THE IMPACT OF WIND ENERGY ON WILDIFE AND THE ENVIRONMENT

Papers from the Berlin Seminar

The Global Warming Policy Foundation

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THE IMPACT OF WIND ENERGY ON WILDIFE AND THE ENVIRONMENT

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Edited by Dr Benny Peiser

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Introductory statements

Professor Fritz Vahrenholt, German Wildlife Foundation

This publication focuses on a topic that has previously been a taboo for policymakers, but also for nature conservation organisations in Germany. The environmentally destructive effects of renewable energies has never been widely discussed – mainly because they are seen as reducing carbon dioxide emissions.

Renewable energy is generally regarded as being a good thing in itself. I can judge this from my own experience. I was in a leading position in the renewable energy industry for 12 years and commissioned many thousands of megawatts of wind and biomass power plants. Their environmental impact was never a real issue. More recently, however, the negative effects of rapeseed and corn monocultures for the production of biofuel and biogas have become evident, as has the impact of slashing and burning rainforests for the production of palm oil. Even the environmental impact of hydropower has become widely known. But we are still slow to grasp the extent of the fatal effects on birds and bats when wind farms are built in or near their natural habitats.

The German Wildlife Foundation is not generally against wind energy. We are not opposed to any technology. But we are opposed to the unbridled expansion of energy projects in natural environments and natural spaces, a process that is increasingly happening today, especially in Germany.

In recent years, particularly in the hill country in the state of Hesse, the majority of wind turbines have been built in forests. For companies and officials, these locations are the most simple choice because there are few residents to object and most of the time the forest belongs to the community, the county or the state. In addition, very high yields can be earned by landowners for leasing out their land for wind turbines.

Meanwhile, the federal government plans to double or triple the number of wind turbines in Germany. Today there are 28,000 of them, a figure which thus might increase to about 50,000–70,000. In Germany, on average, there is one wind turbine every 2.6 kilometers. And since you cannot build any wind farms in Lake Constance or in cities, the density is even higher in natural environments.

That this will have a negative impact on nature is obvious. The papers in this publication show what threats nature and wildlife now face from this expansion.

I would like to point out an unprecedented development in connection with wind turbines. Flying migratory insects rise up to heights above 60 metres and then allow themselves to be transported to more remote areas before oviposition. That's what the admiral butterfly does, and that's how ladybirds do it. This process has evolved so as to enable these insects to find new environments without food competition, but they can be carried hundreds of kilometers away. It has been like that for millions of years.

Now, however, these insects hit wind turbines at 100 metres altitude and their dead bodies cake the turbine blades at certain times of year, causing a significant drop in the energy yield. When I was CEO of REPower, the second largest German wind power manufacturer, we had to develop a new technology to allow us to clean the blades, which required washing at least annually, and sometimes twice each year.

Initial studies estimate that about 1200 billion migratory insects (or 3600 tons) are killed in this way. To give you an idea of the magnitude of this kill rate: it is about 5%. To be clear: 5% of the migrating insects are destroyed in this way. This is an important revelation, which needs to be investigated properly. The German Wildlife Foundation will be researching whether there is a correlation between the rapid expansion of wind turbines and the estimated decrease of flying insects by 75% in the last 20 years. After all, we are still looking for the main reason for this dramatic development. What are the actual causes? Is it agriculture? The clearing of land? Monocultures? Or could it be linked to another potential cause, namely wind turbines? If that were the case there would be an important indirect effect on the nutritional foundations for birdlife. This would represent another impact of wind turbines on birds, one of the focuses of this paper.

Benny Peiser, Global Warming Policy Foundation

The Global Warming Policy Foundation, an educational think tank based in London, does not have a position on wind energy or renewable energy. We neither oppose nor promote it. However, we are in favour of weighing up the pros and cons. Any form of energy production, whether conventional or renewable, has its costs and benefits, and many environmental problems come with every form of energy generation.

One of the big problems that confronts us today is that we live in an age where some of these issues are taboo; where particular topics cannot be openly discussed. Throughout history, whenever societies were faced with a lack of openness or censorship, grave mistakes have been inevitable. After all, you can only learn from mistakes if you are allowed to talk about problems openly. It is in this context that it is eminently important that the pros and cons of all forms of energy generation are openly addressed. Only by weighing up the pros and cons can politicians and the wider public get a better idea of what is reasonable and what is unreasonable.

We are not opponents of wind energy. Where wind energy makes sense it should be used. Wherever it is unreasonable and destructive, it should be avoided. The problem, of course, is that we often don't fully understand the positive and negative impacts. I hope that this booklet will allow readers to have a better understanding of both German and international developments, so that the interested public can get a better picture of these particular problems of conservation.

Ecological impacts of wind turbines: are they the greener option?

Peter Henderson, Pisces Conservation Ltd and University of Oxford

About the author

Peter Henderson has many years' experience in applied ecological research, lecturing in population ecology and ecological methods at the University of Oxford. He co-authored the book Ecological Methods *with Sir Richard Southwood, and is a specialist in population dynamics and tropical and temperate crustacean and fish ecology.*

Introduction

Wind turbines, which convert wind kinetic energy into electrical power, are a familiar sight in many parts of Europe and North America. Wind was a primary source of power until the industrial revolution, and windmills were a feature of country views in many countries. English speakers still tend to refer to electricity generating wind turbines as windmills. There is a bewildering variety of windmill and wind turbine design, but horizontal three-bladed machines are by far the most common in large-scale wind farms (see Figure 1). It is the ecological impact of this common design that is the principal focus of this article. The tri-blade machine is popular because in most conditions it is the most efficient. The aerodynamic blades generate lift to drive the turbine faster.

Worldwide installed wind capacity has grown exponentially since 1997 (Figure 2). In 2016, total global installed capacity was nearly 487 GW, with the fastest growth in new capacity occurring in China, the USA, Germany and India. While future growth may deaccelerate, it is certain to continue for many years to come. The ecological effects of wind turbine operation and installation is therefore likely to become increasingly important.

Atmospheric emissions of carbon dioxide and global warming

The key driver in the deployment of wind turbines has been the desire to reduce atmospheric carbon dioxide emissions caused by electrical generators. While there are no significant atmospheric emissions associated with operating wind turbines, there are emissions during materials production, material transportation, on-site construction and assembly, operation and maintenance, and decommissioning. Estimates of total global warming emissions depend on a number of factors, including wind speed, percentage of time the wind is blowing, and the material composition of the wind turbine. Most estimates of life-cycle global warming emissions of wind turbines are in the range 0.009–0.018 kg of carbon dioxide equivalent

Figure 1: Newly constructed wind turbines.
Thornton Bank, 28 km offshore, in the Belgian part of the North Sea. The turbines are 157 m (+TAW) high, 184 m above the sea bed. ©Hans Hillewaert, via Wikimedia Commons.

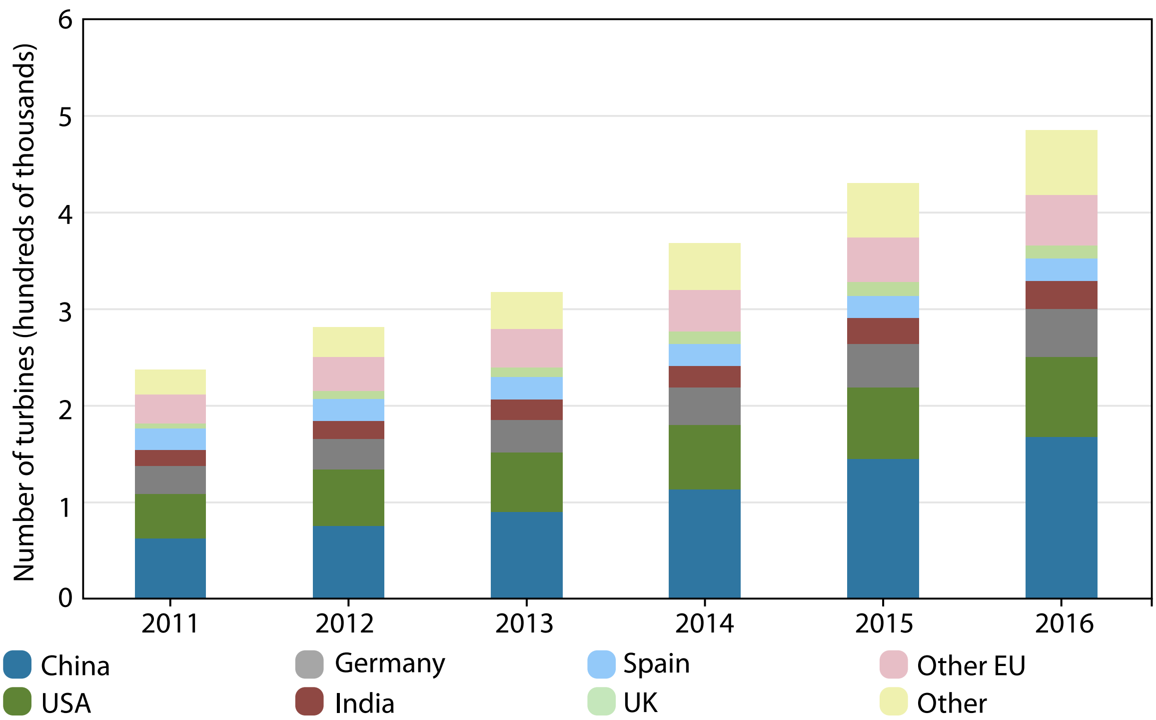

Figure 2: The growth in worldwide wind turbine generating capacity
Data from http://www.gwec.net/wp-content/uploads/2015/02/GWEC_GlobalWindStats2014_FINAL_10.2.2015.pdf

per kilowatt-hour. To put this value into context, life-cycle global warming emissions for natural-gas-generated electricity are 0.27–0.91 kg and for coal-generated electricity 0.64–1.6 kg.

Ecological impacts of large-scale wind farms

While onshore and offshore wind turbines share some ecological impacts, it is useful to consider them separately. This is because, during construction, they impact different ecosystems and many terrestrial species do not move far offshore.

Offshore plant

Ecological impacts relating to large-scale offshore wind generation on marine wildlife are discussed by Bergström *et al.* (2014),[1] and the areas of concern identified are discussed below. The bulk of our present knowledge has been acquired over the last 10 years and our understanding is far from complete.

Construction-phase impacts

The key issues in many wind farm construction projects concern acoustic disturbance and increased sediment dispersal linked to the engineering works required to anchor the turbines to the seabed. Offshore wind farms are usually built on monopiles or jacketed foundations, and the associated pile driving may generate appreciable levels of underwater noise. Noise levels close to the pile driver (within about 5 m) can exceed the levels that will hurt or kill fish[2] and other marine life (peak quoted values are 218 dB). Unlike percussive piling, the installation of gravity foundations does not generate high sound levels. However, there is an appreciable level of disturbance caused by boat noise and dredging.

Dredging is a locally destructive activity, and can have a range of ecological impacts. As with piling, it is a common procedure, and is not only associated with offshore wind farm construction. Major dredging campaigns can occur during harbour construction and for the construction of cooling water intakes and outfalls at conventional and nuclear power plants. Dredging can cause sediment plumes, oxygen sags, increased contaminant levels entrainment mortality, and damage to important habitats, all of which can affect fish and other marine life.

Operational-phase impacts of offshore wind farms

Seabed and underwater structure use and exclusion Offshore wind farms create hard surface habitat: in effect, an artificial reef. In areas with little seabed structure, artificial reefs can lead to an increase in biodiversity. Increased species abundance has been observed in several studies close to offshore wind farm foundations. Wilhelmsson *et al.* (2006),[3] in a

1 Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Capetillo, N. Å., and Wilhelmsson, D. (2014). Effects of offshore wind farms on marine wildlife – a generalized impact assessment. *Environmental Research Letters*, 9(3), 034012.

2 Nedwell J. and Howell D. (2004). A review of offshore windfarm related underwater noise sources. *Cowrie,* 544, R 0308. (available at: www.subacoustech.com/information/downloads/reports/544R0308.pdf).

3 Wilhelmsson, D., Malm, T., and Öhman, M. C. (2006). The influence of offshore windpower on demersal fish. *ICES Journal of Marine Science*, 63(5), 775–784.

