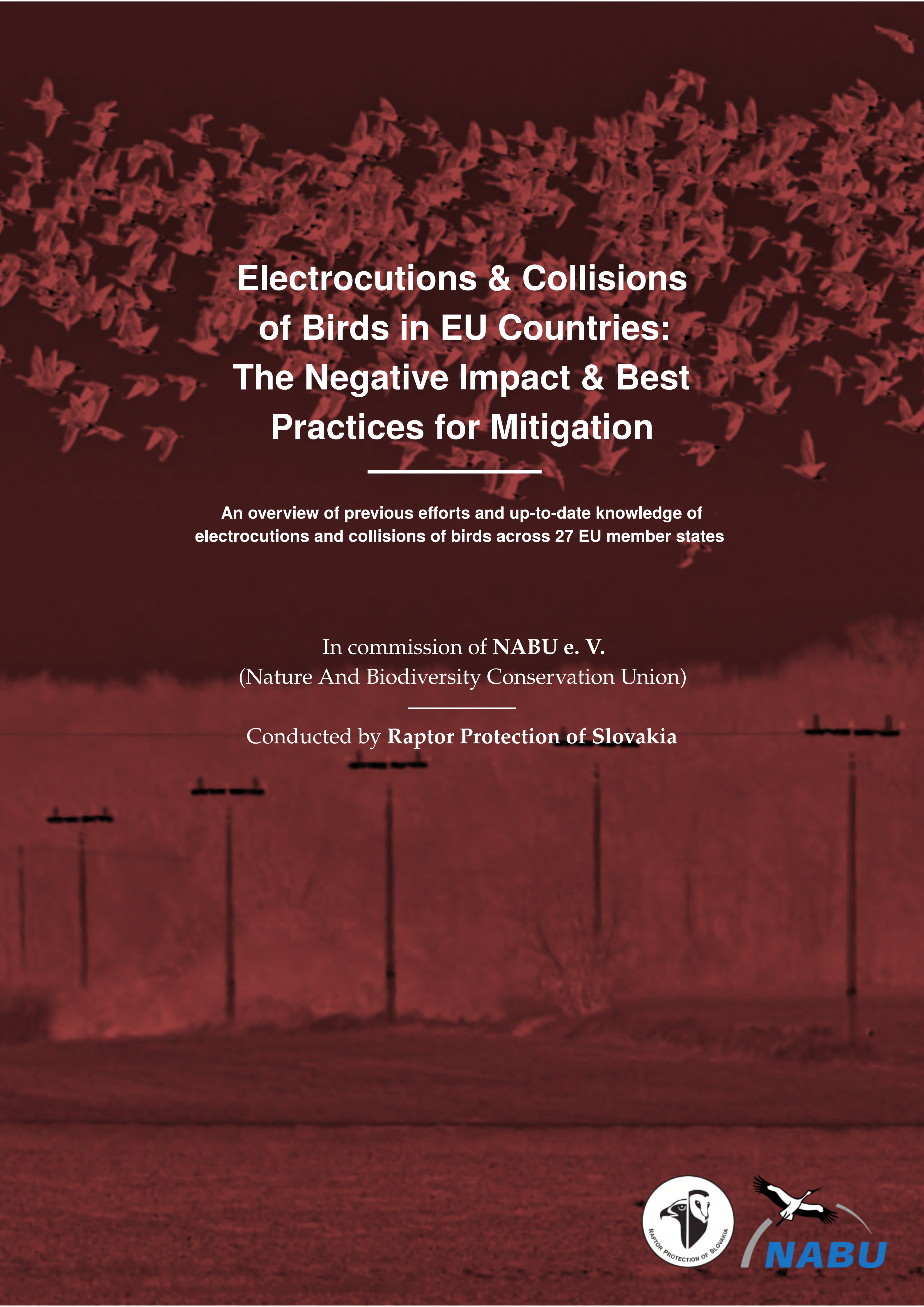

# Electrocutions & Collisions of Birds in EU Countries: The Negative Impact & Best Practices for Mitigation

**An overview of previous efforts and up-to-date knowledge of electrocutions and collisions of birds across 27 EU member states**


In commission of **NABU e. V.**
(Nature And Biodiversity Conservation Union)

Conducted by **Raptor Protection of Slovakia**

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**Raptor Protection of Slovakia (RPS)**
Since 1974 our mission is to improve conditions for birds of prey and owls in wild nature all over Slovakia with a special emphasis on endangered species. We study the breeding biology, threats, habitats and carry out actions to create and/or conserve safe nesting conditions, suitable foraging habitats and roosting sites for birds of prey, owls as well as other bird species. One of the topics we focus on since the beginning is the birds vs. power lines interaction.

**Nature and Biodiversity Conservation Union/BirdLife Germany (NABU)**
Founded in 1899, NABU is one of the oldest and largest environment associations in Germany. The association encompasses more than 820,000 members and supporters, who commit themselves to the conservation of threatened habitats, flora and fauna, to climate protection and energy policy. NABU's main objectives are the preservation of habitats and biodiversity, the promotion of sustainability in agriculture, forest management and water supply and distribution, as well as to enhance the significance of nature conservation in our society.



**Colophon**
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https://github.com/fmarotta/kaobook

*Electricity has become part of the standard of living, posing a fatal risk to birds at the same time. It is our job to find the best solution for bird safety on power lines. Mutual communication and knowledge exchange between experts of EU countries is necessary, as the birds do not know the borders.*

# *Foreword*

*Electric power is still regarded to be a major benefit for humankind, but it is also turning to be a significant threat for wildlife. Transmission and distribution electricity grids are expanding rapidly worldwide with significant negative impacts on biodiversity. Unfortunately, the routes of Eurasian migratory birds are concentrated in those regions at which mankind has erected the most elaborate grid of electric power lines.*

*In recent years, awareness has risen surrounding the dangerous interactions of birds and electric powerlines. Electrocution and collisions are substantial mortality factors for numerous bird species, despite the increasing number of mitigation measures implemented worldwide. The risk of power lines for birds is still an underestimated reason of mortality in some countries or areas and the data are either missing or absolutely insufficient. Hence, there is no legal setting for the mitigation of collisions on power lines as for electrocution. From some countries, only sporadic data were recorded by local experts and the wide public. Nevertheless, that greater investment in scientific research aimed at bridging gaps is needed - current knowledge already offers a solid basis for actions to improve the safety of electric powerlines.*

*This document provides a general overview on the current handling and knowledge of the birds vs. power lines issue on the national level of all 27 European (EU) member states by providing answers on a questionnaire prepared by Raptor Protection of Slovakia. The questionnaire was sent to a number of non-governmental organizations, BirdLife International offices, and electric utility companies. Unfortunately, low-quality information was retrieved from some countries. This possibly reflects the fact that available information on the subject of bird-power line interactions is genuinely limited and/or that relevant stakeholders are just not aware of the topic. Nevertheless, some of the missing information could be retrieved from scientific (and other) publications and documents. Through these sources, it was possible to prepare this document to present an up-to-date account of the scale and impact of electrocution and collision of birds with power lines. It also provides recommendations for actions and examples of best practices to reduce bird mortality.*

*We hope that this short overview can serve as a framework necessary for implementing best practice standards to reduce bird mortalities, document utility actions, improve service reliability, and comply with bird protection laws in the EU. An EU wide implementation can set the ground for the adaption in flyway regions with extraordinary demand for practical and effective measures like the Balkans, Middle East, or East Africa.*

*Raptor Protection of Slovakia*

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# Introduction 1

Collisions and electrocutions on power lines are known to kill large numbers of birds annually on a global scale for more than 130 years [1, 2] . Most power lines constructed so far pose fatal risks for birds and significantly affect the habitats of large birds (in their breeding, staging, and wintering areas). Bird mortality from interaction with power lines and other electric-utility structures has been documented for over 380 species of birds, including critically endangered and threatened species. Interactions between birds and power lines are a complex mixture of biological, environmental, and engineering factors. Power lines that span water bodies over more than 100 meters or that are located Natura 2000 sites represent the first priority for the implementation of the protection measures [3, 4] .

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*
[2]: Derouaux et al. (2012), 'Reducing Bird Mortality Caused by a High-and Very-high-voltage Power Lines in Belgium'

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*
[4]: Ferrer (2012), 'Aves y tendidos eléctricos'

Depending on the type of construction, power lines may cause fatal injuries and death to birds due to electrocution or collision. The birds vs. power lines issue is dealt with in a large number of reports and publications from various European countries. Although huge attention was given to this issue in the past, there are still regions and types of power line infrastructures for which data are either missing or insufficient. In several countries, the problem has just got attention recently and the efforts to prevent this threat are just developing. In many countries (such as Belgium, Germany, Czech Republic, Slovakia, Hungary, Bulgaria, Spain, Sweden, Portugal...) different methods, efforts, and solutions for bird safety are studied under study & monitoring of efficiency to obtain proper mitigation measures (line marking, insulation of medium-voltage poles, burying of cables etc.).

According to current knowledge, it is possible to reduce the risk of electrocution and collision significantly, within acceptable inputs for the electric utility companies. Technical solutions against bird collisions exist and can reduce mortality by 60–95% [5, 6] . Although some of those measures were implemented in more than half of the countries, the risk of power lines for birds is still an underestimated reason of mortality in some countries, local habitats and migratory corridors. The positive fact is that only parts of potentially dangerous lines and utility poles are responsible for the majority of killed birds. These most dangerous lines and poles should be fully identified and treated by the energy utility companies. In various parts of Europe, different technical solutions for bird safety were/are being tested and evaluated. Many of them are not effective, some of the turn out to be highly effective. 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.

[5]: Barrientos et al. (2011), 'Meta-analysis of the Effectiveness of Marked Wire in Reducing Avian Collisions With Power Lines'
[6]: Gális et al. (2019), 'Monitoring of Effectiveness of Bird Flight Diverters in Preventing Bird Mortality from Powerline Collisions in Slovakia'

**The following chapters present a source of information gathered through a questionnaire, which was sent to a range of parties across all 27 EU member states, and through literature review of published material.**

# Electric Grid Infrastructure | 2

Electric power transmission is the movement of electrical energy from a generating site (power plant, wind turbines etc.) to an electrical substation (transformers reduce the voltage to a lower level) via a transmission and distribution power line network to the end customers (Figure 2.1).

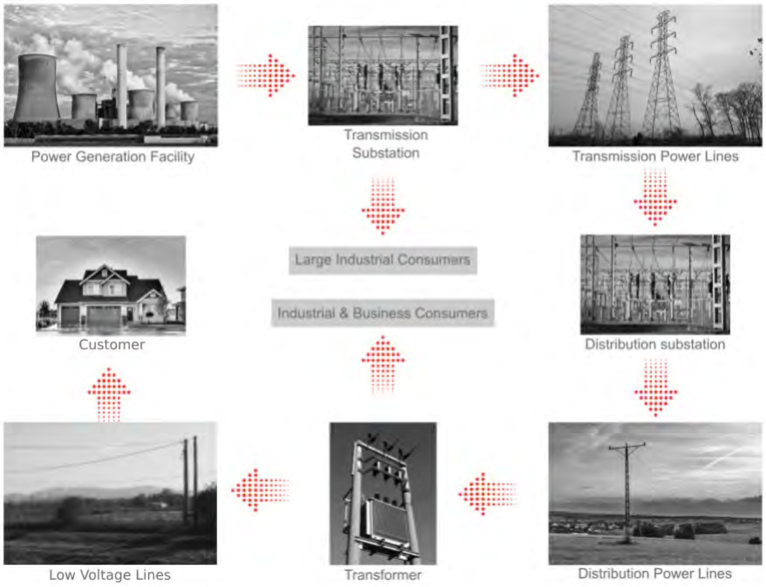


**Figure 2.1:** Schematic of the electric power system from the generation facility to the customer.
*Source: Raptor Protection of Slovakia*

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-voltage, medium-voltage, and low-voltage (Annex A).

**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 neighboring countries. The high-voltage grid is the backbone of the electricity transmission system. Transmission lines transport energy from large production centers (thermal, hydroelectric, and nuclear power stations, or from renewable sources) to the main centers of consumption (e.g. cities and heavy industry) and to substations, which feed the energy into the distribution lines and onto the smaller centres of demand. Even to laymen, the differences in the different types of lines are apparent. Transmission lines mostly use high-voltage three-phase alternating current (AC), that deliver large amounts of power over long distances [3] . Electrical power may be transmitted through overhead lines or underground cables.

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

Transmission lines (Figure 2.2) loop between large pylons, over 30 m high that aside from the conductors, often have another cable on top – usually referred to as groundwires or earth (shield) wires, that protect the power line from lightning.

**Figure 2.2:** Pylons of transmission power grid carry electricity at high voltages from generating facilities to substations over long distances.
*Source: Raptor Protection of Slovakia*

Due to the voltage they carry, these types of lines have long chains of insulators and normally three conductors/cables per circuit [7] .

[7]: Ferrer (2012), 'Birds and Power Lines. From Conflict to Solution'

**Medium-voltage power lines** (1–59 kV) or "distribution lines" carry electricity to residential and business consumers [8] . The poles/pylons on distribution lines are much smaller than those used on transmission lines and are normally only 8–12 m high (Figure 2.3). They are made, depending on the country, of metal, concrete or wood mainly as central mast – with metal crossarms [7] and in many variations of type and positions of cross-arms, pin insulators, exposed jumper wires, and other energized elements. In some countries and by some electric utility companies, the whole medium-voltage power network has been laid under-ground. However, worldwide the majority are still overhead power lines.

[8]: Bernardino et al. (2018), 'Bird Collisions with Power Lines: State of the Art and Priority Areas for Research'

**Figure 2.3:** Single-phase 22 kV utility pole — most common for distribution power lines in Slovakia.
*Source: Raptor Protection of Slovakia*

**Low-voltage power lines** (>1 kV) are used in a number of countries to transport the 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. Collision risk is minimized, because the well-visible black thick cable replaces a number of conducting wires. On low-voltage overhead power lines, the risk of electrocution is limited, because of the relatively low voltage and the high electric resistance of birds (Figure 2.4).

**Figure 2.4:** Low-voltage lines use often well insulated thick black cable.
*Source: Raptor Protection of Slovakia*

**Other power line constructions** such as overhead power lines of railways transmit power at typically 10,000 V to 15,000 V (Figure 2.5). This corresponds to the medium-voltage range of the electric utility companies, and similar aspects of bird safety must be thus taken into consideration. Even the railway poles use different construction of cross-arms, many „killer poles“ are in use [1] .The problem itself is almost unknown; only recent studies start to reveal the dangers involved to birds. In the past, these dangerous power lines received little attention.

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*


**Figure 2.5:** Poles of electric railway lines correspond to the medium-voltage poles, and similar aspects of bird safety must be thus taken into consideration.
*Source: Raptor Protection of Slovakia*

## 2.1 National Grids

The split of competencies is geographical, or by the voltage range. There are grids of distribution and transmission power lines in each country. Transmission system operators (TSO) are often state-owned and are responsible for the operating network of high and extra-high-voltage lines for the entire country. Distribution system operators (DSO) are mainly small or larger private companies, they operate on the level of the whole country or are divided based on the regions, provinces, municipalities, etc. Especially in some smaller countries, only one company is in charge of the transmission and the distribution grid.

**Austria:** Extra-high-voltage grid is administered at the federal level (APG, Austrian Power Grid), whereas lower networks are often administered at the state level or by certain companies (railway companies, etc.). Austrian Power Grid AG operates the largest [1] supra-regional high and ultra-high-voltage grid in Austria with voltage levels of 110, 220, and 380 kV. Electricity also flows at high and medium voltage levels in the nine regional distribution networks before continuing to the local low-voltage networks, where it comes out of the socket at 230 volts. (www.apg.at). There are more than 130 electricity suppliers in Austria. Some offer their products across Austria, others only at a local level. The following companies are the dominant players in the supply market: Verbund, Wien Energie, KELAG, Salzburg Netz, Linz Strom and EVN. DSOs operate distribution grids generally from 110 kV to 0.4 kV. The 110 kV grids are connected to the TSOs 220/380 kV grids. The majority of the end-consumers are provided with electricity from the 230/400 V grids (www.cms.law).

1: approximately 6,970 km and 12,000 pylons

**Belgium:** TSO ELIA (www.elia.be) is responsible for the entire network of high voltage (30 kV to 400 kV) power lines in Belgium, operating over 8,781 km overhead lines and underground cables. Elia owns the entire Belgian very-high-voltage grid (150 to 380 kV) and around 94% (ownership and user rights) of the Belgian high-voltage grid (30 to 70 kV). Elia's grid comprises 5,614 km of overhead lines and 2,765 km of underground cables (www.renewables-grid.eu). DSO Ores (www.ores.be) and DSO Resa (www.resa.be) manages medium (>70 kV) and low-voltage lines in Wallonia. DSO Eandis and DSO Infrax are distributors in Flanders; while DSO Sibelga is active in Brussels. Such companies ensure the operation of their member's distribution grids.

**Bulgaria:** The split of competencies is geographical, as well as by the type of power line – there are Distribution and Transmission power lines. The state-owned National Electricity Company is responsible for high tension power lines. Three private electric distribution companies (EVN, Energo-Pro, and CEZ) are operating medium (20 kV) and low-voltage power lines, each operating in a different geographically region.

**Croatia:** The split of competencies is geographical, as well as by the type of power line – there is one distribution and one transmission grid operator. Low and medium-voltage lines are managed by HEP-Distribution system operator Ltd. and high-voltage power lines by HOPS-Croatian Transmission System Operator Ltd. They both operate in the whole of Croatia. The electricity infrastructure of transmission lines includes 1,247 km of 400 kV power lines, 1,210 km of 220 kV power lines and 5,013 km of 110 kV power lines (www.cms.law).

**Cyprus:** The Electricity Authority of Cyprus (EAC) is responsible for the generation, transmission (66 kV, 132 kV), distribution (11 kV, 22 kV), and supply of electricity in Cyprus. The length of all transmission lines is 1,150 km of which 212 km of cables are underground.

**Czech Republic:** The split of competencies of power companies is geographic. 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. ČEZ Distribuce, E.ON Distribuce and PREdistribuce manage 73,268 km medium-voltage electrical lines (50,881 km – ČEZ Distribuce 2018, 18,506 km – E.ON Distribuce 2018 and 3,881 km – PREdistribuce 2019). DSO ČEZ Distribuce, a. s. – operates 110 kV and less voltage lines in regions: Plzeňský, Karlovarský, Ústecký, Středočeský, Liberecký, Královéhradecký, Pardubický, Olomoucký[2] and Moravskoslezský region, partly region Zlínský – only the district Vsetín town and region Vysočina – only the district Havlíčkův Brod town. DSO E.ON Distribuce, a. s. - operates 110 kV and less voltage lines in regions: Jihočeský, Vysočina[3] , Jihomoravský, Zlínský[4] . DSO PRE distribuce, a. s. operates 110 kV and less voltage lines in the capital Prague and the town Roztoky nad Vltavou.

2: with the exception of the district Prostějov town

3: with the exception of the district Havlíčkův Brod town

4: with the exception of the district Vsetín town

**Denmark:** The Danish transmission system is owned and operated by Energinet. This TSO is only responsible for voltage 132 kV, 220 kV, and 400 kV. Energinet operates nationwide. For medium (50 and 10 kV) and low-voltage lines (0.4 kV), there is geographic division.

**Estonia:** The split of competencies is geographical, as well as by the type of power line. The biggest DSO is Elektrilevi OÜ covering ca 90% of Estonian customers. TSO Elering AS is a national transmission system operator for electricity and natural gas with headquarters in Tallinn, Estonia. This TSO manages 110 kV and 330 kV power lines.

**Finland:** The split of competencies is geographical, as well as by the type of power line. The power system in Finland consists of power plants, a nationwide transmission grid, regional networks, and distribution networks. TSO Fingrid operates power lines of 110 kV, 220 kV, and 400 kV on a nationwide level and across national boundaries. The distribution networks operate at a voltage level of 10 and 20 kV. The total length of high-voltage networks is approximately 22,500 km, the medium-voltage network consists of 140,000 km and the low-voltage network consists of 240,000 km. The high-voltage networks consist entirely of overhead lines. Of the medium-voltage networks, 80% are overhead lines, 7% are aerial cables, and 13% are underground or underwater cables. (www.energia.fi).

**France:** The split of competencies is geographical, as well as by the type of power line. TSO Réseau de Transport d'Électricité (RTE) operates high and extra-high-voltage of 63 kV, 90 kV, 150 kV, 225 kV and 400 kV. DSO Enedis manages the electricity distribution network across 95% of mainland France. Local DSO manages the remaining 5% in their exclusive service zones. DSO ERDF is the EDF subsidiary that operates 95% of the distribution system in terms of length of networks. TSO RTE owns and operates the public electricity transmission network, which runs for a total length of around 100,000 km . The total length of cables and infrastructures is well in excess of 1.3 million km. Between the medium and low voltages networks are some 700,000 distribution substations (www.cre.fr).

**Germany:** The split of competencies is due to the former service area of the big power provision companies, as well as by the type of power line – there are over 900 small and larger distribution system operators and 4 transmission system operators (50Hertz, Amprion, TenneT, TransnetBW). The German grid comprises four voltage levels: the extra-high-voltage level (380 and 220 kV), the high-voltage level (110 kV), the medium-voltage level (6 to 60 kV) and the low-voltage level (230 and 400 V). The extra high voltage grid is over 35,000 km long. The high, medium and low-voltage level grids have a length of about 77,000, 480,000 and 1.7m km respectively (www.cms.law).

**Greece:** The split of competencies is geographical, as well as by the type of power line. The network in Greece is covered by 2 state-owned companies. TSO Independent Power Transmission Operator (IPTO) is responsible for the high voltage (150 & 400 kV) network and Hellenic Electricity Distribution Network Operator (HEDNO) for the medium & low voltage (22 kV and 230 V) network.

**Hungary:** The split of competencies of power companies is geographic. North East – company ELMŰ-ÉMÁSZ is managing power lines of 120 kV, 22 kV and 230/400 V; West and East – company E.ON Hungária is managing power lines of 120 kV, 22 kV and230/400 V; South-East – company NKM is managing power lines of 120 kV, 22 kV and 230/400 V; Countrywide – company MAVIR (Hungarian Transmission System Operator Company Ltd.) is managing 120 kV (several sections), but mostly 220 kV and 400 kV power lines, with one section of 750 kV power line in eastern Hungary.

**Ireland:** TSO EirGrid plc is the state-owned electric power transmission system operator that covers the whole Ireland. The transmission system comprises 6,800 km of overhead power lines operating at 400 kV, 220 kV, and 110 kV. It comprises networks operating at 110 kV in the Dublin area, and nationwide the networks operating at 38 kV, 20 kV, and 10 kV and low voltage (LV) operated by DSO ESB Networks (www.esbnetworks.ie).

**Italy:** The transmission of electricity is carried out by TSO Terna, which owns 94% of the national grid and operates 380 kV, 220 kV, and 132/150 kV lines. Distribution activities are carried out by a few operators on the basis of government concessions. Enel Distribuzione is the main DSO, with 86% of the distributed electricity volumes. Other DSOs are: A2A, Acea Distribuzione and Aem Torino Distribuzione. The remaining distributors hold units lower than 1% (www.cms.law).

