TECHNICAL REPORT

INSTALLATION OF THE BIRD PROTECTION MEASURES ON THE HIGH VOLTAGE ELECTRICITY TRANSMISSION GRID IN LITHUANIA

THE REPORT PREPARED BY:
Marius Karlonas, Julius Morkūnas

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Introduction

In 2014-2018 the Lithuanian Ornithological Society (LOD) together with the Partner Litgrid implemented the Project ***Installation of the Bird Protection Measures on the High Voltage Electricity Transmission Grid in Lithuania*** *(LIFE13 BIO/LT/001303)* funded by the ES LIFE+ Programme (hereinafter – Project). The Project implementation aimed at the objectives, as follows:

- To improve the conservation status of the migratory, wintering and some breeding bird species, through reduction of the negative impact of high voltage overhead electricity transmission lines on their populations;

- To support reproduction conditions for breeding populations of the Common Kestrel and other falcon species, through the implementation of special supportive conservation measures.

Seeking for these objectives the most important goals were achieved, as follows:

- The bird mortality rate caused by collisions with high voltage overhead electricity transmission lines was reduced significantly in their staging areas introducing special installations to increase visibility of the electricity lines;

- The white stork mortality rate caused by electrocution was reduced significantly installing special bird protection measures on pylons of high voltage overhead electricity transmission lines;

- In Lithuania, breeding conditions of falcons (namely, *Falco tinnunculus*) were improved erecting nest-boxes designed specially for this species on pylons of high voltage electricity transmission lines;

- Public awareness of the bird mortality problem within the high voltage electricity transmission grid and its possible solutions was raised.

The Project experience implementing practical measures to reduce bird mortality in the high voltage overhead electricity transmission grid and to improve breeding conditions for falcons are provided in this Technical Report. It contains a detailed review of measures implemented within the Project framework, also applied in foreign countries, assessment of their effectiveness and contribution to protection of breeding, migratory and wintering birds. In Lithuania, it is the first study of this nature, bird observations in the high voltage electricity transmission grid prior to the Project implementation had been fragmented, and the data collected during these observations did not allow to make overall conclusions concerning scopes of bird mortality caused by collisions with wires of electricity lines. Besides, practical bird protection measures to reduce collisions with electricity transmission wires had been introduced only in fragmented segments of newly erected lines, bird death cases were observed solely within these segments, not along the entire national grid. Based on the survey data of bird vic-

tims and the situation concerning breeding population of common kestrels gathered within the 4-year Project implementation period, the Report provides recommendations how to improve bird protection in high voltage electricity transmission grids. It would lead to significant reduction of bird victims caused both by electrocution and collisions with electrical wires. Besides, the Report overviews effectiveness of applied and other measures for bird protection, assessed based on the bird survey data collected within the Project implementation and in other countries. Following the recommendations bird protection measures can be foreseen in the existing high voltage electricity transmission grid as well as the newly planned lines in Lithuania, also this experience may be applicable in other countries.

Technical Report: Project Experience

1. Electricity transmission grids also pose threats to birds

Not all overhead electricity transmission lines pose uniform threats for birds. Lines with introduced measures increasing their visibility are noticed quicker by birds, thus most often they succeed in avoiding collisions with wires. Collision threats for birds are reduced installing electricity lines in the areas where migration routes of birds do not extend, staging areas of birds are absent, attractive nutritional or important breeding habitats do not exist. In such cases collision dangers for birds reduce to minimum. Low and medium voltage overhead electricity lines are most dangerous. Overhead lines of high voltage transmission grids, 330 kV in particular, are less dangerous. Wires used in high voltage (330 kV, in particular, and more) overhead lines are of a bigger diameter, thus, birds notice them better and can avoid collisions with them more easily. But high voltage lines above electrical voltage transmission wires contain one (sometimes two) ground wires which are much thinner and difficult to notice by flying birds. Such wires determine the biggest share of bird collisions with electricity transmission lines. However, it should be noted that significantly fewer bird deaths by electrocution in high voltage electricity transmission grids are registered, compared to low voltage distribution lines.