Baltic Sea study, found demersal fish abundance was highest in the vicinity of the turbines when compared with surrounding areas.[4] However, species richness and alpha diversity, which measures the complexity of the local species community in terms of both evenness of abundance and species number, were similar. The monopiles of the turbines had a lower species richness than the seabed and this was dominated by mussels and barnacles, but the associated fish community had a greater abundance. The authors concluded that 'offshore windfarms may function as combined artificial reefs and fish aggregation devices for small demersal fish'. As offshore wind farms offer a novel, artificial habitat, they run the risk of attracting or supporting non-native species. It has been argued[5] that artificial substrates had facilitated the spread of a non-native alga, *Codium fragile*, in the Adriatic.

Rubins *et al.* (2014)[6] concluded from studies in the North Sea that pout (*Trisopterus luscus*) and cod (*Gadus morhua*) juveniles were present in large numbers in the reefs at the base of wind turbines, where they fed on the epifauna present. However, they noted that these aggregations had not, as yet, resulted in a detectable increase in pout or cod at a regional level. They did not dismiss the possibility of long-term change and suggested continued monitoring.

Not all seafarers view offshore wind farms positively, as other vessels and fishermen can be excluded for safety reasons and, even when permitted to enter, they may no longer be able to trawl in traditional areas. Vessel movements would typically be prohibited from an offshore wind farm site during construction, maintenance and decommissioning. Fisheries exclusion is likely to increase local species abundances. Exclusion of shipping also carries environmental costs in terms of potentially longer travel distances and an increased risk of collision and subsequent pollution.

Lindeboom *et al.* (2011)[7] summarise what is likely to be the general situation. Offshore wind farms create a new type of habitat that supports a higher biodiversity of benthic organisms than the surrounding, typically soft, sediments. This community generates increased use of the area by the benthos, fish, marine mammals and some bird species. However other species, including some birds, avoid the areas.

Electrical fields and subsea cables The effects of electromagnetic fields (EMFs) generated by undersea cables is discussed by Gill *et al.* (2012).[8] The authors highlight our present lack of knowledge, but suggest that EMFs from subsea cables may interact with migrating eel *Anguilla* sp. and possibly other diadromous fish,[9] to temporarily change their swimming direction. Whether this represents a biologically significant effect is unknown. Scott *et al.*

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4 Demersal fish are those living near the bottom of the sea.

5 Bulleri, F., and Airoldi, L. (2005). Artificial marine structures facilitate the spread of a non-indigenous green alga, *Codium fragile* ssp. tomentosoides, in the north Adriatic Sea. *Journal of Applied Ecology*, 42(6), 1063–1072.

6 Reubens, J. T., Degraer, S., and Vincx, M. (2011). Aggregation and feeding behaviour of pouting (*Trisopterus luscus*) at wind turbines in the Belgian part of the North Sea. *Fisheries Research*, 108(1), 223–227.

7 Lindeboom, H. J., Kouwenhoven, H. J., Bergman, M. J. N., Bouma, S., Brasseur, S. M. J. M., Daan, R., and Lambers, R. H. R. (2011). Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. *Environmental Research Letters*, 6(3), 035101.

8 Gill, A. B., Bartlett, M., and Thomsen, F. (2012). Potential interactions between diadromous fishes of UK conservation importance and the electromagnetic fields and subsea noise from marine renewable energy developments. *Journal of Fish Biolog* y, 81(2), 664–695.

9 Fish that migrate between fresh and saltwater.

(2018)[10] found that crabs showed a clear attraction to EMF-exposed shelters (69%) compared to control shelters (9%) and reduced their time spent roaming by 21%. Consequently, EMF emitted from marine renewable energy devices (MREDs) will likely affect edible crabs both behaviourally and physiologically, suggesting that the impact of EMFs on crustaceans must be considered when planning MREDs. When subsea cables carry DC power, EMFs are greater, and the potential for biological impacts higher, than when AC is used at the same power level.

Interest in the ecological effects of power cables is growing, and we are just beginning to get scientific analyses. Taormina *et al.* (2018)[11] reviewed their potential impacts. In summary, subsea cables may cause:

- habitat damage or loss
- noise
- chemical pollution
- heat
- EMFs
- risk of entanglement
- artificial substrates
- reserve effects by excluding fishing.

Noise Vibration generated by wind turbine gearbox mesh and generators typically cause underwater noise,[12] at wavelengths that are within hearing range of both fish and mammals. In addition, acoustic disturbance may increase due to increased vessel movements for service and maintenance. There is, at present, no evidence of negative effects linked to wind turbine noise.[13]

Impacts on bird, bats and other flying animals This important area of concern is discussed in more detail in the section on onshore windfarms, for which we have considerably more useful data. It is almost impossible to detect fatalities at offshore facilities and so we have no data upon which to assess the impact. With respect to birds, the key concerns are collisions, barrier effects and habitat loss. Particular concern is focused on species undertaking regular seasonal migrations. For example, hundreds of millions of birds cross the North and Baltic Seas at least twice every year. A study by Hüppop *et al.* (2006)[14] concluded that almost half of these birds fly at altitudes at which they could be killed by a turbine. They also showed that, especially when there is poor visibility, terrestrial birds are attracted by illuminated offshore structures and that some species, particularly passerines, collide in large numbers. They argued for:

[10] Scott, K., Harsanyi, P., and Lyndon, A. R. (2018). Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.). *Marine Pollution Bulletin*, 131, 580–588.

[11] Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., and Carlier, A. (2018). A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews*, 96, 380–391.

[12] 80–150 dB re 1 μPa.

[13] Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Capetillo, N. Å., and Wilhelmsson, D. (2014). Effects of offshore wind farms on marine wildlife – a generalized impact assessment. *Environmental Research Letters*, 9(3), 034012.

[14] Hüppop, O., Dierschke, J., Exo, K. M., Fredrich, E., and Hill, R. (2006). Bird migration studies and potential collision risk with offshore wind turbines. *Ibis*, 148(s1), 90–109.

- the abandonment of wind farms in zones with dense migration
- turning off turbines on nights predicted to have adverse weather and high migration intensity
- actions to make wind turbines more recognizable to birds, including modification of the illumination to intermittent rather than continuous light.

While the impacts of offshore wind farms on bats are not understood, it is known that bats do fly offshore and are therefore vulnerable to harm. For example, they regularly migrate across the Baltic and North Seas[15] where there are extensive wind farms. Migration by bats over water has also been observed in North America. For example, Johnson *et al.* (2011)[16] report the presence of five migrating bat species on a barrier island off the coast of Maryland, USA.

Insect concentrations are known to occur around onshore wind farms, but the situation offshore is unknown.

Large-scale onshore wind farms

Onshore wind farms are often unpopular because of damage to the landscape and visual amenity. This is a matter of personal taste rather than ecology and not discussed further here.

Land use

A key issue is land use. Typically, horizonal wind turbines must be spaced 5–10 rotor diameters apart. The turbines and associated infrastructure, including roads and transmission lines, therefore only occupy a small portion of the total area of a wind farm. A survey by the National Renewable Energy Laboratory of large wind facilities in the United States found that they use between 30 and 141 acres (57 hectares) per megawatt of power output capacity. However, less than 1 acre per megawatt is permanently disturbed and less than 3.5 acres (1.4 hectares) per megawatt are temporarily disturbed during construction.[17] The remainder of the land can be used for agriculture and other purposes. Wind turbines are also frequently placed in commercial and industrial locations, such as ports, which reduces land use concern.

Wildlife impacts

The key areas of concern relate to operational impacts on flying organisms, particularly birds, bats and insects. Each of these groups is considered in turn.

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15 Rydell, J., Bach, L., Bach, P., Diaz, L. G., Furmankiewicz, J., Hagner-Wahlsten, N., and Ptersons, G. (2014). Phenology of migratory bat activity across the Baltic Sea and the south-eastern North Sea. *Acta Chiropterologica*, 16(1), 139–147.

16 Johnson, J. B., Gates, J. E., and Zegre, N. P. (2011). Monitoring seasonal bat activity on a coastal barrier island in Maryland, USA. *Environmental Monitoring and Assessment*, 173(1–4), 685–699.

17 Denholm, P., Hand, M., Jackson, M. and Ong, S. (2009). Land-use requirements of modern wind power plants in the United States. National Renewable Energy Laboratory.

Birds Bird deaths and bird habitat loss linked to wind turbines is a particularly contentious issue and brings into focus deep divisions within wildlife conservation organisations. Perhaps the most striking example of this conflict occurs in the UK, where the Royal Society for the Protection of Birds (RSPB) concluded that:

> Wind power has a significant role to play in the UK's fight against climate change. With the right strategic approach, it can be expanded without detrimental effects on important bird populations.[18]

Note a common feature in discussions of wind farm impacts is the belief that climate change threats are sufficiently severe to trump the immediate issues linked to local harm.

It is clear that the risks to birds depends on numerous factors, including the design and size of the turbines and their location. The adverse impacts can also arise from a variety of factors. The key four are: [19]

- disturbance and displacement from desirable habitat[20]
- barrier effects – the disruption of favoured flight paths
- collision risk[21]
- habitat loss or damage.

The number of birds directly killed by collision with turbine blades is not insignificant. Smallwood (2013)[22] estimated 573,000 bird fatalities/year at 51,630 megawatt (MW) of installed wind-energy capacity in the United States in 2012. This number included a worrying 83,000 raptor (birds of prey) fatalities. In Europe and the USA, it is the loss of large raptors that has attracted the most concern. The Pine Tree Wind energy project near Tehachapi, California has been considered to have particularly high raptor mortality rates and has killed eight golden eagles, according to the US Fish and Wildlife Service. Farfán *et al.* (2017)[23] note that most studies on the effects of wind farms on birds focus on large species and those of conservation concern. They present data on the abundance of birds in the vicinity of a wind farm in an upland habitat in southern Spain, both immediately after installation and 6.5 years post-construction. They observed 11 raptors and 38 non-raptor species, of which 30 were passerines. They concluded that while raptor numbers recovered from initial disturbance to levels only slightly lower than those pre-construction, the numbers of non-raptors significantly declined. They noted that while numbers had only slightly decreased, the turbines at this site did act as a barrier to raptor flight. It is also notable, given the significant declines in small bird numbers, that they only observed one bird killed by collision with the

18 https://www.rspb.org.uk/search/index.aspx?q=wind+farms.

19 Drewitt, A. L., and Langston, R. H. (2006). Assessing the impacts of wind farms on birds. Ibis, 148(s1), 29–42.

20 Pearce-Higgins, J. W., Stephen, L., Langston, R. H., Bainbridge, I. P., and Bullman, R. (2009). The distribution of breeding birds around upland wind farms. *Journal of Applied Ecology*, 46(6), 1323–1331.

21 Hötker, H., Thomsen, K. M., and Köster, H. (2006). Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats. Facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut im NABU, Bergenhusen, 65.

22 Smallwood, K. S. (2013). Comparing bird and bat fatality rate estimates among North American wind energy projects. *Wildlife Society Bulletin*, 37(1), 19–33.

23 Farfán, M. A., Duarte, J., Real, R., Muñoz, A. R., Fa, J. E., and Vargas, J. M. (2017). Differential recovery of habitat use by birds after wind farm installation: A multi-year comparison. *Environmental Impact Assessment Review*, 64, 8–15.

blades. It is clear that simply stating that killed birds are rarely observed cannot be used to argue that adverse impacts are not occurring.

Bats The impacts of wind turbines on bats has been recently reviewed by Arnott *et al.* (2016).[24] The authors highlight the seriousness of the situation. Bats are killed in a variety of ways: by blunt force trauma, barotrauma and through inner ear damage and other injuries not readily noticed during examination of carcasses in the field. To gain some appreciation of the scale of the problem, the annual mortality rates reported from European and North American studies are summarised in Table 1. Arnott *et al.* (2016) noted the 'alarming' lack of data from Mexico, Central and South America, the Caribbean, Africa, New Zealand, and Australia. They found no information on bat fatalities at wind farms in mainland Asia; the situation in China is particularly concerning, given the rapid growth of wind generation in that country (See Figure 2).

Table 1: Wind turbine annual mortality rates for bats from different habitats and geographical regions.

Region	Habitat	Annual death rate per MW installed capacity
USA and Canada	Northeastern deciduous forest	6.1–10.5
USA and Canada	Midwestern deciduous forest – agricultural	4.9–11
USA and Canada	Great Plains	6
USA	Great Basin/Southwest Desert region	1–1.8
Germany	Black Forest	10.5
Europe	Agricultural land	0.6–5.3

Data collated from Arnott *et al.* (2016).