**Latvia:** DSO joint stock-company „Sadales tikls" – manages power lines of 230 and 400 V and 6–20 kV in Latvia, which covers 99% of the country's territory. The total length of electricity distribution networks in 2020 reached 92,958 km (www.sadalestikls.lv). TSO ALS „Augstspriegumu tikls" – manages power lines of 330 kV and

110 kV with a total length 5 612,91 km within the territory of Latvia (www.ast.lv).

**Lithuania:** Power lines are divided into high-voltage transmission network and a distribution network. The main function of these networks is to supply electricity to users while most of them are 400 V and 10 kV voltage power lines. Distribution networks in the country are managed by the state enterprise AB ESO. These networks are made up of 121,698 km power lines with 79% of them being overhead and 21% – electrical cables. Meanwhile, the Lithuanian high-voltage electricity transmission network consists of 400 kV, 330 kV, and 110 kV power lines, the majority of which run overhead[5] . The high-voltage network is operated by the state enterprise AB LITGRID. The company is responsible for the management and development of this network. Currently, it covers 7,029 km of power lines and 236 transformer substations and distribution units.

5: underground power lines constitute a relatively small part

**Luxembourg:** The split of competencies is geographical. Company "Creos" operates the grid for the whole country. The total length of the Luxembourg electricity network managed by Creos is 10,023 km, including 587 km of high-voltage lines, 3,653 kilometres of medium-tension lines and 5,783 kilometers of low tension lines. The electricity is transmitted to six transformer stations (Flebour, Roost, Itzig/Blooren, Heisdorf, Bertange and Schifflange) where the voltage is reduced from 220 kV to 65 kV before being distributed to industries and large municipal distribution networks. The voltage is then reduced further from 65 kV to 20 kV in more than 60 transformer stations distributed across the whole country. The electric energy obtained is distributed to SMEs, towns and villages where the transformers reduce the current voltage to 0.4 kV before distributing it to the end consumer. A control center, known as Electricity Dispatching, remotely controls and manages these high and medium-voltage networks.

**Malta:** DSO Enemalta is the leading energy services provider in the Maltese Islands, entrusted with the distribution of electricity, and the development of the national electricity distribution network. The distribution of electricity from the Delimara Power Station, from the Maghtab Terminal Station of the Malta-Italy Interconnector and from several grid-connected renewable energy sources located in different parts of the country, is achieved through a four-level network, comprising four different voltage levels, 132 kV[6] , 33 kV[7] , 11 kV (1,134 km underground) and 400/230 V. And other few kilometres of overhead high voltage lines are mostly in rural areas. Where possible, the company is phasing out overhead high voltage lines and replacing them with underground cables (www.enemalta.com).

6: 87 km are underground

7: 260 kilometres as underground cables

**Netherlands:** All transmission networks (i.e. electricity networks with a voltage level of 110 kV and higher) with around 23,500 km are owned and managed by the TSO TenneT, which is entirely owned by the state (www.tennet.eu). The country's distribution network operates on different regional levels. DSO Liander, operates in the Amsterdam area, DSO Stedin is active in cities as Rotterdam and Utrecht and most of the South Holland and Utrecht provinces.

DSO Enexis operates in five of the 12 Dutch provinces: Groningen, Drenthe, Overijssel, Noord-Brabant[8] and Limburg. Together, these three DSOs supply electricity to the majority of inhabitants in the Netherlands (www.statista.com).

8: except for the city of Eindhoven

**Poland:** The split of competencies of power companies is geographic. TSO Polskie Sieci Elektroenergetyczne S.A. (PSE) is a transmission system operator. The transmission grid is 110 kV, 220 kV and 400 kV and consists of 269 lines with a total length of 13,445 km, including: 104 lines of 400 kV voltage with a total length of 7,008 km and 164 lines of 220 kV voltage with a total length of 7,570 km (www.pse.pl).[9] In 2016, there were five big DSOs operating on the electricity market. DSO Energa Company is Poland's third-largest distribution network operator (191,000 km of power lines) serving North and Central Poland, with the other major distributors being. PGE Polska Grupa Energetyczna S.A. (PGE SA or PGE Group),a state-owned public power company and the largest power producing company in Poland. DSO Enea SA is a power industry company based in Poznań and is the fourth largest energy group in Poland.

9: as at 31 December 2019

**Portugal:** The split of competencies is geographical, as well as by the type of power line. DSO EDP – Distribuição manages low, medium and high voltage power lines. The transmission of extra-high voltage electricity (150 kV, 220 kV and 400 kV) is done in the RNT (Redes Energéticas Nacionais), under a concession granted by the Portuguese state in the form of a public service provided exclusively by TSO REN - Redes Energéticas Nacionais. The low-voltage distribution grids are operated under concession contracts between municipalities and distributors. The Portuguese electricity grid is connected with Spain's and consists of 71,000 km of high/medium voltage transmission lines and 112,000 km of low voltage lines (www.geni.org).

**Romania:** The split of competencies of power companies is geographic. TSO Transelectrica is a state-owned company and manages very-high and high voltage power line grids in Romania. The high, medium and low voltage lines are geographically split in 8 areas among different companies: CEZ Distribute SA; ENEL Distributie Banat SA; ENEL Distributie Dobrogea SA; E.ON Moldova Distributie SA; ENEL Distributie Muntenia SUD SA; FDEE Electrica Distributie Muntenia Nord SA; FDEE Electrica Distributie Transilvania Sud SA; and FDEE Electrica Distributie Transilvania Nord SA (www.cms.law).

**Slovakia:** The split of competencies of electric companies is geographic. The western part of Slovakia – company Západoslovenská distribučná, a.s. (ZSD) manages power lines of 110 kV, 22 kV, 230/400 V; Central part of Slovakia – company Stredoslovenská distribučná, a.s. (SSD) manages power lines fof 110 kV, 22 kV, 230/400 V; Eastern Slovakia – company Východoslovenská distribučná, a.s. (VSD) manages power lines: of 110 kV, 22 kV, 230/400 V. Countrywide - company Slovenská elektrizačná prenosová sústava, a.s. (SEPS) manages 110 kV (several sections), but mostly 220 kV and 400 kV power lines. The total length of transmission and distribution power lines is about 35,000 km.

**Slovenia:** TSO ELES, a 100% state-owned company. The ELES Company is responsible for 500 km of transmission lines in the 400 kV transmission network, 260 km of transmission lines in the 220 kV transmission network and 1,800 km of transmission lines in the 110 kV transmission network (www.eles.si). A distribution network consists of transformers and lines of different voltage levels (110 kV, 1–35 kV and 0.4 kV). Electricity DSO, company SODO d.o.o, is carrying out the tasks of general economic interest – an obligatory state service of electricity distribution in the territory of the Republic of Slovenia. Based on a concluded contract on leasing of the distribution network and carrying out the tasks of the electricity DSO on behalf of SODO, the electricity distribution activities are carried out by: Elektro Celje, d.d.; Elektro Gorenjska, d.d.;Elektro Ljubljana, d.d.; Elektro Maribor, d.d.; Elektro Primorska, d.d. (www.agen-rs.si).

**Spain:** The split of competencies is geographical, as well as by the type of power line. TSO Red Eléctrica Española (REE) is the manager of the transport network and the function of the single carrier function, under the exclusivity regime. The company operates around 20,000 km each of 400 kV and 220 kV power lines. Distribution company E-distribución supplies electricity in 27 Spanish provinces of 10 autonomous communities (Andalusia, Aragon, Balearic Islands, Extremadura, Catalonia, Castile and Leon, Valencian Community, Galicia and Navarra). Electricity distribution in Spain is regulated by the government through a geographical distribution:Galicia: Gas Natural – Fenosa; Madrid: Gas Natural – Fenosa + Iberdrola; Asturias: EDP; Cantabria: E.ON; Aragón: Endesa; Cataluña: Endesa; Baleares: Endesa; Andalucía: Endesa; Euskadi: Iberdola; Navarra: Iberdrola; La Rioja: Iberdrola; Castilla y León: Iberdrola; Extremadura: Endesa + Iberdrola; Castilla-La Mancha: Gas Natural-Fenosa + Iberdola; Murcia: Iberdrola; Comunidad Valenciana: Iberdrola; Canarias: Endesa.

**Sweden:** The split is geographical, as well as by the type of power line. The Swedish electricity grid is divided into a 15,000 km national grid (400 kV and 220 kV), 31,000 km regional grid (40 kV to 130 kV), 160 backbone grid transformers and 2,330 region grid transformers. There is one state-owned company, TSO Svenska kraftnät that is responsible for 220–400 kV in the whole country. A few DSOs such as E.ON, Vattenfall, Ellevio, Skellefteå kraft, Jämtkraft and a few others run 30–150 kV in specific larger regions. The local grid 0.4–20 kV is owned by a large number of companies. Many of these small companies are very local in specific cities and municipalities. There are about 170 different net owners and distributors of electricity in Sweden.

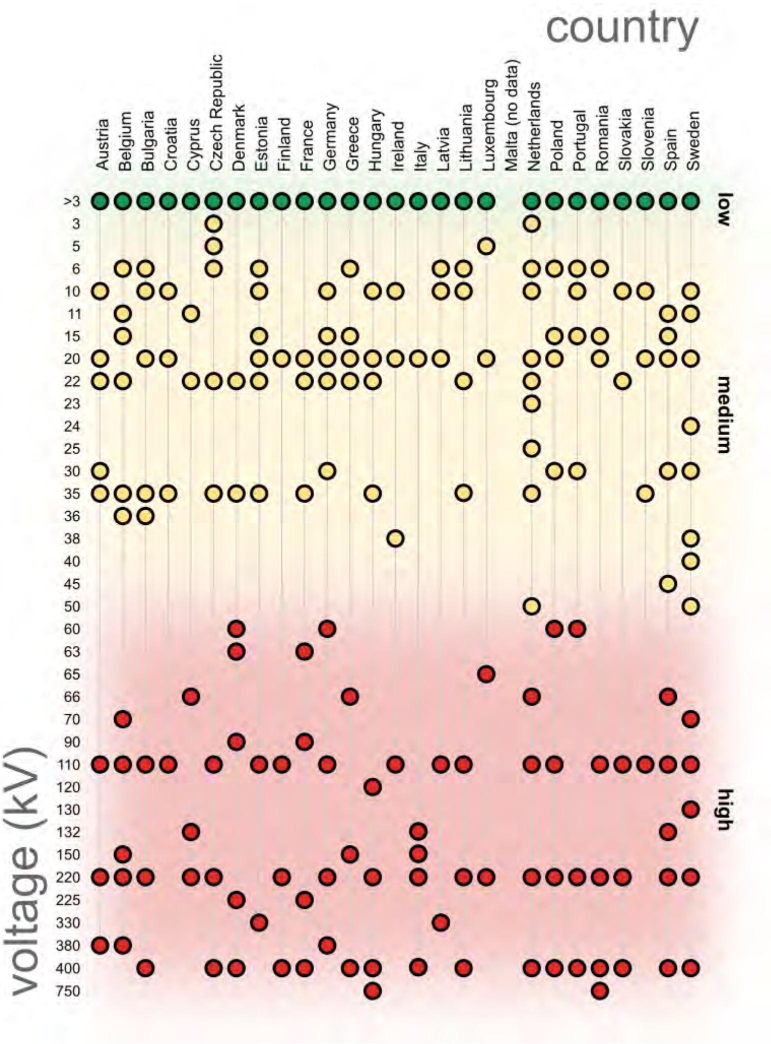


**Figure 2.6:** Voltage level used in a given country.

# Birds vs. Power Lines | 3

Collisions and electrocutions on power lines are known to kill large numbers of birds annually on a global scale. E.g. 700 dead birds per kilometer of power line in a year in a Dutch wetland; 250,000–300,000 birds died each year in Denmark by collision or electrocution; 1,000,000 birds died in a single year in France and 2,000 dead birds found every year in 100 km of power lines within the Coto Doñana National Park in Spain[1] . Depending on the type of construction, power lines may cause fatal injuries and death to birds due to electrocution and collision. The unexpected effect of the development of power lines on birds – both transmission and distribution lines – was probably first noticed in the United States of America. Several publications began to warn of what was to become one of the most serious conservation problems resulting from human activity for many threatened species of birds. Since then, the number of publications on the interaction between birds and power lines has increased rapidly also in Europe [2, 4, 9–12] .

1: Carcasses get removed quickly by predators. Therefore findings are made less more often than they happen. Removal rates by predators and scavengers may vary widely between sites and seasons.

[4]: Ferrer (2012), 'Aves y tendidos eléctricos'
[9]: Karyakin et al. (2009), 'Raptor Electrocution in the Altai Region; Results of Surveys in 2009, Russia'
[10]: Raab et al. (2012), 'Underground Cabling and Marking of Power Lines: Conservation Measures Rapidly Reduced Mortality of West-Pannonian Great Bustards Otis tarda'
[2]: Derouaux et al. (2012), 'Reducing Bird Mortality Caused by a High-and Very-high-voltage Power Lines in Belgium'
[11]: Demeter et al. (2018), 'Documenting and Reducing Avian Electrocutions in Hungary: a Conservation Contribution from Citizen Scientists'
[12]: Gális et al. (2019), 'Comprehensive Analysis of Bird Mortality along Power Distribution Lines in Slovakia'

**Above-ground power lines pose three main risks or perils to birds:**

**Risk of electrocution:** birds sitting on power poles and/or conducting cables are killed if they cause short circuits (short circuit between phases, or short-to-ground). In particular, „bad engineering" practiced on medium-voltage power pole constructions has resulted in an enormous risk for numerous medium-sized and large birds, which use power poles as perching, roosting, and even nesting sites. Many species of large birds suffer heavy losses and are strongly decimated by electrocution. Some species are even threatened by extinction.

**Risk of collision:** in flight, birds can collide with cables of power lines, because the cables are difficult to perceive as obstacles. In most cases, the impact of collision leads to immediate death or to fatal injuries and mutilations, which cannot be survived.

**Risk degradation, fragmentation and loss of habitat quality in staging and wintering areas:** areas are avoided by sensitive bird species mainly when aboveground power lines cut across open landscapes and habitats important as a feeding, breeding or hibernating place for species (wetlands, steppe, etc.).

Overhead power lines are an important factor significantly influencing the life of birds. The level of collision risk does not correlate with constructions of the power line. More important is the composition of present avifauna, weather, and visibility factors, location of the power line sections, whether they cross important bird habitats/breeding areas or main migration routes, etc. The specific design of the power lines themselves plays a decisive role especially in the case of electrocution. Morphology is also one of the main factors [13] . Species that are long-lived, have low reproductive rates, and/or that are rare or are already in a vulnerable conservation state (such as many eagles, vultures and storks) may be particularly endangered.

[13]: Bevanger (1998), 'Biological and Conservation Aspects of Bird Mortality Caused by Electricity Power Lines: a Review'

The distances between the cross-arms or other energized parts of high voltage power lines and medium voltage distribution lines is an important one from a nature conservation point of view as the risk of electrocution only exists for medium voltage distribution power lines whereas the risk of collision however exists for both transmission and distribution lines. Bird accidents on the medium-voltage and high-voltage network can lead to interruptions (power outages), associated economic damages, and inconveniences for the local public and business customers. Mitigation measures have proven to be effective in reducing the level of mortality from both electrocution and collisions. The placing of power lines underground as the most effective solution was completed in the Netherlands and is currently being carried out in Belgium, Denmark, Germany, Luxembourg and Norway. Otherwise, it has been only implemented in chosen regions, e. g. in Austria or Hungary due to the protection of the great bustard populations [10, 14] . More often, recent efforts of responsible authorities, bird protection organizations and also distributors concentrate on an improvement of used lines and pylon types.

[10]: Raab et al. (2012), 'Underground Cabling and Marking of Power Lines: Conservation Measures Rapidly Reduced Mortality of West-Pannonian Great Bustards Otis tarda'
[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

# Bird Electrocution | 4

Electrocution is a worldwide problem identified especially on the medium-voltage typey of power lines (1–52 kV) and railway infrastructure. It can have a major impact on several bird species and cause the death of thousands of birds annually. It has been documented in a number of earlier and more recent reports from the USA. The problem has also been described in various countries in Asia, e.g. Mongolia, Saudi Arabia, India, Dagestan, and Europe [9, 11, 15–25] . Several of the available studies include quantified avian electrocution rates. The highest risk is associated primarily with medium-voltage power lines representing very attractive perches to many birds in open rural areas without tree growth [15]. An elevated seating place attracts birds from the surrounding and provides predators in particular a suitable point for observing prey and if necessary also defense of the territory. In many cases, electric pylons and cross-arms are a risk to abutting species.

Avian death can occur either by **(1) short – circuits** (bird touches the two phase conductors and electricity flows through its body causing severe and often fatal burns and injuries) or by **(2) earthed-faults** that links the bird's body itself and an earthed part of the metal structure (Figure 4.1). The death can also occur after the bird will fall from the pole and crash onto the ground, immediately after electrocution.

The electrocution of large birds such as raptors, owls and corvids can also cause damage and sometimes result in interruption of power distribution. Large electrocuted birds (eagles, storks) very often remain in place, resulting in failure of the circuit as the operating system tries to reenergize the grid. The fall of burying carcasses can also start the fire of surrounding dry vegetation.

[15]: APIC (2006), *Suggested Practices for Avian Protection on Power Lines: the State of the Art in 2006*
[16]: Lehman et al. (2010), 'Raptor Electrocution Rates for a Utility in the Intermountain Western United States'
[17]: Dwyer et al. (2015), 'Critical Dimensions of Raptors on Electric Utility Poles'
[18]: Gombobaatar et al. (2004), 'Saker Falcon (Falco cherrug milvipes Jerdon) Mortality in Central Mongolia and Population Threats'
[19]: Harness et al. (2008), 'Mongolian Distribution Power Lines and Raptor Electrocutions'
[9]: Karyakin et al. (2009), 'Raptor Electrocution in the Altai Region; Results of Surveys in 2009, Russia'
[20]: Shobrak (2012), 'Electrocution and Collision of Birds with Power Lines in Saudi Arabia: (Aves)'
[21]: Harness et al. (2013), 'Avian Electrocutions in Western Rajasthan, India'
[22]: Gadzhiev (2013), 'Death of Birds of Prey on Power Lines in Daghestan'
[23]: Demerdzhiev et al. (2009), 'Impact of Power Lines on Bird Mortality in Southern Bulgaria'
[24]: Samusenko et al. (2012), 'The Problem of Bird Mortality on Power Lines in Belarus: Preliminary Results of Studies'
[25]: Demerdzhiev (2014), 'Factors Influencing Bird Mortality Caused by Power Lines within Special Protected Areas and Undertaken Conservation Efforts'
[11]: Demeter et al. (2018), 'Documenting and Reducing Avian Electrocutions in Hungary: a Conservation Contribution from Citizen Scientists'

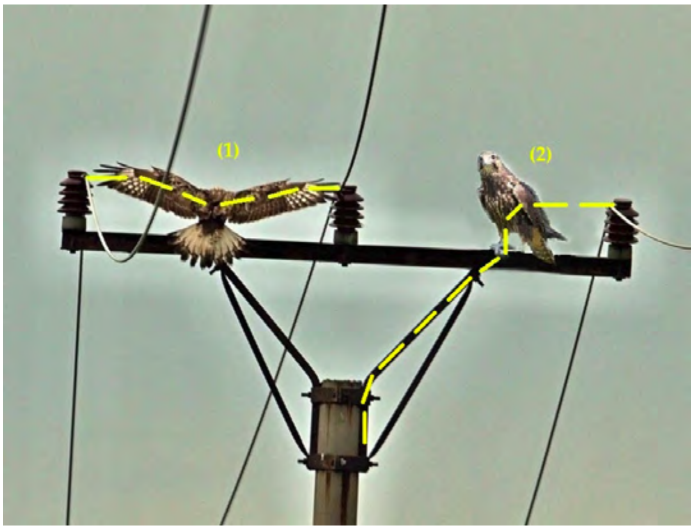


**Figure 4.1:** Typical pattern of electrocution on medium voltage pole: (1) short–circuit; (2) earthed-fault.
*Source: Raptor Protection of Slovakia*

## 4.1 National Overview of Electrocution Issue

Electrocution is not much of a problem in Luxembourg, the Netherlands, and Sweden, where most of the dangerous low and medium voltage lines have been placed underground. In some countries, such as Germany, the problem was reduced not mainly by underground cabling but by retrofitting dangerous poles, meeting the requirements of national law. There are still many countries in Europe, where low and medium voltage lines have not been placed underground or equipped with effective mitigating measures. There is a lack of data on bird fatalities from electrocution in some countries in general and it has never been under any systematic and long-lasting monitoring e.g. in Austria, Belgium, Estonia, Finland, Greece, and Latvia. The problem of electrocution has however been known for a long time and victims of electrocution had been located sporadically and local monitoring had been realized, to identify the risk of electrocution on bird species. Several studies have been carried out, which have revealed the interaction with power lines as one of the main causes of the threat of numerous birds (Bulgaria, Czech Republic, Italy, Romania, Slovakia, Spain and Sweden).

In many countries, the problem was identified and cooperation started, when large numbers of bird individuals were found dead. Meetings were organized with the power line companies and the first steps took place to develop a cross-arm cover insulator and other devices. For many countries no systematic monitoring in the sense of scientific investigations was realized, but they have a database where random findings are registered (e.g. Austria & Belgium). In other countries, the problem was identified after several repeated findings, latter this data was published and mutual communication with representatives of electric utility companies started, because apart from the environmental aspect, the companies also don't have relevant data which could showcase the amount of damage caused in the network and the subsequent costs that derive from bird electrocution incidents. This data initiated activities to study the loss of birds on power lines and their protection (e.g. Germany, Hungary & Slovakia). The data often comes from observations reported by birders or citizen scientists and finding a dead bird near a power line which they can directly register in the data portals or via cell phone application (Austria, Belgium, Slovakia). Another source of data is electrocution causing power breaks so the power companies get a picture of the problem (e.g. Slovakia & Sweden).

Since the second half of the 20th century, attention has been paid to this problem in many countries. First regular monitoring started mainly in the 70s, 80s and 90s, for some countries (Figure 4.2), victims of electrocution had been located sporadically, but the first more extensive results were found after the year 2000. Often the surveys were/are realized under LIFE + projects; national and international funds, etc. within Natura 2000 sites and conflict areas outside SPAs + all priority territories of rare and/or endangered bird species and species most vulnerable to electrocution at the same time like eagles, hawks, vultures, kites and falcons.