In Lithuania, electricity lines are categorized as high voltage transmission and low (less rarely – medium) voltage distribution lines. The main function of the latter is to supply electricity to consumers. 0,4 and 10 kV voltage electricity lines account for the main share, though 35 kV voltage lines are also assigned to this segment. The national electricity distribution network is operated by the State Enterprise ESO. The grid consists of 121 698 thousand kilometres of electricity lines, including 78,7 percent of overhead lines and 21,3 percent of cable lines, whereas the national high voltage electricity transmission network consists of 400 kV, 330 kV and 110 kV lines, mainly overhead ones (underground cable lines account for a comparatively small share). The operator of the high voltage electricity transmission grid is the State Enterprise Litgrid which manages the network and is responsible for its maintenance and development. Currently, its lines are 7 029 km long, also include 236 substations. The Study provides an overview of the impact of high voltage electricity transmission grids on breeding, migratory and wintering birds.

Globally, as well as in Lithuania, bird death cases in networks of overhead electricity lines are broken up into two groups:

- caused by collision with wires;
- caused by electrocution.

The risk of collision with electricity transmission wires for various bird species is estimated differently. Mostly, it depends on the bird's body size and weight, the character of its flight, the eyesight field, time of the day/night and features of habitats around the lines. Earlier the body size and weight of birds were considered the main factors as bulky birds are not very manoeuverable when flying and are not able to avoid collisions with wires having noticed them too late. However, the latest research, including the ones carried out in Lithuania, disclosed a higher percentage of bird victims fell on smaller birds. It appears that more collisions occur in staging areas or on intensive migration routes of birds. Overhead lines pose high threats to flying flocks of birds. Leading birds in the flock usually notice the obstacle on time and succeed to manoeuvre around it, whereas birds in the middle of the flock are blocked from seeing the obstacle by birds flying in the front lines, and the latter having suddenly diverted from the flight trajectory, the middle size birds are not able to react instantly and collide with wires. Researches carried out in foreign countries show higher risks in breeding areas abundant with bigger numbers of birds (nearby formed colonies, in particular).

A relatively small number of bird casualties occur due to electrocution in high voltage electricity transmission grids, compared to low and medium voltage electricity distribution networks. Before starting to introduce special bird protection measures (wishbone and saucer type bird flight diverters) in Lithuania, each year up to 50 white stork death cases were registered in the staging areas important for white storks gathering for migration. At first sight the total number does not seem big. However, with consideration that it is a long living species and producing relatively low numbers of chicks, continuous losses of the aforementioned numbers of individuals make an obvious impact on the population of the species. Besides white storks, in the Project implementation period due to electrocution victims of raptors, i.e. a common kestrel and buzzards, were found.

2. Electricity transmission operators suffer losses due to a negative impact of birds

Electricity transmission operators suffer economic losses due to birds when birds make their nests on pylons of overhead lines, or when electrocution occurs caused by a bird. Man-made pylons became a comfortable place for nesting and short rests of birds. Thus, birds cause additional hindrances for electricity lines' operators assigned to ensure safe and uninterrupted power supply, including in transmission networks.

What hindrances are caused by breeding birds? In low and medium voltage electricity distribution lines nests of large birds (white storks, Northern ravens) cause problems for servicing operators, firstly, due to increased risks of electrocution caused by their massive nests and birds visiting them. Furthermore, the load of bird droppings (leading to bigger corrosion of wires) and bulky nests on electricity line pylons and wires cause set-back dangers for electricity lines' functioning. In high voltage electricity transmission networks bird nests do not cause direct danger for power transmission, however, they encumber maintenance works of such lines and incur damages to pylons. Thus, in compliance with effective regulations (both, international and national) for maintenance of electricity transmission systems bird nests are impertinent and have to be removed from high voltage electricity lines. Certainly, it has to be done outside their breeding period, thus no damage is done to the birds. It is no secret that to the nests of Northern ravens (more rarely to nests of white storks) other birds that do not make nests by themselves, move in, primarily common kestrels (*Falco tinnunculus*) – a protected endangered species in Lithuania. When nests of large birds are removed, common kestrels find less places suitable for breeding. The operators of high voltage transmission grids following the exploitation regulations suffer losses due to extra works removing bird nests from line pylons.

