Handbook for the application of effective methods and approaches to improve the safety of power lines for birds

Prevention and mitigation of bird mortality associated with power lines in the Czech Republic, Slovakia and Hungary

Introduction

One of the biggest threats to the wild living species of birds is electrocution and collisions with power lines causing thousands of avoidable deaths and injuries. Overhead power lines are an unnatural feature in the landscape to which birds must react and adapt.

Preventing birds from collisions and electrocution is important to compensate for other threats that the endangered species need to face. The positive fact is that only parts of potentially dangerous lines are responsible for the majority of killed birds due to collisions. In the case of electrocution, the problem needs to be addressed more widely and the safety of all poles needs to be ensured gradually. These most dangerous lines and poles should be fully identified and treated by energy utility companies. In various parts of the world, different technical solutions for bird safety were/are being tested and evaluated. Many of them are not effective, while some of them turn out to be highly effective. A transnational approach is necessary to achieve adequate results and share knowledge between experts on this issue to prevent mistakes and adopt best practice methods and standards. In the Czech Republic, Slovakia, and Hungary bird species are secured through laws regulating the construction of power lines to make them safer for bird species and through internal standards set by energy companies. On the other hand, it is important also to establish collaboration between ornithologists and electricity companies, policy decision-makers, civil society, rescue and rehabilitation stations, etc. to identify dangerous power lines, modify them and thus prevent the negative impact on bird species at international, cross-border, and national level.

Energy grid infrastructure

Power lines are rated and categorized, in part, by the level of electrical voltage they carry. In the European area of application, power lines are mostly divided into three basic categories: high/extra-high-voltage, medium-voltage, and low-voltage.

High and extra-high-voltage power lines (60–750 kV) or "transmission lines" carry electricity at high voltages from generating facilities to substations for importing and exporting electricity from and to neighbouring countries.

Medium-voltage power lines (1–59 kV) or "distribution lines" carry electricity to residential and business consumers. The poles/pylons on distribution lines are much smaller than those used on transmission lines. They are made of metal, concrete, or wood, with metal cross-arms and in many variations of type and positions of cross-arms, pin insulators, exposed jumper wires, and other energized elements.

Low-voltage power lines (>1 kV) are used in a number of countries to transport electricity directly to consumption points such as residential homes, public lighting, or industrial areas. Often, low-voltage lines use well-insulated thick black cables, directly attached (as suspended) to poles without additional cross-arm construction.