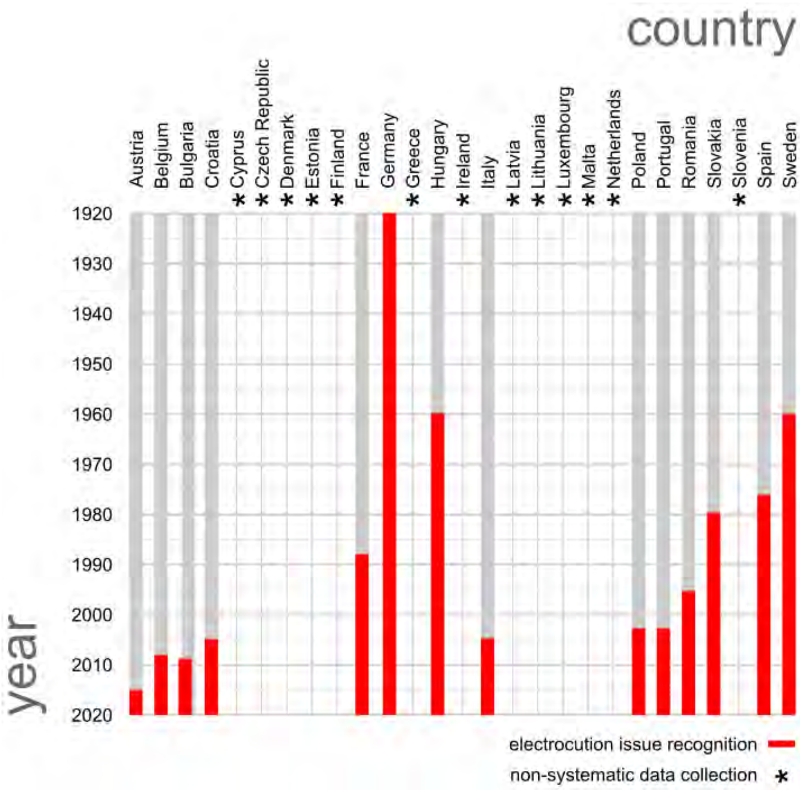


**Figure 4.2:** Historic overview of electrocution monitoring. The problem of bird electrocutions was addressed around the 70s and 90s. Since then, extensive research has been conducted on the problem of bird electrocutions.

In **Czech Republic**, the public attention to the problem of bird mortality on power lines was first widely attracted by an exhibition „The Light for Prague“ in 2001. But up to now, no system of regular monitoring has been developed. Data on electrocutions have been collected from various sources – rescue stations, results of particular projects, studies or assessments focused entirely or partially on this topic, public databases. Nevertheless, thanks to the general pressure of nature protection organizations and especially to an adoption of the EU legislation, distributors are now allowed to use only bird-friendly types of pylons and devices during the construction or reconstruction of medium-voltage power lines and they have to retrofit all dangerous pylons with approved measures till 2024 [26] .

[26]: Hlaváč et al. (2013), 'Ochrana ptáků na linkách vysokého napětí - Blýská se na lepší časy?'

In **Germany** since the 1920s there were some kinds of agreements for bird protection on power lines. In 1958 they got integrated in a VDE guideline norm but removed in 1969. Major activities by nature conservationists from 1974 to 1985 led to a reintroduction of the paragraph in the guideline. High losses of white stork and eagle owl were well documented and severe back then. A VDEW measure catalogue with new technical solutions was introduced in 1986 and became updated in 2011.

In **Hungary** the problem was identified in the late 1970s, early 1980s, in the Hortobágy when many of storks and some raptors were found electrocuted. Meetings were organized with the power line companies and first steps took place to develop a cross-arm cover insulator. The first type of such an insulator was designed by MME in 1991 (plastic cover to hinder electrocution while birds are sitting on poles) and was installed in large numbers (50,000 pylons covered) countrywide. Regularly national surveys started in 2004 by MME.

In **Slovakia** the problem of electrocution was identified in 1980, since when a number of meetings took place with the power lines providers. The first bird protective device was designed by Raptor Protection of Slovakia (RPS) around 1990 (plastic „combs“ to keep birds away from perching on poles) and was installed in 1993 in Mala Fatra mountains (Párnica – Zázrivá). The regular monitoring has started about this time around.

In **Spain**, the first data comes from the work of the naturalist Jesus Garzón, when he finds several bodies of Iberian imperial eagle (*Aquila adalberti*) in the Donana National Park and communicates at an international conference in Vienna (1977). Since then and until now, the interaction with power lines has been revealed as one of the main causes of mortality of Spanish birds. Several studies have been carried out, which have revealed the interaction with power lines as one of the main causes of the threat of numerous birds.

It has never been any systematic monitoring in **Sweden**. The problem of electrocution has been known for a long time. Sometime around 1990, it led to actions when cooperation's between power companies and ornithologists took place. The protection device Huven-Uven was developed between grid owners and ornithologists and is now standard in the local grid used on pole-mounted transformers. When electrocution occurs there is usually a power break so the power companies get a picture of the problem this way. All kinds of power breaks are monitored and investigated. All birds that are ring marked and found dead on or under power lines are sent to the Department of Environmental Research and Monitoring, Swedish Museum of Natural History in Stockholm. The museum has published a report on this 2019. These data are unique in Europe. This is also a way of monitoring the problem.

There is no regular monitoring of electrocution in many other countries (Belgium, Croatia, Finland, etc.), the problem itself is low, or only sporadic victims are identified and recorded. Data come from observations mentioned by birders, field workers of utility companies.

## 4.2 Bird Species at Risk

The group most threatened with electrocution are defined as the diurnal bird species, specifically eagles, hawks, vultures, kites, falcons, storks and corvids [27] . The highest mortality rate due to electrocution is registered mainly for medium-sized and large birds whose body and wingspan are big enough to bridge electrified components. In certain cases, it can have a significant negative effect on the species, either on the local scale or even at the population level, such as has been documented for the saker falcon or imperial eagle [9, 11, 19, 28, 29] .

The negative impact of electrocution on endangered raptors, with many other direct and indirect mortality factors, can lead to great reduction in population strength and density. This is especially for species where the loss of a few or even one individual may impact a local population or the overall population viability.

[27]: Fransson et al. (2019), 'Collisions with Power Lines and Electrocution in Birds: an Analyses Based on Swedish Ringing Recoveries 1990-2017'

[19]: Harness et al. (2008), 'Mongolian Distribution Power Lines and Raptor Electrocutions'
[28]: Kovács et al. (2014), 'Saker Falcon Falco Cherrug Global Action Plan (SakerGAP)'
[29]: Bagyura et al. (2002), 'Population Increase of Imperial Eagle (Aquila heliaca) in Hungary between 1980 and 2000'
[9]: Karyakin et al. (2009), 'Raptor Electrocution in the Altai Region; Results of Surveys in 2009, Russia'
[11]: Demeter et al. (2018), 'Documenting and Reducing Avian Electrocutions in Hungary: a Conservation Contribution from Citizen Scientists'

Main factors influencing the risk of bird electrocution can be divided into three main categories generally based on factors of origin, namely from the **biological** (morphology, behaviour, age), **topographical/environmental** (habitats, season) and **technical perspective** (pole configuration, presence of jumper wire and other energized elements).

Energized hardware, such as transformers, can be especially hazardous, even to small birds, as they contain numerous, closely-spaced energized elements. The risk of the individual abutting significantly increases with an increase in body proportions, mainly for medium-sized and large birds. Species susceptible to electrocution are particularly medium to large bird species such as the saker falcon (*Falco cherrug*), imperial eagle (*Aquila heliaca*). They are among the most frequent victims of electrocution, especially in areas with the highest appearance in farmland and nearby grassland and in areas where places to perch are rare [16]. They offer increased concentrations of field hamsters, small rodents and other main dietary sources of predators [28]. On the electric poles more species perch or rost, for example, storks, herons, owls. Birds that use power poles to nest on are also more vulnerable [13] .

[13]: Bevanger (1998), 'Biological and Conservation Aspects of Bird Mortality Caused by Electricity Power Lines: a Review'

Young individuals are often reported as victims of electrocution (in Germany young white storks represent many victims). Juveniles of imperial eagle and saker falcon are especially common victims of electrocution in Slovakia, corresponding to results from other countries [28, 30–32] . Proximity of nests to non-insulated medium-voltage poles poses a fatal risk for many young and inexperienced birds with lower ability to fly (Figure 4.3), as they try to take off or land on poles.

[30]: Nemček et al. (2016), 'Habitat Structure of Temporary Settlement Areas of Young Saker Falcon Falco Cherrug Females during Movements in Europe'
[31]: Veselovský et al. (2018), 'Telemetria orlov Kráľovských (Aquila Heliaca) na Slovensku. [Telemetry of Imperial Eagles in Slovakia]'
[28]: Kovács et al. (2014), 'Saker Falcon Falco Cherrug Global Action Plan (SakerGAP)'
[32]: Stoychev et al. (2014), 'Survival Rate and Mortality of Juvenile and Immature Eastern Imperial Eagles (Aquila Heliaca) from Bulgaria Studied by Satellite Telemetry'

**Figure 4.3:** Proximity of nesting imperial eagle to medium-voltage power line can increase the mortality risk of young individuals from electrocution.
*Source: Raptor Protection of Slovakia*

Many of the nesting pairs of saker falcon and imperial eagle have gradually resettled from the foothills to the neighbouring agrocenoses, with higher risk of possible electrocution and/or collisions [33, 34] .

[33]: Danko et al. (2002), 'Orol Kráľovský (Aquila heliaca) [Imperial Eagle]'
[34]: Chavko (2002), 'Sokol Rároh (Falco cherrug). [Saker falcon]'

Species protection and population increase successes are contradicted as soon as these species expand their distribution areas to nonsecure places. It shows that not only in nature reserves or the current breeding/resting areas measurements must be undertaken but everywhere (in suitable habitats).

Also man-made habitats can be of great attraction for bird susceptible for electrocution. Many of bird species are observed in increasing numbers on garbage dump. Presence of poles of 22 kV with exposed jumper wires above the central phase close to the dumb, led to many victims in Slovakia. More than 110 individuals of corvids, magpies, storks and buzzards and many other species were identified under only 10 „killer poles" within only 14 field surveys in years 2015–2020 (Figure 4.4).

**Figure 4.4:** Poles and bird victims: medium-voltage lines near garbage dumps (*up*) and carcasses of buzzards, storks and corvids founds (*down*).
*Source: Raptor Protection of Slovakia*

The frequency of bird mortality from electrocution has often two main peaks. Most casualties are reported from early spring (March) and late summer (September) also because of the many unexperienced juvenile birds. Such seasonal trends depend on migratory activity, density of bird populations and prey availability in the area around the power lines. During winter (December–January) and early summer (May–June), incidents are less common [12, 16, 35] .

[35]: Manville (2005), 'Bird Strike and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science—next Steps Toward Mitigation'
[16]: Lehman et al. (2010), 'Raptor Electrocution Rates for a Utility in the Intermountain Western United States'
[12]: Gális et al. (2019), 'Comprehensive Analysis of Bird Mortality along Power Distribution Lines in Slovakia'

Typical signs of deceased individuals are burns to the feathers, legs and their claws are held in a convulsive pose, large necrotic areas on the limbs, skull fractures (Figure 4.5).

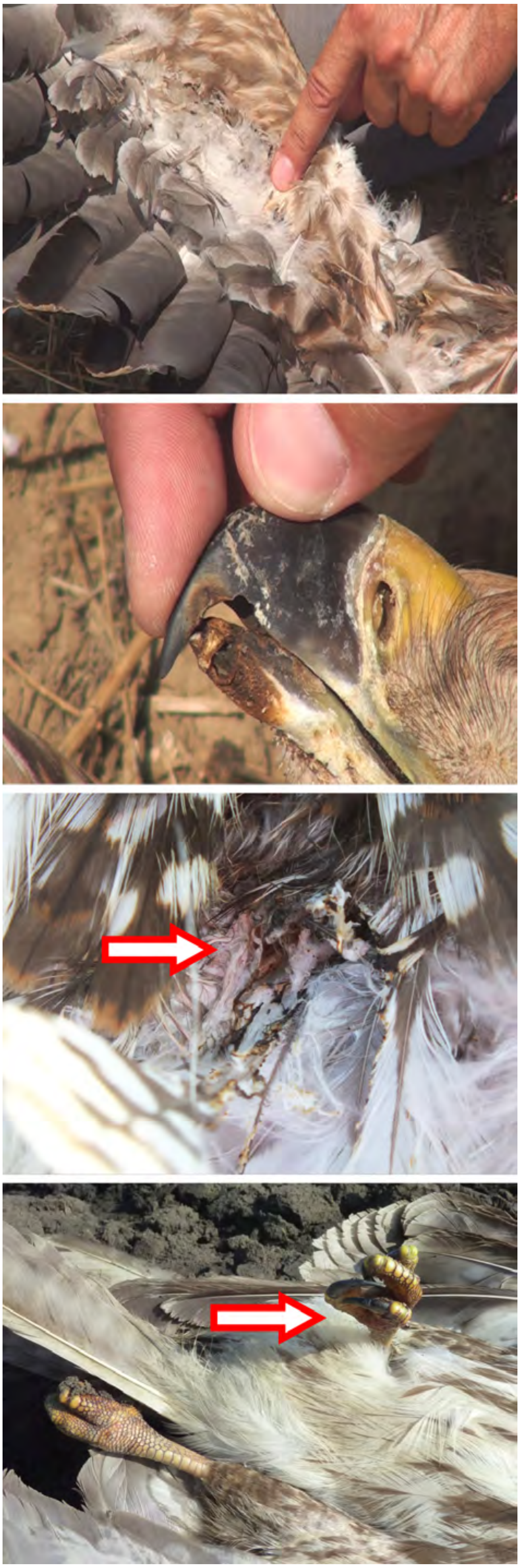

**Figure 4.5:** Typical signs visible on carcasses after electrocution. Arrows indicate places through which an electric current has entered the body.
*Source: Raptor Protection of Slovakia*

As the most threatened groups of birds by electrocution were defined nocturnal birds (owls) and diurnal birds of prey/raptors, specifically eagles, hawks, vultures, kites; falcons; storks and corvids (Corvidae) [1, 11, 14, 15, 22, 37] included in reports from various parts of Europe. Detailed list of three bird species most affected by electrocution in individual countries is provided in Figure 4.6 and the most reported are visualized in Figure 4.7.

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*

[37]: Bahat (2008), 'Wintering Black Storks (Ciconia nigra) Cause Severe Damage to Transmission Lines in Israel: a Study on the Risk and Mitigation Possibilities'

[22]: Gadzhiev (2013), 'Death of Birds of Prey on Power Lines in Daghestan'

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

[15]: APIC (2006), *Suggested Practices for Avian Protection on Power Lines: the State of the Art in 2006*

[11]: Demeter et al. (2018), 'Documenting and Reducing Avian Electrocutions in Hungary: a Conservation Contribution from Citizen Scientists'

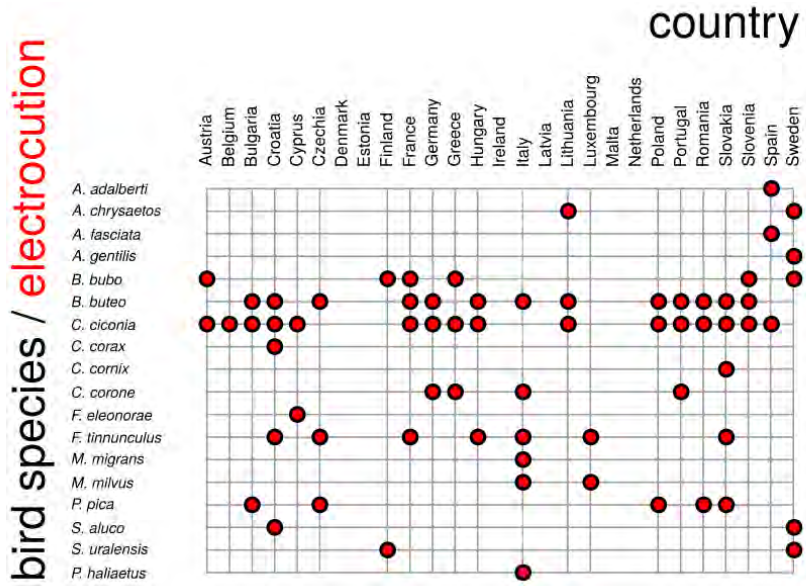


**Figure 4.6:** Most frequent victims of electrocution (as reported by countries). Storks, raptors and owls seem to dominate. *Source: Raptor Protection of Slovakia*

There is a large difference in the quantitative amount of information available between countries. The data about the victims of electrocution are often composed from the mixture of many sources: e.g. from results of several previous surveys of the avian mortality carried out within the Interreg and LIFE + projects (e.g. Bulgaria, Croatia, Czech Republic, Hungary, Italy, Lithuania, Slovakia etc.), also from bird ringing data and their recoveries (e.g. Finland, Sweden, Spain Slovakia), from publication of the agencies of nature conservation (e.g. Cyprus, Germany), museums and universities (Sweden). Typical sources of data are small-scale monitoring realized by ornithologists, members of NGOs and their long term knowledge from the field plus reports from rehabilitation centers and energy companies (all countries, we regard here e.g. Austria, Belgium, France, Greece, Hungary, Luxembourg, Poland, Romania, Spain etc.). For the rest 5 countries (Denmark, Latvia, Malta, Netherlands and Slovenia), the data was missing or insufficient.

**Figure 4.7:** Individuals of buzzards, storks, corvids and owls, were reported as the main victims of electrocution on power lines.
*Source: Raptor Protection of Slovakia*

Altogether 18 bird species were the most reported victims of electrocution within the EU countries. Owls and raptors where most reported from Finland, Denmark and Sweden. Corvids, storks and raptors seem to be largely affected by electrocutions in countries (Bulgaria, Czech Republic, Hungary, Slovakia) as they frequently use poles for roosting or hunting, often the tallest structures in grassland and open agricultural land [11] . Corvids and birds of prey represented 85% of all identified electrocutions in a study from Slovakia [12]. Raptors were associated with 40% of all identified victims of electrocution. In Bulgaria, crows and birds of prey represented more than 53% of detected electrocutions, while in the Czech Republic this percentage is even higher, up to 88%. Larger dominance of corvids and birds of prey have been recorded in France - 85% of all electrocution records, and from Spain, crows and birds of prey represented more than 80% of all identified electrocuted birds [23, 38–40] .

[11]: Demeter et al. (2018), 'Documenting and Reducing Avian Electrocutions in Hungary: a Conservation Contribution from Citizen Scientists'

[23]: Demerdzhiev et al. (2009), 'Impact of Power Lines on Bird Mortality in Southern Bulgaria'
[38]: Škorpíková et al. (2019), 'Bird Mortality on Medium-voltage Power Lines in the Czech Republic'
[39]: Bayle (1999), 'Preventing Birds of Prey Problems at Transmission Lines in Western Europe'
[40]: Janss et al. (2001), 'Avian Electrocution Mortality in Relation to Pole Design and Adjacent Habitat in Spain'

## 4.3 Dangerous Types of Power Lines

The following subchapter describes the most widely used types of poles in the 27 EU countries and their potential risk to birds. The risk of electrocution on pole depends primarily on the technical construction and detailed design of power facilities: how pin insulators are attached to the cross-arms and the space/distance between e.g. the exposed jumper wires and/or other energized and/or grounded elements.

The construction types of above-ground power lines used in different countries have many similarities (e.g. poles used in Slovakia and in Czech Republic), but many different types exist, even differing from company to company within one country. Some commonly used constructions of medium-voltage power poles are also known as „killer poles".

**A questionnaire answered by experts, revealed that the medium voltage poles and their mortality risk can be classified in three main groups:**

**A) Low risk:** Many type of poles and pylons with suspended insulators; poles with conductors arranged to one black cable design mounted to concrete/wooden[1] pole without metal cross-arms and insulators. These poles are designed to minimize bird electrocution risk by providing sufficient separation of energized elements and conductors to prevent electrocution for all sizes of birds (Figure 4.8). Also metal and concrete poles with suspended insulators seemed to pose a low risk.

1: wooden poles are not 100% safe, especially when they are wet

**Figure 4.8:** Completely insulated medium-voltage cable in Slovakia hanging from concrete pole without need for insulators. *Source: Raptor Protection of Slovakia*

**B) Medium risk:** Utility poles with upright position of pin-insulators. They are the most common poles of medium-voltage power lines and are also known as „killer poles“ due the higher and repeated bird losses. The gap between the wires and the cross-arm is small especially for large bird species (Figure 4.9). They are more numerous but are responsible for lower number of electrocuted birds than the poles listed under high risk category.

**Figure 4.9:** Concrete poles with pin-type insulators mounted upward. *Source: BirdLife Bulgaria*

**C) High risk:** Poles with complex construction (Figure 4.10), such as corner, tensioning or branch types with several levels of cross-arms, pin insulators (Czech Republic, Greece, Portugal) and with combination of jumper wires and closely spaced conductors (Czech Republic, Slovakia, Spain); transformer stations and switch towers (Bulgaria, Hungary, Finland, Poland, Portugal). The gap between the wires and the cross-arms and all energized elements is small even for medium and small bird species.

**Figure 4.10:** Strain poles with exposed jumper wires passing over the pin-insulators above the cross-arms are the most dangerous configuration responsible for many recorded electrocution fatalities. *Source: Raptor Protection of Slovakia*

Corner, strain and branch poles are significantly more dangerous for birds than utility poles in straight lines [12] . Bird mortality is lower for power line switch disconnectors and pole transformers, which are often situated at the edges of human settlements or are part of urban/industrial areas, with lower presence of birds and thus lower incidence of mortality Corner and branch poles on medium voltage lines were also identified as the most dangerous in a survey done in the Czech Republic [38] . Similar results are reported also from Bulgaria: metal branch poles featuring jumper wires accounted for 54.3% of total detected electrocution mortality. Anchor poles in particular have been shown to pose a significant electrocution risk to birds, particularly due to the configuration of the jumper wires [23, 38, 41, 42] .

[12]: Gális et al. (2019), 'Comprehensive Analysis of Bird Mortality along Power Distribution Lines in Slovakia'

[38]: Škorpíková et al. (2019), 'Bird Mortality on Medium-voltage Power Lines in the Czech Republic'

[41]: Dixon et al. (2013), 'The Problem of Raptor Electrocution in Asia: Case Studies from Mongolia and China'
[42]: Dixon et al. (2017), 'Avian Electrocution Rates Associated with Density of Active Small Mammal Holes and Power-pole Mitigation: Implications for the Conservation of Threatened Raptors in Mongolia'
[38]: Škorpíková et al. (2019), 'Bird Mortality on Medium-voltage Power Lines in the Czech Republic'
[23]: Demerdzhiev et al. (2009), 'Impact of Power Lines on Bird Mortality in Southern Bulgaria'

For more pictures of safe and dangerous constructions of poles, please see the Annex B.

## 4.4 Mitigation measures & Prevention of Electrocution

This chapter summarises the latest technical standards on electrocution mitigation and presents know-how to mitigate electrocution risk for birds. According to current knowledge and experience, it is possible to reduce the risk of electrocution significantly, within acceptable costs for the electric utility companies.

There were many types of measures and solutions tested in some EU countries. Energy companies with experts tried to solve the electrocution problem and thus started to use exclusion devices, or perch discouragers. Many of them turned out to be ineffective; even more some of the applied devices multiplied the possible risk. Because the birds will still try to perch on the constructions and the space is even more limited, birds have a higher chance to contact the energized wires and elements. 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.