Another factor causing higher economic losses for electricity grids is electrocution, rather often disrupting electricity supply. In such cases operators of electricity transmission grids experience discontent among their customers instantly. In high voltage transmission grids disruptions of electricity supply caused by electrocution incur big economic losses. In critical cases it may derange operation of the entire electricity transmission grid causing even bigger threats. Thus, power transmission outages in high voltage networks due to electrocution caused by bird activities, that as a rule occur more rarely, may incur big economic losses.

3. Are duly planned high voltage electricity transmission lines not dangerous for birds?

All overhead lines pose potential threats for flying and migratory birds because of possible collision. The overhead lines crossing staging areas or stopover sites of birds, and areas offlyway bottlenecks , in particular, make the biggest negative impact. Overhead lines extending over water bodies are also dangerous for birds. When planning overhead transmission lines important staging areas and migration routes of birds, Natura 2000 sites have to be taken into consideration and potential negative impact for birds must be assessed.

In the opinion of international bird protection organisations and the European Commission, the negative impact on birds may be reduced, primarily, with the help of adequate planning of areas for electricity networks, also their installation terms and methods. It‘s obvious that underground electricity transmission lines make the smallest negative impact on birds, as it is observed a very short period of time during laying cables. Certainly, one condition is highly important: upon completion the habitat is restored to the previous state. So, the potential impact on birds due to collision with electrical wires first of all, may be reduced (or eliminated) if adequate areas are chosen for the lines. All nature conservation recommendations by the European Commission emphasize it. Solely in the cases when no opportunity to avoid overhead electricity transmission lines in bird staging places exists measures diminishing the potential negative impact, i.e. increasing visibility of wires, are proposed.

4. Why is it necessary to reduce a negative impact of overhead lines on birds?

Comprehensive research concerning the scope of bird death cases caused by collision with electricity wires within the overhead electricity grids were carried out in the USA and Canada, where nearly 50 million death cases are registered annually. In European countries investigation of collisions of birds with electricity transmission (not distribution) overhead lines was started in late seventies of the 20th century. At that time frequent collision cases were registered and the number of bird deaths, for example in marshy areas of the Netherlands , accounted for 700 victims per 1 km segment, and the number of collision cases exceeded 1 million. In France, over 1 million bird death cases were identified annually. In Western Germany, within the period of 40 years over 500 dead white storks were found, this figure accounting for a significant share of the population of this bird species in the country. In Estonia, near the Matsalu National Park within a couple of decades over 200 victims of whooper and Bewick's swans as well as other birds were found beneath one overhead line.

As mentioned in the above sections, in many cases it is possible to avoid the negative impact with the help of adequate planning of overhead lines. However, if an overhead transmission line has already been installed its negative impact may be reduced solely through improvement of wire visibility or installation of underground electrical cables. Using the latter method bird death cases could be fully avoided, and furthermore, to mitigate visual pollution of landscapes. But it is an expensive measure and rather rarely being used globally, mainly such installations are introduced solely in urban areas to meet needs of the population. A higher probability of collision with overhead electricity lines lies with birds that have relatively longer and broader wings and bulkier bodies. These birds possess low maneuvering abilities, their flights are slower. Thus, egrets, cranes waterfowl and raptors being not so numerous as many smaller birds are found dead beneath overhead electricity lines. A greater number of death cases of bulky birds caused by collisions with electrical wires is also conditioned by the fact that carcasses of larger birds are noticed in high grass more easily, and thus their death rate is relatively higher. Besides large waterfowl (swans, geese), in Europe collisions of loons, grebes, cormorants, cranes, terns, gulls, pigeons and owls with overhead high voltage electricity transmission lines are registered. Waders enjoying strong maneuvering abilities also suffer from overhead electricity lines because in migration periods they stick together in big flocks. Birds migrating low at night are often among victims colliding with overhead electricity lines as in darkness it is difficult to notice thin ground wires of high voltage lines and electricity supply wires including thicker 330 kV voltage lines. Among such migrants Eurasian woodcocks, European robins, thrushes, etc. prevail.

