The effects of wind turbines on bat mortality and available solutions

An executive review

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1. Bats in danger

Wind turbines are known to be dangerous for birds, but recent studies have started to turn their focus to the impacts on bats as well. According to Rydell et al (2012) the average number of bats killed by wind turbines in Europe and North America is higher than that of birds (2.3 birds/turbine/year compared to 2.9 bats/turbine/year). The variation is very different between turbines, as some have no reported deaths, while others have killed many bats. The difference depends on the location of the turbine.

Wind turbines are one of the top five threats to bats in Latvia according to the 2014 EUROBATS Report. The report states that two species (P. nathusii, N. noctula) are affected by wind turbines during their migration. Research on bat fatality caused by wind turbines was conducted in 2013 in Latvia, which gave results of 40 dead bats from 4 different species under 6 wind turbines.

This review will consider several aspects of the effect of wind turbines on bat mortality, including the different factors which impact bats, how mortality risk changes over time and the current legislations and practices put in place to reduce the risk of bats being killed. Finally, the avoidance, mitigation and compensation measures will be considered, along with concrete examples and results.

1.1 How wind turbines impact bats

Bats are affected by wind turbines because their roosting places, feeding areas and migrating routes coincide with the most suitable placements for wind turbines. Such places usually are coastlines, lake shores, rivers, top of distinct hills and mountains in forested areas. Turbines also seem to be attractive to bats, but the source of attraction remains speculative. The recurrent assumptions are:

- Modifications of landscapes due to the installation of wind turbines create favorable conditions for aerial insects, so bats fly there to feed. Also, some turbines are illuminated at night, which attracts insects to the nacelle.
- Bats are attracted by the noise coming from the turbines.
- When they use visual cues, bats do not have the cognitive ability to differentiate wind turbines (and other tree-like structures) from real trees.
- Bats confuse airflow paths around turbines with those around tall trees, so may follow them because they expect the resources that they usually find there such as shelter, social opportunities or food (Cryan P. et al., 2014).

Bats are most commonly killed by the moving rotor blades, therefore the longer the blades are, the more bats they can kill as the area they cover is bigger. Another cause of death is internal hemorrhaging caused by the pressure drop behind the rotor blades.

Not only do wind farms affect the mortality of bats, but the construction of the wind farms leads to a loss of the bats' habitat as trees are cut down to clear land. A number of cumulative factors disturb their usual movements and behaviors, which may threaten the species in the long run.

1.2 Times of increased risk

It is easy to predict which time of year bats are more likely to be killed by wind turbines. Bat migrations usually occurs in late summer (August-September) while July is the maternity period, when there are fewer bats flying. According to Rydell et al. (2012), 10% of accidents happen in May-early June, the other 90% of accidents happen solely between August and early October.

In order to assess bat movement on a smaller timescale, the weather forecast can be used. Bats are likely to fly during warm nights with low wind, below 6 m/s. Bats are unlikely to fly in rain, or in winds above 8 m/s.

2. Current legislation and practices

2.1 European Directives

In the European Union, the Habitats Directive is currently in effect to ensure biodiversity and the conservation of habitat, flora and fauna across the EU. The Directive lists endangered animals, including several different bat species. The Directive itself does not give any propositions regarding wind turbines, it only states that the listed endangered species cannot be disturbed, harmed, killed or kept in captivity, and their habitat should be kept intact. The Natura 2000 network of protected areas belongs to the Habitats Directive.

The EU issued a guidance about wind farm development in the Natura 2000 sites (Wind energy developments and Natura 2000, 2011). According to the Guidance, the Directive does not prohibit the installation of wind turbines in or near Natura 2000 sites, but says that each case has to be considered separately.

Neither the Guidance, nor the Directive, prohibits or legally binds development or projects related to wind turbines, they merely give advice and recommendations. The Guidance acknowledges the risk that wind turbines have on bats. It also agrees on the facts about the behavior of bats, the fatality rates and the relationship of placement and fatality. The Guidance instructs wind farm developers to take into account areas outside of the Natura 2000 sites as bats (and also birds and whales) are affected by the turbines at a higher level due to their migration. Therefore each farm has to study the population and seasonal fluctuation of migrating bats.