Many of the installed devices were tested and proved to be not effective in preventing electrocution. In Bulgaria, the use of "anti-bird spikes" solution is not efficient[2] in preventing electrocution (Figure 4.11 *up*). Another solution, the "wing spacers" are also not entirely effective as bird protection device (Figure 4.11 *down*).

2: There were recent reports where storks even use these spikes as a good basis for nest building

**Figure 4.11:** Anti bird protection: (*up*) anti bird spikes - an inefficient retrofitting used in Bulgaria; (*down*) wing spacers attached on metal pylon in Bulgaria are also not entirely effective.
*Source: BirdLife Bulgaria*

Artificial bird perches and perch deterrents are not safe for small birds in some cases in Croatia. In Czech Republic none of the following measures were thoroughly tested however their short use on power lines revealed their inappropriateness: The *combs* similar are used also in Slovakia have many negatives: short lifetime; damaged combs are more dangerous than missing protection. The *bench* takes up space on the console, but the birds still sit on the console and, worse, are pushed further to the powered conductors than in the case without a bench.

*Plastic belts cover on the insulators* and has very short lifespan. Damaged are more dangerous than missing protection (Figure 4.12).

**Figure 4.12:** Inappropriate anti bird protection: bench (*up*); plastic belt (unrolled) (*middle*); plastic covers on insulators (*down*).
*Source: Nature Conservation Agency of the Czech Republic*

In Hungary a number of different experiences have been made. Regarding to new data, any cross-arm cover insulator (green and orange) or plastic phase coverts and various types of plastic insulators which allow birds to perch safely on the console, or other products installed as retrofitting mitigation on the poles. The plastic products could be attached the wrong way to the cross-arms and insulators, ignoring the recommendations and have a short lifetime. After any retrofitting mitigation methods power line companies never pay enough attention to regular maintenance or replacements of missing elements/kits.

Insulating tape around the conductors was used in Portugal. Energias de Portugal (EDP) Distribution company has tested these kinds of tape alone and raptors and corvids mortality was observed on pylons retrofitted with this. It turned out that the birds tear the tapes with their claws and sometimes with their bills, opening holes in it and got electrocuted in consequence.

In Slovakia plastic „combs" in different colors (Figure 4.13), as well as other products installed in a wrong way (Figure 4.13 (*up*)) or installed in a way without respect to recommendations, often turned out to be inefficient and birds have a higher chance to contact the energized wires and elements because the „safe" space is even more limited (Figure 4.13 (*down*)).

**Figure 4.13:** Because the birds will still try to perch on the constructions, plastic combs are wrong solutions. Many birds were electrocuted on damaged combs, especially if the remains of the product were located in the middle of two insulators, forcing birds to perch closer to the phase conductors or other energized elements. *Source: Raptor Protection of Slovakia*

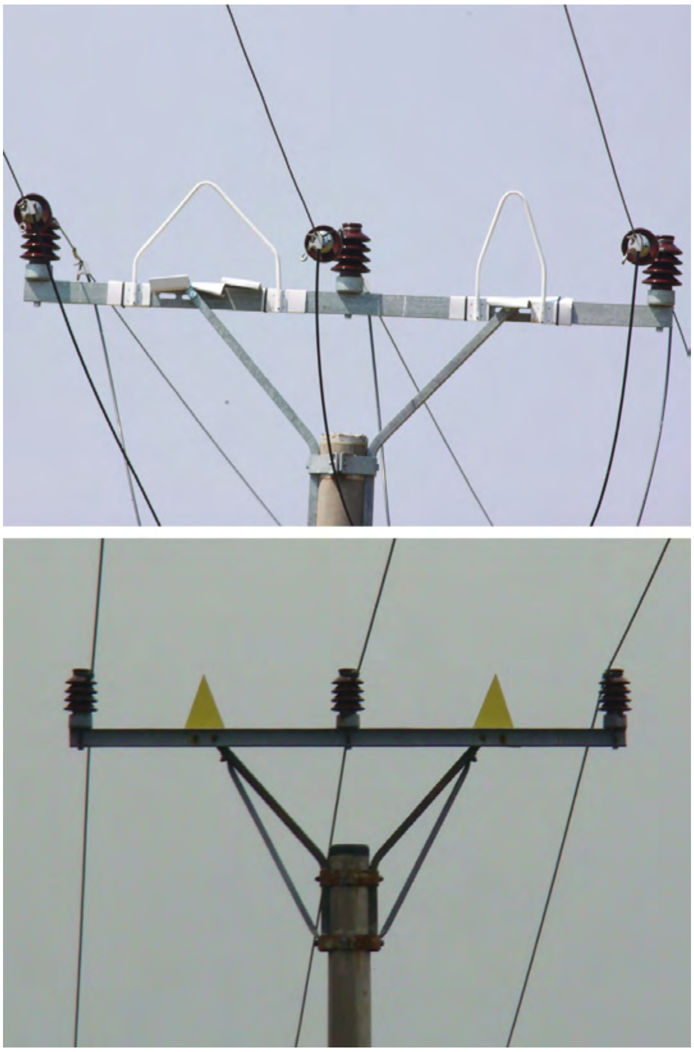

**Figure 4.14:** Wrong installation, can increase the risk of electrocution rapidly. Due the installation (even if correct) of protective device in the middle of the cross-arm, the space could be more limited and birds are forcing to perch close to the energized parts.
*Source: Raptor Protection of Slovakia*

In Spain, the main problem related with the mitigation measures for electrocution is the degradation of the insulating material with time. The devices are ineffective because they deteriorate very fast with inclement weather. Some devices that birds cannot rest on have also proved ineffective.

In several countries, the „killer poles" started to disappear or to be retrofitted on a large scale only after legislative action and the construction of new „killer poles" became generally prohibited. Also catalogs of suitable designs and solutions was set up by the electric utility companies, in close co-operation with government and conservation groups [1] .

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*

There are many types of **effective measures and solutions** (please see the Annex 3) to mitigate electrocution on medium-voltage power lines such as: plastic hood, silicon tubes, long rod insulators, plastic insulators covering the metal console etc. **The best solutions how to prevent electrocution are those, which allow the birds to perch safely on poles.**[3]

3: Off course, the ultimate solution is still replacing the overhead conductors by underground cables.

Cross-arms, insulators and other parts of the power lines should be constructed so that there is no space for birds to perch close to energized wires or the shape of console discourages birds from sitting down.

It is necessary to mention, that almost no insulation measure is 100% safe for birds, especially in long-term. It depends mostly on how well the equipment gets installed, local weather conditions (salty air, strong winds, temperature), landscape and which bird species we are trying to save from getting electrocuted. Some pole designs like disconnectors and substations can´t be entirely insulated because of moving parts, the only way is to change their construction.

Where underground cabling is impossible (for whatever reasons) like in Austria, bird protection hoods in particular have proved to be very valuable services. Correspondingly adapted systems were used at junctions and transformer stations (Figure 4.15).

**Figure 4.15:** Bird protection hoods installed on branch poles are proven to be a very valuable measure.
*Source: BirdLife Austria*

Insulation caps for pin-type pylons turned out to be 100% efficient in protecting birds from electrocution in Bulgaria (Figure 4.16).

**Figure 4.16:** Insulator cap on 20 kV pole pin-type in Bulgaria.
*Source: BirdLife Bulgaria*

The exchange of bare conductors for insulated phase conductors is the safest solution (Figure 4.17) for preventing avian electrocution adopted in Croatia and Sweden. In Croatia, insulated overhead lines are used in a few short stretches, representing a very small portion of the total overhead grid. It also represents a long-term solution and its effectiveness does not decrease with use, as opposed to the solution which implies the installation of insulation equipment. In the long term, the installation of insulated lines (where possible) represents the most cost-effective solution, and its additional advantage is easier detection of breakdowns and regular network maintenance.

**Figure 4.17:** Replacing of bare conductors of overhead power lines with covered conductors is long lasting solution and it doesn't cause difficulties with maintenance in comparison with insulation equipment installation.Full Covered Conductor Solution provides even more complete protection for the line and bird species
*Source: HEP Croatia, BirdLife Sweden*

The practice of installing insulated conductors in Croatia is currently mostly installed in forest areas by HEP DSO. The installation of insulation equipment onto pole transformer stations, disconnectors and individual dangerous poles is the most appropriate and cost-effective solution for "dotted" protection of birds from electrocution (Figure 4.18).


**Figure 4.18:** Insulated conductor is the most appropriate and cost-effective solution of birds from electrocution on pole transformer stations and disconnectors. *Source: HEP Croatia*

The most effective measure in Czech Republic is „Pařát console type" with a perch or „Delta Variant console type" with a perch. The shape of console discourages birds from sitting down and at the same time, perch offers place to sit. A study realized in years 2011-2012 evaluated results of that testing [43] . The new technical solution consisted of a bar with a perch below the console, allowing safe landing for the birds (Fig. 4.19). The monitoring of this solution at 4 selected power lines in different parts of the Czech Republic has shown that perches were frequently used by common buzzards with a high protective value and results indicate that positive effect will be also for other raptors typically using poles as perches: black kite, red kite, rough-legged buzzard, etc.). Despite of that, species as magpie, common crow used perches only with low frequency. In case of these two species the perches were evaluated as useless, for common kestrel a positive effect of the perch was not possible to prove. Overall evaluation of the perch was positive and only 10% of tested common buzzards performed risky behaviour; the rest of birds were protected against electrocution due to using the perch.

[43]: Škorpíková et al. (2012), *Monitoring Účinnosti Bidel na Konzolách Typu "PAŘÁT"*

**Figure 4.19:** The shape of console discourages birds from sitting down and at the same time, the perch offers a place to sit. *Source: Nature Conservation Agency of the Czech Republic*

Different type of solutions have been tested and are applied (mainly plastic insulating covers on central wire and "sheathed bridges", anti-landing tool and installation of perching structure above switches poles) in France.

As reported in many countries, also in Germany especially underground cables, pylons with suspended insulators (cross-arm to constructor > 60 cm), insulating hoods for pin-type insulators and switches attached below the cross-arms seem to be effective measure how to decrease the mortality due the electrocution. Underground cables as long-time and most effective solution are reported from Nehterlands.

In Hungary the most effective solution appears to be a complete change of the pylon head construction for the new, bird friendly scaled type with well geometry. Switch poles could be changed to closed types filled with gas. To branch poles could be attached a new perching frame generating a safe sitting and landing surface for birds.

There is a lack of data from Poland on most effective protective measures, as there is no general evaluation. Removal of dangerous parts of installation can usually help in most cases, but regularly gathered data is missing.

“Derancourt insulators” - insulating silicon sleeves around the wires near the pylon and protection around the conductors have shown very good efficiency in reducing the overall mortality on pylons (>85% and sometimes >90%) in Portugal. However they reported some problems due to the debris that enters the empty space between the wire and the sleeve. "Combined solution" – EDP Distribuição is now testing a device that combines insulating tape with conductor protectors (Figure 4.20). It seems to be effective, but more data is necessary.

**Figure 4.20:** Insulating tape with conductor protectors on a medium voltage pole. *Source: SPEA - Portuguese Society for the Study of Birds*

In Romania underwater cables and cable insulations have been recommended as effective solutions.

In Slovakia the most effective solution appears to be a complete change of the construction for the new type – so called Antibird and Ecobird (Figure 4.21). Then also phase covers and various types of plastic insulators which allow birds to perch safely on the console or do not allow the birds to perch on the construction at all. Antibird is effective thanks to the shape of the console (45° angle of the arms). In the years 2006–2007 three new elements were tested that proved to be the most appropriate type; they are still used today and are called "Tooth" - insulators, which allows the birds to securely perch. New type of insulation with telescopic parts was developed for 22 kV power lines, to eliminate the distance between the insulation and support insulators (Figure 4.22).

**Figure 4.21:** Antibird (*up*) and Ecobird (*down*) cross-arms solution is effective thanks to the shape of the console (45° angle of the arms).
*Source: Raptor Protection of Slovakia*

**Figure 4.22:** Telescopic construction of device eliminates the dangerous "free" space between the protection and pin- insulators and allow the birds to perch safely on poles in the same time.
*Source: Raptor Protection of Slovakia*

Also changes in pole construction and position of jumper wires could be rated as one of the most effective mitigation measures against electrocution (Figure 4.23).

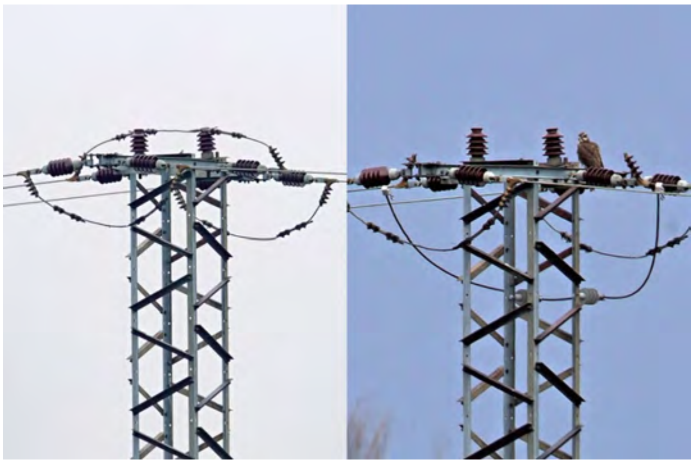

**Figure 4.23:** Medium voltage pole in Slovakia unsafe for perching raptors, because of conductors attached above pin-insulators on top of cross-arm (*left*). The same pole voltage after mitigation measures. Fully covered jumper wire is suspended below cross-arm and the pole is now safe for perching of saker falcon (*right*).
*Source: Raptor Protection of Slovakia*

In Sweden larger parts of the power grid (0.4–20 kV) have been rebuilt since the 1990s, especially since 2005 when a big storm occurred. Many kilometers of this grid have been laid down as underground cables and most of the remaining grid has been built with plastic isolated phase wires (please see Figure 4.17). The dangerous pole mounted transformers have been built with isolator protection called "Huven-Uven" (Figure 4.24) since around the midd 1990s. On certain power lines of 10–20 kV that are not yet rebuilt plastic protection has been mounted on isolators in important areas e.g. for eagles. On 40–50 kV with upright pin insulators the distance between phases have been increased from 1,350 mm to 1,600 mm to reduce the risk of electrocution of large birds. The statistics of the energy company show that bird caused electric problems were reduced.

**Figure 4.24:** Insulator protection called "Huven-Uven" used on a pole transformer in Sweden.
*Source: Swedish Ornithological Society*

Retrofitting of poles is an effective way how to decrease the mortality of birds. In study Gális et al. [12] the highest percentage (78%) of bird carcasses were found under non-retrofitted poles. The rest consisted of 5% under poles with a damaged product and 3% under poles where the product/device was installed incorrectly.

[12]: Gális et al. (2019), 'Comprehensive Analysis of Bird Mortality along Power Distribution Lines in Slovakia'

# Bird Collisions | 5

Bird casualties due to collision with aboveground power lines can happen on distribution or transmission electricity grids. Larger, heavy-bodied birds with short wing spans (e. g. swans, bustards...) and poorer vision are more susceptible to collisions than smaller, lightweight birds with relatively large wing spans, agility and good vision [37] . Moreover, species with narrow visual fields (e.g. swans, ducks, herons, storks...) are at higher collision risk as they cannot see the wires from a certain angle [54, 61] .

[37]: Bahat (2008), 'Wintering Black Storks (Ciconia nigra) Cause Severe Damage to Transmission Lines in Israel: a Study on the Risk and Mitigation Possibilities'
[61]: Martin et al. (2010), 'Bird Collisions with Power Lines: Failing to See the Way Ahead?'
[54]: Martin (2011), 'Understanding Bird Collisions with Man-made Objects: a Sensory Ecology Approach'

Collisions of birds are relevant to the main cause – the flying individual is unable to register such an obstacle ahead. Power lines crossing the birds' daily movement corridors can be particularly problematic. There are great differences between habitats: on grassland there are 113 collisions/km/year on agricultural land 58 collisions/km/year and near river crossings 489 collisions/km/year. Collision risks also are exacerbated during low light, fog, or inclement weather conditions [3, 45–48] .

[45]: Savereno et al. (1996), 'Avian Behavior and Mortality at Power Lines in Coastal South Carolina'
[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*
[46]: Frost (2008), 'The use of 'Flight Diverters' Reduces Mute Swan Cygnus olor Collision with Power Lines at Abberton Reservoir, Essex, England'
[47]: Stehn et al. (2008), 'Whooping Crane Collisions with Power Lines: an Issue Paper'
[48]: Erickson et al. (2001), *Avian Collisions with Wind Turbines: a Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States*

Understanding the nature of bird collisions is essential for minimizing them. Problems of collisions with power lines can be divided into four main categories generally **biological**, **topographical**, **meteorological** and **technical** factors [3]. The biological parameters include the physiology of the bird's vision, type and speed of flight behavior. Significant contributions to the collisions are meteorological factors such as gusts of wind and bad weather reducing the visibility of the power lines. Technical factors include the height of pylons and power lines, horizontal and vertical division of aerial space and the presence of one/two earth (ground) wires on the top of the transmission voltage pylons, which is almost "invisible" for the birds. Data from many studies indicate that up to 80% of collisions occur with the ground wire [3] .

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

## 5.1 National Overview of Collision Issue

There is a lack of data on bird fatalities from collisions in some countries in general [1] . and it has never been under any regular and long-lasting monitoring. Main focus was given to mortality related to electrocution and power lines. Collisions had been located only sporadically and the problem has only recently received more serious attention. Local monitoring had been realized, to identify the risk of collisions on bird species in hot spots. Several studies have been carried out, which have revealed the interaction with power lines as one of the important causes of the threat of numerous bird species (Austria, Belgium, Bulgaria, Hungary, Italy, Latvia, Lithuania, Romania & Slovakia, etc.). The problem was identified and cooperation started, when high bird numbers were found dead under dangerous sections of power lines.

1: Mainly because electrocution was more in focus relating bird mortality and power lines.

In other countries, the problem was identified after several repeated findings, latter this data was published and mutual communication with representatives of electric utility companies started. The results proved the need of using proper mitigation measures in important habitats to increase wire visibility for most susceptible bird species (e.g. Hungary & Slovakia). The data often comes also from observations by birdwatchers or citizen scientists and all registered data in the data portals (Austria, Belgium & Slovakia). When collision occurs on low or medium voltage line, there is usually a power outage so the power company also provides a report with GPS coordinates of the span where, the incident was identified (e.g. Slovakia, in case of collisions of mute swans).

First regular monitoring started later than for electrocution, mainly in the 90s; victims of collisions had been located sporadically. Since the end of the 20th century, an increased attention has been payed to this problem in many countries, but more intensive focus was given after the year 2000 and in the recent 4-5 years (Croatia, Denmark, Estonia, Netherlands, Latvia & Lithuania). Often the surveys were/are realized under LIFE + projects; national and international funds etc. within Natura 2000 sites and conflict areas outside of SPAs + all priority territories of rare and/or endangered bird species and close to important bird habitats and migration routes.

The collision topic has not been worked on so intensively so far by BirdLife in Austria. However, there were numerous projects in this direction, such as the efforts to save the great bustard.

In Slovakia deaths from collisions had been located sporadically, but first more extensive results were found out in the year 2010 in the SPA Ondavská rovina. The results proved the need of a systematic approach; therefore collisions are monitored regularly since 2014. A project LIFE Energy has started, its duration is planned for 5 years period (2014-2019).The project is focused on collisions of birds with 22 kV and 110 kV power lines. First there is a need to identify the most dangerous types of power lines for collisions (e. g. in Slovakia 22 kV and 110 kV power lines) as well as to identify most dangerous sites with high collision rates. In Slovakia project LIFE13 NAT/SK/001272 a complex methodology for monitoring of these power lines has been identified during period May 2016 – May 2019, results were evaluated in the study Galis et al. [6] .

[6]: Gális et al. (2019), 'Monitoring of Effectiveness of Bird Flight Diverters in Preventing Bird Mortality from Powerline Collisions in Slovakia'

In Hungary deaths from collisions had been located sporadically. First extensive survey and results were found out in the frame of the LIFE project titled „Conservation of Otis tarda in Hungary" between years 2004-2008, mainly in Kiskunság National Park Directorate. The results proved the need of using bird diverters in bustard habitats on the wires increasing visibility and focusing on building underground cable system instead of existing power lines.

In Lithuania, during the implementation of the EU LIFE+ funded project "Installation of the bird protection measures on the high voltage electricity transmission", most frequently recorded were deaths of night-migrating passerines, sandpipers in dense flocks and large waterbirds. Some electrocuted predatory birds were also found under the electricity transmission lines. For example, 72 sections of high-voltage electricity transmission lines in various locations of North and Middle Lithuania were inspected during the period from October 2017 until April 2018. During this period 51 dead birds (18 species) were found under the power lines in the mentioned sections. Most frequent among them were plovers and lapwings.

In Sweden, ringmarked dead birds found under power lines are sent to the Swedish Museum of Natural History. In many cases it is hard to determine if a bird has been electrocuted or if it died from collision. It is very difficult to monitor collisions. It takes a lot of time to monitor with the help of a specialized bird-dog for example.

There is no regular monitoring of collisions in many countries, the problem itself is low or only sporadic victims are identified and recorded (e.g. in Cyprus, Greece, Finland & Luxembourg).

## 5.2 Bird Species at Risk

Collisions of birds with electrical infrastructure represent a significant mortality factor of several species. Such clashes at high speed have fatal consequences for birds. Frequently they can be observed especially in open areas where the power line crosses feeding, foraging and nesting habitats used by birds and can occur equally with transmission and distribution lines [12, 49] . A particular problem arises when there are frequent movements of large flocks between their feeding and nesting biotopes, or if the power lines pass perpendicularly across the birds' main migration routes [20, 33]. If the "cables" are perpendicular to the wetlands, rivers, coastal areas, agricultural fields for foraging, the risk of collision increases. At such locations, bird losses can exceed hundreds of casualties per kilometer of power line every year.

[49]: Jenkins et al. (2010), 'Avian Collisions with Power Lines: a Global Review of Causes and Mitigation with a South African Perspective'
[12]: Gális et al. (2019), 'Comprehensive Analysis of Bird Mortality along Power Distribution Lines in Slovakia'

Bird casualties due to collision with above-ground power lines can happen to any species of bird, capable of flight. Some bird species which are active in the vicinity of power lines are more susceptible to collision risk than others. Usually it depends on the bird size, weight, character of flying, field of vision, time of the day and the special features of habitats near the power lines. Morphology plays a decisive role [50, 51] . Birds with low maneuverability, i.e. those with high wing load and low aspect ratio, such as bustards, pelicans, waterfowl, cranes, storks and grouse, are among the species most likely to collide with power lines . Species with narrow visual fields (e.g. swans, ducks, egrets) are at higher collision risk as they cannot see the wires from a certain angle [52-54].