It is far from clear what impact these levels of mortality are having on bat populations. However, some idea of the losses can be gained from German data. An estimated 10–12 bats are killed annually at each wind turbine in Germany, which suggests that, if all wind turbines are equally destructive, about 200,000 bats are annually killed at onshore wind turbines in Germany alone. These numbers are sufficient to produce concern for future populations, as bats are long-lived and have a low fecundity and so cannot quickly replace such losses.

Why bats are vulnerable to wind turbines is unclear. Kunz *et al.* (2007)[25] discuss various hypotheses, as do others.[26] There is evidence that collisions are not chance events; bats may be attracted to turbines either as a roost, as a gathering point during the breeding season, or to hunt insects concentrated near the blades. Arnett *et al.* (2016) believe that bats that regularly move and feed in more open air-space are most vulnerable. The species most often killed in Europe are aerial-hawking, where the prey is pursued and caught in flight, they are relatively fast-flying, open-air, species.

[24] Arnett, E. B., Baerwald, E. F., Mathews, F., Rodrigues, L., Rodríguez-Durán, A., Rydell, J., and Voigt, C. C. (2016). Impacts of wind energy development on bats: a global perspective. In *Bats in the Anthropocene: Conservation of bats in a changing world* (pp. 295–323). Springer International Publishing.

[25] Kunz, T. H., Arnett, E. B., Erickson, W. P., Hoar, A. R., Johnson, G. D., Larkin, R. P., Strickland, M. D., Thresher, R. W., Tuttle, M. D. (2007). Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. *Frontiers in Ecology and the Environment,* 5, 315–324.

[26] Cryan, P. M., and Barclay, R. M. (2009). Causes of bat fatalities at wind turbines: hypotheses and predictions. *Journal of Mammalogy*, 90(6), 1330–1340.

As most bat fatalities in temperate countries occur during relatively low-wind conditions in late summer, restricting turbine operation in light wind conditions can produce an appreciable reduction in bat deaths. One simple approach is to increase the wind speed at which turbines start to operate during periods of the year when bats are particularly vulnerable. Such approaches may reduce mortalities by 50–90%. The use of ultrasonic sound and radar has also been proposed. Changing to other more bat-friendly turbine designs would also be possible, but is unlikely to happen. Recently, more complex sets of rules to determine turbine operations, based on parameters including temperature, wind speed, season, time of day and known bats, have been developed. These rules cannot be generalised because they are tailored to the situation at a specific site and turbine design.

If bats are attracted by the availability of insects then it may be possible to reduce the death rate by painting turbines in colours less attractive to flying insects (see below).

Insects That wind turbines can kill large numbers of insects is supported by the remarkable fact that insect bodies adhering to the blades' leading edges have been implicated in halving turbine power output in high winds.[27] It is well established that insects can be attracted to wind turbines and the degree of attractiveness can be altered by the paint colour used. It is known that the common turbine colours pure white and light grey both attract insects, as does UV-reflecting paint.[28] Wind turbines are of sufficient size to interfere with flying insect migrations. For example, monarch butterflies in North America have been reported as killed by wind turbines.

Ecological issues relating to transmission lines on land

Large-scale use of wind generation requires the construction of extensive cable networks. In most regions, large scale electrical transmission is undertaken using cables supported on pylons. In urban areas, transmission lines are placed underground or even along the beds of canals or rivers. However, placing high-voltage transmission lines underground is uncommon and can cost two to ten times as much as an overhead line.

Impacts linked to above-ground transmission lines

There are clearly aesthetic considerations with transmission lines, and it is not uncommon for those in areas of outstanding beauty or cultural significance to be avoided or taken underground. Aesthetic issues are not considered further here.

Impacts on birds

Birds are probably the animals most impacted by above ground transmission cables. Power lines are one of the most important causes of bird mortality. They kill birds following collision and through electrocution. Electrocution tends to occur when large birds, such as white-tailed eagles, with a 2.45-m wingspan, take off from a perch on a pylon and touch a cable in the process, causing a fatal short circuit. Such large birds may also, on occasion, touch two power lines simultaneously while in flight, again causing electrocution. Transmission

27 Corten, G. P., and Veldkamp, H. F. (2001). Aerodynamics: Insects can halve wind-turbine power. *Nature*, 412(6842), 41.

28 Long, C. V., Flint, J. A., and Lepper, P. A. (2011). Insect attraction to wind turbines: does colour play a role? *European Journal of Wildlife Research*, 57(2), 323–331.

systems can also cause habitat loss, as some bird species avoid areas with power lines. Large birds such as raptors and storks are particularly vulnerable.[29] BirdLife International state that

> …high losses (sometimes in excess of 500 casualties per kilometre of power line per year) are reported from lines with multi-level arrangements, and with thin and low-hanging wires in sensitive areas.

Table 2 summarises impacts of power lines on different families of birds.[30]

Transmission line impacts are getting worse because of the need to build more transmission lines to support wind farms and solar installations. American Bird Conservancy have identified what they claim are the ten worst sites for bird loss following collision with wind turbines and their associated power lines.[31]

Mortality can be reduced with good design, and guidelines are available to help.[32] However, it may not be possible to design overhead lines that are more visible to some species of birds: a study[33] on three particularly vulnerable species – kori bustards (*Aerdeotis kori*), blue cranes (*Anthropoides paradise*), and white storks (*Ciconia ciconia*) – found that they typically look down while in flight. Therefore, the addition of tags, or reflective markers to make power lines visible are ineffective.

Power lines can also lead to changes in species composition by changing the behaviour of birds. Ravens in US sagebrush habitat were found to build their nests on electricity power line poles and use the height afforded to target their prey.[34] Raven numbers in the study area increased 11-fold between 1985 and 2009, and 58% of nests were located on transmission line poles. From their nests high above the sagebrush, the ravens have perfect viewpoints: the height gives both a greater attack speed and an easier take-off. They are able to use these advantages to attack the nests of greater sage grouse and prey on other endangered species including the San Clemente loggerhead shrike and the desert tortoise.

In some areas, the only acceptable approach may be to bury the cable; see effects of underground cables below.

Effects linked to the electric and magnetic fields

A magnetic field is created when electric current flows along a wire. According to various estimates, the upper limit to the magnetic field strength of an AC power transmission system varies from 10 to 50 μT. In the past, there was considerable concern about the long-term effects of magnetic fields linked to transmission lines on human health and animals. Some early studies suggested a link between transmission lines and diseases such as childhood

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29 http://www.birdlife.org/eu/pdfs/Nature_Directives_material/BHDTF__Position_Power_Lines_and_birds_2007_05_10_.pdf.

30 T-PVS / Inf (2003) 15 Protecting birds from power lines: a practical guide to minimising the risks to birds from electricity transmission facilities. D Haas, M Nipkow, G Fiedler, R Schneider, W Haas, B Schürenberg, 2003 and published under Nature and environment, No. 140, Council of Europe Publishing, March 2005

31 https://abcbirds.org/10-worst-wind-energy-sites-for-birds/.

32 T-PVS / Inf (2003) 15 Protecting birds from power lines: a practical guide to minimising the risks to birds from electricity transmission facilities. D Haas, M Nipkow, G Fiedler, R Schneider, W Haas, B Schürenberg, 2003 and published under Nature and environment, No. 140, Council of Europe Publishing, March 2005

33 Martin, G. R., and Shaw, J. M. (2010). Bird collisions with power lines: Failing to see the way ahead? *Biological Conservation*, 143(11), 2695–2702.

34 Coates, P. S., Howe, K. B., Casazza, M. L., and Delehanty, D. J. (2014). Landscape alterations influence differential habitat use of nesting buteos and ravens within sagebrush ecosystem: Implications for transmission line development. *The Condor*, 116(3), 341–356.

Table 2: Severity of impact on bird populations of mortality due to electrocution and collision with powerlines for the different families of bird.

Taxonomic group	Electrocution impact	Collision impact
Loons (Gaviidae) and grebes (Podicipedidae)	0	II
Shearwaters, petrels (Procellariidae)	0	I–II
Boobies, gannets (Sulidae)	0	I–II
Pelicans (Pelicanidae)	I	II–III
Cormorants (Phalacrocoracidae)	I	II
Herons, bitterns (Ardeidae)	I	II
Storks (Ciconidae)	III	III
Ibisses (Threskiornithidae)	I	II
Flamingos (Phoenicopteridae)	0	II
Ducks, geese, swans, mergansers (Anatidae)	0	II
Raptors (Accipitriformes and Falconiformes)	II–III	I–II
Partridges, quails, grouse (Galliformes)	0	II–III
Rails, gallinules, coots (Rallidae)	0	II–III
Cranes (Gruidae)	0	II–III
Bustards (Otidae)	0	III
Shorebirds/waders (Charadriidae, Scolopacidae)	I	II–III
Skuas (Sterkorariidae) and Gulls (Laridae)	I	II
Terns (Sternidae)	0–	III
Auks (Alcidae)	0	I
Sandgrouses (Pteroclididae)	0	II
Pigeons, doves (Columbidae)	II	II
Cuckoos (Cuculidae)	0	II
Owls (Strigiformes)	I–II	II–III
Nightjars (Caprimulgidae) and swifts (Apodidae)	0	II
Hoopoes (Upudidae) and kingfishers (Alcedinidae)	I	II
Bee-eaters (Meropidae)	0–I	II
Rollers (Coraciidae) and Parrots (Psittadidae)	I	II
Woodpeckers (Picidae)	I	II
Ravens, crows, jays (Corvidae)	II–III	I–II
Medium-sized and small songbirds (Passeriformes)	I	II

0 - no casualties reported or likely. I - casualties reported, but no apparent threat to the bird population. II - regionally or locally high casualties; but with no significant impact on the overall species population. III - casualties are a major mortality factor; threatening a species with extinction, regionally or on a larger scale.

leukaemia. No causal link has been proved and there is a growing belief within the scientific community that exposure to transmission lines magnetic fields is not responsible for human ill-health. There are also persistent beliefs that transmission lines can alter animal behaviour. For example, some anglers favour fishing under where power lines cross rivers, believing the fish move into this zone. However, there is no supporting scientific analysis.

Implantable medical devices can suffer from EMF interference. It is believed that the standard threshold of 1 gauss, below which no effect occurs, makes any impact unlikely as this is 5 to 10 times higher than the EMF produced by high voltage transmission cables.

Noise and light impacts

There may be noise and light disturbance during construction of transmission lines, but this is likely to be minor and short-lived. Noise will be generated by the construction equipment and vegetation cutting and logging. Transmission lines and equipment can generate an irritating humming noise, often linked to the mounting of the conductor. Crackles or hissing noises may occur in high humidity or when foam from waves is blown onto the lines.

Transmission line systems need transformer substations and these can produce noise pollution. It is generally assumed that transformer noise pollution is a nuisance rather than an ecological impact.

Chronic noise exposure is now recognised as an important ecological issue. Barber *et al.* (2010)[35] point out that noise creates masking: the inhibition of sound perception. Birds, primates, cetaceans and rodents have all been observed to shift their vocalizations to reduce the masking.

Agricultural land impacts

Transmission line pylons and other structure can cause the following agricultural impacts:

- hindering the manoeuvring of machinery and preventing efficient patterns of work
- increasing soil erosion
- creating opportunities for weed and other pests to invade
- compacting soils and damaging drainage
- producing safety hazards such as low-lying power cables
- hindering or preventing aerial spraying.

Wetlands impacts

The construction and maintenance of transmission lines can damage wetlands in several ways including the following:

- Heavy machinery can damage vegetation.
- Wetland soils, especially peaty soils, can be compacted.
- The construction of access roads can disrupt the natural drainage.
- Construction and maintenance activity can increase suspended sediment loads.

[35] Barber, J. R., Crooks, K. R., and Fristrup, K. M. (2010). The costs of chronic noise exposure for terrestrial organisms. *Trends in Ecology and Evolution*, 25(3), 180–189.

- Transmission lines can be collision obstacles to waterfowl and large birds such as swans and geese.
- Vehicles and construction equipment can introduce invasive plant species.

Woodlands

An electric transmission line right-of-way (ROW) is a strip of land used by electrical utilities to construct, operate, maintain and repair the transmission line structures. Building a transmission line through woodlands generally requires the clear felling of all trees and brush from the transmission path. The width of the cleared zone will vary with the size of the transmission lines and the voltage. For a 330 kV transmission line the ROW width would typically be about 40 m. Under this regime a 1-km stretch of line results in the loss of 40,000 m^2 (4 ha) of forest.

