WINDPOWER MONTHLY

Artificial eyes in the skies

Next generation technology is simultaneously protecting birds and wind farm operators from collision risks

bioseco
Innovation for bird monitoring

Introduction

As the world ramps up renewable energy installation to meet net zero carbon emission ambitions, there is an increasing need to reduce any negative environmental impacts that can be inadvertently caused by wind energy.

The fact that wind turbines can kill birds – if sited incorrectly and without any bird protection technology - has long been known. Accurate mortality figures are hard to find, but the US Fish and Wildlife Service cites the most robust studies as estimating that some 140,000-500,000 birds die in turbine collisions each year in the US alone.

Although there is no aggregate data for the whole of Europe, some studies based on regional assessments confirm that the situation in Europe is similar. International statistics covering all wind farms is lacking, making it hard to assess the impact of collisions on bird population.

Meanwhile, the US is targeting a six-fold rise in wind turbine installation compared with current levels, which will in tandem increase the risk to birds, potentially reaching 1.4 million deaths a year, depending on where the turbines are sited. The risks are highest near migratory routes, in areas with high concentrations of birds, along rivers and ridgelines, or near the coast. The EU is in the forefront of the global energy transition and since wind energy is a cornerstone technology, bird mortality will increase.

Songbirds are more commonly killed than raptors, but populations of the larger birds are more at risk due to their lower reproductivity rates. Data also suggests that bird collisions may increase with structures taller than 106 metres, again increasing future risk as turbines become taller over time. Some species are more prone to collision risk than others, including kestrels, red kites, common buzzards, white-tailed eagles and vultures in Europe[1], whereas bald and golden eagles the main concern in the US[2]. It is likely that with increased wind energy penetration other species of bird of prey will be affected as well.

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The world is facing a nature crisis as well as a climate crisis, with one million species at risk of extinction, according to international biodiversity scientists. It is imperative that the solution to one problem does not worsen the other – even very green industries can have an impact.

Although existing wind turbines may take a few years to have a significant impact on bird populations, expected capacity growth could rapidly exacerbate the situation. Wind energy capacity has increased from zero to 200GW in Europe, and is expected to triple in the next decade to roughly 600GW – meaning some 200,000 turbines in operation. Globally, the International Renewable Energy Agency (IRENA) is forecasting that by 2050, onshore wind could rise tenfold to around 5,044 GW[3] compared with 2018.

1. https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6791-5.pdf?pid=21758
2. http://www.bioone.org/doi/full/10.3356/JRR-12-00019.1

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Adam Jaworski, chief executive, Bioseco

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Effective solutions minimising the long-term risk of negative impact to birds must be implemented now.

Bird experts[4] around the world are increasingly aware of the problem, and environmental regulators are limiting the siting of wind farms in areas with high risks to birds. This is especially the case in locations that are habitats for birds of prey, or migration routes. Yet due to the need to increase wind energy capacity across the globe wind farms are being placed in bird sensitive areas, where mortality is confirmed only after a few years of operation.

In some geographies the authorities are requiring operators to turn the turbines off at certain times of the year, such as breeding or migratory seasons. In others like Spain, France, Poland the use of bird protection systems is allowed to reduce the collision risk instead of using generic shutdowns.

Turning wind farms off can be very expensive for operators – in Germany, some turbines are required to be switched off during daylight from March to September, causing losses of 20-25% of annual energy production. In other projects, temporary shutdowns for a few hours during the day are applied.

These generic shutdowns, that are not related to actual bird activity, cause a huge loss of green energy production and impact negatively business plan.

The issue needs to be solved in a smart way that will save endangered bird species, but also protecting wind farm operators from excessive turbine shutdowns. This balanced solution could be achieved using modern technology.

There are many research projects investigating the effectiveness of using modern technologies to limit the risk of collisions, including the NatForWinSent initiative in Germany, MAPE project in France or various projects by the AWWI in the US. Some of the technologies tested in these pilots might provide solutions.

3. IRENA (2019), Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation paper), International Renewable Energy Agency, Abu Dhabi

4. https://www.birdlife.org/sites/default/files/bhdtf_position_2016_wind_energy_birds_and_bats.pdf
https://www.eagles.org/

Technological limits

Meeting regulators' demands often means that operators must use some kind of bird protection technology. However, these have so far have been limited in scope and effectiveness. Radar can be used, and can detect birds up to 5km.

However, radar cannot detect the difference between a bird or other flying object such as a drone, but the main drawback is very high cost of this technology and special requirements related to permitting of radar use. Together with the development of affordable UHD/4K cameras and availability of processing power, it has become possible to develop visual detection systems with high efficiency of bird detection.