[50]: Brown (1993), 'Avian Collisions with Utility Structures: Biological Perspectives'
[51]: Crowder et al. (2002), 'Relationships between Wing Morphology and Behavioral Responses to Unmarked Power Transmission Lines'

From the biological point of view the group most susceptible to collisions and therefore at greatest risk are the large, heavy bird species [55] and certain specific orders of birds, e.g. Anseriformes, Ciconiiformes, Gaviiformes, Pelecaniformes, Otidiformes, Gruiformes, defined according to their morphological parameters (e.g. weight, wing size/ area, manner/-type of flight). The species which tend to group together into large flocks (Figure 5.1) are also included here, as they are associated with higher probability of collision [56] .

[55]: Rubolini et al. (2001), 'Eagle Owl Bubo Bubo and Power Line Interactions in the Italian Alps'

[56]: Drewitt et al. (2008), 'Collision Effects of Wind-power Generators and Other Obstacles on Birds'

**Figure 5.1:** An important factor is the habit of some bird species such as ducks, swans, geese and waders, to fly in (large) flocks, which increases the chance to collide with obstacles especially for the birds in the back of the group.
*Source: Raptor Protection of Slovakia*

Power line features can also influence the risk of bird collision based on different power line voltage and thus configuration, especially including the number of vertical levels, wire height and presence of shield wire [49, 57, 58] . The technical installations of the power line can also take damage from bird accidents: collisions can cause conductor cables to sever or to strike together. Short-circuits to ground can damage insulators and switches. Bird accidents can lead to outages (Figure 5.2) and economic damages [1].

[57]: Murphy et al. (2009), 'Effectiveness of Avian Collision Averters in Preventing Migratory Bird Mortality from Powerline Strikes in the Central Platte River, Nebraska'
[58]: Shaw et al. (2018), 'High Power Line Collision Mortality of Threatened Bustards at a Regional Scale in the Karoo, South Africa'
[49]: Jenkins et al. (2010), 'Avian Collisions with Power Lines: a Global Review of Causes and Mitigation with a South African Perspective'

**Figure 5.2:** Collisions of large bird species, such as swans, can results in a short circuit, with current flowing through the bird's body, and electrocution, often accompanied by an outage of the electricity supply.
*Source: Raptor Protection of Slovakia*

In case of collision accidents, birds crash at high flight speed into cables or wires. The resulting injuries such as broken bones, wings, legs and shoulder bones, wounds (Figure 5.3) vary widely and can be comparable to traumata caused by collisions with cars.

**Figure 5.3:** Broken neck. Typical reason of death due the collision, especially for large and long necked bird species, such as mute swan and purple heron.
*Source: Raptor Protection of Slovakia*

Collision susceptibility may be influenced by flight behaviour. Gregarious species are generally thought to be more vulnerable than species with solitary habits [3] . On the basis of published data groups of birds are most often and most seriously threatened by collisions in various parts of the world include pelicans, storks, cranes, grouses (Tertaonidae), rails, gallinules, coots (Rallidae), bustards, waders (Charadriidae + Scolopacidae) [1] . As the most threatened groups of birds by collision are defined birds of order, e.g. Anseriformes, Ciconiiformes, Gaviiformes and Pelecaniformes, often included in reports from various countries of Europe. Detailed list of three bird species most affected by collisions in individual countries is provided in Figure 5.4.

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*

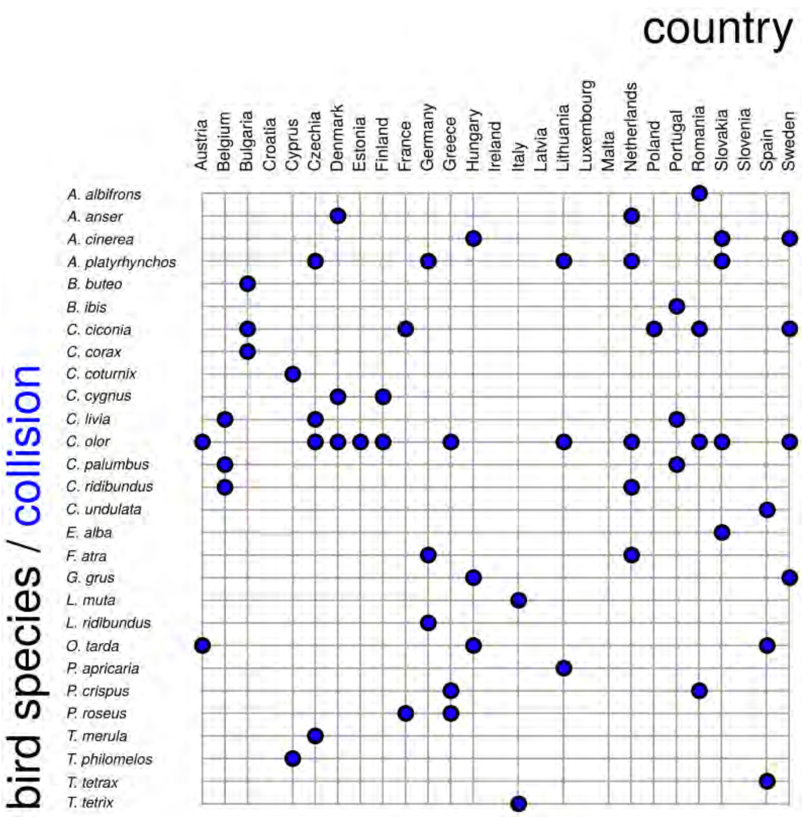


**Figure 5.4:** Most frequent victims of collision (as reported by countries). Swans, ducks, herons seems to dominate

The data about the victims of collision are often composed from the mixture of many sources: e.g. from results of several previous surveys of the avian mortality carried out within the Interreg and LIFE + projects (e.g. Bulgaria, Croatia, Czech Republic, Hungary, Italy, Lithuania, Slovakia etc.), also from bird ringing data and their recoveries (e.g. Finland, Sweden, Spain, Slovakia), from publication of the agencies of nature conservation (e.g. Cyprus, Germany), museums and universities (Sweden). Typical sources are small-scale monitoring realized by ornithologists, members of NGOs and their long term knowledge from the field, reports from rehabilitation centers and energy companies (main share of all 27 EU countries, e.g. Austria, Belgium, France, Greece, Hungary, Poland, Portugal, Romania, Slovakia, Spain, etc.). For the rest 4 countries (Latvia, Luxembourg, Malta and Slovenia), the data was missing or insufficient.

Altogether 28 bird species were the most reported as victims of collisions within the EU countries. The percentage of raptors and corvids colliding with power lines was very small, compared to electrocuted individuals. The highest mortality was recorded for the mute swan [35, 51] .

[51]: Crowder et al. (2002), 'Relationships between Wing Morphology and Behavioral Responses to Unmarked Power Transmission Lines'

[35]: Manville (2005), 'Bird Strike and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science—next Steps Toward Mitigation'

For this reason swans are often among the commonly recorded victims [50, 59, 60] . The dominance of mute swans is probably a result of their behaviour, as swans fly mainly in flocks. They also require long stretches for takeoff and landing. Spring growth of winter wheat and oilseed crops on surrounding arable land provides a timely alternative food supply for the swans and geese, resulting in large numbers flying out several times a day of the wetlands to feed in these fields, returning to the wetlands for safe refuge when they cease feeding (Figure 5.5). Moreover, species with narrow visual fields (e.g. swans, ducks, herons, storks. . . ) are at higher collision risk as they cannot see the wires from a certain angle [54, 61] .

[59]: Perrins et al. (1991), 'Collisions with Overhead Wires as a Cause of Mortality in Mute Swans Cygnus Olor'
[50]: Brown (1993), 'Avian Collisions with Utility Structures: Biological Perspectives'
[60]: Mathiasson (1993), 'Mute Swans, Cygnus olor, Killed from Collision with Electrical Wires, a Study of Two Situations in Sweden'

[61]: Martin et al. (2010), 'Bird Collisions with Power Lines: Failing to See the Way Ahead?'
[54]: Martin (2011), 'Understanding Bird Collisions with Man-made Objects: a Sensory Ecology Approach'

**Figure 5.5:** Mute swans are more susceptible to collision, if they regularly cross and fly close to power lines that are situated between the resting and main feeding field with oilseed rape. Often tens of killed individuals can be found on these locations. *Source: Raptor Protection of Slovakia*

## 5.3 Dangerous Types of Power Lines

More important than the voltage is the location of the construction regarding to habitats inhabited by birds or to main migration routes. Although different bird species fly at differing heights above the ground, there is a prevailing consensus that the lower power line cables are to the ground, the better they are for preventing bird collision. There is also a consensus that reduced vertical separation of cables is preferred as it poses less of an “obstacle” for birds to collide with. Horizontal separation of conductors is therefore preferred [14] .

[14]: Prinsen et al. (2011), ‘Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region’

Collisions could be observed most frequently in areas where the power lines cross the feeding and nesting biotopes used by large bird populations. Even if the power lines are just in the vicinity of those areas, there is still high probability of numerous collisions [62, 63] , especially near places used for taking off and landing [57]. The environmental conditions of the site influencing the resulting degree of risk of collision are above all the character and composition of the landscape. Open, flat land with low vegetation enables birds to fly low and close to the terrain, seeking out sources of food and resting places. In such open habitats vertical obstacles or linear structures in the air are not "learned" by the relevant bird species. As a result, they may tend to have reduced levels of concentration on potential obstacles such as electric power lines. Birds have a general tendency to look downwards, and thus for certain species the space ahead of them becomes a so-called blind zone [54, 61] .

[62]: Wallace et al. (2005), *A Summary and Comparison of Bird Mortality from Anthropogenic Causes with an Emphasis on Collisions*

[63]: Andriushchenko et al. (2012), ‘Birds and Power Lines in Steppe Crimea: Positive and Negative Impacts, Ukraine.’

[61]: Martin et al. (2010), ‘Bird Collisions with Power Lines: Failing to See the Way Ahead?’

[54]: Martin (2011), ‘Understanding Bird Collisions with Man-made Objects: a Sensory Ecology Approach’

The principal technical parameters affecting the degree of risk represented by a power line are the thickness of the cables, the height of the line and the number of parallel lines. Higher lines probably increase the risk of collision. Not only do the birds have to overcome a higher barrier, but relatively often they then collide with the earth wire which is present at the top of higher tension distribution and transmission lines to protect them from lightning strikes, and at the same time is much thinner than the phase conductors (Figure 5.6).

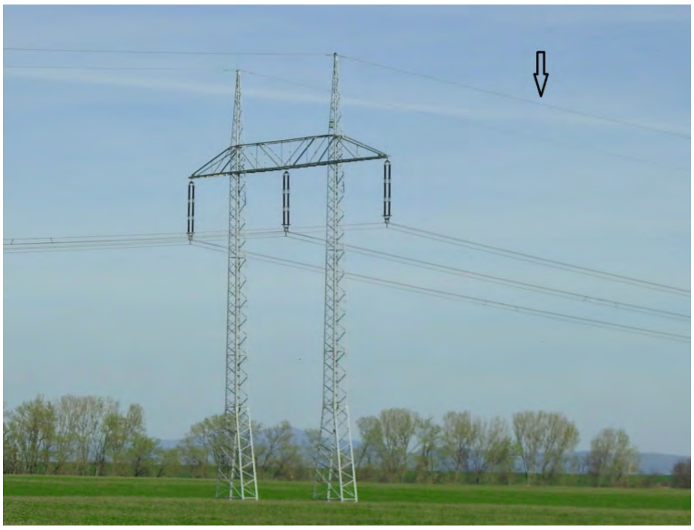

**Figure 5.6:** The single thin wire in the top of the power line is the shield wire (also called earth wire) that is mostly positioned above the phase conductors. Without any equipped diverters, is almost invisible for birds.
*Source: Raptor Protection of Slovakia*

This is connected with the fact that birds try to avoid power lines primarily by flying over them [65] so they react to the visibly thicker live cables but then fly into the practically “invisible” earth wire above them. Denser networks of parallel power lines are more visible to birds, so they manage to react to the obstacle earlier [56, 64] , and they can usually fly over sets of parallel lines with a single soar.

[64]: Bevanger (1995), ‘Estimates and Population Consequences of Tetraonid Mortality Caused by Collisions with High Tension Power Lines in Norway’

[56]: Drewitt et al. (2008), ‘Collision Effects of Wind-power Generators and Other Obstacles on Birds’

There is a strong correlation from all provided answers, that more important than the voltage is the location of the construction regarding to habitats inhabited by birds (e.g. rivers and water bodies, coasts, extensively used low lands) or to main migration routes. Open, flat land with low vegetation enables birds to fly low and close to the terrain, seeking out sources of food and resting places. In such open habitats vertical obstacles or linear structures in the air are not "learned" by the relevant bird species. As a result, they may tend to have reduced levels of concentration on potential obstacles such as electric power lines. Birds have a general tendency to look downwards, and thus for certain species the space ahead of them becomes a so-called blind zone [54, 61] . For constructions of 110 kV, 220 kV, 400 kV, the highest risk is associated with optical ground wires, especially the highest one, which is the thinnest. Even a single barbed wire fence could cause mortality in an unfavorable location.

[61]: Martin et al. (2010), 'Bird Collisions with Power Lines: Failing to See the Way Ahead?'
[54]: Martin (2011), 'Understanding Bird Collisions with Man-made Objects: a Sensory Ecology Approach'

## 5.4 Mitigation Measures & Prevention of Collisions

Even if collisions themselves cannot be completely eliminated, they can still be reduced by means of proper mitigation measures. When hazardous power lines cannot be put underground then line marking is one of the best solutions, based on making the wires more visible to birds in flight [65, 66] . This has become the preferred mitigation option worldwide. A wide range of potential line marking devices has evolved over the years, including avian balls, swinging plates, spiral vibration dampers, strips, ribbons, tapes, plates, flags and crossed bands [3]. The effect of marking lines has varied widely across studies, primarily with habitat, bird species, season and type and configuration of power lines [67, 68] .

[65]: Morkill et al. (1991), 'Effectiveness of Marking Powerlines to Reduce Sandhill Crane Collisions'
[66]: Brown et al. (1995), 'Evaluation of Two Power Line Markers to Reduce Crane and Waterfowl Collision Mortality'

[67]: Koops (1987), 'Collision Victims of High-tension Lines in the Netherlands and Effects of Marking'
[68]: Wright et al. (2009), 'Mortality of Cranes (Gruidae) Associated with Powerlines over a Major Roost on the Platte River, Nebraska'

Barrientos et al. [5] reviewed 21 wire marking studies and similarly concluded that wire marking reduced bird mortality by 55–94%. Understanding the nature of bird collisions is essential for minimizing them. To date, fewer studies have attempted to reduce avian collisions with distribution power lines, and more attention has been paid to transmission power lines [69–71] .

[69]: De La Zerda et al. (2002), 'Mitigating Collision of Birds Against Transmission Lines in Wetland Areas in Columbia by Marking the Ground Wire with Bird Flight Diverters (BFD)'
[70]: Sporer et al. (2013), 'Marking Power Lines to Reduce Avian Collisions near the Audubon National Wildlife Refuge, North Dakota'
[71]: Yee (2008), *Testing the Effectiveness of an Avian Flight Diverter for Reducing Avian Collisions with Distribution Power Lines in the Sacramento Valley, California: PIER Final Project Report*

In planning of infrastructure risk mitigation succeeds when power line routing leaves out sensitive bird areas in the first place. Once infrastructure exists, line modification in various forms is the other known approach. Line modification can take several forms, which can be broadly divided into those measures that make power lines present less of an 'obstacle' for birds to collide with, those that keep birds away from the power line and those that make the power line more visible [14].

**I.) Line design or configuration–less of an 'obstacle' to flying birds** Birds are believed to collide most often with the earth or shield wire (the thinnest wire at the top of the power line structure (see Fig.39). At close range, birds recognise the relatively thick conductor cables and perform obstacle avoidance maneuvers, that can lead them crashing into the thin shield wire. Removing this wire or designing power lines from the outset without this wire is therefore a potential collision mitigation measure. However, since these wires are used to protect the infrastructure from lightning, this is unlikely to be a widely used measure unless a viable alternative for lightning protection is developed [3] . Reducing the

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

height and the number of pylon levels (and therefore number of vertical obstacles) lowers the collision risk.

Often, low and medium-voltage supply lines use well insulated cables, directly attached to support poles (see Fig.4), which is the second-best solution. Collision risk is minimised, because the well-visible black cables replace a number of conductor wires.

**II.) Line marking – making lines more visible to birds** Line marking is the best solution (besides burying the wires), how to make the cables more visible to birds in flight. The presence of bird flight diverters is associated with a decrease in collision mortality [66, 70] . The placement of various designs of diverter devices on wires has shown to effectively reduce bird collisions in a range between 55 to 94% [12]. It has become the preferred mitigation option worldwide. A wide range of potential line marking devices (please see Annex D) has evolved over the years, including: spheres, swinging plates, spiral vibration dampers, strips, SWAN-FLIGHT Diverters, FireFly Bird diverters, bird flappers, aerial marker spheres, ribbons, tapes, flags, fishing floats, aviation balls, crossed bands (Figure 5.7).

[66]: Brown et al. (1995), 'Evaluation of Two Power Line Markers to Reduce Crane and Waterfowl Collision Mortality'
[70]: Sporer et al. (2013), 'Marking Power Lines to Reduce Avian Collisions near the Audubon National Wildlife Refuge, North Dakota'

**Figure 5.7:** The main used bird diverters (*from up to down*): SWAN-FLIGHT Diverter, RIBE Vogelschutzfahnen, FireFly Bird Diverter, Aviation balls.
*Source: Raptor Protection of Slovakia*

The various types of line marking devices require different installation techniques: from the ground bucket truck, boat, drone or other means. Some devices can be attached by hand and others need to be attached by a hot stick (Figure 5.8). Among major factors that impact the cost of marking include: line design, voltage, locations in the terrain, negotiation with landowners/users, type of selected diverter to be used, installation method, period of installation, weather, duration of installation, use of trained expert staff, use of special devices and machines and if the installation is carried out on energized or switched-off power line.

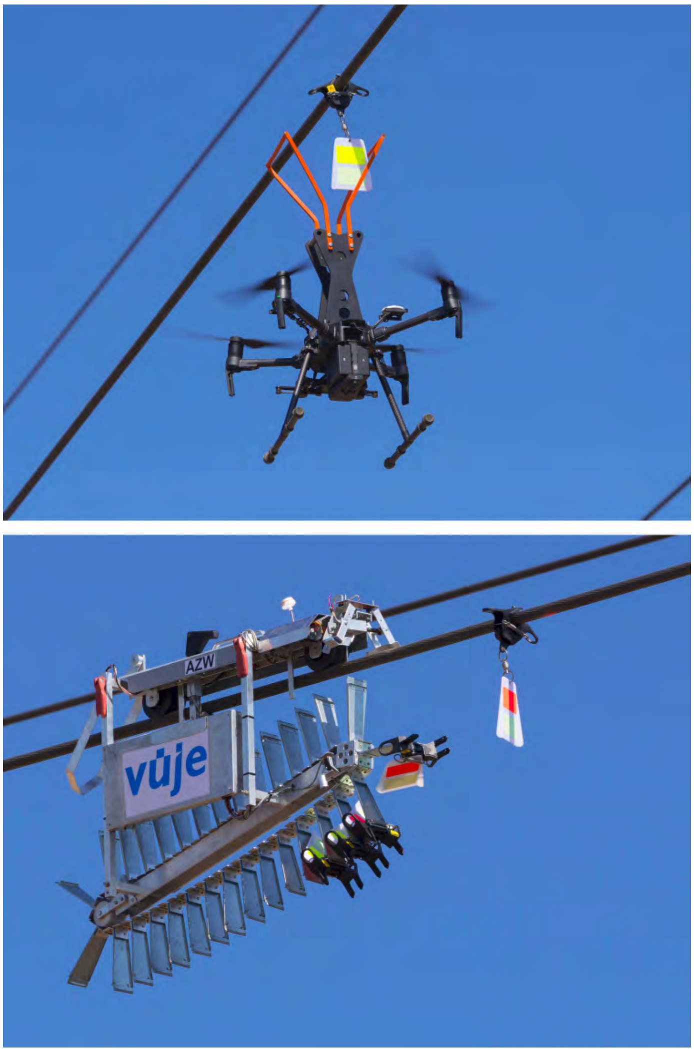


**Figure 5.8:** Drone and special self-movement device constructed and used for installation of FireFly Bird Diverter in Slovakia.
*Source: Východoslovenská distribučná, a.s.*

There is a large amount of literature available on efficiency of such marking devices in mitigating collision mortality, some examples from the African-Eurasian Flyways region are presented in the AEWA/CMS International Review on Bird-Power Line Interactions [14] . Spacing recommendations vary depending on species considerations, environmental conditions, line location, and engineering specifications (e.g., pylon construction and statics, wind and ice loading, conductor size, and the presence or absence of the shield wire). In general, intervals of 5 to 30 m have been most commonly used and recommended for all markers [3] .

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

Some of the installed devices were tested and proved to be not effective in preventing collision. From Germany, diverters in orange, yellow and red are reported as non-effective, especially when they don't move (e.g. spirals) or if they are too small. Many bird species don't see color the same as humans do and they don´t work in the dark.

In Portugal, simple spirals or pigtails diverters (Figure 5.9), either grey or alternated colors red and white, were observed as ineffective. These devices have shown to have low efficiency in reducing collision mortality (in average not more than 18%); even though the colors are better than the grey, they are not visible enough by the birds.

**Figure 5.9:** "Pigtail" diverter in grey color can be ineffective in prevention of collision. Due the low level of contrast to the background, markers can be invisible for approaching birds at twilight or even at day time.
*Source: Raptor Protection of Slovakia*

Short life span of some wire markers (because of extreme weather/poor quality of used materials), as whole or part of them felt down, was the one of many problems reported from Spain. Among others included the maximum effectiveness of 60% in general and different effectiveness for each bird species, such as great bustard.

Testing of markers has not been performed systematically. Results from the long term monitoring are not available yet. Bird diverters have been often installed on several power line sections but their efficiency was not evaluated (Croatia, Czech Republic, France, Latvia, Luxembourg, Poland).

Positive experiences and high efficiency of marking devices in mitigating collision mortality however prevailed. In Austria several effective types of bird diverters were used in the past: e.g. double black and white aviation marker balls (Figure 5.10) and marker plates (alternating in contrast between black and white). Five years after underground cabling and marking of power lines within core areas of the West-Pannonian distribution range of the Great Bustard, the population already benefited through a significantly decreased mortality rate [10] . In recent years, also flapping hard plastic black&white strip diverters from RIBE are used on high-voltage power lines.

[10]: Raab et al. (2012), 'Underground Cabling and Marking of Power Lines: Conservation Measures Rapidly Reduced Mortality of West-Pannonian Great Bustards Otis tarda'

**Figure 5.10:** Double black and white aviation marker balls used for 220 kV power lines (one marker per 30–35 m earth wire and conductor).
*Source: Raptor Protection of Slovakia*

Highest contrast bird diverters, black and white flapping diverter and FireFly marker from Sweden, lead to best recognition (up to 90%) in Germany. Recently, testing is in progress for FireFly diverters with drone-adjustable system in Hungary. As other effective methods and products RIBE, BirdMark and different aerial balls are known from different project results (see [10] ) showing that aerial balls are maybe more effective products, than FireFly for example - highlighting the fact, that every mechanically fixed diverter causes high financial implications in case of any retrofitting mitigation on already working transmission power line system in comparison than marking of new power lines.

