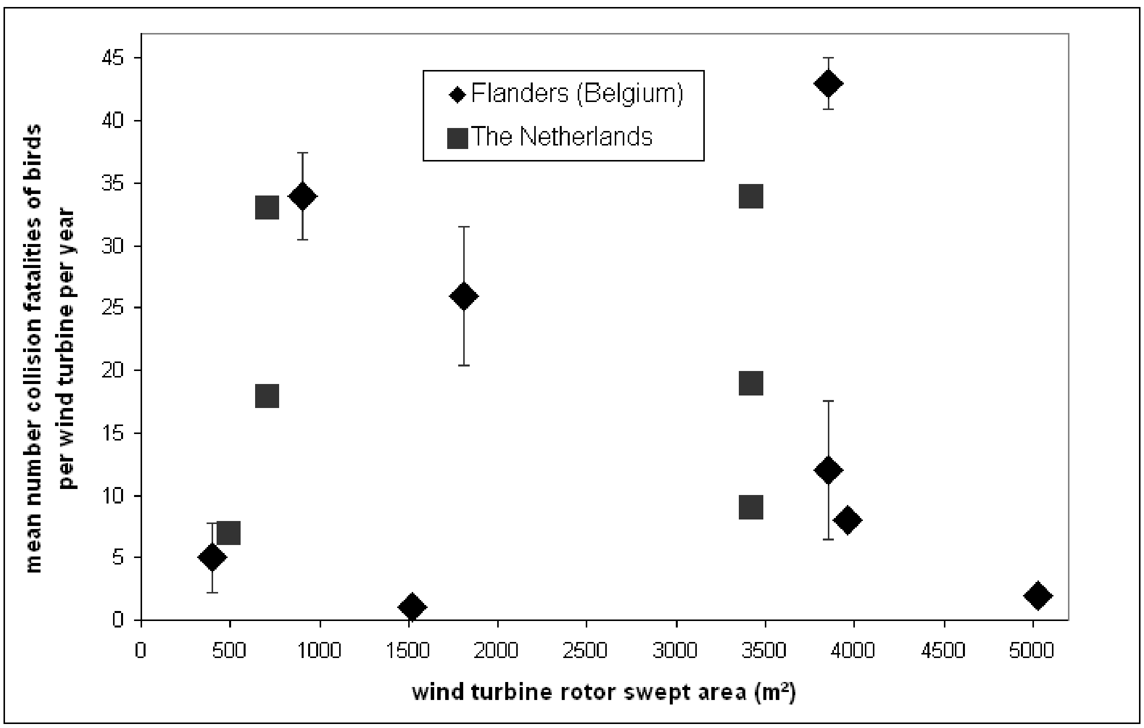

Figure 1. Mean number of collision fatalities of birds per wind turbine per year for several wind farms in Flanders (Belgium) and The Netherlands (± STDEV for data from several years, see also Table 1).
No significant relation with the rotor swept area of the different types of turbines (R^2=0.0024 ; P=0.87).
Note: left group are turbines of 250-600 kW and right group are turbines of 1500-2000 kW.