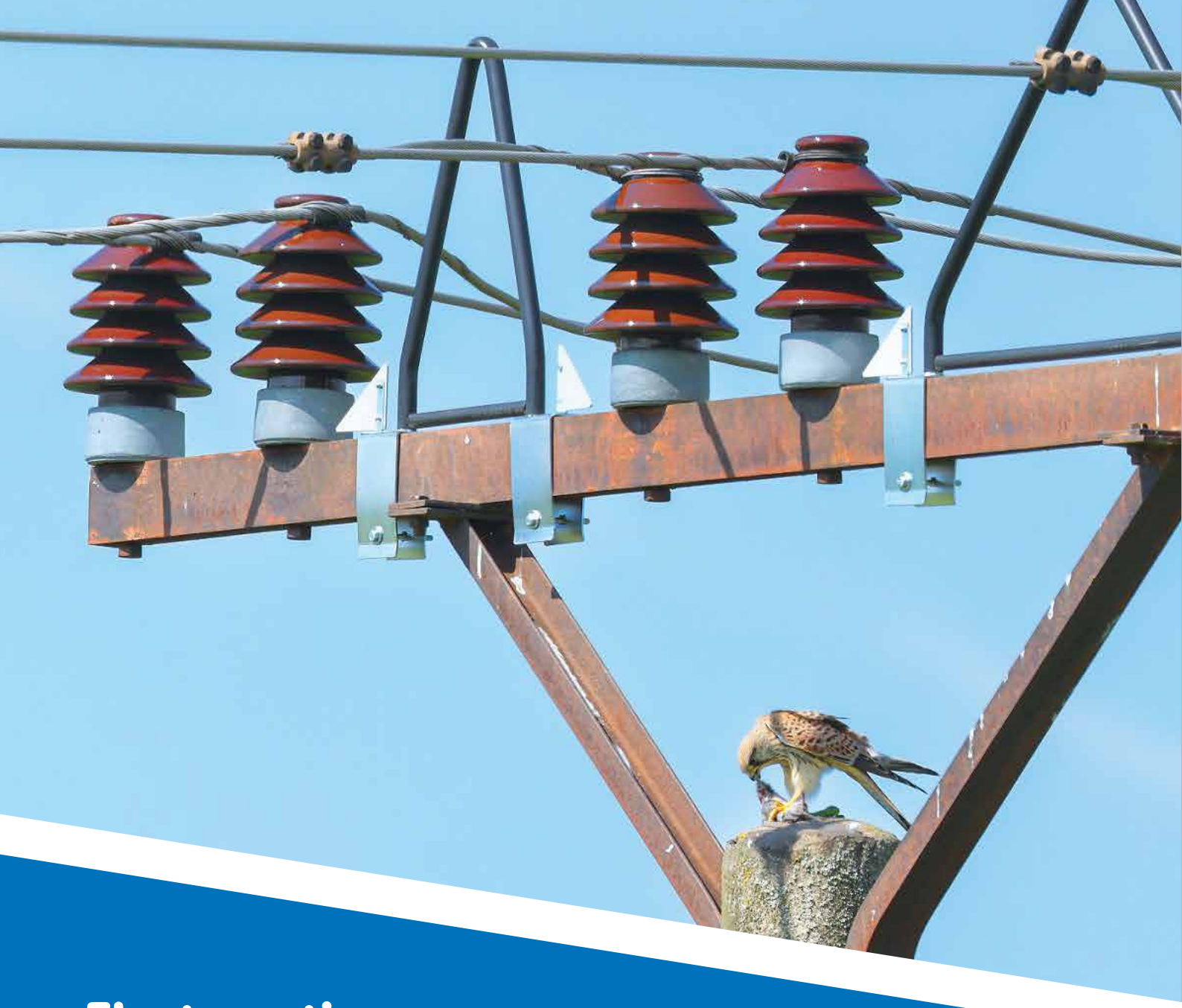
In the Czech Republic, the split of competencies of power companies is geographical. TSO ČEPS, a.s. operates 400 kV, 220 kV, partly 110 kV on the whole territory of the country. Three companies are responsible for the electricity distribution on 110 kV, 35kV, 22 kV, 230/400 V, namely ČEZ Distribuce, a.s., E.GD, a.s. and PREdistribuce, a.s. In Slovakia, the split of competencies of power companies is geographical. TSO SEPS manages 110 kV, 220 kV and mostly 400 kV power lines on the whole territory of the country. DSO ZSD, a.s., SSD, a.s., and VSD, a.s. manage power lines of 110 kV, 22 kV, 230/400 V. In Hungary, the split of competencies of power companies is geographical. TSO MAVIR manages 120 kV, 220 kV and 400 kV power lines, with one section of 750 kV power line in eastern Hungary. E.ON Hungária, DSO MVM-ÉMÁSZ, and MVM DÉMÁSZ manage power lines of 120 kV, 22 kV and 230/400 V.

Birds and power lines

The network of power lines around us can lead to biodiversity loss, fragmentation of populations and habitat degradation via various impacts on the ecosystems through which they pass. However, the most well-known impacts are probably those related to interactions with birds. These can be beneficial if they support some bird species, for example by allowing them to nest and perch on poles, or harmful because they can lead to mortality of individuals, particularly due to electrocution and collision. These often fatal injuries and bird deaths can occur anywhere in the world where there are power lines. While interactions with electric power lines are one of the main threats to certain species, these interactions (especially electrocutions, but also a collisions of heavy birds such as bustards, cranes or swans) are also a problem for electricity companies and can be costly, causing power outages and damage to equipment.

Carcass removal by scavengers often biases the real mortality rate, with very high initial removal rates among smaller carcasses, most of which disappear within the first few days. Many injured birds after electrocution or collision often move by themselves, hide in nearby vegetation, or continue to fly hundreds of meters, but subsequently die anyway. Both factors together with searcher efficiency can vary significantly bias the real mortality rate and underestimate the quantification of the impacts of power lines on birds.

The number of dead or injured individuals found should not be the sole determining factor in evaluating the severity of the findings and the situation. Other factors should also be taken into account, such as the period in which the incident occurred, the threat status of the species, and population parameters at different levels. Negative impacts related to bird injuries and mortality can pose a biologically significant risk, as the loss of a few or even a single individual may affect the local population or the viability of the entire population in the case of rare or endangered species.