It is important to pay attention to death cases caused by electrocution of large birds landing to perch on pylons of high voltage electricity lines, though at a smaller scale compared to low or medium voltage grids. In Lithuania, white storks suffer most in this respect.

5. The main principles to identify dangerous overhead electricity lines or their segments

The principals to follow identifying dangerous overhead lines:

- Each year in the migration or pre-migration period power outages caused by birds are registered in the line:

- An overhead line crosses water bodies;

- An overhead line extends over fish ponds;

- An overhead line extends over a river delta;

- Beneath an overhead line bird death cases are registered on a regular basis or in numbers at a time;

- An overhead line extends along a narrow section between two big forest massifs or larger water bodies;

- An overhead line extends between a breeding site abundant with birds (colony) and their feeding area;

- An overhead line stretches through fields crossing a migration route (in the east – west or southeast – southwest directions);

- Close neighbourhood to very rare and/or protected breeding sites.

6. The most sensitive areas for birds due to high voltage power transmission lines in Lithuania (areas of flyway bottlenecks, environment of water bodies, edges of forest massifs, intensively lighted areas, concentration of birds in feeding sites, etc.)

In Lithuania, the most sensitive high voltage power transmission lines for birds consorted with the distribution of protected areas. Areas where abundant flocks of birds' mass in different seasons were identified (Fig. 6.1). Also, dangerous high voltage overhead lines are provided in Table 1.