The Guidance suggests either the refusal of the construction of wind turbines if they are located in areas where they present a high threat to bats, or to introduce different mitigation tools into the permit, such as turning off the turbines in specific times (e.g. August-September, from dusk till dawn). The Guidance also encourages the use of nature sensitivity maps at the planning phase.

There are two other Directives that regulate the placement of wind turbines and their effect on the environment. These Directives are the SEA Directive (2001/42/EC) and the EIA Directive (2003/35/EC).

The SEA Directive requires Member States to publish environment reports on the effects of new plans and programmes and to consult with the responsible authorities regarding them. It is mandatory to carry out a Strategic Environmental Assessment (SEA) in the case of new wind farms. SEAs helps to identify conflicts and problems at an earlier stage, so they can be addressed and mitigated as soon as possible.

The EIA Directive addresses individual public and private projects, whereas the SEA Directive is meant for public plans and programmes. An Environmental Impact Assessment (EIA) is required to be carried out prior to granting any permission. The EIA takes into consideration the effects on flora and fauna.

2.2 Current practices in European countries

EUROBATS collects datas on the national and regional guidelines concerning wind power and bats. The latest report (9th Meeting of the Standing Committee, 2015) shows that national guidelines exist in 13 out of 45 European countries, either officially or unofficially. National guidelines are in preparation in some countries.

A 2015 study commissioned by the Swiss Federal Office of Energy (Bryner and Wimmer-Kornmann, 2015) compares how different regions deal with the protection of bats and birds in wind power projects. 9 regions in 4 countries (Germany, France, Austria and Italy) have been studied, according to the criteria that has been partially transcribed in the table below.

	Germany	France	Austria	Italy
National guidelines according to EUROBATS	*Yes*	*Yes*	*No*	*No*
Assistance in planning	Partial list of species and maps	Available	Partial but not public - zones of high risk of collision become exclusion zones	Unspecified
Requirements for the impact assessment	Evaluation of the collision risk by an expert Analysis of the activity within a 1-2 km distance Evaluation of the hospitable habitats	3 phases : pre-diagnosis, diagnosis and follow-up The pre-diagnosis states if a diagnosis is required	The administration works closely with external experts	Analysis within a 2km distance
Bats detection	Acoustic detection required at different heights During a whole year cycle	Acoustic detection is highly recommended Free choice of equipment and heights	Acoustic detection from April to October at the hub height Manual ultrasonic sensors on the ground	Acoustic detection from April to October at the hub height 24 transects on the ground with manual ultrasonic sensors
Regulation of the operation	Yes, 1st year according to climate criteria 2nd and 3rd year according to the follow-up	Uncommon Other means are applied to lower the impacts	Usually not Strong recommandation since 2014 from the national protection organisation to start it	Unspecified
Post-implantation follow-up	2 years - Acoustic detection in the hub Where justified, search for dead bodies	During 3-5 years Search for dead bodies Monitoring of behavioral changes (flight, breeding)	2 years - Acoustic detection in the hub Search for dead bodies	Unspecified

3. Solutions

3.1 Avoidance

At the planning stage, the easiest way to decrease the effect of wind turbines on bats is to avoid constructing them in areas where bats are likely to roost or routes where they migrate. The areas where bats are most likely to roost are generally coastlines, top of distinct hills and mountains in forested areas. In comparison, flat terrain, farmed lowlands and treeless areas are considered to be safe, as bats are not likely to be there. However, a pre-survey should be carried out at a 10km radius of every turbine to investigate whether bats roost or migrate in the area. The pre-survey should be carried out at an appropriate time depending on the behavior of the bat species present, and the latitude of the region. Rydell et al. (2012) suggests a pre-survey to be carried out between mid-February and mid-December, with most emphasize on late summer (August-September) as 90% of fatalities happen at that time of the year.

To see the difference between high risk areas and low risk areas, Rydell et al provides mortality averages from forested, mountainous areas and flatland areas. Wind turbines located in the Black Forest, Germany (a high risk area) kill 18 bats/turbine/year and wind turbines in Jura Mountains, Switzerland (another high risk area) give similar results. Wind turbines located in low risk areas, such as Schleswig-Holstein, Germany and Alberta, Canada have bat mortality averages of less than 3 bats/turbine/year.