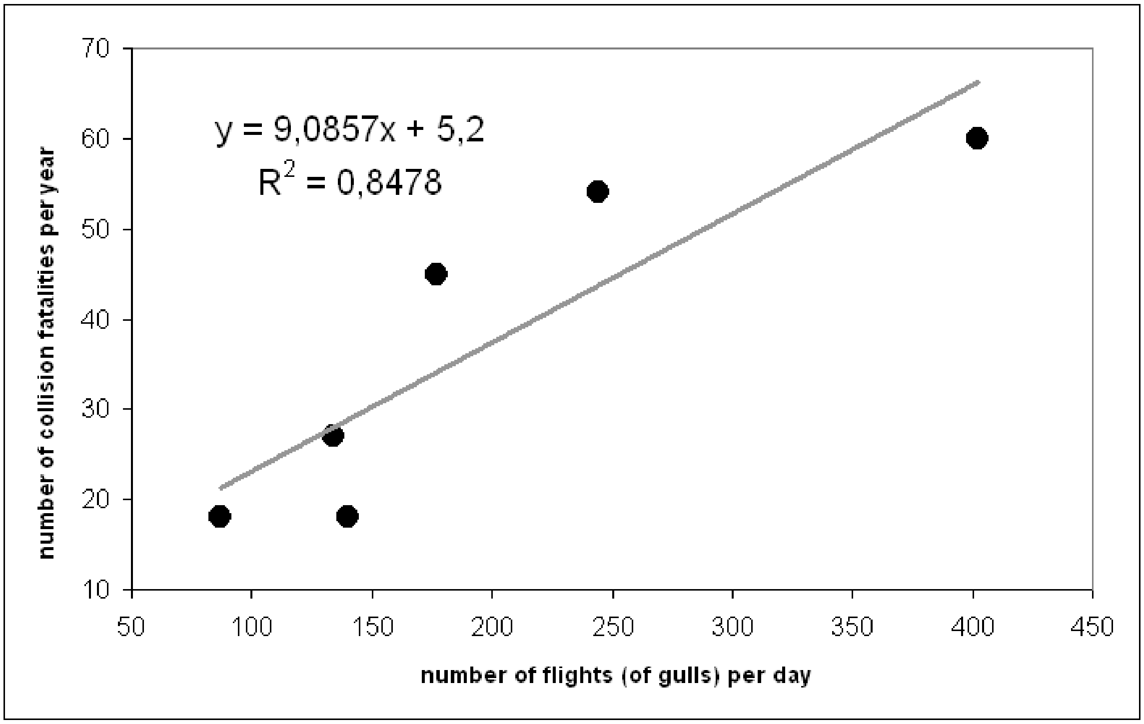

Figure 2. Significant relation between the daily number of local flights of large gulls per wind turbine sector on the eastern port breakwater in Zeebrugge Belgium (mean of breeding season 2001 and autumn 2001) and the number of gull collision fatalities per sector (6) with 4+3+4+4+4+4 turbines ($R^2=0.85$; $P<0.05$).

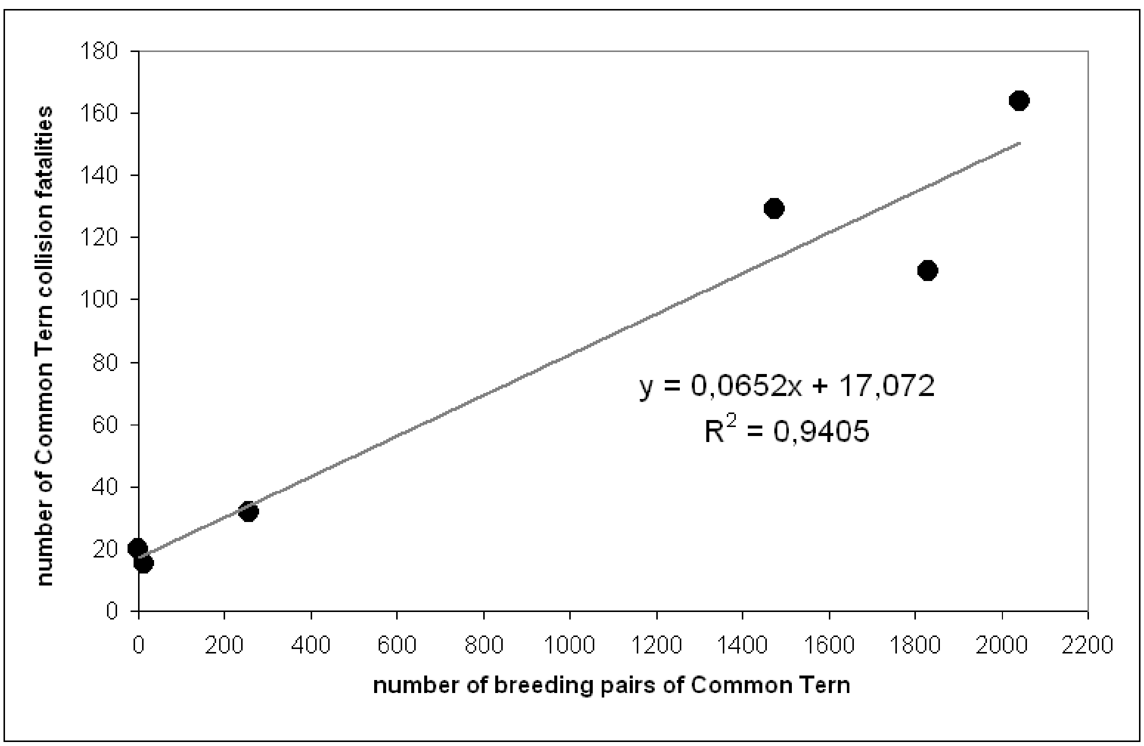

Figure 3. Significant relation between the number of Common Tern pairs in the breeding colony next to the wind turbines in Zeebrugge and the number of collision fatalities in the years 2001-2006 ($R^2=0.94$; $P<0.01$). More information, see Everaert & Stienen (2006).