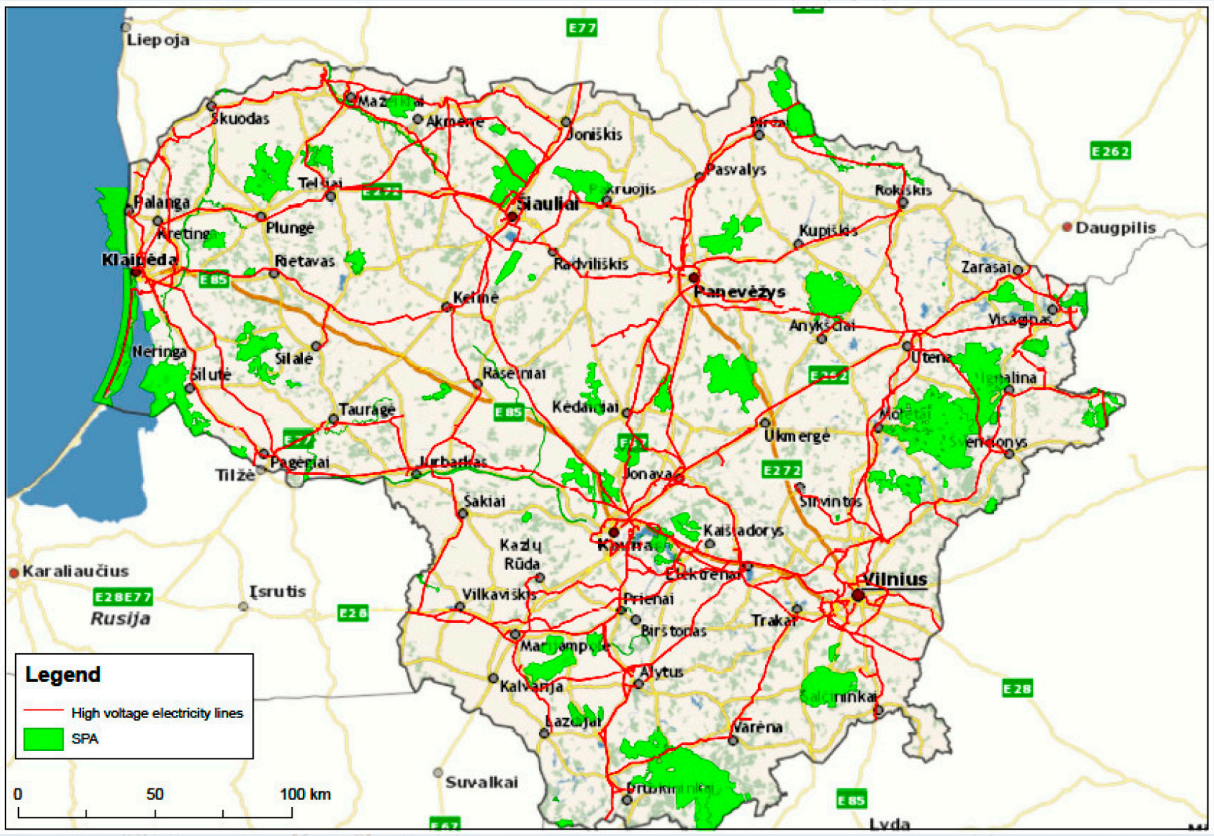

Fig. 6.1. *High voltage transmission lines (red) and protected areas (green)*

Table 1. *Identified dangerous high voltage overhead lines in Lithuania*

No.	Name of place in Lithuania	Name of line
1.	Klaipėda strait and Curonian spit	Marios-Juodkrantė
2.	Būtingė, Palanga municipality	Vėjas 1-Šventoji
3.	Pasruoja ponds / JSC „Žemaitijos žuvis“ (Telšiai district)	Telšiai-Seda
4.	Kamanos Strict Nature Reserve, protection zone (Akmenė district)	N.Akmenė-Jučiai
5.	Outskirts of Mūšos tyrelis (Joniškis district)	Atš. Telšiai
6.	Leitgiriai surroundings (Šilutė district)	Šilutė - Juknaičiai
7.	Outskirts of Senrusnė SPA* (Pagėgiai municipality)	Pagėgiai-Sovietskas
8.	Piktupėnai settlement vicinity (Pagėgiai municipality)	Taurai-Pagėgiai
9.	Lumpėnai surroundings (Pagėgiai municipality)	Klaipėda-Bitėnai
10.	Nemunas Kaunas city I	Atš.Drobė 1, Drobė2
11.	Nemunas Kaunas city II	Kaunas HPP-Aleksotas Kauno HPP -Kr. HAE Kauno HPP -Kazlų Rūda
12.	Išlaužas ponds (Kaunas district)	Kauno HPP -Kazlų Rūda
13.	Bebruliškė ponds - JSC „Karpis“ (Kazlų Rūda municipality)	Kauno HPP -Kazlų Rūda Kapsai-Kazlų Rūda
14.	Žuvintas BR**, edge (Lazdijai, Marijampolė, Alytus districts)	Alytus-Šeštokai Šeštokai-Bukta
15.	Laukysta fishery ponds (Kaišiadorys district)	LE-Jonava
16.	Kietaviškės ponds / JSC „Bartžuvė“ (Elektrėnai municipality)	LE-Kr.HAP LE-Alytus LE- Vilnius LE-Neris
17.	Kretuonas SPA (Švenčionys district)	Švenčionėliai-Ignalina
18.	Dysna river valley / Birvėta fishponds (Iganalina district)	Ignalinos AE-Smorgonys Didžiasalis-Vydžiai

In the implementation of the EU LIFE+ Project *Installation of the Bird Protection Measures on the High Voltage Electricity Transmission Grid in Lithuania* death cases of migrating at night passerines, waders forming abundant agglomerations and large waterfowl were highest. Also, during migration period dead raptors were found beneath overhead power transmission lines. For example, October 2017 – April 2018, in different areas of North and Middle Lithuania 72 segments of overhead power transmission lines were checked and 51 dead birds (18 species) were found beneath the lines. Among them European golden plovers (8) and lapwings (7) were biggest in numbers. In autumn these birds congragate in large numbers in the fields. It was unusual to find 4 dead grey partridges that are low flying and not abundant birds. All birds were found in cold periods, on unploughed stubble fields underneath electricity lines. It is likely efficiency of the field-worker's search for dead birds was higher in winter due to better visibility - grass was scarce and more individuals were found compared to warm seasons.

Sometimes bird victims are found solely beneath certain segments of high voltage power transmission lines. For example, in Biržai district in a relatively short segment of the electricity transmission line 16 dead birds were found within several months: 6 European golden plovers, 2 mallards, a lapwing, a mute swan, several thrushes and European robins. Most likely, in this section between two forest massifs "a bird migration corridor" (an area of flyway bottlenecks of local importance) is formed. Existing threats for birds caused by this segment of the overhead line had

not been known prior to the Project, thus protection measures were introduced in 2018 after bird victims had been found.