Transmission construction impacts can include forest fragmentation, and the risk of biodiversity loss. The ROW creates an additional, very extensive, forest edge, allowing forest-edge plants and animals to invade the interior.

Underground electric transmission lines

It is a common practice in residential areas to place low-voltage distribution lines underground. While this practice may reduce aesthetic and other impacts, it may increase others. For example, damage to tree roots resulting in tree death frequently occurs. High-voltage transmission lines differ from lower-voltage lines in that above ground structures are necessary to support the underground cable.

Underground transmission lines can have the following disadvantages:

- an increase in the area of environmental disturbance
- the complete removal of small trees and brush along the transmission row
- increased construction and repair costs
- increased operation and maintenance costs.

They may also increase the costs of transmission if the lines need to be cooled.

Decommissioning and recycling of wind turbines

It is often assumed that wind energy is a clean renewable energy source without any adverse emissions. However, this is does not fully consider the construction and decommissioning phases. For example, the blades, one of the most important components in the wind turbines, are now made of unrecyclable composite.[36] 43 million tonnes of blade waste may be produced worldwide by 2050, with China handling 40% of the waste, Europe 25%, the United States 16% and the rest of the world 19%.

What method of generation is best?

I have briefly reviewed the main environmental concerns linked to the use of wind turbines. Similarly, extensive lists of issues could have been compiled for other large-scale electrical

[36] Liu, P., and Barlow, C. Y. (2017). Wind turbine blade waste in 2050. *Waste Management*, 62, 229–240.

generating methods; there is no approach to electrical power generation which will always minimise harm and is always the outstanding choice. The generating method of choice will, in part, be determined by the location and the relative vulnerabilities of the habitats present. If the region is home to a population of large aquatic birds, then wind farms may be disastrous. Conversely, if there are local natural gas supplies and it is possible to place a gas turbine on an industrial estate at the edge of town, this may be an ideal solution, particularly when combined with household solar PV and thermal panels. However, even efficient gas-fired plant releases appreciable quantities of carbon dioxide, which some would view as unacceptable if global warming is to be reduced.

A local power plant has the great advantage that power losses in transmission are minimised and animal and plant losses linked to transmission lines are eliminated. There is also the possibility of increased efficiency from combined use of heat and power. It is particularly important not to simply view renewable technologies as intrinsically less damaging to our environment. They may reduce carbon dioxide emissions, but if they cost us the loss of the large raptors or migratory fish, renewables will not be the best course to follow. Similarly, there seems no future in biomass production, except on a small scale to utilise agricultural waste products. Wood chip is a waste product of the timber industry, but the demand for wood chip is such that there is a danger that its use for energy generation will result in deforestation. One direction of travel is clear: we need to use electricity as efficiently as possible and technological advances are making this possible. All methods of generation have environmental costs, so any reduction in the amount generated will reduce environmental harm. There is also considerable merit in improving the thermal efficiency of our houses and fitting them with solar PV and thermal panel water heating systems. While large-scale solar plant will create environmental damage to some extent, there is much environmental merit in small-scale PV generation, providing the manufacturing and recycling can be efficiently undertaken. It is particularly important that we take a precautionary approach to recently developed renewable technologies. I cannot help feeling that the enthusiasm for wind turbines is a little like our previous enthusiasm for DDT. This miracle insecticide seemed to offer man huge advantages; the disadvantages only became gradually apparent as it passed up the food chains and the loss of top predators began to be noticed. Similarly, tidal and wave generators should be viewed as potential technologies with unknown ecological downsides.

We are presently living in a period of rapidly changing and developing technologies for the generation of electricity. It seems unlikely that some technologies, such as nuclear and coal-fired plant, will continue to be widely developed or built. The huge 3200 MW Hinkley C power plant now starting construction in England at a cost of more than £25 billion, with exceptional guaranteed subsidies, has all the hallmarks of a late grand gesture. Like the last few battleships, it is the final flowering of a soon-to-be-irrelevant technology. However, power plants last for upwards of 60 years, so major changes in the pattern of power generation can only be observed over a generational time period. We will therefore all see a vast range of technological approaches in use for the foreseeable future.

The only rational approach is to step lightly upon the Earth and use our energy resources carefully and sparingly while carefully recording ecological changes linked to the operation of the various generating methods.

Wind power and birds of prey: problems and possible solutions

Oliver Krüger, University of Bielefeld

About the author

Oliver Krüger is Professor of Animal Behaviour at the University of Bielefeld in Germany. His research focuses on life history strategy evolution – the way natural selection optimises the entire life of an organism.

In this paper, I will explain how to move from the search for windfarm collision victims to assessing the effects at population level. That is not an entirely trivial process. But once you see how we do it, you can see that we can potentially draw some conclusions. Again and again we hear that there are problems with birds of prey. That is true, but there are also successes. The growth of bird of prey populations in recent years is a very, very great conservation success story and thanks are owed to the many conservation organisations who have helped make this happen.

As an example, consider the data on birds of prey around Bielefeld, in Westphalia (Figure 3). We have data on the buzzard in this area from 1989 and the trend is clear: it's going upwards. The data for the goshawk goes as far back as 1975 and is very similar. The red kite is now slowly discovering Bielefeld too. Here the data is still a little thin, but you can see that overall, over the last 30 years, the trend has been upwards. The eagle owl had disappeared in the Teutoburg Forest, but was reintroduced and has now reestablished itself. Its population is now growing.

In this respect, we could now theoretically end the lecture and say 'There is no problem', because – at least in Bielefeld – everything is fine; the population is growing. But there is another story. On three sites in Schleswig-Holstein that are monitored by a colleague of mine, the number of buzzards has decreased by 75% over the last 20 years. Some say it is because the fields are being converted to maize monocultures. Others think it is something to do with wind energy, and Schleswig-Holstein certainly has a great deal of wind power. This is possible, but I don't know, and neither does anyone else.

We know of several species that are adversely affected by wind energy: griffon vultures, sea eagles and golden eagles, for example. Bird collisions with wind turbines are often seen as a major nature conservation problem. The Norwegian town of Smola, for example, has a large population of sea eagles. Nevertheless, a wind farm was built there. Norwegian ornithologists warned against this, but their advice was ignored. In the last 16 years, more than 60 sea eagles have collided with the turbines. A classic example of 'We told you so'.

The Altamont Pass in the USA is another example. The location is significant because large numbers of golden eagles pass through it. Again, despite the warnings of ornithol-

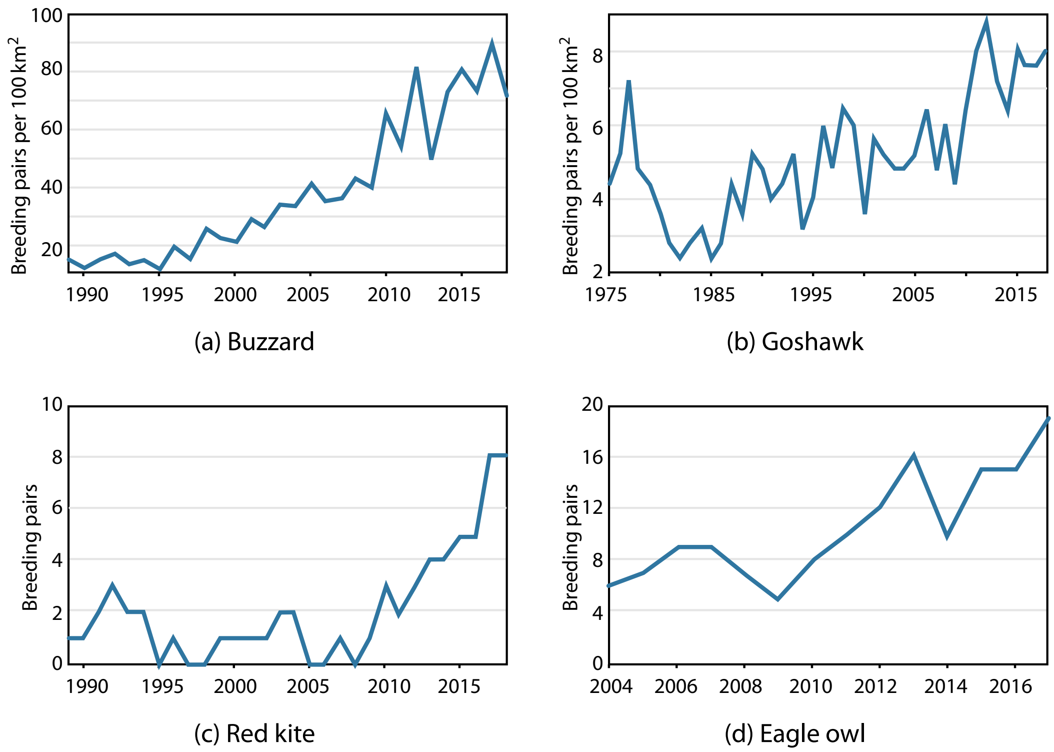


Figure 3: Bird of prey population trends for Bielefeld.

ogists, a wind farm was built, and now, every year, between 75 and 110 golden eagles are killed in this one location.

Figure 4 shows the number of onshore wind turbines in Germany for the last 18 years. There has been a tripling. There are now 29,000 of them and they will not disappear. Indeed, there will be more. This means that we are dealing with a problem that we have to research, that we have to understand better in order to develop solutions.

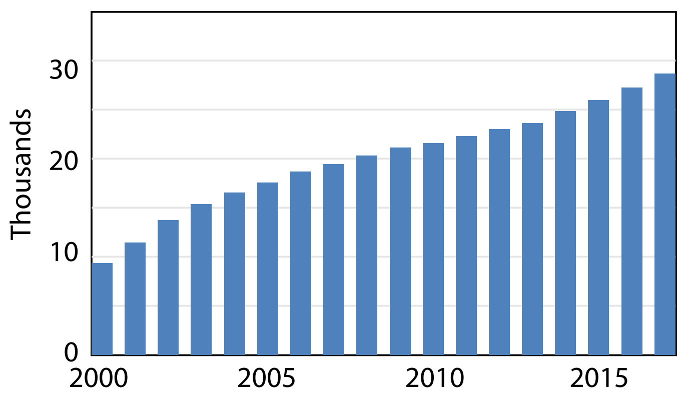


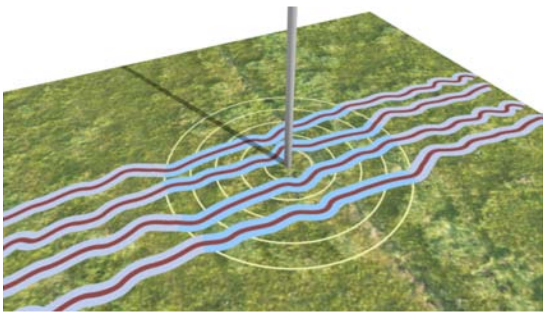
Figure 4: Wind turbine numbers in Germany, 2000–2017.

How do you determine the number of birds killed by each turbine? The area that has to be searched around each turbine is 3–10 hectares. Your immediate reaction might be to think you can search that area quite quickly, but there are 365 days in a year and 29,000 wind turbines. And even if you had the resources to search under all of them there would still be obvious sources of error. On the one hand, there is the search rate: you don't find every bird that has collided with a turbine. And there is the erosion rate too: even if you could find every corpse in theory, many would no longer be there by the time you came to look: scavengers get to work quickly.

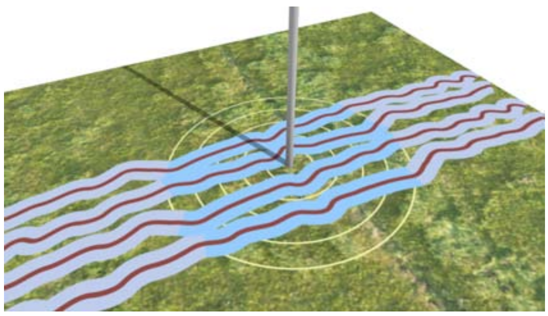
So preparing a meaningful estimate is not trivial. Nevertheless, this is what we have attempted to do in the PROGRESS project, in which I played a small part. It is the largest research effort ever undertaken into collision rates.

Forty-six different wind farms in Germany were considered. Some were examined more than once, so in total 55 wind farm datasets (termed 'seasons') were recorded. Each season involved visiting the windfarm on twelve separate days; once a week over a three-month period. Maize and grassland sites were visited only in spring, but sites in cereals areas were also visited in autumn.