Electrocution of birds

Electrocution occurs predominantly on medium-voltage power lines which form a dense grid in the country. They represent a very attractive location for many bird species in the open countryside. This elevated perch provides a good vantage point for raptors in particular to observe potential prey, accelerated attack on prey, resting, and defending the territory. Electrocution occurs mainly in places with high concentrations of susceptible bird species, most often in agricultural landscapes of lowlands, basins, and uplands. These productive habitats create suitable conditions for small ground mammals, a preferred food source for several species of raptors and owls.

Species groups that are more susceptible to electrocution than others include storks, medium-sized and large raptors, namely eagles, kites, falcons, hawks, buzzards, and corvids. In our conditions, this classification has been confirmed by field research, with the highest mortality rates shown for the common buzzard (*Buteo buteo*), white stork (*Ciconia ciconia*) and also for smaller species such as the magpie (*Pica pica*), the hooded crow (*Corvus cornix*) and the common kestrel (*Falco tinnunculus*). Rare raptor species such as saker falcon (*Falco cherrug*), imperial eagle (*Aquila heliaca*), red or black kite (*Milvus milvus* and *M. migrans*) and the red-footed falcon (*Falco vespertinus*) have also been identified among the victims.

Typical signs of injuries in affected individuals are burns localized on the areas with the highest probability of contact with the structures, i.e. legs, wings, claws, and beak. Spasmodically clenched claws are also an easily identifiable feature. External signs of burns are not always present on an individual's body. Electrocution can lead to internal tissue burns, muscle damage, and fractures to limbs that may not be visible at first glance and easily identifiable in the field. A dead individual is most often found within 2-3 m of the base of a pole, or usually in close proximity to it.

The risk of electrocution for a bird mainly depends on the design, and configuration of the pole. Certain types, especially metal structures with a horizontal location of cross-arm and jumper wires (e.g., top over the cross-arm) and pin insulators, are among the riskiest. It can be said that the more complex the structure and the shorter the distances between the parts of the structure, the risk also for smaller bird species increases.

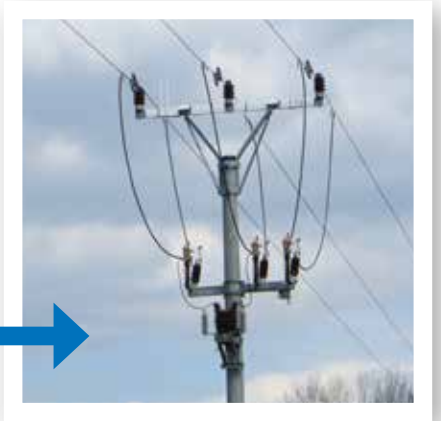


Anti-electrocution measures

According to current knowledge and experience, it is possible to reduce the risk of electrocution significantly, within acceptable costs for the electric utility companies. In order to reduce electrocution mortality, bird protection must be taken into account, particularly at the initial planning stage of any new power distribution line. In infrastructure planning, risk mitigation will be achieved if sensitive bird areas are avoided in the first instance when the power line is routed. When new poles are constructed, a safe design of cross-arms must already be installed. If the infrastructure is already in place, another familiar approach is to modify the design of the poles in various forms or installation of additional protective measures. This approach ensures that new and fully reconstructed power line sections are safe for birds by design. Poles configurations in Hungary are very similar to those in nearby Slovakia and the Czech Republic, thus similar approaches can be also applied.

There are several effective solutions used by grid operators. The most effective appears to be a complete change of the pylon head construction for the new, bird-friendly scaled type with good geometry used in Hungary, Slovakia, and the Czech Republic. The shape of the console discourages birds from sitting down near dangerous elements and at the same time, the cross-arm or attached perch offers a place to sit safely.