In addition, several segments of lines where significant numbers of bird death cases caused by collision with high voltage wires were recorded are found in the central and northern part of the country:

1. The line PK-LG extending across the Kruoja river valley, one of the most valuable natural sites in Pakruojis district, poses significant threats to gathering and migrating birds in abundant flocks during spring and autumn migrations. Upon completion of the Project it is recommended to improve visibility of the line in the segment between pylons 50-76, with particular attention to the segments between pylons 50-60, 63-64 and 68-74.

2. The line PN-PŠ in Pasvalys district extends across fields preferred by migrating birds. In autumn and spring migration periods abundant bird flocks gather here and they often collide with high voltage electricity wires Upon completion of the Project it is recommended to improve visibility of the line in the segment between pylons 68-74.

3. In Kaunas, visibility of three high voltage electricity lines were improved during the Project implementation, however, this region continues to pose particular threats for wintering waterfowls and those stopping here during migrations. The area at the Lampėdþiai quarry and the Nemunas river next to it is the most problematic site. The lines VL-NR 11, VL-AL2, ATĐ-MR1, ATŠ-MR2 across the river and quarry pose significant threats to waterfowl flying over the river and quarry.

According to data by the Litgrid white storks perching on pylons of overhead electricity lines as their droppings on the wires trigger electrocution often causing bird deaths. In Lithuania, the biggest number of power outages in high voltage electricity transmission lines were registered in pre-migration staging areas in late July – August where up to several hundreds of individuals of the species flock together. This information was collected by the Litgrid. In Lithuania, before starting to introduce protection measures for high voltage electricity grids in such areas up to 50 death cases of white storks were registered each year. In the future planning for erection of new high voltage electricity lines it is necessary to take summer pre-migration staging areas of white storks into account.

7. The most dangerous areas for various birds identified in the Project implementation and the principles of their selection

Areas of flyway bottlenecks and / or sites of intensive attraction

In Lithuania, international criteria for designation of areas of flyway bottlenecks are met by two natural sites – the Curonian spit (*Lith*. Kuršių nerija) and the Nemunas delta, the area of Kintai – the Vente Cape (*Lith*. Ventės ragas), in particular. For this reason both areas based on the criteria were designated Natura 2000 sites. In these areas important for bird protection high voltage overhead electricity transmission lines may predestine a bigger number of death cases of migratory small birds due to collisions with wires. It is considered that in other territories high voltage overhead electricity transmission lines are not significantly dangerous for transiting small and other birds, thus no special protection measures, including those increasing visibility of electricity wires of lines, are required. But in areas of flyway bottlenecks visualization of overhead lines should be increased, especially if the flight route crosses overhead lines.

In the aforementioned areas such stretch of high voltage of overhead lines was identified in the northern part of the Curonian spit. In the Nemunas delta (the area between Kintai and the Ventė Cape, also between Šilutė and Rusnė island) 35 kV medium voltage overhead lines are operated by the ESO, not Litgrid.

However, besides the aforementioned two areas of flyway bottlenecks international criteria for designation, in the opinion of many ornithologists of the country, are met in the Lithuanian coastal land stretch (from the Lithuanian-Latvian state border to Klaipėda), 2 km wide, and the land stretch of the same width on the eastern coast of the Curonian Lagoon between Klaipėda and the settlement of Kintai. Besides the high voltage overhead electricity line within the boundaries of the city of Palanga, on these stretches one segment of the overhead line at Būtingė was identified. In our opinion, the lines within Klaipėda and Palanga will make no significant impact on transiting migratory birds as they bypass urban areas or cross them at bigger height than high voltage overhead electricity lines.

It is important to mention that flyway bottlenecks is observed in some continental areas too. Mostly, such areas are between bigger forest massifs or land among water bodies where concentrations of birds migrating over the mainland occur in an extended manner. In the Project implementation period such areas were established in the districts of Biržai, Zarasai, Pakruojis, Pasvalys and Kaunas.