[10]: Raab et al. (2012), 'Underground Cabling and Marking of Power Lines: Conservation Measures Rapidly Reduced Mortality of West-Pannonian Great Bustards Otis tarda'

Rotating FireFly Bird Diverters and rubber strap devices seems to be effective in Portugal. These devices have shown good to very good efficiency in reducing collision mortality (in average more than 65%), even though the samples were not enough to have significant results. Rotating devices seem to be the best and they are the only satisfactory device for steppe land birds, especially great bustards.

In the year 2016, RPS carried out a first short monitoring of efficiency for device BirdMark in Slovakia. Reactions of swans were tested for the diverter. 92% efficiency was confirmed when comparing the number of individuals flying above to the number of collisions. Within the project LIFE Energy (www.lifeenergia.sk) bird flight observations and carcass searches were carried out along distribution power lines in Slovakia. 77 km of 22 kV and 110 kV lines were marked on a total of 108 sections to evaluate the effectiveness of three types of bird flight diverters (Fire-Fly Bird Diverter, RIBE Bird Flight Diverter and SWANFLIGHT Diverter). Numbers of carcasses were compared before and after installation of the devices and reaction distances on marked power lines were surveyed. 94% reduction was observed (93 vs. 6) in the number of fatalities under the marked power lines after line marking (06/2016–06/2019) compared to the period before installation (12/2014–02/2016). 2,296 flight reactions were observed and an estimated total of 41,885 individuals (57 bird species belonging to 13 orders) were recorded with their reactions to marked lines in the period 06/2016–06/2019 [6] .

[6]: Gális et al. (2019), 'Monitoring of Effectiveness of Bird Flight Diverters in Preventing Bird Mortality from Powerline Collisions in Slovakia'

One positive and very important fact is that only some parts of potentially dangerous lines are responsible for the majority of killed birds. These sections need to be identified and treated with proper mitigation measures. RPS prepared a special methodology [72] aimed at classifying power lines according to the risk they present. The identification of power lines with the highest risk of possible bird collision requires easily accessed biological, technical, and landscape information of power line orientation relative to the important migration routes of birds, the effect of nearby tree growth higher than the evaluated power lines, and the complexity of landscape relief.

[72]: Šmídt et al. (2019), 'Methodology of Risk Assessment for Electricity Distribution Lines in Slovakia with Regard to Potential Bird Mortality Due to Collisions with Power Lines'

Attaching bird flight diverters to the wire has proved to reduce, not eliminate, collisions in Spain. The best solution is to use the anti-collision luminous devices, such as FireFly Bird Diverter from Sweden, recommended also from Belgium, Bulgaria, Lithuania, Romania, Sweden and black and white flapping diverter recommended from Germany, Hungary and Slovakia. Due to cost of marking devices, previous monitoring to identify the hotspots where to apply this management, should be realized. Also, to investigate of new flight diverters (including non-visual devices) is needed.

**III.) Burying the power lines.** Enhancing the visibility of wires is widely applied also when setting up new power lines, firstly in the territories where concentration of birds is really large and secondly, when the alternative places for the lines are not possible. If power lines must be constructed then burying the power lines underground offers the best solution against electrocution and collisions of birds. E.g. 43 km of an overhead power line was replaced by an underground cable in Bulgaria, as the most effective and long-lasting solution. Although this has relatively seldom been implemented for any significant length of line, mainly due to the technical and financial challenges (estimated at 3 to 20 times more expensive – [73] , it does appear that at least in certain parts of Europe, burying power lines is more widely practiced. The process of placing low voltage utility and medium voltage distribution lines underground has been completed in the Netherlands and is currently being carried out in Belgium, the United Kingdom, Norway, Denmark and Germany, and hence the severity of the electrocution problem is reducing in this region [14] . . In Hungary, for example, laying cables underground is estimated to be 20 times more expensive (approximately 48,000 €/km) than the use of bird flappers (a type of line marker) to mitigate collisions. In Slovakia, for example, laying cables of 110 kV lines underground is estimated to be at least 650,000 €/km and for cables of 22 kV at least 50-60,000 €/km.

[73]: APIC (1994), 'Mitigating Bird Collisions with Power Lines: the State of the Art in 1994'

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

# EU Legislation & Policy Framework 6

Three main international treaties address the conservation of birds of prey in Europe: the 1979 Convention on the Conservation of Migratory Species of Wild Animals (known as the 'Bonn Convention'), 1999 African-Eurasian Waterbird Agreement (AEWA) and the 1979 Convention on the Conservation of European Wildlife and Natural Habitats (known as the 'Bern Convention'). Within the EU, the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds) also establishes a general system of bird species protection [74] . The Birds and Habitats Directives are the cornerstones of the EU's biodiversity policy. They enable all EU Member States to work together, within a common legislative framework, to conserve Europe's most endangered and valuable species and habitats across their entire natural range within the EU, irrespective of political or administrative boundaries.

[74]: Stroud (2003), 'The Status and Legislative Protection of Birds of Prey and Their Habitats in Europe'

Guidelines on the conflict between birds and power lines have been published before, most notably the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention) published detailed guidelines to be implemented for the protection of birds on medium voltage power lines, based on Haas et al. [1] , and the Bern Convention Standing Committee in 2004 adopted Recommendation No. 110 on minimising adverse effects of above ground power lines. Furthermore, in 2002 CMS/COP 7 adopted a resolution (No. 7.4 "Electrocution of Migratory Birds"), which called on Parties and Non-parties to implement technical and legislative measures to mitigate the electrocution of birds on power lines, based on guidelines published in a brochure by NABU (German BirdLife partner), which is a precursor of Haas et al.. Also for North America, extensive practical guidelines are available, published by APLIC [3, 15, 73] .

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*

[73]: APIC (1994), 'Mitigating Bird Collisions with Power Lines: the State of the Art in 1994'
[15]: APIC (2006), *Suggested Practices for Avian Protection on Power Lines: the State of the Art in 2006*
[3]: APIC (2012), *Reducing Avian Collisions with Power Lines: the State of the Art in 2012*

Guidelines for mitigating conflict between migratory birds and electricity power grids has been prepared and adopted in 2011 by the AEWA and CMS (Bonn) Conventions, the report has been prepared by Prinsen et al. [14]. The report presents the available information (including references to other reviews) on the topic from the wider area of the African-Eurasian region. All these documents summarizes the latest technical standards on electrocution mitigation and review and present guidelines to mitigate collision risk for birds, a topic that received less attention in both the guidelines of the Bern Convention and the 2002 CMS Resolution 7.4.

The Position statement of BirdLife International „On the risks to birds from electricity transmission facilities" and how to minimise any such adverse effects has been prepared by Rybanič in 2007, derived from materials prepared by NABU, presented by [1]. The Position statement defines main adverse impacts of power lines on birds, appeals on urgency to address and minimize the on-going worldwide threat to birds from electrocution, collision and loss of habitat availability due to electricity transmission facilities.

After years of bilateral negotiations between stakeholders, all three utility companies in Hungary, the Ministry of Environment and Water (MEW), and MME/BirdLife Hungary signed the 'Accessible Sky' agreement in 2008. They pledged full cooperation in all aspects to efficiently reduce electrocution and collision problems. The Coordination Committee of the agreement became the most important forum of problem solving. It convenes at least twice a year to discuss plans, implementation and monitoring. Both reactive and proactive actions are undertaken with the announced goal to retrofit all dangerous lines before 2020. Also in Hungary, the Budapest Declaration on bird protection and power lines has been adopted by the conference 'Power lines and bird mortality in Europe' (Budapest, 13 April 2011). The declaration called on all interested parties to jointly undertake a programme of follow up actions leading to effective minimisation of the power line induced bird mortality across the European continent and beyond.

Another national and international initiatives (The Renewables Grid Initiative, The Energy & Biodiversity initiative) are implemented by adopting the technical standards, development for safety of power lines, planning, anti-collision measures and minimize harm to biodiversity and also by supporting environmental and nature conservation projects (The LIFE+ programme).

Fortunately, many types of electric lines will be removed with the continuing technical progress. In many countries, overhead telephone and telegraph lines will continue to disappear. In addition favorable trends can be reported from the low-voltage and medium voltage networks of some utility companies, which have made the step to change from above-ground power lines to under-ground power lines [1] .

[1]: Haas (2005), *Protecting Birds from Powerlines: Convention on the Conservation of European Wildlife and Habitats (Bern Convention)*

## 6.1 National Legislation, Legal Obligation, Standards & Cooperation

All 27 EU countries are contracting parties of Bern Convention, Bonn Convention, CITES and AEWA and almost all countries have legislation that brings the construction of power lines under a regime of an Environmental Impact Assessment (EIA), which should take into account existing habitat and wildlife conservation legislation, including for birds [14] .

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

Important step in the legislative and organisational approach of the conflict between power lines and birds is cooperation between government agencies and/or NGOs with the electrical utility companies on a voluntary basis. The first step by conservationists dealing with this issue should therefore be one of collaboration with the relevant utility companies, realising that energy supply is an overriding public interest. Similarly successful cooperation between electricity companies, government agencies and/or NGOs also exists in Czech Republic, Germany, France, Hungary, Portugal, Slovakia, Sweden etc. From the returned questionnaires it has become clear that lot of countries over the years have developed national legislation and/or adopted also legislation that brings the building of power lines under a regime of an Environmental Impact Assessment (EIA) (see Annex E for overview).

Detail information has been provided by a limited number of only 23 countries through the questionnaire. Brief summary of general and/or specific national legislation and/or national regulation and legal obligation of owner/provider of the power line, energy company standards in the area of bird protection, cost coverage for protection of birds from power lines, internal technical guidelines of energy companies and memoranda and agreements of cooperation between energy companies and nature protection organizations, NGOs, etc. as provided through the questionnaire by a number of countries and information received from NGOs, experts and representatives of energy companies. For some countries, due the insufficient quality of provided data and/or missing reply and answers, this information was taken and combined with the results of questionnaire survey in study Prinsen et al. [14] .

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

**Austria:** It is important to note that in Austria there is no legal obligation for bird protection measures on overhead lines (unless they are prescribed by the authorities in individual cases of a construction project) but EIA procedures are in place on high voltage power lines. A high percentage of medium voltage lines are already underground. Marking on wires has taken place for specific areas such as Natura 2000 sites and especially those areas important for the Great Bustard. Approval procedures for power lines may include the application of mitigating measures [14].

Experts from BirdLife cover consultations, managing a database of projects, implementation (i. e. buying and fitting), however, has to be covered by the operators on their own. However, there are official approval processes, in the course of which mandatory regulations for the operator can be made. It is therefore important for BirdLife Austria to inform the authorities about the dangers of overhead lines and solutions for bird protection. In principle, the agreement with energy companies is good. However, projects that are too big cannot be carried out in this way, they are simply too expensive.

**Belgium:** In some permits marking is asked for certain parts of a line, this was never asked in the past, there is no legal obligation to do so. Once a permit is delivered, no extras can legally be imposed, it has to be imposed in the permit to construct the line. TSO ELIA reacted to the reports of bird collisions under high voltage lines by contacting specialized NGOs to identify the „black lines“ and to advise her for the best management in order to mitigate the number of collisions. It is internal policy of TSO ELIA to take into consideration the results of the studies made by the NGO's and to place markers where this was proposed in these studies by private sources of company.

**Bulgaria:** There are no legal obligations newly built or reconstructed power lines to be bird-safe. The authorities might prescribe to the owner to insulate particular pylon if legally protected bird specimen has been electrocuted on it, but there are no legal obligations. If the energy companies have some internal guidelines in Bulgaria, they are not public. There is a good cooperation on specific issues in particular areas but large scale cooperation for change in the state policy and retrofitting of all hazardous power lines is lacking.

**Croatia:** The Nature Protection Act has no specific provisions for power line constructions. Also the National Strategy and Action Plan on Biodiversity addresses this issue as well. Planning and construction of power lines is subject to detailed EIA procedures [14] . Pursuant to the Regulation on conservation objectives and basic measures for the conservation of birds in the ecological network (OG 25/20 and OG 38/20), measures for the conservation in the field of energy industry include 23 strictly protected bird species endangered by electrocution: planning and constructing new electricity infrastructure to prevent electrocution of birds on medium voltage lines and implementing measures for preventing bird fatalities on the existing transmission lines where an increased risk of electrocution is identified by monitoring.

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

TSO HOPS is compliant with the relevant national legislation from the design and construction of transmission lines by installing diverters on power lines to prevent collisions. In the case of detecting the high risk for birds collision with certain power transmission line, owner / provider of the power line has legal obligation to install diverters to prevent collisions.

HEP DSO is committed to reduce its negative impacts on biodiversity and environment and electrocution is proved to be a significant threat to protected bird species. Company is working on it with their means and by implementing own solutions.

It is very important to establish good cooperation between different sectors in solving common problems. Joined innovative technical solutions from the energy sector and biology and ecology knowledge of species from conservation sector against bird collision and electrocution have become possible.

- **Special agreement for protection of White Stork** with Ministry of Environment and Energy since 2004 (revision 2016).
- **Implementation of bird protection measures** in Natura park Lonjsko polje (2018-2019)
- Associated Beneficiary in project **"Transnational conservation of birds along Danube River"** (LIFE DANUBE FREE SKY)
- **Memorandum of cooperation** with Birdlife partner in Croatia-Association Biom since 2016.
- **Active stakeholder** in national action plans for protection of *Gyps fulvus*, *Coracius garrulus* and *Aquila chrysaetos*.

In 2019 PINPKR and HEP DSO signed Memorandum of Cooperation. This Memorandum of Cooperation intends to foster and further develop the cooperation among Public Institution Nature Park Kopački rit and HEP DSO to protect birds at power lines along the Danube. TSO HOPS has been taking appropriate actions to prevent bird mortality regarding the collisions with power lines. The cooperation is based on the joint participation on projects of nature and landscape conservation.

**Cyprus:** Probably none, but the cooperation is very good. Approach of the Electricity Authority of Cyprus is positive. No memorandum, agreement or contracts are in place.

**Czech Republic:** Based on Act no. 114/1992 Coll., on nature and landscape protection, everybody who builds or reconstructs high-voltage lines has to apply efficient protective measures to protect birds from being killed by electrocutions.

According to Act no. 114/1992 Coll., on nature and landscape protection, natural and juridical persons must act in such a way to avoid excessive death and injuries to animals, which can be prevented by technically and economically available measures (also in the energy sector that is explicitly mentioned). If this is not done by the person alone, the use of such measures can be ordered (in practice, such a “command” is very rare).

Distributors have a legal obligation to ensure bird protection on power lines till 2024. This fact motivates them to cooperate - but there is no penalty if they do not keep limit of 2024. Hence, it devalues the function of this time limit. Another motivation of companies is to obtain a positive image in the eyes of the public. In 2016, the Ministry of the Environment issued Guidelines for bird protection against electrocutions. The Guidelines are binding upon nature conservation authorities. Distributors collaborated on these guidelines and they should keep the rules given by them. The organization ČSO cooperates with the company E.ON ČR, a. s., on the basis of term contracts.

In the above-mentioned methodological Guidelines and methodological Guidelines prepared by Ministry of the Environment of the Czech Republic, distributors undertook to include in their technical requirements for components providers only components safe for birds. The safety of components is evaluated by a written opinion of the Nature Conservation Agency of the Czech Republic. E.ON Distribuce, a. s. fulfills the commitment given by the Guidelines, ČEZ Distribuce, a. s still only partially.

Cooperation in the case of the company E.ON Distribuce, a. s. is rather positive. In the case of the company ČEZ Distribuce, a. s. it is not optimal. Cooperation with the company PRE distribuce, a. s., due to the minimal extent of above-ground lines, is not taking place. In general, the problem lies in slow rate of replacing dangerous poles or their refitting with protective measures. Also timing and organization of reconstructions is an issue, as it seldom takes account of bird’s protection priorities. The costs are paid by providers of power lines.

**Denmark:** A decision has been taken on a major project to underground all power lines starting with the lower voltage ones and later, pending technical solutions, also higher voltage power lines. This decision is directly related to the strong increase of the number of wind turbines and therefore a much denser power line network. Besides this long term and costly plan, EIAs must always been carried out and the outcome can influence places and transects for power lines or partially placing them underground e.g. when crossing wetlands, larger streams, valleys etc. is unavoidable. Protected areas will, as much as possible, be avoided [14] . To make an Environmental Assessment (Natura 2000-Assessment) to prove whether there is need for protection. Legal obligation is related to the Habitats- and Birds Directives. The cooperation is based on the joint participation on projects of nature and landscape conservation.

[14]: Prinsen et al. (2011), ‘Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region’

**Estonia:** No specific legislation on birds and power lines but there are EIA procedures that have to take the issue into account. There are strong efforts to bring power lines underground [14] . Conduct an environmental assessment of the new power lines with mitigation measures and line markers.

[14]: Prinsen et al. (2011), 'Review of the Conflict Between Migratory Birds and Electricity Power Grids in the African-Eurasian Region'

**Finland:** The problem is not recognised in national legislation or environmental policy on the national level and no national standards or mitigation guidelines are available. The electricity suppliers have their own guidelines on bird mitigation measures (e.g. plastic ball markers and a short transect has been placed underground). Mitigation by the companies focuses on outage prevention and aircraft safety and there are some bird related recommendations [14]. Companies are interested in the issue and cooperative (willing to get information), but we have not had discussion with them of larger scale projects or monitoring. NGOs have not had own resources for that. With Elenia we have a small scale cooperation agreement. There is lack of data from Finland which shows that this is a major conservation problem and this is the reason why this is not of importance in Finland.

**France:** There is no real legal obligation for new lines. But with time, bird friendly material is always used for new construction (mainly change of poles). With agreements, is possible to change the practice of companies and the risk for birds is now taken into consideration. But if a dead bird is found at a foot of a pole, company has to correct the risk.

The cooperation is doing better and better. We needed time to share a common language and now it's ok. Main problem is the turnover of people in utility companies.

Energy companies have a kind of guidelines that is not yet shared at all levels. NGOs and experts help the process by providing training for teams but it is not enough. Nevertheless, work supervisors think to birds before scheduling the work!

**Germany:** For medium voltage operators and railway (for new constructions): 1. Bundesnaturschutzgesetz (Federal Nature Conservation Act) § 41 Bird protection on energy transmission lines: „For the protection of bird species, newly erected masts and technical components of medium-voltage lines must be constructed in such a way that birds are protected against electric shock. On existing masts and technical components of medium-voltage lines with high risk to birds, the necessary measures to protect against electric shock must be carried out by 31 December 2012. Sentence 2 does not apply to the overhead line retrofitting of dangerous pylons is obligatory since 2009 (but still not fully fulfilled). 2. application guide VDE-AR-N 4210-11 with obligatory technical solutions for medium voltage power lines since Aug. 2011 (in fact implementation guide for nature conservation act) before that VDEW Measurement catalogue.

One of the most important milestones for bird safety on medium-voltage power lines was the reinstatement of the article on bird protection in the technical standard DIN VDE 0210 (VDE 0210):1985-12 which states that "the crossarms, insulator supports and other elements of power lines shall be designed so that birds cannot perch in dangerous vicinity of energized conductors". When an electrocution case occurs and gets documented (not centralized through governmental controls) providers either upgrade constructions to prevent electrocutions according to VDE guidance paper or installing diverters on power lines prevent collisions. Sometimes critical constellations get ignored and then seldom brought to court by NABU or other organisations.

Transmission grid operators have to do an EIA for every new 380-kV-grid project and often have to fulfill official requirements for installing bird diverters. But there is no requirement for retrofitting for transmission power lines."

Most companies are cooperative and retrofit after incidents very fast. TSOs support the RGI/NABU project „Vogelfund und Stromleitung“ by funding RGI and some do own research on bird collision (50Hertz, TenneT) or even held conferences (50Hertz in Oct 2017, Amprion in Apr 2018) to get recognized as responsible for social and conservational acceptance.

Energy companies have their own internal guidelines. Internal guideline on bird protection of 50Hertz (March 2018) and guideline on ecological line management (50Hertz and Amprion).

RGI-TSO-NGO work underlies a memorandum of understanding, based on the Renewables Grid declaration. Under this in 2014 and 2015 the BESTGRID project runs in 3 European countries (2 grid projects in Germany). No such agreement with medium voltage operators – but legal requirements and hard struggle since 2014 with German Railway especially over NABU request on stop of using pin type insulators.

Main resources to cover the cost of mittigaton measure are company budgets (electricity tax), when grid developement projects partly or full refunding by Federal grid agency.

**Greece:** The obligations of the providers are currently under investigation by HOS policy team. In practical terms, until this day companies are not obliged to do something.

Cooperation with power utility companies is gradually developing during the last 5 years but it is still very weak. Project-specific memorandums. No national-scale implementation plan has ever been adopted.

**Hungary:** The general basis of legal responsibility in the field of environmental protection and nature conservation is laid down in Law for protection of the Environment (Act LIII. /1995/ on the Protection of the Environment) IX. Chapter 101-102. §. Power line companies are declared as environmental users. The environmental user's obligation to cover environmental measures includes measures to prevent damage to the environment and restore the damage that has already occurred.

Special rules for protected areas and species of nature conservation are laid down in Law for Nature Conservation (Act LIII /1996/ on Nature Conservation) 78/A §.

Nature Conservation Law have been changed in 2009, forcing electric companies, that newly developed or rebuilt power lines have to be built in a birdfriendly design.

Everyone building or planning an aerial power line is requested to use a technical solution that is preventing electrocution of birds:

7 § (5) When installing electric power supply air power lines, and when renovating/ reconstructing a mid-voltage free air line over a full length, technical solutions shall be applied that do not endanger wild birds.

43 § (1) It is forbidden to disrupt, damage, torture, destroy, proliferate and otherwise endanger the individual's protected species, to destroy or damage their living, living, feeding, breeding, resting or hiding places.

78 / A. § The species and their habitats, poets and rest areas, natural habitats, protected natural sites and protected natural values specified in each separate law, Section 10, point 10 and impairment of point 13, the criteria for determining the degree of damage and the order of prevention and restoration of the environment shall be determined by the Government. These Government Decrees are as follows:

- Decree 90/2007 on the Prevention and Remedy of Environmental Damage; (IV.26.) Government Decree,
- Decree 91/2007 on the Determination of the Damage in Nature and the Remedies Regulations. (IV.26.) Government decree.

Both laws cover the species, their habitats, their poets and their resting places as defined in Article 4 (2) and Annex I to EU Council Directive 79/409 / EEC ('the Birds Directive') on the conservation of wild birds; EU Council Directive 92/43 / EEC on the conservation of natural habitats and of wild fauna and flora ('the Habitats Directive'). and IV. and their habitats, their reproductive and resting places and their natural habitats as set out in Annex I; for protected and highly protected species; Natura 2000 sites and nationally-protected protected natural areas.