The research approach was a so-called line-transect sample. One can complain a lot about such studies, but we did not make it easy for ourselves. In total, the research team walked more than 7,600 km under wind turbines in order to obtain the data. Moreover, there were 12,800 wind turbines in the study area, about half of the total German wind fleet at the time. You can see in Figure 5 what a line transect search is: you walk under the wind turbine along the transects and you try to find the birds – the collision victims – in the blue areas within the search circle. Small birds, like skylarks, are harder to see, making the transects effectively rather narrow (Figure 5a). With large birds, like eagles, the transect is effectively wider (Figure 5b).



(a) With small birds the transect is effectively rather narrow



(b) With larger birds the transect is effectively wider

Figure 5: How the effective size of a line transect changes with species.

All of the transects taken were tracked with GPS, and all of the variables were recorded to make the research reproducible. As you can imagine, there was pressure from all sides, so it was very important to make everything reproducible. It remains to be seen whether we succeeded.

You always have to make assumptions in a study. If you find a dismembered golden plover under a wind turbine, it is clearly a collision victim. But if you find a large pile of feathers, it is not clear whether this represents a collision victim that has been scavenged, or a bird that was killed in some other way. It is debatable. Based on the literature, we assumed that all finds in the search circle were collision victims. But it is clear that this assumption is a potential source of error.

If you find evidence of a victim, you then have to extrapolate this information. For example, you need to apply a correction factor to account for the fact that not every collision victim will have been found. One reason for this is that you can only search a fraction of the area underneath the wind turbine. Another correction is required because the monitoring teams will simply miss some of the corpses: this is easily done depending on the vegetation type beneath the turbines. To address this problem, we carried out experiments on search efficiency. A total of well over 100 bird cadavers were placed around a wind turbine, and then we assessed how many of them our teams located. So for the first time we were able to derive a meaningful correction factor for search efficiency.

Another possibility is that birds disappear before they are found because they are removed by scavengers. So experiments were performed to allow us to assess this factor too. We carefully laid out bird carcasses around turbines, and then repeatedly visited them to see how quickly they were removed. In this way we are able to determine, or at least estimate, for the first time the probability of finding a collision victim five days after a collision.

This work has given us for the first time experimental backup to underpin the correction factors we need. Let us now look at the findings. After walking nearly 7700 kilometres we found 291 collision victims, a rather small number. However, as you know, this is almost certainly just a fraction of the true death toll and so we have to extrapolate.

Figure 6 shows the results of the PROGRESS study and, in particular, the distributions of birds observed alive and those found dead. This was a very important part of the research: we now know what birds were in the vicinity of these wind turbines, and we know what corpses were found. So we know that there are groups of birds that are disproportionately affected by collisions. We can see, for example, that birds of prey and geese account for two percent of all observations, but almost one third of all finds. This indicates that birds of

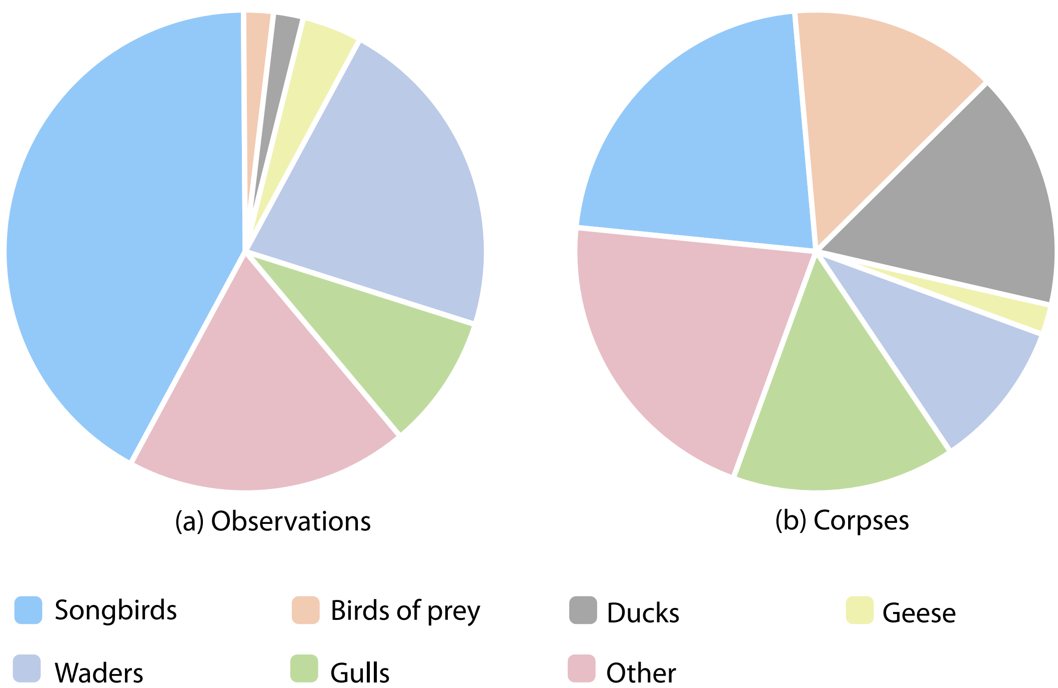


Figure 6: PROGRESS study results.

prey and ducks are disproportionately endangered by collisions with wind turbines. On the other hand, 42% of the observations were songbirds. However, these accounted for only 22% of the collisions. So this is a first quantitative estimate of whether the collision risk is proportional to the frequency or not. And there is a clear conclusion: especially for birds of prey, but also for ducks, the collision risk is much higher than would be expected from the frequency of observations.

The results from the PROGRESS study can be compared to the so-called Dürr list, a dataset of bird cadavers recorded for Brandenburg (Table 3). There are some overlaps: the buzzard is at the top of the Dürr list, and in third position in our study. Mallard duck, wood pigeon, black-headed gull are in both lists. But there are also differences: the Dürr list contains more sea eagles, perhaps because it was not systematically compiled. Anyone who finds a sea eagle also reports it, but they would be less likely to do this for a dead starling. I believe that both data sets have problematic aspects, so we should use them both with care, but there are parallels, so they do not seem to be entirely meaningless.

Table 3: Comparison of the Dürr list and the PROGRESS study.

Dürr list		PROGRESS	
Buzzard	514	Wood pigeon	41
Red kite	398	Duck	39
Duck	185	Buzzard	25
Wood pigeon	171	Black-headed gull	18
Black-headed gull	170	Starling	15
Swift	147	Herring gull	12
Sea eagle	144	Lapwing	12
Kestrel	119	Golden plover	10
Herring gull	118	Skylark	10
Goldcrest	111	Pigeon	9
Skylark	104	Lesser black-backed gull	8

With these data in hand, it is simply a matter of extrapolation from the cadavers found to an estimate of the number actually killed in the twelve-week monitoring period, and from there to the impact rate: the number of each species killed per turbine per year. We can also derive an estimate of how certain we are with our numbers, information that is of central importance for the population estimates. Some of the impact rates are shown in Table 4.

On the basis of the PROGRESS data, we estimate a median collision rate of 0.47 buzzards or 0.14 red kites per wind turbine per year. Now you may be thinking that is nothing, but of course we have to recall that there are many wind turbines. You also have to take into account the probability of survival and the life cycle of birds of prey. We do this in so-called matrix models. This is a female-specific model, which means that we halve these rates because we follow the development of the population and only look at the females. This is no problem at all with birds of prey, because they are long-lived and monogamous.

Consider the life cycle of a bird of prey. From when it is a chick, it has, each year, a certain probability of surviving until the following year, and a different probability of reproducing. You can simulate changes in the population of this species taking these two factors into account. However, in the presence of wind turbines, the probability of surviving to the follow-

Table 4: Impact rates for selected species.

Species	Impact rate (Collisions/turbine/year)	
	Median	Confidence interval
Buzzard	0.471	0.142–0.909
Red kite	0.141	0.005–0.458
Sea eagle	0.038	0.000–1.373
Lapwing	0.649	0.170–1.299

ing year is reduced due to collision deaths. It is then relatively straightforward to estimate what might happen to the overall population.

Figure 7 shows the effects of different levels of windfarm-caused mortality on three different simulated red kite populations. In each case the blue line is the expected population trend without any windfarm effect, while the red line indicates the most likely effect of the presence of windfarms, and the shaded area represents the confidence interval. In Figures 7a and 7b, the most likely scenario is for a growing population to be tipped into decline, while Figure 7c suggests that a population that is already struggling could quickly be wiped out.

In almost all scenarios, if we extrapolate and simulate the status quo of 2015 wind turbine mortality, the average population of the Red Kite will decrease. As you can see, however, we are uncertain and other outcomes are possible.

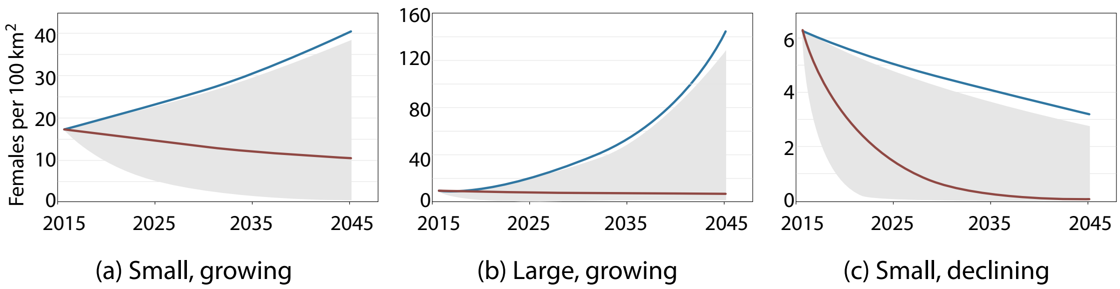


Figure 7: Effect of wind turbines on red kite populations.
The best estimates (red) are determined by a collision mortality rate of 0.07 per turbine. The confidence intervals are between 0.003 and 0.21 collisions per turbine. The blue line is the baseline, with no wind turbine collisions.

What about the buzzard? Figure 8 shows similar data for four separate populations of this species (see also location map in Figure 9). In Bielefeld, Altenpleen, and Danish Wahld (Figure 8a–c), the populations should be increasing, but the mostly likely effect of the presence of wind turbines is to push it into decline. In Rathenow (Figure 8d), where the population is slowly decreasing, wind energy mortality may cause serious problems.

In summary, and allowing for all the uncertainty that arises from the many assumptions that such a model has to make, the most likely scenario is that wind turbines will have a population-relevant effect on the buzzard and the red kite.

Are there ways to mitigate these problems? I believe there are. The placement of wind farms is one important factor that needs to be examined: expert opinions and maintenance

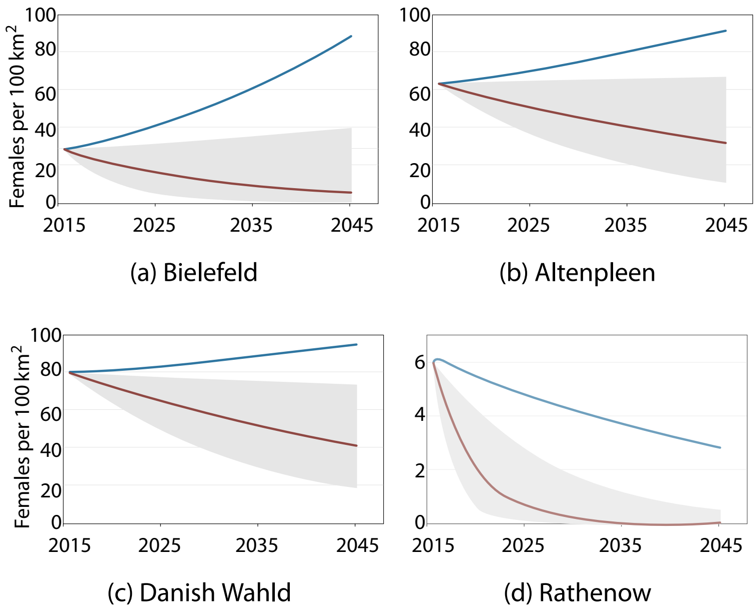


Figure 8: Effect of wind turbines on buzzard populations.
The best estimates (red) are determined by a collision mortality rate of 0.217 per turbine. The confidence intervals are between 0.0663 and 0.42 collisions per turbine. The blue line is the baseline, with no wind turbine collisions.