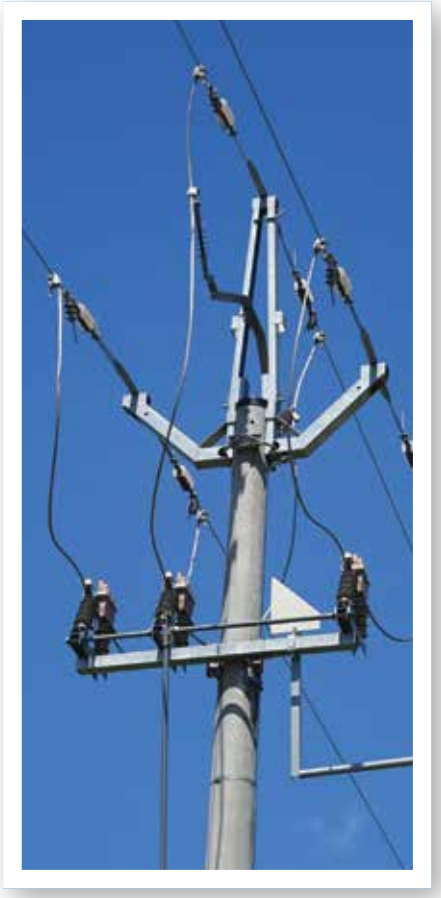
Adoption of this measure will depend on the configuration of the cross-arm and insulators and the species present in the region. The adoption of permanent measures on power lines with dangerous supports may involve the total or partial modification of the line/cross-arm. Replacing of bare conductors of overhead power lines with covered conductors is a long-lasting solution and it doesn't cause difficulties with maintenance in comparison with insulation equipment installation. Changing the location of risk elements can also help many times. Switcher attached below the cross-arms was reported to be effective measure of how to decrease mortality due the electrocution.


Even the riskiest poles can be made more safe by only changing one exposed jumper wire for the suspended type. It is a simple, effective, and cheap solution applied on 22 kV poles in Slovakia. Bare wires are replaced with insulated ones, the mortality rate has been reduced to zero. Also in case of changing the insulator to the 800mm long new type, and using insulated power connections, the mortality could be eliminated from the most dangerous type, the tension poles.

The use of insulated and twisted conductors is a permanent measure but also expensive if an existing risky wires need to be replaced. The risk of electrocution is reduced to zero. This thick and thus well-visible wire also help to prevent collision mortality.

If it is not possible to change the design of cross-arm, the best solutions to prevent electrocution are those that allow birds to perch safely on the poles or push them out of risk, creating a safe perching and landing area for birds. These solutions are frequently used in Slovakia, low mortality has been recorded on them.



Covering the conductors and other live elements with insulating materials can help to reduce the mortality risk and can be also effective solution. This solution is the very common, universal and is used in many countries and by many grid operators. On metal cross-arms, another possible type of insulation consists of placing rigid plastic covers on the parts where birds perch, so that they avoid contact with the ground connection of the pole.

The products used to mitigate the electrocution risk should be made from durable, long-lasting materials and should be installed properly to ensure the protection of birds. If they are damaged or incorrectly installed, they are useless or even more dangerous than non-insulated poles. Even small gaps in retrofitting can allow electrocutions to occur, and many retrofitting measures used in Hungary, Slovakia often included such gaps and are the main cause of persistent mortality.

It is important to note that the electrocution risk depends not only on the cross-arm design but also on how frequently poles are used by birds. Another main factor is the characteristics of the surrounding habitat and thus the presence of prey species.

In order to properly select the appropriate protection element, it is necessary to perform monitoring not only before installation, but also after installation, to determine its effectiveness or to make the necessary changes if technical problems occur.

Collisions of birds

Collisions of birds with power lines represent a significant mortality factor for several water bird species. They are related to a very important fact - power lines are unnatural obstacles in the landscape, and a flying individual is not always able to register such an obstacle in front of him in time. Most often the collisions could be observed in areas where power lines cross wintering, feeding, and nesting habitats preferred by birds, or in places where such lines lie perpendicular to the main migration route or cross wetlands, etc. The risk of collisions is increased especially in the spring and autumn migration period.

It is not only important what kind of power grid (distribution or transmission) is present in the area, but its location in relation to habitats that are important for birds plays a major role. In general, the factors of line collisions fall into three basic categories: biological, environmental, and technical. These are also important in the process of evaluating power lines in terms of collisions. Biological factors include weight, size of the individual, bird visual physiology, flight style and speed, age, behaviour during the hunting season, mating season, breeding season, and daytime or nighttime migration.