Once a bird is detected, various methods can be used to deter the bird from flying near the turbine blades[5]. Sound and light can both be effective yet efficiency will depend on distance, bird species and type of deterrent. Such systems should be used only when the bird is directly approaching the turbine, to avoid them becoming used to the effect over time and ignoring it.

If deterrent systems are not allowed by regulators, or the bird continues to fly towards the turbine blades, the turbine might be stopped to allow the bird to pass safely.

5. Gradolewski, D.; Dziak, D.; Kaniecki, D.; Jaworski, A.; Skakuj, M.; Kulesza, W.J. A Runway Safety System Based on Vertically Oriented Stereovision. Sensors 2021, 21, 1464. https://doi.org/10.3390/s21041464

Bioseco – next generation bird protection

Most bird protection technologies available up till now rely on a single camera for detection. However, monoscopic vision cannot estimate a bird's size, nor its distance from the turbine, both of which are essential making the right decision to avoid a collision.

But Bioseco has introduced the Bird Protection System (BPS) – a two-camera system with a stereoscopic set up. Using artificial intelligence, advanced detection algorithms and dedicated computing units (IoT), it allows for very high bird detection efficiency and a very low rate of false positives.

The two-camera system works like a pair of eyes, as Jaworski explains: "They're calibrated so that they see the same flying object at the same time, but they are one metre apart, which means that the distance from the object can be calculated in real time."

"If you've got one camera, then you could see a fly from 2 metres away, or you could see a big bird 400 metres away. But for the camera it will just be a black dot on the sensor matrix, so it will be very difficult for the such system to establish which of those it is." Ability to estimate the distance is crucial for the system to efficiently distinguish between various objects using a distance/size ratio. Additionally, distance estimation allows the system to track the actual flightpath of bird and verifying if the bird is actually approaching the turbine.

In most cases, the authorities are very concerned about birds of prey or other very large birds. The size classifications based on stereovision allows the system to differentiate actions to prevent collisions, for example, use the deterrent system for smaller birds and turbine stoppage for larger ones.

"The ability to estimate the distance also enables us to classify the size of the flying object, so we know not only if it is a bird or not, but also whether it is small, medium or large, which would affect whether the turbine needs to stop or not. This is a smart deterrent system," Jaworski says.

False positives

False positives – or where insects, planes, helicopters or clouds are incorrectly identified as birds – are a major threat to wind farm operators, and their investors.

False positives have been a weak point in many previous bird protection technologies, and cause unnecessary loss of production and turbine component fatigue. Just three unnecessary stops per day due to false positives might mean even 4000 EUR of loss of revenue for a single turbine per year.

A low rate of false positives is therefore vital to the viability of a wind farm. Bioseco's standard Bird Protection System results in fewer than 10% false positives, while the premium version has a rate of less than 5% of detections stopping the turbine, confirmed during evaluation tests and data from operating systems.

Cascade effect

Bioseco's technology is new, with a prototype first installed on a wind farm in Poland in 2016, with market launch only in 2019. It has been enabled by improvements in processing power which have only recently become available – one system for one turbine processes roughly 3GB of data per second. To be precise, distributed computing technology with IoT allows reaching the goal. IoT alone is used to monitor the system status.

Bioseco's Bird Protection System was developed using a User-Driven Design (UDD) approach, with all stakeholders including environmental authorities, future users and designers actively involved. "The system was designed from scratch during intensive research and development related to both hardware and software, making it very efficient for this particular application," says Jaworski.

"Data can be viewed via a web application and used to submit reports to regulators."

Data is collected by the system, including time, location, estimations of height and distance, size of the bird, approximate flightpath, weather conditions and what action was taken to prevent bird collision. The data is supported by black and white photos of detection, and full-colour HD video. All this can be viewed via a web application, and used to submit reports to regulators.

There are two versions of the system available – standard, and premium. Both cover a 360-degree radius around the turbine, and use stereovision technology. The premium version has two extra modules, giving it a larger vertical field of view.

It also has two enhanced features – bird size classification, and advanced filtering using AI, both of which lead to fewer unnecessary stops.

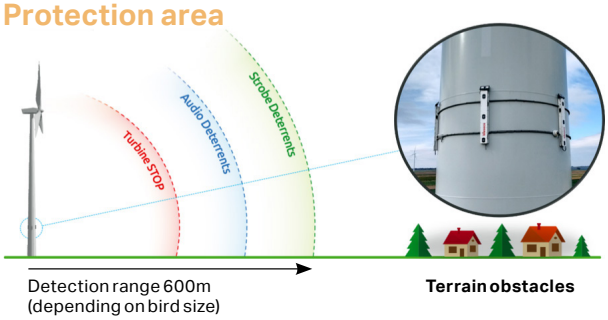
"We are not stopping our development works, and currently we are set to start testing a new version called BPS Long Range with one of largest wind energy developers in Germany. We also want to develop species recognition based on machine learning," adds Jaworski.