Figure 9: Map of Germany showing locations mentioned in Figure 8.

of setback distances are important and well known factors. Then there is the so-called micrositing: the arrangement of turbines in a wind farm. Here, too, one can perhaps do something to reduce collision rates. Plant characteristics, such as heights and diameters, are important here.

Other issues include avoidance of attraction. For example, it is important to consider when to mow grass underneath the turbines, because mown areas are very attractive to the red kite. It is common to set up alternative feeding sites for red kites, to lure them away from the turbines, but I am not aware that anyone has scientifically tested whether these actually work in practice.

One idea that is being researched is remote detection: colleagues at the Swiss Ornithological Institute and others have developed a system called 'DtBird', which uses either cameras or radar to detect birds. Machine learning algorithms now allow birds of prey to be recognised at distances of two or three kilometers, so they can now be scared away or the turbines shut down. These systems are currently being tested and early results suggest there is a clear reduction in the number of near misses, but much more testing is required.

Another possibility is to increase the start-up speed. This means that a turbine only starts to run when there is a little more wind. In the case of bats, there is a major study which shows that with a small increase in the start-up speed, the mortality rate at the wind turbine can be reduced very sharply without significant economic losses. This should also be considered.

A more bird-friendly control system for wind turbines might help too. At the moment, many wind farms have a strict annual shutdown imposed during the nesting period. Their operators are obviously unhappy about this, and conservationists are also unhappy, because they don't want to have a wind turbine there at all. Differentiated algorithms can be developed. Bird of prey flight activity is not random; there are parameters. With sufficient data, it might be possible to design an intelligent control system that could limit shutdowns to the periods when birds of prey were most active.

We should also investigate the effects of repowering. We have not been able to find any meaningful parameters in the data: there is no correlate of the collision rate with plant height, rotor diameter, micrositing or macrositing. The variance in the collision rate that these factors can explain is zero. In other words, collisions are simply rare stochastic events that cannot simply be reduced by changing the layout, location or other characteristics of windfarms. If this is the case, one has to consider reducing the number of turbines by installing bigger ones. It would also give a chance to reassess local conditions. For example, since the original construction, a red kite population might have established itself in the area. This means that we have both opportunities and risks when repowering, so I think we should look carefully at this possibility.

So what about birds of prey and wind turbines? You can see it pessimistically and say that the prospects looks dim, or you can hope that we can find a way for birds and windfarms to coexist. I think we have to try. Wind energy will not disappear – this is not a particularly daring prediction – so we should sit down and try to reconcile the objectives for wildlife and the objectives for renewable energy.

Wind energy in forests and species conservation: vision and reality

Klaus Richarz, Bundesverband Wissenschaftlicher Vogelschutz

About the author

Klaus Richarz spent 33 years as a full-time civil servant in nature conservation, and was, until his retirement, in charge of the State Bird Sanctuary for Hessen, Rheinland-Pfalz and the Saarland.

Introduction

In this paper, I will focus on the development of wind energy in forests and the incorporation of nature and species conservation in the planning process and in the operation of the wind turbines. As I was also active in nature conservation on a voluntary basis during my working career, and I am still chairman of the Federal Association for the Science of Birds[37] and managing director of the Bat Conservation Association of Hesse,[38] my examination of wind energy use is from the perspective both of a nature conservation administrator, with a legal responsibility to take nature conservation into account, and that of a committed citizen who has always also taken the protection of our wild animals very seriously.

The construction and operation of wind power plants always involves interference with nature in the sense of the German Federal Nature Conservation Act. In order to mitigate these conflicts, there are guidelines issued by the competent nature conservation ministries of the federal states, which require nature conservation concerns – in particular of birds and bats and protected areas – to be taken into account in the planning, construction and operation of wind turbines. I was involved in preparing some of these for the bird protection agency for Hessen, Rheinland-Pfalz and the Saarland.

These guidelines not only reflect the current state of knowledge of the conflict between wind power and birds and bats, but also the political objectives of the individual states regarding wind energy. In the following it will be shown, by means of examples, that in the planning of wind turbine generators (WTGs):

- Technically sound knowledge for the minimisation of killings, disturbance or habitat loss is not always taken into account to a sufficient extent.
- There are examples of inadequate methodological procedures, with key parameters not being recorded.

37 Bundesverband Wissenschaftlicher Vogelschutz (BWV) e.V.
38 Arbeitsgemeinschaft Fledermausschutz Hessen.

- Generally recognised hazard causes are called into question or trivialised by wind turbine operators.
- Some data required for an assessment of the effects of wind turbines on certain species and their habitats remain unavailable.

Expansion of onshore wind energy in Germany

At the end of 2018, 27,291 onshore wind turbines were in operation in Germany (Table 5). In several federal states – Baden-Württemberg, Bayern, Brandenburg, Nordrhein-Westfalen, Rheinland-Pfalz and Hessen – WTGs can be built in forests. Elsewhere in Germany, the laws and regulations are different and such developments are not permitted. But across the country, wind energy in forests is still extremely controversial.

Table 5: Wind turbines in German states.

State	Number of turbines
Niedersachsen	6,305
Brandenburg	3,821
Nordrhein-Westfalen	3,661
Sachsen-Anhalt	2,862
Mecklenburg-Vorpommern	1,920
Rheinland-Pfalz	1,748
Bayern	1,161
Hessen	1,159
Sachsen	899
Thüringen	859
Baden-Württemberg	725
Saarland	207
Bremen	91
Hamburg	65
Berlin	4

According to data compiled by the onshore wind energy agency, 1522 wind turbines were in operation in forests in Germany at the end of 2016, representing 5% of all wind turbines at that time.[39] In that year, there was a record increase of 379 new WTGs in forests. Although WTGs in forest locations are concentrated in southern and western Germany, this has little to do with the proportion of forest in these states. Regulation and the objectives of state policymakers are the main drivers.

The conflict between birds and wind turbines in forests

Wind turbines can affect breeding birds in two ways. Some species, such as black storks, are very sensitive to their presence, and disturbance (within the terms of the legislation) can occur. For other species, such as the red kite, there is an increased risk of collision and mortality.

39 FA Wind 2017.

On the other hand, the Birds Directive and the Habitats Directive attempt to protect species that are endangered or otherwise considered worthy of protection, for example the black stork, the red kite and the barbastelle bat.[40]

In 2007, in an attempt to mitigate the conflict between birds and wind energy, the Working Group of the Federal States published the so-called *Helgoland Paper*, which contained recommendations on minimum setback distances and requirements for test breeding sites for wind-sensitive bird species and important bird habitats.[41] A revised version, supported by numerous species-related study results, was delayed for several years due to interventions by wind power operators, who feared that it might hamper the expansion of their industry. It only appeared in 2015.[42] As soon as it was published, legal opinions on its relevance for official action were obtained from renowned jurists. Some concluded that it was only a contribution to the technical discussion,[43] the use of which was optional, but others saw it as representing a technical hurdle that would be hard to overcome.[44] Subsequently, however, it has been recognised as a technical assessment standard in a decision of the Bavarian Administrative Court.[45] So now, in Bavaria at least, the setback distances previously in use[46] have been superseded by those in the Helgoland Paper of 2015.

So even if views on the legal status of the Helgoland Paper differ, and despite it being repeatedly challenged by parts of the wind power lobby with questionable 'scientific' evidence, its technical relevance has been confirmed by the Bavarian Administrative Court. And the fact remains that the species-specific collision risk at WTGs of red kites and buzzards is so high that the losses for these species are endangering the population:[47] it is no longer just a question of a significantly increased risk of killing individual birds; it is now about survival of whole populations. Moreover, it is not possible to rule out similarly serious impacts on other bird of prey species; even for the past expansion of wind energy, population-relevant losses may occur due to cumulative effects.[48]

The reasons for the high mortality of red kites at wind farms are as follows:

- The birds do not perceive WTGs as a danger.
- Birds scavenge corpses of other birds beneath the turbines, putting themselves at risk in the process.
- Densities of small mammals around the feet of WTGs may be high.
- In some areas in May and June, windfarms can become the only hunting grounds in the open country that are accessible – and thus preferred – to red kites.

The minimum setback distance between wind turbines and breeding sites for red kites as recommended by the Helgoland Paper is 1500 m. This is by no means too high, as demonstrated by the activity patterns of eleven breeding birds recorded in Hesse. During the breeding season, the birds spent 75% of the time within a radius of 2200 m of the nest. WTGs in this area would thus have led to a significantly increased risk of death.

40 *Barbastella barbastellus*.
41 VSW LAG 2007.
42 LAG VSW 2015.
43 Brandt 2015.
44 Schlacke and Schnittker (2015).
45 17 March 2016 (Ref. 22 B 14.1875 and 22 B 14.1878)
46 As set out in the *Windkrafterlass Bayern* of 20 December 2011.
47 See Krüger 2019.
48 See article by Krüger.

The setback distances in the Helgoland Paper are dependent on the species involved, the habitat and technical considerations. Distances and species as defined in the Federal Nature Conservation Act[49] and individual federal states can be very different. Before the Federal Nature Conservation Act, the bird species considered wind-sensitive were by no means the same across the federal states. In some states, the precautionary principle is completely abandoned and the distances to wind turbines are made dependent on the results of individual case studies. The land-use analyses carried out for this purpose are often methodologically inadequate and/or not standardised.

In addition, some wind power operators have repeatedly questioned the proven risks for birds at wind turbines by conducting their own investigations or by reinterpreting data. One example is the current paper by ABO-Wind entitled 'Peaceful coexistence of wind energy and black stork – stable populations/collisions extremely rare/exorbitant distance recommendations unfounded'. However, this attempt to trivialize the problem cannot withstand a fact check. The population of black storks in the Vogelsberg bird sanctuary – the most important site for this species in Hesse – decreased from 13 or 14 breeding pairs in 2002 to only five in 2017 alongside a simultaneous increase of 178 WTGs. In contrast, the black stork population in the other Hessian regions has been stable or only slightly declining.[50] Even though the rapid expansion of wind energy is not seen by nature conservationists as the only reason for the rapid population decline in Vogelsberg, it should be noted that breeding success for this species increases with longer occupation of a breeding site; disturbances of any kind lead to shorter, and not infrequently single use of a hatchery, and thus a significantly lower average number of hatchlings.

The conflict between bats and wind turbines in forests

The importance of forests for bats is undisputed. For almost all of our bat species, forests are indispensable as reproduction/resting places and/or hunting habitats. The number of bat species increases with the age and size of the deciduous and mixed deciduous forests. With regard to the conflict between bats and forests and WTGs, Eurobats – a UN-sponsored coalition of 35 countries, which monitors bat populations – clearly states in its revised *Guidelines for the Consideration of Bats in Wind Energy Projects*:[51]

> Because of the high risk of fatal accidents and the serious impact on habitats for all bat species, wind turbines should not be installed in all types of forests or within a 200 m radius...Older deciduous forests are the most important bat habitats in Europe, both in terms of biodiversity and number of individuals, but young forests or coniferous forest monocultures can also have considerable bat fauna...In the case of wind farms built in forests, it is often necessary to cut down trees to level the ground for the construction of wind turbines and to lay out the infrastructure. This can possibly lead to a considerable loss of roosts. The resulting increase in forest edge habitats also improves the opportunities for bats to feed...which in turn could lead to an increase in bat activity near wind turbines, thus increasing the risk of barotrauma victims. In addition, such major habitat changes reduce the effectiveness of pre-construction studies in predicting likely effects on bats' development.

49 Section 44.
50 Between 2006 and 2014, the number of black stork breeding pairs in Hesse decreased by 1–3% per year.
51 Rodrigues et al. 2014.

Since the use of wind energy in forests has long ceased to be a taboo in our country, and bat collisions with wind turbines outside forests are a serious problem, methods to investigate and reduce the collision risk have been and are being developed and tested on behalf of the Federal Environment Ministry in research projects.[52]

A research project of the federal nature conservation agency[53] found that the most important measures to prevent loss of habitat were to avoid building windfarms:

- in old deciduous and mixed forests with a population age of more than 100 years
- in near-natural coniferous forests with a high roosting potential
- in protected areas[54] where the conservation objectives of bats could be impaired.

It recommended at least a small-scale relocation of the wind turbine sites in order to avoid affecting actual and potential bat roosts within the radius of action of the respective species. In addition, a non-invasive buffer of 200 metres around all roosts identified in preliminary investigations was recommended. To compensate for the loss of bat habitat it is proposed to leave unused elsewhere an area of forest up to five times as big.