The conclusion mentioned above that the type of wind turbine seems to be a less important factor for the number of collision fatalities, is also based on the calculated collision chance at different wind farms. However, the collision chance at rotor height can be a little higher for larger wind turbines as illustrated by the difference between two nearby wind farms in Brugge; one line of 14 turbines of 600 kW, another line of 7 turbines of 1800 kW (Table 2).

Location wind turbines, and species	**Collision chance at rotor height**	**Collision chance at all heights**
'De Put', Nieuwkapelle (600 kW): 2006 Black-headed Gull & Common Gull (1)	1 / 2950 (= 0.034 %)	1 / 4720 (= 0.021 %)
'De Put', Nieuwkapelle (600 kW): 2006 Black-headed Gull & Common Gull (2)	1 / 1003 (= 0.100 %)	1 / 1593 (= 0.063 %)
Eastern port, Zeebrugge (400 kW): 2001 Herring Gull & Lesser Black-backed Gull (3)	1 / 2100 (= 0.048 %)	1 / 3700 (= 0.027 %)
Boudewijn-canal, Brugge (600 kW): 2001 Herring Gull (4)	1 / 750 (= 0.133 %)	1 / 2200 (= 0.046 %)
Boudewijn-canal, Brugge (600 kW): 2005 Herring Gull (5)	1 / 839 (= 0.119 %)	1 / 1119 (= 0.089 %)
Boudewijn-canal, Brugge (600 kW): 2005 Black-headed Gull (5)	1 / 3682 (= 0.027 %)	1 / 5307 (= 0.019 %)
Kleine Pathoekeweg, Brugge (1800 kW): 2005 Black-headed Gull (6)	1 / 3015 (= 0.033 %)	1 / 5259 (= 0.019 %)
Kleine Pathoekeweg, Brugge (1800 kW): 2005 Herring Gull & Lesser Black-backed Gull (6)	1 / 695 (= 0.144 %)	1 / 1247 (= 0.080 %)
Eastern port, Zeebrugge (400 kW): 2004 & 2005 Common Tern (7)	1 / 848 (= 0.118 %) & 1 / 911 (= 0.110 %)	1 / 13387 (= 0.007 %) & 1 / 3338 (= 0.030 %)
Eastern port, Zeebrugge (400 kW): 2004 & 2005 Sandwich Tern (7)	1 / 1130 (= 0.088 %) & 1 / 2176 (= 0.046 %)	1 / 18283 (= 0.005 % & 1 / 16819 (= 0.006 %)

Table 2. Collision chances for flying gulls and terns on wind farm locations (line formations) in Flanders (Belgium) during the day + night (24/24h). Important note: for (1),(2),(4),(5),(6) & (7) this was based on the number of passing birds from 2 hours before sunrise till 4 hours after sunset because a negligible number was found in a spot-check during the night (completely dark period), in fact, for the gulls most birds were crossing the wind farm in the evening (local migration route to the sleeping place), and for the terns all birds were crossing the wind farm during the day (including dawn and dusk).

(1) Based on the calculated number of certain and highly probable collision fatalities, in relation with the maximum number of passing birds within a 100 m radius around the turbines. See Everaert (2006b).

(2) The same as in (1), but in relation with the mean number of passing birds. See Everaert (2006b).

(3) Based on the calculated number of certain and highly probable collision fatalities, in relation with the mean number of passing birds within a 60 m radius around the turbines (=space between the turbines in line). See Everaert et al. (2002) and Everaert & Stienen (2006).

(4) Based on the calculated number of certain and highly probable collision fatalities, in relation with the mean number of passing birds in a 75 m radius around the turbines (=space between the turbines in line). See Everaert et al. (2002) and Everaert & Stienen (2006).

(5) Based on the calculated number of certain and highly probable collision fatalities, in relation with the mean number of passing birds in a 100 m radius around the turbines (=space between the turbines in line). See Everaert (2007).

(6) Based on the calculated number of certain and highly probable collision fatalities, in relation with the mean number of passing birds in a 140 m radius around the turbines (=space between the turbines in line). See Everaert (2007).