The measures for post-mortem outbreaks related to birds (in the case of bird mortality) are mainly due to the nature of damage caused by the nature of birds and the provisions of Remedies Act 91/2007. (IV.26.) Government Decree.

Law regulating electricity service and work of electric companies (VET) (Act LXXXVI. /2007/ regulating electricity service and work of electric companies) has compliance with environmental and nature protection considerations as follows:

According to 24 § (1) (a), network licensees are obliged to operate the transmission and distribution network operated by them safely, efficiently and reliably in order to cooperate with the electricity system and to ensure access to the transmission and distribution grids, taking into account, maintaining.

39/A § (1) A private conductor's licensee is obliged (a) operate the private pipeline safely, in accordance with environmental protection requirements and technical requirements, b) to carry out maintenance, repair and renovation works on time.

78 § When granting new production capacities in a transparent way, in compliance with the requirement of equal treatment, the following criteria shall be applied: (a) the security of the electricity system and its components; the protection of public health and public security; the protection of the environment and nature; site selection; improving energy efficiency; Priority of renewable energy sources; use of advanced technical solutions; security of electricity supply; protecting users.

96 § subsection (da) of section (1), the licensing office is obliged to withdraw the license if the licensee is unable to meet his obligations or the electricity company is responsible for security of supply, life, health, plant and property security, operating in a seriously endangered environment.

So far, the problems have always been solved after mutual communication, either by upgrading constructions to prevent electrocutions or installing diverters on power lines to prevent collisions. Since 2017, implementation of bird friendly retrofitting mitigation or reconstruction works the Electric Companies are considering the protection of birds from the preparing the plans at the very beginning to prevent collisions and electrocution. The good relationship, cooperation we have built with the Electric Companies is far more effective, useful and important than the obligations set by the law, however in some cases (large scale mortality of protected species, or planning old scheme solutions on distribution power lines) the 91/2007. (IV.26.) Government Decree should be and will be used to hinder further incidents.

All of the companies do have internal guidelines how to proceed in case of electrocutions, eventually they have clearly defined ways how to handle with certain type of constructions or which bird diverters to use for which occasion etc. These guidelines are updated regularly. BirdLife Hungary was also working with their Partners on internal guideline for nature conservation authorities and National Park Directorates based on recent results of KFO survey and modeling of geometry and scaling of new bird friendly pylon head structures on the distribution power line system. The costs for protection of birds from power lines are covered mostly by the European Union under the LIFE projects, the „KEOP" and „KEHOP" projects, from the sources of Electric Companies (distribution power lines), MAVIR (transmission p. l.) and also the Ministry of Environment of Hungary, eventually with the support of other donors.

Cooperation is good and it is still working in term of electrocutions. Approach of energy companies to this subject matter is responsible, but in some cases requires more firm action. Cooperation in terms of collision is perfect and working well. The company MAVIR is committed to the matter and regularly initiates the submission of joint projects. Our cooperation is based on the Accessible Sky Agreement. This Agreement works between all of the Power line Companies, the Ministry of Environment and MME BirdLife Hungary since 2008. In case of several projects done in the past we used a Partnership (Companies were also Partners of LIFE projects, or we signed a subcontract to cover the main costs of products used in retrofitting mitigation processes).

**Ireland:** Unknown

**Italy:** At the national level, the legislative interest in issues related to the possible impacts caused by power lines is dating back to 2001 when it was published in the Official "Framework law on protection from exposure to electric, magnetic and electromagnetic fields" (Legge quo sulla protezione dall' esposizione a campi elettrici, magnetici, e elettromagneticadri)n. 36 of 22.02.2001. In this law, in paragraph 2 of article 5, it is emphasized the need, subject to the opinion of the Committee referred to in article 6 and after hearing the competent parliamentary commissions, to adopt measures to contain the electrical risk of the plants referred to in the same paragraph (power lines, mobile telephone and radio broadcasting systems), and in particular the risk of electrocution and bird collision. Furthermore, paragraph 1 of the same article 5 provides for the issue of a specific regulation, issued within one hundred and twenty days from the date of entry into force of this law, in which "specific measures are adopted relating to the technical characteristics of the plants and the location of the routes for the design, construction and modification of power lines – omitted". The decree of 17 October 2007 of the Ministry of the Environment and Land and Sea Protection published in the Official Gazette no. 258 of 6-11-2007 concerning "Minimum criteria for the definition of conservation measures relating to Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) "provides in Article 5 for all SPAs: in point 2. b) the obligation, by autonomous regions and provinces, of the safety, with respect to the risk of electrocution and impact of birds, of high and medium voltage power lines and overhead lines of new construction or under extraordinary maintenance or renovation, and in point 3. b) indicates, as an activity to be encouraged, the removal of suspended cables from disused power lines. Some regions have also issued specific regulations on impact prevention with power lines [75] .

[75]: Pirovano et al. (2008), 'Linee Guida per la Mitigazione Dell'impatto Delle Linee Elettriche Sull'avifauna'

**Latvia:** The legal obligation of owner/provider of the power line when power lines are built or reconstructed are not strictly defined. Cooperation is quite good, but insufficient. The costs for protection of birds from power lines are covered by the European Union and Latvian state under the grid building and reconstruction project.

**Lithuania:** In the Republic of Lithuania, installation of power lines is regulated by the Rules for the Installation of Electrical Lines and Wiring approved by the Minister of Energy. These Rules set out the technical parameters of how the overhead power lines must be installed, specifies the distances, materials, layout of wires, and also installation of power lines across forests and above water bodies. The Rules also specify the distances from overhead power lines to water bodies, trees, and green spaces. The Rules does not provide for any specific requirements or recommendations regarding conservation of biodiversity, which is ensured while drafting technical projects. When building new overhead power lines or reconstructing the currently existing power lines in Lithuania, an Environmental Impact Assessment (EIA) needs to be carried out.

During this assessment, especially in recent years, significant attention is paid to the protection of birds in sensitive ornithological areas. For these areas, EIA provides various measures to reduce negative effects on birds; also measures to ensure better protection are planned.

**Luxembourg:** Energy companies have to make sure, that the power lines are bird-save by law. Legal obligation of owner/provider of the power line when a high risk for birds on a certain power line is detected in unknown. If the energy companies have some internal guidelines is unknown. Majority of power lines in Luxembourg are planned under the surface. Cooperation is good, Creos reacted very fast and took measures immediately and provides these measures by their selves from own sources.

**Malta:** Unknown

**Netherlands:** Unknown. All low utility and medium voltage distribution lines have been placed underground.

**Poland:** Bird species are protected by the Ramsar, Bonn and Bern Conventions, as well as by Polish nature protection law. Today, the fundamental legal measure concerning wildlife protection in Poland is the Wildlife Conservation Act of April 16, 2004 (Journal of Laws, No. 92, item 880), whereas the protective status of individual species is determined by the related order of the Minister of the Environment of September 28, 2004, on wild animal species subject to protection (Journal of Laws, No. 220, item 2237). There are 2-3 general sentences on the topic in the main operator's policies, nothing specific like internal guidelines for ecological power lines.

The legal obligation of owner/provider of the power line is to follow the EIA process and obey environmental decision by regional nature conservation authorities. They usually order to put some mitigations in big investments (like bird diverters) and require pre- & post-construction monitoring, which is reported, but data is not made public (as the investors' money are involved –> private data). However lower voltages (less than 60kV) are usually renovated and operated without EIA –> no monitoring, no mitigation. In theory they act accordingly to the EU Directives, so mitigation is required - usually bird diverters are put on the line and monitoring is being done. The cooperation with public utility companies is weak, as the problem of the collisions and electrocutions is not well enough studied, proven and understood.

These are usually investor´s money at the stage of power line construction. Small actions are done by NGOs with their own money from different small projects.

**Portugal:** The implementation and maintenance of the line is for EDP Distribuição and it is the only owner of the lines and is obliged to keep the electricity supply in good conditions. Even though there is a free market for electrical energy supplies all the suppliers use the national grid that is owned and maintained by EDP Distribuição. The Owner of the private property, when the line crosses that property can ask for a payment for each pylon when the line is built. Environmental license to build medium tension power lines: If the power lines are situated inside protected areas, the national conservation authority requires a previous technical opinion and the mitigation measures specific for this power line, if needed.

All retrofitting that has been done by EDP Distribuição in existing power lines is voluntarily. As mentioned above, for new lines in protected areas, national institutions can oblige to implement mitigation measures. For extra-high-voltge power lines, because they need to go through an EIA process, they are subject to the obligation of mitigation devices against collision, when they are placed in sensitive areas for the avifauna.

Cooperation with the public utility companies (especially EDP-Distribuição, which works directly with us) is very good and tends to improve with the possibility of LIFE projects to implement mitigation measures and identify dangerous power lines. Cooperation is based on contracts for identifying and monitoring dangerous power lines, as well for developing methods for better identify this power lines. In terms of implementation of mitigation measures, an agreement is valid for Birds and Power lines Protocols and a contract is valid for LIFE projects.

REN adopt guidelines that set the criteria for which a new line needs to have anti-collision devices. EDP Distribuição has an internal norm, developed within protocol Avifauna III, which defines criteria for planning and retrofitting new power lines, in ecologically sensitive areas. ICNF has public guidelines for the evaluation of linear infrastructures (ICNB, 2008. Manual de apoio à análise de projectos relativos à Implementação de infra-estruturas lineares).

There are some LIFE funded projects which apply mitigation measures for the protection of birds. Our Birds and Power lines Protocol also implements mitigation measures in identified dangerous power lines and the costs are covered by EDP-Distribuição, the sponsor of the project.

**Romania:** Regarding the implementation of "Nature 2000" Network, Romanian legislation transposed the provisions of the two Directives through Government Emergency Ordinance No. 57/2007 on the regime of protected natural habitats, conservation of natural habitats of flora and fauna approved with amendments by Law No. 49/2011, the Minister Order No. 2387/2011 on the establishment of protected natural area regime for the sites of community importance and by Decision No. 971/2011 regarding the declaration of Special protection areas as integrant parts of the European ecological network „Nature 2000" in Romania (Ministry of Environment and Forests). The law is not very clear here when a high risk for birds on a certain power line is detected. If the power line affects protected species, then the authorities should be notified and they will start an investigation, through which companies may be required to take action, in order to avoid the impact.

Electric companies do have internal protocol how to proceed in case of electrocutions. All the incidents are internal reported and organised in a database. The electric companies have their own prioritization of problematic electric lines. They try to solve the situations in the locations with most of the incidents that caused power failures.

Some collaborations started with the electric companies but there are only some initial steps. In some projects, on specific sites, there were collaborations on these subjects (collisions and electrocution) but there is not an extended action. Discussion with all companies from this sector already started, some years ago, but any memorandum, agreement or contract regarding this were signed. Mutual agreements are signed between DDBRA and electric companies.

**Slovakia:** In the Law 543/2002 Coll. on conservation of nature and landscape it is written: § 4 (4) Everyone building or planning an aerial power line, is requested to use a technical solution that is preventing electrocution of birds. (5) If a proven electrocution takes place on a power line or telecommunication devices, authority of nature conservancy can decide that the administrator must undertake technical measures to prevent electrocution of birds. So far, the problems have always been solved after mutual communication, either by upgrading constructions to prevent electrocutions or installing diverters on power lines to prevent collisions. Since implementation of the LIFE Energy project all Electric Companies in Slovakia are considering the protection of birds even when preparing the plans at the very beginning to prevent collisions and electrocution. The good relationship, cooperation and trust that was built with the Electric Companies is far more effective, useful and important than the obligations set by the law. Also very good cooperation was strengthened with the State Nature Conservancy of the Slovak Republic. Some electric companies do have internal guidelines (the Eastern Slovakia Electricity Company issued an internal technical norm called: 'Construction and amendment of aerial 22kV power lines with respect to bird protection.') how to proceed in case of electrocutions, eventually they have clearly defined ways how to handle with certain type of constructions or which bird diverters to use for which occasion etc. These guidelines are updated regularly based on recent results. The costs for protection of birds from power lines are covered mostly by the European Union under the LIFE projects, from the sources of Electric Companies and also the Ministry of Environment of the Slovak Republic, eventually with the support of other donors.

**Slovenia:** Unknown.

**Spain:** In accordance with Spanish legislation (REAL DECRETO 1432/2008, de 29 de agosto, por el que se establecen medidas para la protección de la avifauna contra la colisión y la electrocución en líneas eléctricas de alta tensión), it is only obligatory that the owners of the electric lines signal the line to avoid collisions and that the electrical lines have a safe design for the birds in the new power lines that are in protected areas of the Natura 2000 Network.

When there is a contracted mortality of birds, law enforcement and NGOs make a complaint to force the owner of the line to correct it. Although there may be specific agreements for the correction of electric lines that are causing a high mortality of birds, the electric companies have opted for the confrontation and because it is the citizens who pay the corrections of the dangerous electric lines with the benefit of the government. There is no internal guidelines for ecological power lines.

The costs of mitigation measures are covered mostly by the European Union under the LIFE projects, from the Ministry of Environment of Spain and the regional administration, eventually with the support of sources of Electric Companies.

**Sweden:** The national law of Sweden is rather weak in this aspect, although the law regulating electricity distribution has a paragraph saying that "concession should save common interests and civil rights and protect human health and the environment from damage and inconveniences". There is a very detailed permit process, especially on 30-400 kV, for building new power lines. The owner that will do the construction have to show how the power line will affect the environment in different ways. The companies must also describe if measures are to be taken to reduce the risks for birds and other environmental aspects. In general the company must perform a field study to describe what species exists in the planned area. In the environmental law there is nothing specific about birds. The legislation on EU-level is followed and incorporated in Swedish law, such as Directive of Birds. Some electric companies do have internal guidelines and work continually to reduce the company's environmental effect and to prevent bird mortality. Some of adopted standards: the grid 0.4-20 kV is always build with isolated lines or as earth cable; pole mounted transformers are built with insulator protection and isolated slacks up to phaselines. Distance between phases on uninsulated power lines 40-50 kV has been increased from 1350-1600 mm. The electric companies must cover the costs for protection of birds from power lines. In the end these cost is payed of the customers/power consumers.

The information provided by the countries shows different policies to deal with and reduce the problems of power lines and birds. Some countries also apply mitigation measures against both electrocution and collision from the very beginning of a construction. A high percentage of medium voltage lines are already underground in Austria, Netherlands, Germany, Luxembourg and Sweden.

The information provided by the countries shows different policies to deal with and reduce the problems of power lines and birds. In particular, EIA procedures are in place in most countries, providing some guarantee that in general the interests of nature are taken into account. Almost all countries apply mitigation measures against both electrocution and collision from the very beginning of a power line construction. Lot of energy companies also have internal guidelines how to proceed in case of electrocutions, eventually they have clearly defined ways how to handle with certain type of constructions or which bird diverters to use for which occasion etc. These guidelines are updated regularly based on recent results. A high percentage of medium voltage lines are already underground in Austria, Netherlands, Germany, Luxembourg and Sweden. Policy of many TSOs is compliant with the relevant national legislation from the design and construction of transmission lines by installing diverters on power lines to prevent collisions. Cooperation between experts and public utility companies is very good and tends to improve with the possibility of LIFE projects to implement mitigation measures and identify dangerous power lines. It is also based especially on contracts for identifying and monitoring dangerous power lines, as well for developing methods for better identify this power lines. Cooperation with power utility companies is gradually developing and most companies retrofit power lines after incidents very fast. The good relationship, cooperation and trust that are built with the electric companies are far more effective, useful and important than the obligations set by the law. The costs for protection of birds from power lines are covered mostly by the European Union under the LIFE projects, from the sources of Electric Companies and also the relevant Ministries, eventually with the support of other donors.

## 6.2 Organisations Dealing with the Topic on National Level

**Austria:** Electrocution is mainly handled by BirdLife Austria. Above all, but not only, in the case of collisions there are initiatives in (Life+) projects (Great Bustard), from the federal states, the operators, etc. I am not aware of the fact that there is a list of activities where all the measures and those responsible have been brought together.

**Belgium:** Natuurpunt and Natagora are 2 NGOs working in nature conservation. We are specialized in bird monitoring and protection. ELIA asked us to help her to manage power lines to avoid or reduce bird collisions. ELIA also lead a LIFE-Nature project to improve biodiversity under the power lines.

**Bulgaria:** Bulgarian Society for the Protection of Birds and the three private companies implements common EU funded projects aiming to protect endangered species that die from electrocution and collision. The priority species are the Imperial Eagle (Aquila heliaca), the Egyptian Vulture (Neophron percnopterus), the Griffon Vulture (Gyps fulvus) and the Dalmatian Pelican (Pelecanus crispus). Other NGOs and Nature Parks also work on local level for safeguarding power lines in specific areas.

**Croatia:** On a higher level, the Ministry of Economy and Sustainable Development-brought the Ordinance on conservation objectives and conservation measures for target bird species in ecological network areas. Also there are several NGO's (like Association Biom and the Croatian Society for Birds and Nature Protection) that deal with these problems conducting monitoring for different protected areas in Croatia and also suggesting mitigation measures that can be incorporated in important documents. TSO HOPS cooperates with manufacturers of products for protection of birds from collisions and prepares plans for implementing the best solutions to eliminate the risks. Before the implementation, these solutions are discussed with local experts. HEP DSO conducted a survey in cooperation with Association Biom (Birdlife partner in Croatia) to identify priority sites, i.e. possible hotspots for electrocution in selected Natura 2000 SPA's. HEP DSO also finds solutions and funds for mitigation of electrocution on its own, there aren´t any guidelines on national level.

**Czech Republic:** Nature Conservation Agency of the Czech Republic (an expert body of the Ministry of the Environment) – issues expert opinions about safety of particular components of the transmission system (e.g. console) for birds, negotiates about methodological approach and new technical solutions with the Ministry of Industry and Trade and with the providers of transmission net, it also asserts using bird-safe components in the transmission net, is an advisor for other nature conservation authorities, organizes monitoring of power lines. Czech Society for Ornithology (NGO) and its regional offices – collects data, identifies dangerous power lines, negotiates with providers of transmission net and asserts using bird-safe components, asserts securing the most dangerous poles and power lines sections, cooperates with NCA and the Ministry of Environment and participates in evaluation of the safety of transmission net components for birds, on methodological and conceptual materials preparation Czech Union for Nature Conservation (NGO) – as the „umbrella organization" of rescue stations in the CR it ensures especially collecting data and sometimes participates in asserting bird-safe components.

**Cyprus:** The Game and Fauna Service is the competent authority for birds in Cyprus. Also partners involved in projects with relevant activities (e.g. Akrotiri Salt Lake Antennae Project, LIFE with Vultures, LIFE Oroklini, LIFE Bonelli East Med) have responsibilities laid out as part of project activities and project partnership agreements.

**Denmark:** Danish Ornithological Society (NGO); Environmental Agency (related to permits and Environmental assessment); Consultancies (related to concrete projects); Energinet (related to concrete projects and existing infrastructure).

**Finland:** More or less all power companies as Elenia and Finngrid are interested to get information about sensitive sites.

**France:** State (regional scale: DREAL & OFB), NGO by means of agreement. At least 10 years long cooperation - 4 agreements with Enedis with the aim at correcting risk of electrocution for birds of prey (namely Bonelli's eagle), collision and training Enedis teams with bird conservation.Priority also an identifying network dangerousness for birds in high-stake areas.

**Germany:** NABU federal association and NABU expert group „BAG Stromtod" (communication and policy work on the issue on federal level, task force member with railway German railway and VDE working group member on collision mitigation means). Deutsche Umwelthilfe e. V. (DUH) (political guideline on grid extension) EGE Eulen e.V. (local policy work on risks for owls and raptors through medium voltage, especially in Northrhine-Westfalia) Kommitee gegen den Vogelmord e. V. (mainly illegal shooting) Authorities: Brandenburg office for bird protection (collecting data); Federal association for nature conservation (BfN): (Initiating and funding of research projects on bird protection); Deutsche Bahn (German railway company) and Federal railway office (bird protection on railway power lines and poles).

**Greece:** HOS (Birdlife Greece) and rehabilitation centers / there is no division of goals and responsibilities.

**Hungary:** BirdLife Hungary (MME) coordinates the field surveys of KFO project (Monitoring of Medium voltage power lines) and cooperates with producers of products for bird's protection from electrocution and collisions. National Park Directorates are dealing with collisions, monitoring the victims and preparing a heat map of relevant sections of transmission power lines for MAVIR. MME is also preparing plans for implementation of various solutions to eliminate the risks.

**Italy:** Lipu has carried out a study with Terna (national transmission company) on the impact of power lines on bird mortality. Lipu is currently involved in an Integrated Life project (Gestire 2020) and is cooperating with Enel and Terna to identify dangerous power lines and mitigate their effects on birds in Lombardy region.

**Latvia:** The only collision research have been taken by LOB in 3 sections of high power line „Kurzemes loks" in 2015-2017. This research was ordered and financed by stock company „Augstspriegumu tikls".

**Luxembourg:** n case a bird is found, natur&ëmwelt contacts Creos. Then the specific measures are planned together.

**Poland:** There is no organization dealing with the topics on regular basis. In general national and regional nature conservation authorities are responsible, esp. when it comes to EIA. NGOs are involved sporadically and act if there is a local problem (raptors in Lublin area - LTO, White Storks in E i NE Poland - TP Bocian, PTOP, etc). Power line operators react only from case to case, only if formally urged by nat. conservation authorities.

**Portugal:** SPEA, Quercus, LPN – Liga para a Protecção da Natureza, ICNF – Instituto para a Conservação da Natureza e Florestas and EDP – Distribuição collaborate in Protocolos Avifauna, identifying the most dangerous areas for avian electrocution and implementing anti-electrocution measures in the dangerous power lines. SPEA, LPN and Quercus do field work to look for avian collision and electrocution evidences, identifying power lines for retrofitting. EDP Distribuição is responsible for implementing mitigation measures. ICNF, the National Nature Conservation Authority, is responsible for providing information about sensible species, such as nesting areas and validating decisions.

**Romania:** Usually this is in the hands of the electric companies. The NGO's such as MILVUS GROUP, ROS (BirdLife Romania) or other institutions have only small and much localized monitoring, research or interests on this subject. On the other hand, this threat for birds and bats was included in many Managements Plans for Natura 2000 sites. Accordingly, to those conservation measures (from the Management Plans), the power lines isolation and signaling will be covered by these projects/programmes/strategies.

**Slovakia:** Raptor Protection of Slovakia coordinates the field survey and cooperates with producers of products for bird's protection from electrocution and collisions. Also prepares plans for implementation of various solutions to eliminate the risks. Before the solutions are implemented, they are discussed with State Nature Conservancy of the Slovak Republic and Energy Supply Companies in Slovakia. Often there are mutual memoranda. However, energy companies do have a responsible approach which makes cooperation easier, for instance a joint participation on projects such as LIFE Energy. Last but not least, it is also Act 543/2002 Coll. about Conservation of Nature and Landscape. It imposes an obligation to prevent bird mortality on managers of power lines. In case it happens, they have to take actions to prevent it from happening again in future.

**Spain:** In Spain there are several NGOs that deal with the death of birds in power lines. Currently, the SOS-Tendidos Platform brings together most of the organizations that try to stop bird mortality in power lines.