For the barbastelle bat, as a particularly endangered forest species, the project found:

- On the basis of the results from three very different habitats, as a rule, there is no deadly danger of collision.
- This does not apply to very low turbines whose rotor blades clear the ground or the tree tops by less than 50 metres.
- Very intensive monitoring and appropriate mitigation measures are required for the barbastelle bat and other species in order to avoid an increased risk of collision.
- Due to the demanding habitat requirements of the barbastelle bat, the construction of wind turbines should be avoided in areas with high levels of actual or potential roost sites.

In Hesse, the 1-km setback distance around barbastelle bat roost sites still applies to WTG planning. However, even in current procedures, the often problematic 200-m protection zone around proven roost sites is used. Not all experts have the technical prerequisites and the field experience to be able to record all barbastelle bat roosts in an area.

The project formulates further research needs:

- Can habitat use be better determined by finer structural parameters?
- What is the influence of insect availability/density on the height at which bats fly?
- How far do bats fly from the edge of the forest?
- How high must the roosting densities of the individual forest bat species be to maintain populations?
- What is the impact of roost losses on populations?
- What habitat changes lead to abandonment of roosts?
- What should the setback distances between WTGs and neighbourhood trees be?
- How well are different nesting aids and their locations accepted by bats?

52 See RENEBAT i-III.
53 Hurst et al. 2016.
54 Natura 2000 areas.

- Can the population parameters of bat populations be determined more precisely?

In a recent study, scientists from the University of Trier investigated the extent to which guidelines improve the quality of expert input about bats in the planning of wind turbines.[55] Their conclusion was sobering: although the 156 expert opinions examined only achieved a score of 80% in terms of the quality of the recording methodology and evaluation level used, all were accepted by the planning authorities for project approval. None of the expert opinions led to a rejection of the planned WTG. There is therefore an urgent need to supplement the guidelines and to train those involved in project approvals: project sponsors, authorities and technical experts.

It has been suggested that switch-off algorithms for WTGs might reduce or prevent bat collisions, especially in areas with high activity and simultaneously high species diversity. In my opinion, it is not clear whether these can meet the requirements of nature conservation law, since bat calls will be drowned out by the rotor volume of large modern wind turbines.[56]

Gaps in approval procedures

In general, the following problems can arise when dealing with species protection in the context of the approval procedures for WTGs:

- Pre-construction assessments that collision risk is low are not very reliable, as the scope and quality of the basic investigations is usually insufficient.
- Setback distances are increasingly being undercut with the aid of 'avoidance measures'.
- Cumulative effects are not taken into account in the procedures.

As a result of these trends, exceptions are gradually becoming the rule. Despite an improved legal situation, impacts on population levels are therefore becoming more likely.

High growth in WTGs in forests – major deficits in the designation of natural forests

It remains to be seen whether there will be an increase in wind turbines in forests in future. The proportion of forest land that can be used for wind turbines outside protected areas amounts to 4% of the total area of Germany.[57] This corresponds to 13.6% of the total area of forest in Germany. On the other hand, there is still a lack of reliable data on the impact of wind turbines in forest locations on some bird species and groups during the breeding and rearing periods. The effects of wind turbines on forest-dwelling bat species, especially at population level, are also incomplete. In addition, the National Biodiversity Strategy's target of returning 5% of forests to nature by 2020 is being missed. Only 2.3% will be achieved by 2020, and up to 3% in the long term. A total of 2% of natural forests is still too little, corresponding to a forest area of just 223,000 hectares.

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[55] Gebhard *et al*. 2016.

[56] Runkel & Gerding (2016).

[57] Fraunhofer IWES (2011).

Time to take a break?

The German onshore wind agency, FA Wind, has concluded:[58]

> Wind energy in the forest will continue in the near future. The use of forests continues to require special sensitivity with regard to the possible effects of wind turbines on forest-dwelling species, the balance of nature or the landscape. The scientific findings in this area are still incomplete. In order to ensure a natural and environmentally compatible expansion of wind energy at forest locations, existing knowledge deficits must be eliminated. There is still a great need for research in this area.

The problems with wind energy in forests, as shown in the assessment of FA Wind, raise the question of whether it is necessary to pause for a moment to consider the changes that are required to properly mitigate conflicts between nature and wind energy. This question is of course rhetorical: we should have long ago suspended the further expansion of wind power in the forest and made it dependent on having a robust scientific understanding of the actual impacts on species and their habitats, and the development of practical prevention measures.

58 FA Wind (2017)

Wind energy in Ireland

Paula Byrne, Wind Aware Ireland

About the author

Paula Byrne is the public relations officer for Wind Aware Ireland, an alliance of 50 community groups in 22 counties in Ireland. Wind Aware campaigns for a moratorium on wind energy projects and the associated grid infrastructure in Ireland. Wind Aware is a voluntary organisation, with no funding or political allegiances.

Four case studies

This paper presents four cases where the environment is impacted negatively by either wind energy, or the associated grid infrastructure. There is state involvement in a lot of these developments, and this is part of the problem in Ireland. So, these bodies – the state forestry company, our electricity supply board, our transmission group, and even the planning body itself – are problematic. The paper also summarises a new study on songbirds, which has come from an Irish academic group.

The four case studies are:

- Ratheniska, a planned electricity substation in County Laois
- Cullenagh windfarm, which is my own local wind farm proposal
- Meenbog wind farm in County Donegal
- Keeper Hill wind farm in County Tipperary.

Their locations are shown in the map in Figure 10. Before beginning, there are a few terms that need to be defined:

> *Natural Heritage Area (NHA):* an area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection.
>
> *Special Area of Conservation (SAC):* prime wildlife conservation areas in the country, considered to be important on a European as well as Irish level. The legal basis on which SACs are selected and designated is set out in the EU Habitats Directive.
>
> *Areas of Special Scientific Interest (ASSI):* This is an assignment used in Northern Ireland rather than the Republic but it is relevant later on.

Ratheniska substation

Ratheniska is in County Laois, in the Midlands of Ireland. The name Ratheniska comes from the Irish word 'uisce', which is 'water'. So it means: 'The Fort of the Water', and is the site of an aquifer that has always been important locally (Figure 11). The water that comes from this

Figure 10: Location of the case study sites.

aquifer flows into an SAC called the Timahoe River. It fills seven reservoirs and supplies about 10,000 domestic users, as well as schools, businesses and so on. Ratheniska is surrounded by areas of something called tufa, which is a very soft limestone that forms because of water flowing over peatland. The tufa is sensitive to changes in the chemical composition of the groundwater, and the flow itself. The material itself is protected, but because the site itself is not in a special area of conservation, in reality the protections are meaningless.

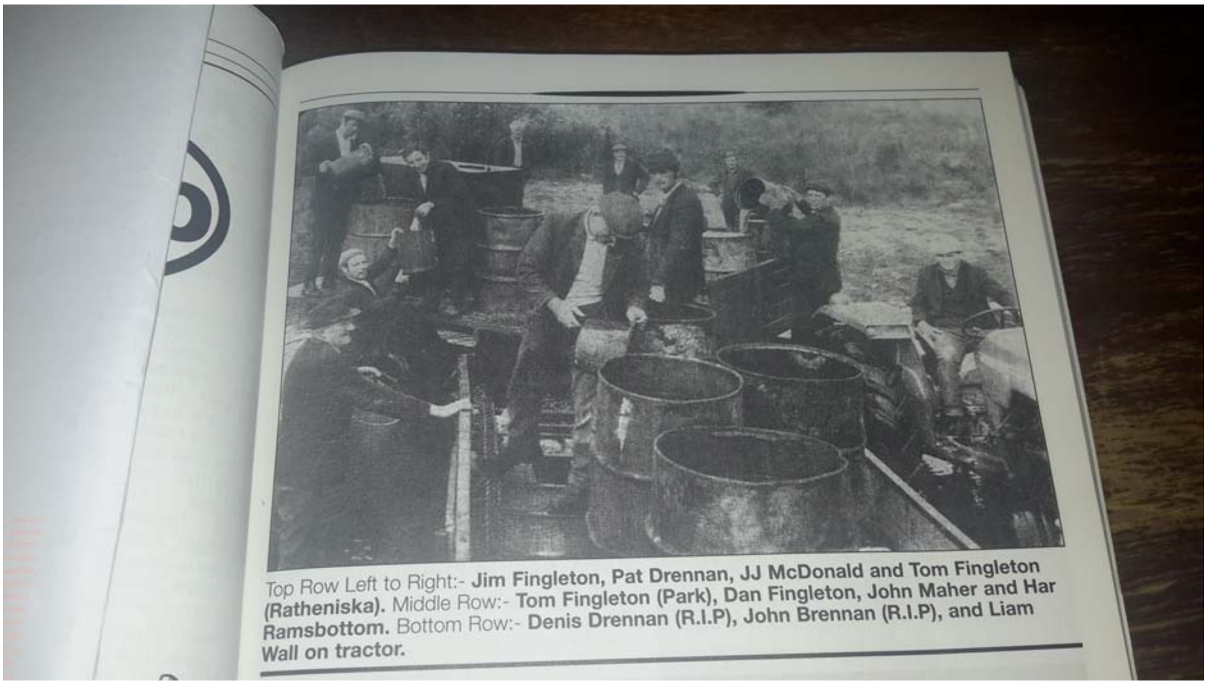

Figure 11: Collecting water from the Ratheniska aquifer.
This is a picture taken around 1968 of some of my husband's predecessors: his grandfather, I think, is in there somewhere, where people were actually collecting water from the aquifer to bring to schools, homes and farms.

The project in Ratheniska is called the Laois/Kilkenny Reinforcement Project. It involves the building of an electricity substation. The proposal was originally put forward by EirGrid, the state transmission/electricity transmission body, who described it as 'strategic infrastructure'. This allowed them to bypass local planning authorities and to waive the requirement for environmental impact assessments. They said the aquifer would be unaffected.

However, the local community objected, and the planning body, An Bórd Pleanála (ABP), reinstated the requirement for an impact assessment. There followed a battle, during which the community fought the development through the planning system. Ultimately, however, they were forced out of the judicial system because ABP told them they would be pursued for costs if they proceeded with another appeal. This is a regular tactic of ABP.

The developers therefore got the go-ahead, but they then went ahead with works far beyond what had been authorised and – important for the future of the aquifer – excavating deeper than they were supposed to. The local planning body served an enforcement notice on them and the developer responded by saying they would prepare a hydrological and a geological analysis. The one-page document that resulted was accepted by ABP, and additional permission was granted. The community again decided against appealing the new permission in the courts because of the threat of costs.

Since this summer, the community has physically blocked the site of this development, and no development has proceeded. The community say that the water maps that were used by the developer in the planning process were out of date and that unknown amounts of chemicals and potential pollutants would be used at the site without any assessment of the risks to the aquifer and the wider environment. They also uncovered a letter that said that, contrary to the claims made by EirGrid, the development is for attaching renewables to the system.

So this is a huge structure on top of an important aquifer. The case is currently being investigated by the EU and the UN Aarhus Compliance Committee on the grounds that:

- the community were not given full information
- the community were not allowed to participate in decision making
- the community did not have access to justice
- failure to apply EU directives and meet the requirement for a Strategic Environmental Assessment (SEA).[59]

Cullenagh Mountain windfarm

The second case is close by Ratheniska, and this is my own local community in Cullenagh. It's an absolutely beautiful area. It's also important for another reason. It is home to the Nore Freshwater Pearl Mussel (*Margaritifera Durrovensis*), a subspecies which is only found in the River Nore, which flows through the area and has therefore been designated an SAC. Nore mussels are almost the size of your hand and live for 100 years, but have experienced a considerable decline in recent years. No juveniles have bred in the river since the 1970s. The problem appears to be silt. The Nore mussel has a very unusual lifecycle, in which eggs are implanted in the gills of fish, where they grow for a number of years before hatching. Silt seems to prevent this happening.

However, there is a glimmer of hope. Captive breeding has taken place. You probably know that mussels can be bred on a rope and the same approach has been shown to work in the laboratory for the Nore mussel: after five years, they can now be reintroduced to the river.

Coillte, the state forestry company, proposed the construction of a wind farm just upstream of this important site: 18 turbines, each 131 metres tall. The site itself is commercial forest, but contains within it many areas of great natural beauty.