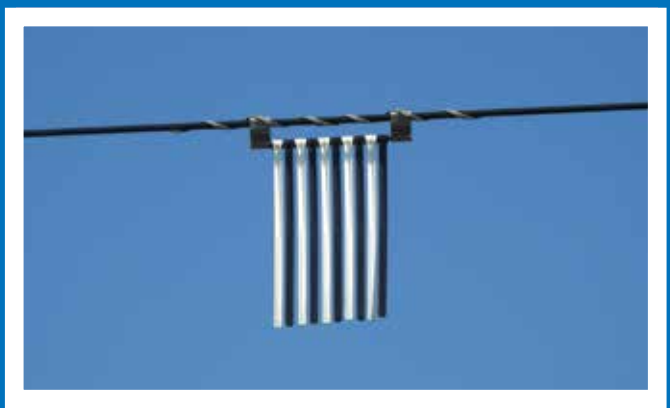
The set of environmental factors includes the nature of the topography, the importance of the habitat for birds, weather conditions, and visibility. The importance of these factors varies according to the location, season and species composition in the landscape. Technical factors include the location, orientation, height of the line itself, its horizontal and vertical articulation, and the diameter of the conductors. Of particular concern is the presence of ground/shield wire, which is a particular threat to birds because its thickness is significantly less than that of the conductors, making it almost ‚invisible' to birds.

Larger, heavy-bodied birds with large wingspans and poor eyesight are more prone to collisions than smaller, lightweight birds with smaller wingspans, mobility, and good eyesight. In our conditions, the first category includes e.g. swans, bustards, storks, herons, and ducks, i.e. species that are specific in their weight and wingspan and are adapted for long and slow flights. The highest mortality rates are shown for the mute swan (*Cygnus olor*), mallard (*Anas platyrhynchos*), great bustard (*Otis tarda*) grey heron (*Ardea cinerea*), common crane (*Grus grus*), white stork (*Ciconia ciconia*) and also for smaller species such as the common blackbird (*Turdus merula*), etc. The longer the wing is from the midline, the lower the manoeuvrability of the individual, as the moment of inertia is much higher compared to short wings birds. In many cases, repeated collisions are observed in individuals of species with long legs and necks (herons, swans, storks, cranes, etc.) compared to species with a more compact body structure. The risk of potential collision increases dramatically for species concentrated in large flocks.

Anti-collision measures

Even if collisions themselves cannot be completely eliminated, they can still be reduced by means of proper mitigation measures. Line marking is one of the best and quick solutions, based on making the wires more visible to birds in flight. There are different types of collision avoidance measures, which can be categorised according to when they are applied. These are preventive measures (route planning outside areas of importance for birds, migrating routes, etc.) and corrective or mitigating measures (retrofitting of markers). The choice of anti-collision measures should take into account not only the technical and economic feasibility of each site/management, but also the target species that will be most sensitive in terms of collisions.

In good visibility, birds can detect power lines well in advance and avoid them, usually by flying over them. The addition of various types of diverters/markers, is the most commonly used mitigation measure to reduce the number of collisions. For example, aerial spheres, spirals of different sizes/ colors and shapes, colored flags, neoprene belts, dynamic/static plastic elements with reflectors, slats, metallic spheres reflecting sunlight, etc. are still in use today.



In general, the selected bird flight diverter should meet the following environmental parameters: movement of all or part of the device, contrasting color to the surrounding landscape, reflectivity, and glow after sunset for at least 6 hours. The placement of various designs of diverters on wires has shown to effectively reduce bird collisions, up to nearly 95%. Despite this potentially important conservation issue and the many power lines marked, few studies have looked in detail at the analysis of the effectiveness of installed diverters, or only sporadic observations have been made.

Some devices can be attached manually from the ground (e.g. during the construction of the line), others are snap on automatically via a claw, and some need to be manually attached in place from hanging basket. Related to this is the speed of installation. For example, a FireFly diverter can be installed from the ground using a telescopic stick in 1 day in a quantity of 50 pieces, which means about 500-600 m of secure power line. In the case of installation using rollerblading, from a bucket truck, it is necessary that the power line is switched off, when using a drone it is not necessary. Installation of bird diverters by drone on from field requires 1 drone, 1 pilot and 1 navigator. It is possible to attached 200 pcs/day which means, app. 1.5 minutes on 1 diverter.

The installation must be carried out according to the design of the bird diverter, the technical possibilities resulting from the type of power line and the conditions given by the position of the power line in the area. The spacing between the diverters varies and ranges from 5 to 30 m, depending on the type used. (e.g. FireFly-10m; RIBE bird diverter/ Swan-Flight Diverter, spacing 20-40m). The installation of bird diverters is recommended for 220 kV and 400 kV lines only on the ground/ shield wire, which is the main cause of bird mortality due to collisions. The installation of diverters on the phase conductors of transmission lines is not recommended, as they could gradually destroyed and fall off due to the so-called corona effect. It is recommended to install them in a zig-zag pattern for the distribution power lines with one horizontal position of wires. An optical spacing declaring the efficiency of the diverters is ensured, when using a lower number of pieces.