**Sweden:** BirdLife Sweden deals with the topic, both nationally and through its regional societies, and Kungsörn Sverige ('Golden Eagle Sweden') as well as regional Eagle Owl projects (such as 'Berguv Nord') are engaged in the matter. Discussions occur with the Ministry of Environment, Swedish Environmental Protection Agency, Swedish Energy Markets Inspectorate (Ei). We also have local initiatives with different electric companies such as Vattenfall, E.ON, Fortum and Skellefteå Kraft to discuss and find solutions to minimise both collision and electrocution. The authorities that gives permission to power lines always look on to what extend a power line will affect the birdlife and what precautions are to be taken. In Sweden it is Energimarknadsinspektionen and Länsstyrelserna (County administrative board) that are responsible authorities.

# Conclusions & Recommendations

# 7

This document provides a useful source of ideas on the different types of techniques and approaches that can be used for implementing best practice standards to reduce bird mortalities and might be also be useful for the adaption in flyway regions with an extraordinary demand for practical and effective measures.

The overhead transmission and distribution power lines are experiencing a strong expansion due to the continuous increase in the human population and the consequent increase in energy demand. The power line cross different types of ecosystems and represent an important factor in the anthropization of the landscape and mortality of many bird species. A certain percentage of power lines cross areas of primary conservation importance for wildlife and the environments associated with it. Interaction with power lines causes the deaths of millions of birds worldwide and, in some areas, has been identified as the leading cause for the decline of threatened species. The issue of electrocutions is dealt with in quite a detail. It has been a long running problem and more attention was paid to it in the past. In several countries, the „killer poles" started to disappear or to be retro-fitted on a large scale only after legislative action and the construction of new „killer poles" became generally prohibited. Collisions are newer topic, which lacked a systematic approach in the past; however, it gets more and more attention now. In reality this problem is large enough to represent one of the main factors of unnatural mortality for birds.

The good practice procedures and proposed recommendations described in this chapter aim to offer useful advice, ideas and suggestions based on feedback and input from competent authorities, energy business representatives, NGOs and other experts and stakeholders.

**Electrocution.** The risk of electrocution on pole depends primarily on the technical construction and detailed design of power facilities: how insulators are attached to the cross-arms and the space/distance between e.g. the exposed jumper wires and/or other energized and/or grounded elements.

The highest risk is associated with medium voltage power lines representing attractive perches to many birds.The highest mortality rate due to electrocution is registered mainly for medium-sized and large birds as they are more likely to make simultaneous contacts with unprotected elements of the pole construction.

Electrocution can have significant negative effect on the species, either on the local scale or even at the population level, such as has been documented e.g. for the saker falcon or imperial eagle. Young individuals are common victims of electrocution. Proximity to nests of non-insulated medium voltage poles can pose a fatal risk for many young and inexperienced birds with lower ability to fly, as they try to take offor land on poles.

Corner, strain and branch poles are significantly more dangerous for birds than utility poles in straight lines. Bird mortality is lower for power line switch disconnectors and poleborne transformers, which are often situated at the edges of human settlements or are part of urban/industrial areas, with lower presence of birds.

**Mitigation of Electrocution.** Electrocution is not much of a problem in Germany, Luxembourg, Netherlands, Sweden, where most of the dangerous low and medium voltage lines have been placed underground or have been retrofitted sufficiently, but there are still many countries in Europe, where low and medium voltage lines have not been equipped with effective mitigating measures.

Mitigation measures should be generally focused especially on medium-sized birds and on corner, strain and branch pole types. Medium and large perching birds can easily bridge the gap between wires, consoles and jumper wires, which are in much closer proximity.

The risk of possible electrocution is significantly higher on utility poles without insulation, especially for construction types with one pin-insulator per phase conductor. Most appropriate solution is to substitute them with insulators in suspended position. If substitutes are not possible they have to become retrofitted by e.g. plastic caps of plastic insulations which allows birds to perch safely on the console.

The products used to mitigate the electrocution risk should be made from durable, long-lasting materials and should be installed properly to ensure protection of birds. If they are damaged or incorrectly installed, they are useless and more dangerous than non-insulated poles.

Switches should be attached below the cross-arms with insulated jumper wires and upright insulators substituted with suspended insulators.

Change the position of jumper wires on strain pole below the cross-arm and use the insulated conductor.

All dangerous constructions of cross-arms should be replaced with cross-arm (45° angle of the arms) with a perch attached bellow: the shape of console discourages birds from sitting down and at the same time, perch offers place to sit.

Use bare conductors for insulated phase conductors as the safest solution for preventing avian electrocution (besides underground cabling). It also represents a long-term solution and its effectiveness does not decrease with use, as opposed to the solution which implies the installation of protective devices.

**Collisions.** Bird casualties due to collision with aboveground power lines can happen on any electricity grids (distribution or transmission). Larger, heavy bodied birds with short wing spans and poorer vision are more susceptible to collisions than smaller, lightweight birds with relatively large wing spans, agility and good vision.

The level of collision risk does not correlate with constructions of the power line. More important is the composition of present avifauna, weather and visibility factors, location of the power line sections, whether they cross important bird habitats/breeding areas or main migration routes etc.

For high and extra-high power lines, the highest risk is associated with ground wires (the highest one, which is the thinnest).

Much fewer bird individuals (but more bird species) were killed by collision than electrocution. Birds with low maneuverability, i.e. those with high wing loading and low aspect ratio, such as bustards, pelicans, waterfowl, cranes, storks and grouse, are among the species most likely to collide with power lines.

The species which tend to group together into large flocks are also included, as they are associated with higher probability of collision. A particular problem arises when there were frequent movements of large flocks between their feeding and nesting biotopes, or if the power lines pass perpendicularly across the birds' main migration routes.

Habitats with oilseed rape fields played an important role in high mortality of mute swans, especially if the power line was located close to them.

**Mitigation of Collisions.** For infrastructure planning/routing is recommended to avoid priority areas and sites (breeding and wintering areas, migration bottlenecks, breeding colonies, congregation sites, coast lines, wetlands) when possible.

It is very important that in areas with a special risk of bird collision, new overhead power lines should not be installed and existing ones should be modified by burying them or installing visual marks (beacon-birds) that are durable and effective.

Line marking is one of the best solutions, based on making the wires more visible to birds in flight. The best solution is to use contrasting black and white flapping diverters and anti-collision luminous devices, able reflect sunlight during the daylight hours and emit luminescent light at twilight and at night. Bird species that regularly fly low at night or in twilight are more susceptible to collision than species that mostly fly during the day.

The placing of power lines underground as the most effective solution has not been credibly studied and evaluated worldwide regarding impairments for other protected goods. More knowledge about the factors increasing collision mortality rates on the species level is necessary to produce essential guidelines for proper bird friendly measures in the case of existing and/or for the construction of new power lines.

It is very important that in areas with a special risk of bird collision, new overhead power lines should not be installed and existing ones should be modified by burying them or installing visual marks (beacon-birds) that are durable and effective.

**General recommendations.** Energy companies should assume the cost of adapting their facilities to make their business compatible with the conservation of birds.

The competent administrations in the matter of conservation of wild species must assume their responsibility in the solution of this serious problem. It is necessary that the environmental managers identify the most problematic points of mortality, demand their modification or isolation and be actively involved in solving the problem.

The European Commission should enact a binding guideline for member states on how to address and how to minimize bird mortality on power lines and provide national authorities with a catalogue of most effective measures. Based on the binding guideline, each TSO and DSO should produce guidelines for technical solutions to mitigate bird strikes or electrocution hazard on the national level and an implementation plan for mitigation measures.

It is strongly recommended that for planned/reconstructed power lines, expert field surveys should be realized, including at last one year of ornithological investigations in order to characterise local and regional avifauna, bird movements, key sites for breeding, feeding and resting areas as well as seasonal migration to ensure 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 dawn and dusk period, when the light conditions are insufficient and birds are most active at the same time, hence there is a highest risk of possible collision.

Before-After Control-Impact (BACI) assessment and supporting monitoring should be planned.

It is recommended to prepare a national/international sensitivity map for locating the most critical areas of bird and power line interactions, to prioritize time and money to those power lines sections, which are the most risk-bearing for electrocutions and collisions.

It is strongly recommended that special attention is paid to vulnerable and endangered species as listed under national and international legislations.

Sections with highest risk should be considered as priority for the implementation of mitigation measures including e.g. installation of bird flight diverters, changes in power line routing and configuration.

Important step is to increase and support the systematic data monitoring, which would enable to persuade public opinion and electricity power companies for the need of mitigation measures in countries without relevant data about the problem at this time.

Long-term studies to assess local/regional population trends and prioritize the main stake areas for bird conservation purpose taking into account the cumulative impact of existing or foreseen energy infrastructure are necessary.

Sharing of already existing know-how among countries, experts is very important. This regards not only technical possibilities but also legal guidance and implementation on the national level.

It is recommended to design the international database to collect information about bird collisions and electrocutions to help with preventing future bird/power line incidents and standardised protocols to improve reliability and potential utility in meta-analyses.

Preventing birds from collisions and electrocution is important to compensate other threats that the endangered species need to face. A systematic approach and standardized monitoring on transnational level will enable to invest into the real effective measures and focus on areas with the highest priority. It is important to rise of awareness of stakeholders through education, volunteering and other activities. The transborder cooperation is a big advanted for transferring knowledge, share experience and put in practice immediately. Increase of sources for EC LIFE project funding and own national sources for conservation project to support more intensively the international exchange of experience is highly recommended. E.g. within the LIFE Danube Free Sky project (www.danubefreesky.eu) a standard for mitigation measures that could be replicated in countries and other large rivers in Europe for migratory birds will be defined: marking of power lines crossing large rivers, international monitoring scheme standards, avian reporting system, international database, construction design standards, etc. The project represents a unique example of wide transnational cooperation along with one of the most important migration corridors, stop-over sites, and wintering places for many bird species in Europe - the Danube river. Bird conservation of power lines should be absolute the TOP priority especially in areas of important EU migration corridors.

The information provided by the countries shows different policies to deal with and reduce the problems of power lines and birds. Some countries also apply mitigation measures against both electrocution and collision from the very beginning of a construction. In order to reduce electrocution/collision mortality, bird protection must be taken into account especially early in the planning stage of new distribution and/or transmission line. The findings of ornithologists and results of field surveys and observations must be addopted in the planning and in the construction features of the power line. In many EU countries, a large amount of knowledge is available, because different methods for bird-safety on power lines were tested - and many of them were found to be highly effective and cost effective in the same time. This is a strong international benefit, because the construction principles of power lines are almos the same world-wide. That is also why new national and international projects and cooperation are needed to continue. When only the most dangerous lines are treated and highly effective methods are applied more birds will be prevented from losses. More expert knowledge about the main inputs and factors increasing collision and electrocution mortality rates will produce essential guidelines and technical standards for proper bird friendly measures in the case of existing and/or for the construction of new power lines. The mitigation of all lines identified as being the most lethal lines, should be carried out quicker but in frame of practical, organisational and legal aspects. It is necessary to work on raising the awareness of the electrocution and collision problem not only in corporate culture of energy companies and with its business associates but also within nature protection institutions and local population.

# Annexes

# Pylons/Poles of Electrical Grid A

**Figure A.1:** High-voltage pylons of 400 kV transmission line in Slovakia.
*Source: Raptor Protection of Slovakia*

**Figure A.2:** High-voltage pylons of 110 kV distribution line in Slovakia.
*Source: Raptor Protection of Slovakia*

**Figure A.3:** Medium-voltage pole of 22 kV distribution line in Slovakia.
*Source: Raptor Protection of Slovakia*

**Figure A.4:** Low-voltage lines bringing the electricity directly to customers.
*Source: Raptor Protection of Slovakia*

# Dangerous & Safe Construction | B

**Figure B.1:** Branch pole of 22 kV line with many exposed jumper wires used in Slovakia.
*Source: Raptor Protection of Slovakia*

**Figure B.2:** Dangerous construction of metal frame pole in Bulgaria.
*Source: BirdLife Bulgaria*

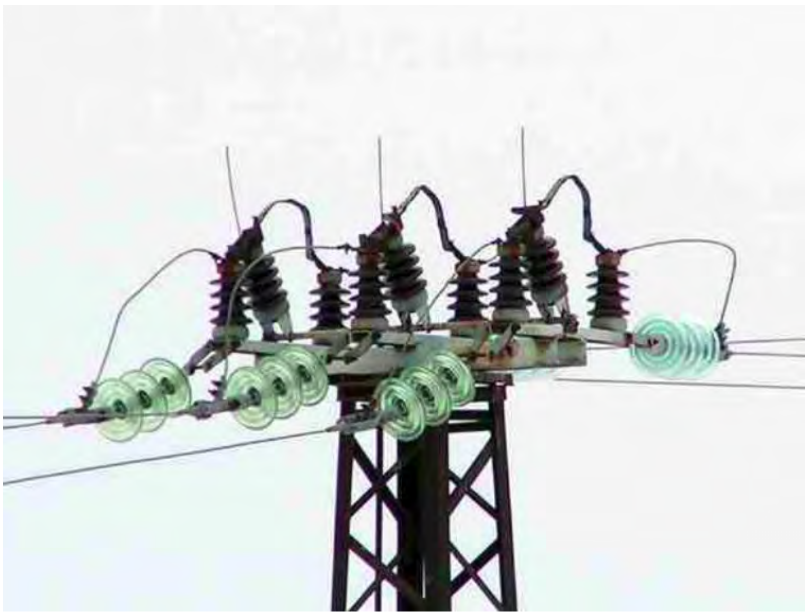

**Figure B.3:** Detail on elements of a switch tower in Bulgaria.
*Source: BirdLife Bulgaria*

**Figure B.4:** Branch pole of 22 kV line in Czech Republic. Construction is very similar to poles used in Slovakia.
*Source: Nature Conservation Agency of the Czech Republic*

**Figure B.5:** Unisolated jumper wires on 10 kV pole in Sweden.
*Source: EON Sweden*

**Figure B.6:** Pole transformer with many energized elements can pose a great risk also to small bird species.
*Source: Raptor Protection of Slovakia*

**Figure B.7:** Medium-voltage pole with suspended insulators for single-circuit line.
*Source: Raptor Protection of Slovakia*

**Figure B.8:** Medium-voltage pole with suspended insulators for double-circuit line.
*Source: Raptor Protection of Slovakia*

# Effective Solutions Against Electrocution

# C

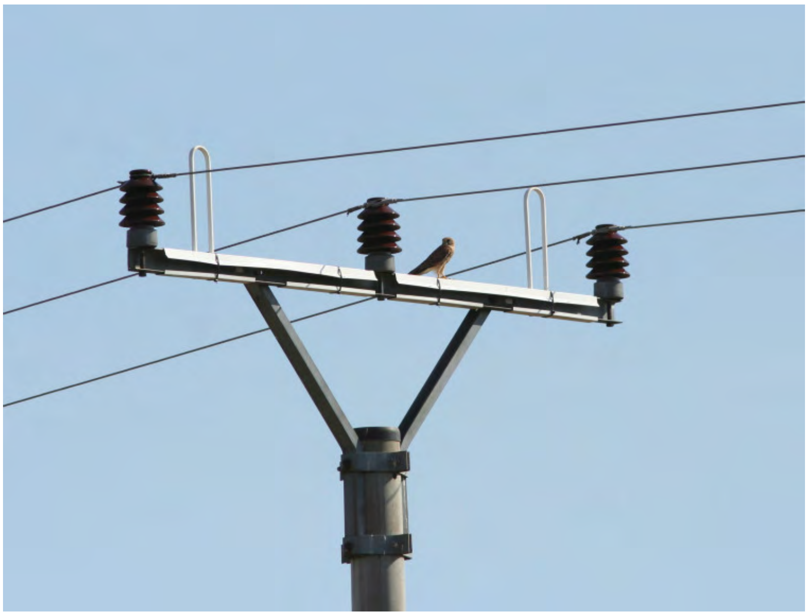

**Figure C.1:** Plastic cover of cross-arm allows to bird perch safely.
*Source: Raptor Protection of Slovakia*

**Figure C.2:** Insulation caps for pin-type pylons in Sweden.
*Source: BirdLife Sweden*

**Figure C.3:** Insulation caps for pin-type pylons in Czech Republic.
*Source: Nature Conservation Agency of the Czech Republic*

**Figure C.4:** Insulation with telescopic parts eliminates the distance between the products and pin-insulators.
*Source: Raptor Protection of Slovakia*

**Figure C.5:** Effective solutions for bird protection in Slovakia. Dangerous jumper wires were placed under the cross-arm with fully insulated phase conductors.
*Source: Raptor Protection of Slovakia*

**Figure C.6:** Old types of switch disconnectors can be replaced with new one attached below the main cross-arm, like is preferred in Slovakia.
*Source: Raptor Protection of Slovakia*

# Bird Flight Diverters D

**Figure D.1:** Dangerous sections of 22 kV lines marked with FireFly Bird Diverters.
*Source: Raptor Protection of Slovakia*

**Figure D.2:** Fully protected medium-voltage line in Slovakia. Orange spiral diverters increase the visibility for bird species in their feeding area.
*Source: Raptor Protection of Slovakia*

**Figure D.3:** FireFly Bird Diverters includes orange and yellow part that reflect sunlight during the daylight hours and alert approaching birds to an obstruction in their flight path.
*Source: Raptor Protection of Slovakia*

**Figure D.4:** FireFly Bird Diverters are able emit luminescent light at twilight and at night.
*Source: Raptor Protection of Slovakia*

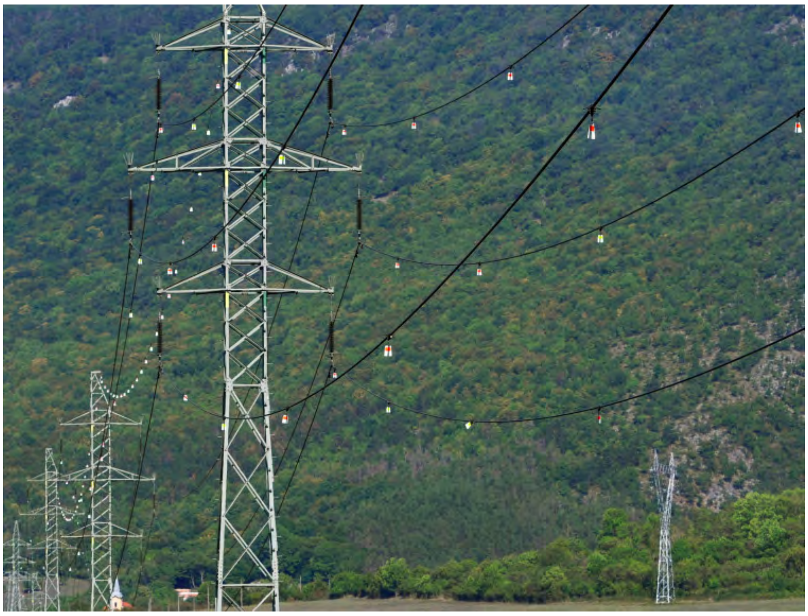

**Figure D.5:** For high-voltage lines up to 110 kV is important to increase the visibility all phase conductors and shield wire on the top.
*Source: Raptor Protection of Slovakia*

**Figure D.6:** Avian marker balls provide visual warning for planes but are also effective for bird protection.
*Source: Raptor Protection of Slovakia*

**Figure D.7:** Flags to prevent bird collisions attached on trolley wires in Krakow.
*Source: Raptor Protection of Slovakia*

**Figure D.8:** Different combination of bird diverters (spiral and RIBE Bird Flight Diverters) can be used to increase the visibility of line.
*Source: Raptor Protection of Slovakia*

# E Legislation Overview

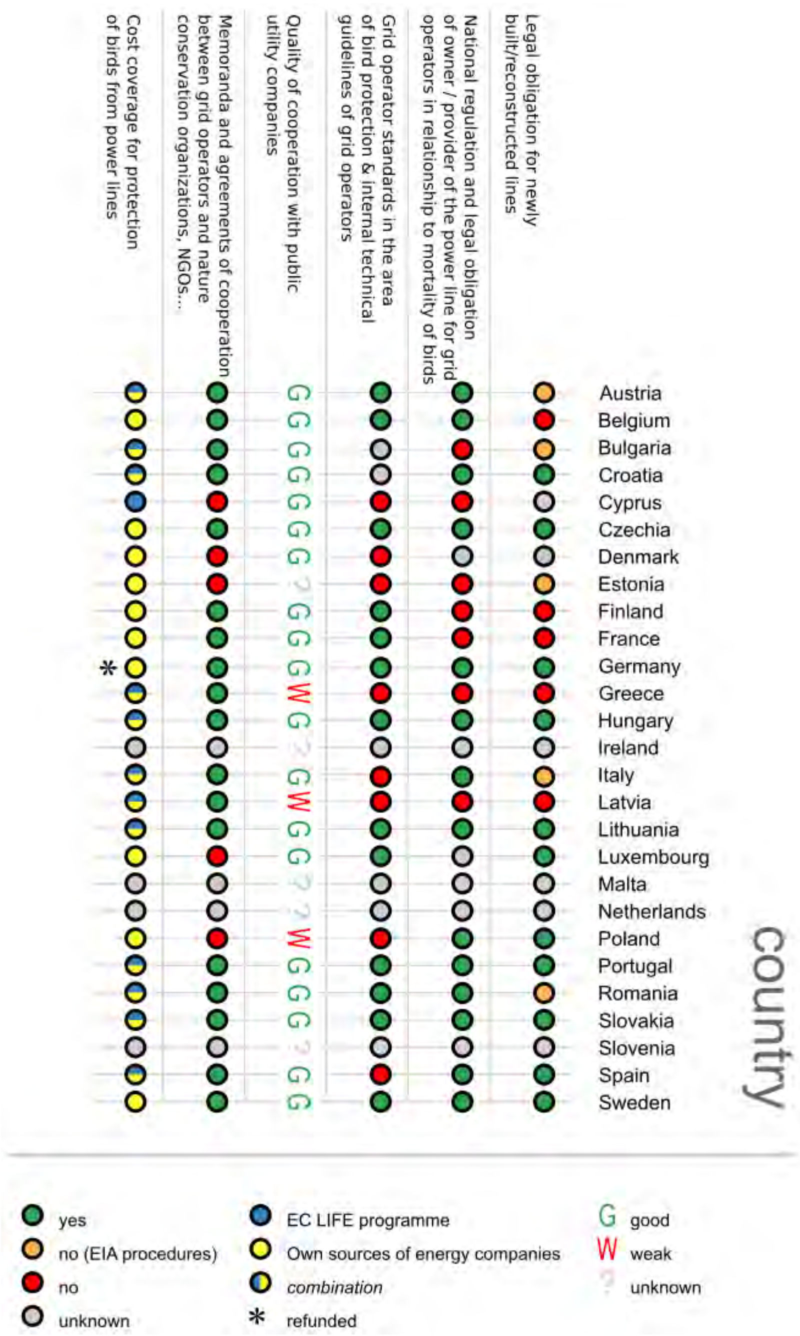


**Figure E.1:** Legislation overview.

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