The community has fought the proposal for four or five years, but nevertheless planning permission was granted. We undertook a series of judicial reviews and appeals, but lost the case: the wind farm got the go-ahead on condition that no silt was released into the river. The developer said they would use silt barriers to do this.

During our legal battles, Evelyn Moorkens, the scientist in charge of reintroducing the Nore Freshwater Pearl Mussel, and the world authority on the subspecies, was highly critical

[59] Before infrastructural plans and programmes are adopted, Member States are required to assess the justifications, impacts, adequacy of mitigation measures, and alternatives to these plans and programmes by means of a SEA. The UNECE Aarhus Convention requires public participation on all plans and programmes related to the environment and according to Ireland and the EU, these requirements are fulfilled by their Regulatory Impact Analysis (RIA) and SEA procedures. Member States are required to undertake RIA procedures on all draft legislation and proposals for EU Directives before they are agreed. However, the legally required SEAs, RIAs and public participation provisions of the Aarhus Convention were bypassed by both the EU and Ireland.

of the proceedings, pointing out that ABP had managed to 'overlook' the scientific importance of the Nore mussel breeding programme,[60] despite the fact that they were fully aware of it:

> This case sets a very low threshold for what is considered 'best scientific evidence'. The developer can now leave out critical pieces of information, which, if not challenged by observers or other parties, permits the board to continue the assessment with incomplete information.
>
> In this instance, details of the breeding programme of the Nore Freshwater Pearl Mussel that has been incubated for 10 years and the fact that 10,000 juvenile mussels were introduced into the river in July 2014 were not identified by any parties to the case.

In fact, it was ABP that had insisted on the introduction of the captive breeding programme in relation to an earlier planning dispute. Although they had planning permission for the windfarm, Coillte went ahead with work on the grid connection, for which they didn't. We fought them again on the grounds of the threat of silt to the mussels, and this time they maintained that they did not have to perform another assessment because they had already done one for the wind farm. Fortunately, the Irish courts referred us to the European Court of Justice, saying:

> …it is difficult…to conceive of an instance where the objectives and provisions of the Habitats Directive could be more fully engaged and require more carefully to be observed than in the circumstances where the potential extinguishment of a species is at stake.

At the ECJ, we were again victorious, and when the case returned to Dublin for reconsideration, was found against Coillte. Now, we wait and see what their next move is, because they won't go away – there is too much money at stake.

Meenbog windfarm

The hen harrier is a very important species for the next two cases I'm going to discuss. This raptor breeds in the uplands and bogs of Ireland, and spends winter in more coastal areas. It's listed on Annex 1 of the EU Birds Directive, and is amber listed, which means there are worries about its conservation status.

Breeding hen harriers are largely confined to heather moorlands. In order to protect them, we are not told precisely where, but the population is spread across a broad area in the north west of Ireland encompassing counties Donegal and Tyrone. Here they benefit from a mosaic of forestry, with both mature and immature trees, interspersed with areas of open moorland and bog. This provides them with abundant food in the shape of small birds and mammals. And moorlands are of course ideal locations for windfarms too, which inevitably means conflict. As the raptor specialist Grainger Hunt, puts it, 'there is nothing in the evolution of eagles, that would come near to describing a wind turbine'.

Figure 12 shows the Barnesmore Gap in Donegal. It is a beautiful area, covering about 10 square kilometres. It is a Natural Heritage Area, Special Area of Conservation, and an ASSI. There are numerous protected views. And because of its location, and the fact that the landscape is ideal hen harrier country, birds moving from the north of the county to the south of the county have to come through this area even if they're not nesting there. Into this wonderful part of Ireland, it has been proposed to build a windfarm called Meenbog, with

60 An Bord Pleanala reference: PL11 .ER2028.

no fewer than 49 wind turbines. The initial application was turned down when the National Parks and Wildlife Service identified that this area takes in 7% of the breeding population of hen harriers in Ireland. In 2018, permission was granted for a smaller development of 19 wind turbines. 150 acres of forest were to be felled.

Figure 12: Barnesmoor Gap.

Unusually, it was an NGO – in this case the Irish Raptor Study Group (IRSG) – which led the campaign against the development. We are so glad that they have done this. The developer contended in their environmental impact assessment that there were no breeding or roosting hen harriers in the area, and that on the sites in question nobody recorded the species during their period of examination, nor within a 2-km buffer zone around the area. However, the IRSG knows of breeding pairs in the area – a nesting pair, and a second pair within the buffer zone. They offered to show ABP where these sites are – they are obviously secret otherwise – but remarkably were ignored. As the IRSG explained:

> Rather than resolving this crucial conflict of evidence, the Bord proceeded to grant permission without regard to whether there would be an impact on the Hen Harrier breeding pairs that IRSG identified on the site.

The IRSG's view is that this is a serious breach of Ireland's obligations under the Environmental Impact Assessment Directive and the Birds Directive.

Since this lecture, the IRSG has pulled out of their legal challenge. We are not sure why but have heard that there was a hostile judge and threats of costs.

Keeper Hill Windfarm

Under the EU Birds Directive, nations are required to designate areas that are home to listed, vulnerable or migratory species, and also wetlands that attract migratory birds, as Special Protected Areas. There are 154 such areas in Ireland.

Keeper Hill in County Tipperary (Figure 13) is also a foraging and nesting site for the hen harrier. In 2014, Coillte, the state forestry body, and a subsidiary of the ESB – the state electricity board – applied for permission and got it for 16 turbines,150 meters tall. Two individuals, Adele Grace and Peter Sweetman, launched a judicial review, arguing that 400 acres of foraging would be lost. The developer argued that they were going to make another area available, using the idea of 'nature compensation'. It remains unclear how the birds would be informed about this arrangement.

Figure 13: Keeper Hill.

In 2017, the case was sent to the Court of Justice of the European Union (CJEU), and Grace and Sweetman won. The judges said:

> ….only when it is sufficiently certain that a measure will make an effective contribution to avoiding harm, guaranteeing beyond all reasonable doubt that the project will not adversely affect the integrity of the area, that such a measure may be taken into consideration when the appropriate assessment is carried out.

The case has now been quashed in the Irish courts.

Research on song birds in Ireland

Finally, I want to present a new piece of academic work that has come from University College, Cork. [61] We have spoken here before about how the impact on birds is largely considered from the perspective of mortality, but there are other impacts too, which we don't

[61] Fernandez-Bellon D, et al. (2018) Effects of development of wind energy and associated changes in land use on bird densities in upland areas. Conservation Biology 33(2), 413–422.

really fully understand: the authors say that effects such as displacement and habitat loss need to be considered. They say– a view that I do not share –that wind energy is perceived as one of the most environmentally responsible and affordable energy sources, but agree that there are unarguably potential environmental impacts, particularly on birds and bats.

What they found was, in terms of total bird populations, densities were lower around wind farms. That is not a surprise. However, forest species numbers were much lower at small distances from the turbines, suggesting that it was the habitat loss caused by clearing trees that affected them. With open-habitat species – songbirds – the population densities were lower, but did not vary so clearly with distance from the turbines. This suggests that something else – perhaps sound or infrasound – was the issue.

Conclusions

So to conclude, we all know that windfarms have significant impacts on the environment, as do the associated grid projects. From our perspective, it would seem that communities and habitats are just collateral damage: nobody cares. In Ireland, state bodies and agencies are part of the problem. There has never been a strategic environmental assessment of the national renewable plans, there has never been a cost-benefit analysis or a regulatory impact analysis, despite both being required by the Irish state, and I assume by other countries' governments as well. The environmental NGOs are also part of the problem, and it absolutely breaks my heart to say that, having been a firm supporter of all these bodies. In fact, some of our environmental NGOs have actually received funding from the wind industry, and it makes me so angry to see that going on. The NGOs are completely ideologically driven, and I have now come to the conclusion that it is a religion, and it's nothing to do with science.

The state, and the environmental NGOs – with the exception of the Irish Raptor Study Group – are not playing their part, and not doing what they should be doing. We, as communities, must fight aline to uphold the idea of environmental protection. But we must do so without any resources to back us. In reality, I don't know how long we can stay in the fight.

Concluding remarks

Hilmar Freiherr von Münchhausen, German Wildlife Foundation

This paper, produced by the Global Warming Policy Foundation and the German Wildlife Foundation, takes a Europe-wide look at the conflict between wind energy and nature conservation. In many European countries, people are opposing wind energy projects that are destroying wildlife habitats.

We need to be aware that all energy sources have a negative impact on the environment and nature. It is therefore all the more important to generate reliable scientific results about these impacts. The German PROGRESS study, which reviews the effects of wind energy on bird life, shows the great effort and difficulty involved in collecting meaningful data. The study is so valuable because it provides scientifically sound quantitative results. This is of the utmost importance for a fact-based political discussion.

In particular, the consequences of wind turbines in forests are serious for many types of wildlife. We observe with great concern the massive expansion of wind power in Germany's forest areas.

The lack of public consultation in the planning of wind energy projects are shown by the examples from Ireland. It is worrisome when valuable landscapes are given official protection, yet those protections become completely ineffective where the construction of wind turbines is concerned. It is rather alarming that there is collusion between the wind industry and actors in the planning and approval process.

As a financially independent advocate of nature conservation and species conservation, the German Wildlife Foundation is implacably committed to the protection of wildlife and its habitats. At the same time, we are working on the subject of wind energy with the same vigour as we do in the field of forestry, agriculture or hunting. An open and constructive debate on the consequences that wind energy can have on wildlife – from insects to black storks to wildcats – is more than overdue. It is important to make people aware of the conflicts affecting nature conservation and ultimately to educate policy makers.

The German Wildlife Foundation regards wind energy as an important contributor to the energy mix of the future. Its further expansion in Germany, Europe and also worldwide, however, should not be promoted at any price. For Germany, at least for the construction of wind turbines in the forest, we demand a moratorium. This would allow us to reconsider the future course of action and, on the basis of scientific findings and national and European nature conservation laws, to adopt a far-sighted course in line with the precautionary principle that is enshrined in environmental policy.

We thank everyone who contributed to this paper. May its contents find their way into the social and political decision-making process so as to guide the future of wind energy in Germany and Europe.

About the Global Warming Policy Foundation

The Global Warming Policy Foundation is an all-party and non-party think tank and a registered educational charity which, while openminded on the contested science of global warming, is deeply concerned about the costs and other implications of many of the policies currently being advocated.

Our main focus is to analyse global warming policies and their economic and other implications. Our aim is to provide the most robust and reliable economic analysis and advice. Above all we seek to inform the media, politicians and the public, in a newsworthy way, on the subject in general and on the misinformation to which they are all too frequently being subjected at the present time.

The key to the success of the GWPF is the trust and credibility that we have earned in the eyes of a growing number of policy makers, journalists and the interested public. The GWPF is funded overwhelmingly by voluntary donations from a number of private individuals and charitable trusts. In order to make clear its complete independence, it does not accept gifts from either energy companies or anyone with a significant interest in an energy company.

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9	Lilley	What Is Wrong With Stern?
10	Whitehouse	The Global Warming Standstill
11	Khandekar	The Global Warming-Extreme Weather Link
12	Lewis and Crok	Oversensitive
13	Lewis and Crok	A Sensitive Matter
14	Montford and Shade	Climate Control: Brainwashing in Schools
15	De Lange and Carter	Sea-level Change: Living with Uncertainty
16	Montford	Unintended Consequences of Climate Change Policy
17	Lewin	Hubert Lamb and the Transformation of Climate Science
18	Goklany	Carbon Dioxide: The Good News
19	Adams	The Truth About China
20	Laframboise	Peer Review: Why Scepticism is Essential
21	Constable	Energy Intensive Users: Climate Policy Casualties
22	Lilley	£300 Billion: The Cost of the Climate Change Act
23	Humlum	The State of the Climate in 2016
24	Curry et al.	Assumptions, Policy Implications and the Scientific Method
25	Hughes	The Bottomless Pit: The Economics of CCS
26	Tsonis	The Little Boy: El Niño and Natural Climate Change
27	Darwall	The Anti-development Bank
28	Booker	Global Warming: A Case Study in Groupthink
29	Crockford	The State of the Polar Bear Report 2017
30	Humlum	State of the Climate 2017
31	Darwall	The Climate Change Act at Ten
32	Crockford	The State of the Polar Bear Report 2018
33	Svensmark	Force Majeure: The Sun's Role in Climate Change
34	Humlum	State of the Climate 2018

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