How does it work?

After detecting a bird, Bioseco's Bird Protection System monitors its flight trajectory, and triggers a series of deterrents if it approaches the turbine. These are activated at particular distances, like a cascade effect, so that each method is used at the most appropriate time. Firstly, pulsing stroboscopic lights are activated, then if the bird continues towards the turbine, an audio deterrent of up to 114dB might kicks in. Sound volume can be adjusted to any noise emission limits in operation at a given wind farm.

Most birds change their flight direction, but if they keep flying, a signal is sent to the turbine to stop it and allow bird to safely fly away. If a turbine needs to stop, it is automatically restarted after three to four minutes.

Concept of smart bird protection based on stereovision and cascade deterrents



Test cases – Poland and Germany

Bioseco's Bird Protection System has been put through its paces in two major tests. The first, in Germany in 2019, was part of the nature conservation research project NatforWINSENT funded by the German Federal Agency for Nature Conservation, and the Germany Federal Ministry for the Environment, Nature Conservation, Nuclear Safety (BMU).

The system detected protected red kites very effectively – 97% were detected within 200m distance; 80% within 300m, and 61% within radius of 400m[6]. Only 7% of identifications were false, of which only one-third would have resulted in a turbine stoppage. A further test on an updated version of the Bird Protection System was carried out in Poland with utility PGE between May and October 2020. Over 28 days of observations, 119 birds were recorded by the system.

The test results were validated by ornithologists and drones, to prove the system was reliable at detecting a bird with a wingspan of over 1.5m from at least 400m. The tests also proved the system could classify the size of the bird depending on bird wingspan and false positive rate below 4%.

Results of BPS Premium evaluation in 2020

Species	Wingspan [m]	Body size category	Maximal distance with detection efficiency at 80% [m]	Maximal distance of detection [m]
Sparrow hawk *Accipiter nisus*	0.7-0.8	S	150	200
Common kestrel *Falco tinnunculus*	0.7-0.8	S	150	200
Marsh harrier *Circus aeruginosus*	1.0-1.3	M	300	400
Common buzzard *Buteo buteo*	1.1-1.4	M	300	400
Red kite *Milvus milvus*	1.4-1.6	L	400	500
White-tailed eagle *Haliaeetus albicilla*	2,2-2,4	L	600	700

6. Aschwanden, J. & F. Liechti (2019): Test of the automatic bird detection system BPS on the test field of WindForS in the context of nature conservation research (NatForWINSENT). Schweizerische Vogelwarte, Sempach. Report on behalf of the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW)

Size classification

In Bioseco's experience, an average of 50-90% of all birds detected are smaller than 1.2m in wingspan, in other words, birds that are usually smaller than those expected by regulators to be strictly protected and requiring turbines to be shut down.

For example, if a turbine is stopped for 15 small birds a day, that would add up to 5,475 stops a year, totalling 365 hours of non-production. Assuming a revenue of €60 for each megawatt hour of energy produced, this could equate to a loss of €21,900 a year, from just one turbine.

Exemplary calculation of the economic impact of turbine stop for small birds

Category	Unit	Scenario		
Turbine stop for small birds	per day	10	15	20
Turbine stop for small birds	per year	3650	5475	7300
Turbine stop time	minutes	14,600	21,900	29,200
Turbine stop time	hours	243	365	487
Loss of income*	EUR	14,600	21,900	29,200

*Assuming 1 hour = 1 MWh and 1 MWh = 60 EUR

Expanding importance

Bioseco's Bird Protection Systems are already in use in wind farms in Germany, Spain, Poland and France by some of global wind farm operators. Bioseco is planning further upgrades to double the number of cameras to 32 per system (i.e. four cameras per detection module); increase the system's detection range; and to raise the processing power from 3GB/second to 15GB/second, which is needed to achieve the goal of extending the efficient detection distance in BPS Long – Range version.

Jaworski believes that Bioseco's Bird Protection System will be vital for the wind energy contribution to low carbon transition. "There is a big expectation to grow the capacity of wind farms, but the problem is the scarcity of land - you cannot develop projects in towns and cities, they need to be in rural areas. They will increasingly be very close to forests, closer to bird sensitive areas where authorities would not currently allow turbines to be located," he says.

There will be increasing pressure from environmental campaigners and conservation organisations, as well as scrutiny from environmental protection authorities to efficiently avoid the risk of bird collisions, especially regarding endangered species, Jaworski believes.

"There is less land available without the potential for bird collisions. Operators, investors and politicians want more wind energy, but authorities will refuse it to protect birds – Bioseco's technology can solve this paradox to the benefit of birds and people," he says.