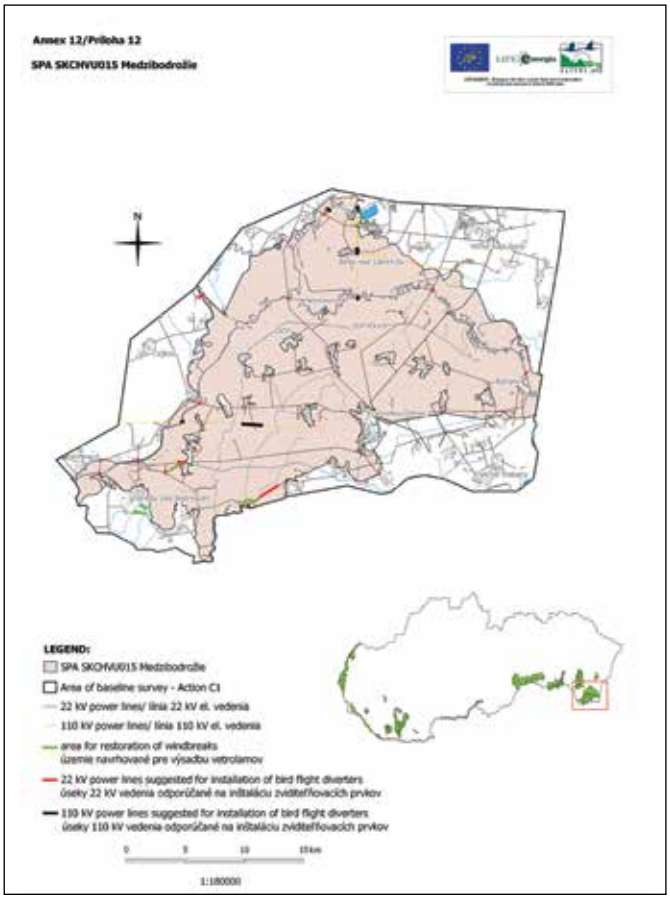
National regulation - legal obligation

Energy companies use only bird-friendly types of pole/cross-arm designs and devices during the construction or reconstruction of medium-voltage power lines. It is not necessary to force them under the law. It is often the result of an adoption of the EU legislation and cooperation, which is often based on joint participation in nature and landscape conservation projects. Many agreements, declarations, and memoranda with power grid operators, nature protection organizations, non-governmental organizations and other key stakeholders have been signed, defining the issues, experiences, cooperation steps and solutions.

Also, catalogues of bird-safe power pole designs were set up by many electric utility companies, in close co-operation with the government and conservation groups. The safety of protective devices is often evaluated by the written opinion of the relevant nature conservation agencies, such as by Nature Conservation Agency of the Czech Republic, Raptor Protection of Slovakia (RPS) in close cooperation with the State Nature Conservancy of Slovak Republic, or by BirdLife Hungary (MME). In practice, only elements and designs that have undergone such a process may be used by grid operators.

Some energy companies also have internal guidelines on how to deal with electrocutions and collisions, or have defined ways of dealing with certain types of structures and insulating elements. These guidelines are regularly updated on the basis of the latest results of field surveys carried out by ornithologists and field experts.

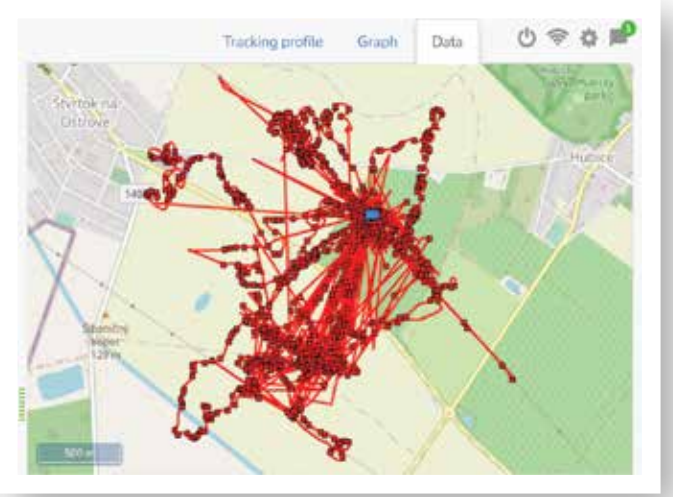
Two basic principles are mainly defined within the national laws and regulations: anyone who builds or plans overhead power lines is required to use a technical solution that prevents birds from being killed or injured: If there is proven electrocution/collision accident on the power line, the network operator must take technical measures to prevent these risks.