Brinkmann et al. (2011) found that moving a wind turbine (which was originally located in a high risk area, near woods or shrubberies) 200m away to a lower risk area, leads to a reduction of bat activity around the turbine of 10-15% on average. However, the study underlines that parameters such as the landscape or the height of the turbine only have a small influence on the bat activity, compared with wind speed and temperature factors.

3.2 Mitigation

After the construction of a wind turbine, the number of bat deaths can be decreased by using different mitigation tools. First of all, in order to assess whether mitigation tools are needed, the bat mortality risk needs to be assessed. A search for dead bats has to be carried out for every turbine in a wind farm within a radius of the height of the turbine, but at least 50 m according to the EUROBATS report. The time interval for the search for small wind turbine farms is one day, while for big wind turbine farms it is a maximum of 5 days. The survey time period is the same as for the pre-survey, with the emphasis on summer and early autumn months.

If the mortality of bats is considered to be high, there are different mitigating tools the wind farm operator can choose from.

Currently the most widely accepted mitigation tool is increasing the cut-in speed. Wind turbines start to produce electricity from a wind speed above 3 m/s. This speed is called the cut-in speed. As described earlier, bats usually fly in low winds, when the speed is below 6 m/s. If the cut-in speed is increased to be between 4-6.5 m/s the fatality rate decreases by 79-90%, while the energy loss is only 0.3%-1% for the whole year (Rydell et al., 2012). According to Arnett et al. (2010), increasing the cut-in speed to 5 m/s is sufficient, and results in a 44-93% decrease in bat fatalities. Further increasing the cut-in speed to 6.5 m/s does not result in further decrease in fatality rates, only increasing the annual power loss. The cut-in speed is recommended to be increased only in summer and autumn months, from half an hour before sunset until half an hour after sunset. A similar interruption in production already works in hydropower plants to help fish migration.

Existing fully-automated monitoring and mitigating systems can provide real-life data and take mitigation measures, such as shutting down the wind turbines, when they detect possible collisions. After the threat is avoided, the turbines automatically switch back on. Such systems can be used also at the pre-survey stage to identify whether the possible wind turbine is in the way of any migration routes.

The Chirotech project (France) is one of these systems.

The monitoring system measures the bat activity at the rotor blade height over a period of months, to prevent deaths from collisions and barotrauma. The module is installed on a measure mast during the assessment phase or during the operation of the wind farm.

The regulation system collects weather data: wind speed, temperature, rainfall through the acquisition systems of the wind farm. This box is the interface between the wind turbine control system (Twido, opc server, scada) and an algorithm calculating the risk of collision. If the collision risk threshold is exceeded, the system stops the machines.

The Chirotech systems resulted for now in a 70% mortality decrease on average, with only a 1% electricity production loss.

Arnett et al. (2013) describes an ultrasonic acoustic deterrent that could reduce the bat fatality. The efficiency is not yet proved, the development is ongoing.

Other ongoing research to reduce bat fatalities is through equipping nacelles with UV LED lights. UV LED is invisible to human eyes, therefore does not cause any disturbance for air traffic, but birds and bats can see it. It is yet to be determined what effect it has on these animals, whether it is attraction, indifference or avoidance.

Vertical-axis wind turbines (VAWT) might be another option which has not been deeply explored. According to Eriksson et al. (2008), the straight-bladed VAWT, referred also as the H-rotor or giromill or cycloturbine, is expected to be less harmful for birds and bats, since the blades move at a slower pace. Further research on VAWTs types and new designs (e.g. the Ogin Turbine) would be valuable.

3.3 Compensation

Compensation measures may particularly benefit sedentary or non-migrant bat species. Compensations measures mainly take the form of a densification of the ecological network near the breeding zones of the bats. The management of autochthonous forests, the plantation of native trees in zones of intensive agriculture and the creation of ponds are among the possibilities recorded by Peste et al. (2015). However, these compensation measures should only take place as a final resort, after the implementation of the avoidance and mitigation measures.

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Products

Chirotech Monitoring and Regulation systems. See: URL

DeTect, Radar system. See: URL

Lite Enterprises, UVLED. See: URL

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