(7) Based on the calculated number of certain and highly probable collision fatalities, in relation with the mean number of passing birds within a 60 m radius around the turbines (=space between the turbines in line). See Everaert & Stienen (2006).

Discussion

Research results of individual wind farms can not be generalised. In general, the collision mortality is mostly related to the number of (flying) birds present (at rotor height). Large modern turbines of 1500 kW or more can have as much or even more collision fatalities than smaller turbines (Akershoek et al. 2005; Everaert 2003; Everaert 2006a; Everaert 2007 + Figure 1 & Table 1). However, more data on large wind turbines (≥ 1500 kW) are urgently needed.

The average number of collision fatalities in different European wind farms on land varies between a few birds up to 64 birds per turbine per year (Langston and Pullan 2003; Everaert 2006a; Everaert 2007; see Table 1). Also within one wind farm, the impact can strongly differ between individual turbines (Everaert et al. 2002; Everaert & Stienen 2006), clearly showing that 'site selection' can play an important role in limiting the number of collision fatalities.

During previous years, for a few wind turbines at the eastern port breakwater in Zeebrugge, up to 111 and 125 fatalities were calculated as a result of the correction factors for some small birds that were occasionally found (Everaert et al. 2002; Everaert 2003). In Sylt and Helgoland, Germany (each with only one wind turbine), after a full year study, bird deaths per turbine per year were estimated to be respectively 2.8-103 and 8.5-309 (Benner et al. 1993). One example of multiple bird kills occurred at a wind turbine in Nasudden, Sweden, where 49 collided birds were found after one night with poor weather conditions; the turbine was not operational at the time, but was lit with a single lamp 10 m above the ground (Gill et al. 1996; Karlsson 1983). Overall, mortality events of this magnitude are rarely recorded, but with more and bigger wind turbines planned (certainly offshore), it is still unclear if this will stay a relatively rare phenomenon. More intensive searches during the whole year and with many wind turbines at different types of locations are urgently needed.

Towards the situation for migrating birds, Kaatz (2002) recommended not to build large wind turbines on the coast, because of disturbance (barrier) at dense migration corridors. Here it is difficult to prove the evidence of the large numbers of victims of which the biggest part are the small birds. Many small corpses are lost after collision with the rotors, whereby they can't be found on the ground or are lost into sea. Even for large wind turbines the speed of the rotors goes to about 230 km/h at the tips. Therefore, the estimated collision of small birds using searches of dead birds on the ground (as with most studies) is not fully reliable, even with corrections for scavenging and search efficiency. The only – known to us – comprehensive study whereby the collision chance for nocturnal migrating birds was calculated by means of the actual observed collisions (thermal image intensifiers) was performed in The Netherlands (Winkelman 1992b). These results showed a remarkable high nocturnal collision probability of 1 on 40 passing birds (2.5%) at rotor height.

The future collision research should include the use of new techniques like the full automatic sound- and image detection system with contact microphones on the turbine mast in combination with web cams (Verhoef et al. 2003; Verhoef 2003), and/or the Thermal Animal Detection System (TADS) for estimating collision frequency of migrating birds and bats at wind turbines (Desholm 2005). The problem is that these new techniques have not yet been tested sufficiently in wind farms with regular bird and/or bat collision victims (on land). Certainly given the current worldwide offshore wind energy plans, a reliable well tested technique for general use is urgently needed.

Questions also remain about the impact of facility lighting (warning lights for aviation) on night migrating birds and bats. There are indications from some first tests with birds that most attraction (most collision problems) can be expected with non-pulsating and slow pulsating red (and possibly white) lights. Less problems would occur with (white) strobe lights (Gauthreau & Belser, 1999).

Some researchers reported (almost) only common species as collision fatalities (Winkelman 1992a; Van der Winden et al. 1999). However, the situation depends on the location and the species. Wind turbine locations with relatively large numbers of protected birds, as in Tarifa and Navarra (Spain), Altamont Pass (California) and Zeebrugge (Belgium), are examples of poorly sited wind farms (SEO/Birdlife 1995; Lekuona 2001; Smallwood and Thelander 2004; Langston and Pullan 2003; Hötker et al. 2004; Everaert & Stienen 2006).
In Germany researchers already found 25 White-tailed Eagles *Haliaeetus albicilla* and 86 Red Kites *Milvus milvus* during occasional searches and the numbers are still increasing every year (Hötker et al. 2004; Dürr 2007). Because of the lack of sufficient research, it is not clear if the collision fatalities in Germany have a "significant" impact on the population. However, the lack of clear figures concerning possible significant effects cannot be a reason not to do anything about the situation. Negative effects always have to be avoided.