Evaluation of dangerous power lines

The identification of power lines with the highest risk of possible bird collision and electrocution requires easily accessed biological, technical, and landscape information. Based on the results of follow-up analyses, the highest-risk sections should be prioritised for the implementation of mitigation measures. Taking into account the economic cost of marking, it is likely more useful to attach flight diverters to these hot-spots rather than to do it to whole sections of power line. In the case of electrocution risk, it is necessary to proceed according to priorities, with the aim of focusing on the most risky sections first, and then gradually on the whole surrounding area. These approaches focus on the most risky poles/line sections while saving money of the distribution and transmission system operators.

One of the ways to identify risky poles in relation especially to juveniles is the installation of satellite transmitters. This approach is applied in the LIFE Danube Free Sky (www.danubefreesky.eu). Thanks to this data, it is then possible to identify which of the dangerous poles/lines are located in the home range of breeding pair and priority habitats and to take effective measures.



Nesting opportunities & management of corridors under power lines

Power lines also have a positive impact on certain bird species. They offer opportunities for resting and hunting prey, and in particular, for nesting. In landscapes where there are few trees and limited availability of nesting sites, some bird species can exist mainly due to the presence of power lines. The use of pylons for the placing of nest boxes can greatly assist in increasing the populations of some species, such as the saker falcon. Standard nest boxes for this species are approximately 80x80 cm, open on 2 sides, with a roof and gravel on the ground (developed by MME BirdLife Hungary) or 60x60 cm, open on one side with a landing platform, as used in Slovakia by the RPS.

One way to reduce the amount of chemistry in the fields while protecting the crop is through biological crop protection. This involves using power lines on which nest boxes are installed for nesting raptors and owls, the natural predators of voles.

Power lines have become part of the landscape around us. Line buffer zones, which are designed to ensure the operation of the electricity network, can play an important role in supporting the diversity of flora and fauna in the landscape. Traditional maintenance strategies i.e. frequent mowing and tree felling, usually encourage vegetation regrowth which may lead to increasing of invasive species that provide little or no benefit to pollinators, birds, and other wildlife. The constant regrowth of vegetation is also costly and labour-intensive. By managing the area under the power line properly, it is possible to create or restore suitable habitats that support the survival of many species of invertebrates, reptiles, amphibians or birds. Thanks to the cooperation of energy companies and the NGO Raptor Protection of Slovakia, many habitats under power lines are effectively managed in this way.

Conclusions & recommendations

In new infrastructure planning, sensitive bird areas should be avoided in the first instance when the power line is routed. In case of new international/national technical standards, national delegates of ministries responsible for nature conservation and/or specialists of NGOs should involve in the process to enforce bird protection aspects and avoid unnecessary subsequent conflicts. It is also strongly recommended that for planned/reconstructed power lines, expert field surveys should be realized, including at least one year of ornithological investigations in order to characterise local and regional avifauna, bird movements, and key sites for breeding, feeding and resting areas as well as seasonal migration route. This ensures that new overhead power lines will be safe for birds. Such investigations should also include research on flight movements during the day and especially in the dawn and dusk period, when the light conditions are insufficient and birds are most active at the same time, hence there is the highest risk of a possible collision. It is important to promote and support financially internationally standardised monitoring of the impacts of power lines on birds, including the necessary evaluation of the effectiveness of mitigation measures.

Close cooperation with other relevant stakeholders is needed. The involvement of energy companies in the development of methodologies, field surveys, and data evaluation is crucial and will help to build mutual trust. Many grid operators and regulators have also realised the benefits of eliminating electrocution risks, often working with bird conservation organisations to ensure win-win solutions are found. It is necessary to define priority areas and to continue systematically to verify the effectiveness of the measures taken and to share the results obtained and learn from others. Various expert groups, both national and international, can be used for this purpose, as birds know no borders.

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