The finding of 9 White-tailed Eagles between autumn 2005 and spring 2006 in a new wind farm on the Smøla archipelago in Norway (with 68 turbines) is also very disturbing. Moreover, breeding results on Smøla have been strikingly poor compared with the 30 years before the wind farm was built, both on the site itself and the remainder of the archipelago (Follestad 2006; Langston 2006; Birdlife International 2006). The Norwegian government ignored advice based on an environmental assessment warning against the development because of the danger it posted to White-tailed Eagles. The Norwegian Ornithological Society (Birdlife in Norway) even took the case to the Bern Convention but the decision was not overturned. The result is a significant negative impact on a treatened species in one of the most important breeding areas. The only "measures" taken on collision losses of White-tailed Eagle until now is planning a project (2006) on what is happening, and to find out if it is possible to do anything to prevent future collisions. The studies include radar observations, the use of colouration to increase the visibility of the blades, or alarm calls on or surrounding the wind turbines. The project depends on collisions affecting at least several tens more White-tailed Eagle simply to get a scientific basis for conclusions. There has been no discussion of the legality of such a project according to the Norwegian Wildlife Act or other acts or treaties, including international conventions like the Bern Convention.

The Research Institute for Nature and Forest in Flanders has the opinion that such wind farms with mortality of critical species should never have been approved. If no measures can be made to reduce the collisions in a significant way, such wind farms should be dismantled immediately. This seems the only way to also give a clear signal for future plans in important bird areas. There are currently several projects planned in highly sensitive bird areas.

General recommendations

Study results clearly show that reasonable amounts of birds and bats can collide with wind turbines. An exhaustive study before the selection of future locations is a key factor to avoid deleterious impacts of wind farms on birds and bats.

Cumulative negative impacts with an increasing amount of wind turbines must be taken into account (Langston & Pullan 2003). This especially is developing along fixed bird migration corridors (coasts, mountain passes). More wind farms also means an extra pressure on top of the already existing sources of negative impact (powerlines, traffic etc.). In a densely populated region like Flanders, this degrades the total suitability for ecological functions such as the presence of bird and bat populations and the guarantee for regional or international migration routes. For the offshore situation, international cooperation will be necessary to determine the possible cumulative impact.

Proper site selection plays a very important role in limiting the impact of wind farms on nature. In general, current knowledge indicates that there should be precautionary avoidance of locating wind farms in regional or international important bird or bat areas and/or migration routes. Locations with high bird or bat use are not suitable for wind farms (see also guidelines on p. 56 in Langston & Pullan 2003, and Draft Recommendation T-PVS (2004) 4 of the Bern Convention).

Developing mitigation measures and advocating temporary shutdowns or a complete dismantling of wind farms where (probable) significant impacts occur, are very difficult and sensitive issues and could take years of study. Such situations must be prevented. A number of environmental impact assessments (EIA) have important shortcomings because of the lack of data and time or the use of incomplete data (e.g. not covering the annual cycle). It is very important that EIA's are made independently or are at least evaluated independently. When important factors remain unclear and an indication exists for an important negative impact, the precautionary principle must be applied. A constructive working method is to map potential and no-go locations for wind energy in a certain country or region, based on all available information, long before concrete projects are planned.

Following the article 6(4) of the European Habitats Directive, it is clear that if a wind farm could have an important negative impact on wildlife, landscape, etc., the obligation exists to look for alternatives first. In most cases there will always be less vulnerable locations or other alternatives for wind farms. To evaluate location or other alternatives, a multicriteria analysis (MCA) is preferable. This complex decision-making tool resembles (strategic) cost-benefit analysis although it does not reduce the disparate phenomena to a common unitary (monetary) base. It permits the inclusion of qualitative as well as quantitative data. Several environmental impacts (positive or negative) cannot be readily assigned a monetary value (for example collision mortality and disturbance for wildlife (birds/bats), impact on landscape, etc.). The current lack of sufficient knowledge concerning positive and negative effects of wind energy, however, remains a problem for the implementation of such analysis.

More information (also for the coming 2007 report and article) can be found at
www.inbo.be/content/page.asp?pid=en_fau_bir_windturbines
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