Bird staging areas

These are the most vulnerable areas of high voltage overhead lines with the potential impact on birds, and in Lithuania up to now the highest death toll of birds caused by collision with wires of high voltage overhead lines is found in the bird staging areas. In different areas bird protection is of particular significance in certain seasons, though in general it is important in all seasons of the year: for wintering waterfowl, in seasonal migrations for waterfowl, cranes, and waders stopping off to rest and feed, birds breeding in abundant colonies.

However, high voltage overhead lines are not equally dangerous to all bird species of the aforementioned groups and in different seasons. Based on studies carried out in foreign countries and experiences in Lithuania high voltage overhead lines are most dangerous to all varieties of swans, cranes, storks, i.e. bulky birds with lower maneuvering abilities that having noticed the wires in the last moment are not able to avoid collision with them, flying in a flock, in particular. Geese, ducks and some waders, for example, Eurasian curlews, ruffs, lapwings, plovers hit the wires when they fly in numerous flocks. In such situations birds flying in the middle of a flock don't see the obstacle in due time and fail to avoid collision in the last moment. In some other cases certain bird species, such as swiftly flying ducks, face a high probability of collision with high voltage overhead lines though the percentage of their death cases caused by collision with overhead electricity lines is comparatively low, if they constantly fly in the environment close to such wires –

over water body channels, shallow productive water bodies or flooded meadows. Thus, besides bird species staging in the area it is important to know how many flying birds cross overhead electricity lines on a regular basis. It is one of the reasons why nature protection organisations consider adequate planning of areas for building overhead electricity grids as a priority measure for bird protection, thus reducing their potential negative impact on wildlife objects, in particular, birds.

Potential impact in particular seasons

Winter season. In Lithuania, in this season the significant impact of high voltage overhead transmission lines was established for mute swans and wintering ducks in the Nemunas river at Kaunas, as well as for common mergansers in the Klaipėda strait. Also, in Lithuania, in winter seasons bird victims were found on cultivated fields, among them passerines and waders prevailed. The area around the Elektrėnai Power Plant where waterfowls winter in the Elektrėnai Reservoir is potentially dangerous.

Bird migration seasons. Various segments of overhead lines may pose threats in different seasons. It is related to the season when in a certain area bird staging is observed, as in certain areas waterfowl and other birds make up abundant concentrations only in spring or autumn. For example, in the Birvėta wetland complex abundant concentrations of waterfowl and waders are registered when the Dysna and Birvėta rivers get flooded, i.e. in March-April. In other seasons danger for birds (swans, in particular) is posed solely by the segments of the overhead lines across the Birvėta fishery ponds. A similar situation occurs in the Nemunas delta meadows at Leitgiriai and in the vicinity of Piktupėnai and Lumpėnai in the Pagėgiai neighbourhoods, i.e. in the meadows where waterfowl forms abundant concentrations, mainly during spring migration. In the Kamanos Nature Reserve and Mūšos Tyrelis bog migrating geese and cranes stop off here only in autumn months. Staying overnight in the bogs they fly to the fields to feed. The Žuvintas Biosphere Reserve has to be mentioned separately where waterfowl, waders and cranes form numerous concentrations both in spring and autumn. They fly to nearby fields to feed. The Bebruliškiai, Išlaužas, Kietaviškės, Laukysta, Birvėta, Pasruojas fishery ponds are important in both seasons.

Breeding period. In this period a topical issue is fishery ponds with overhead high voltage electricity lines; in the Bebruliškiai, Išlaužas, Kietaviškės, Laukysta, Birvėta, Pasruojas fishery ponds the high voltage lines pose biggest threats to both species of swans (mute and whooper swans), breeding geese, feeding white-tailed eagles. In our opinion the high voltage overhead line at Kretuonas lake poses threats as gulls and waders breeding on the lake's island regularly fly to the lakeside meadows to feed. The identified most dangerous areas for birds are provided in Fig. 7.1.

In our opinion, assessment of connection between the high voltage electricity overhead grid and the network of the Special Protected Areas (hereinafter – SPA) reveals that high voltage electricity overhead lines cross some (over 10) SPAs. As the SPAs were designated to protect various bird species with different features of their ecology, behaviour, biology and include different habitats important for different bird species, the fact of presence of the high voltage electricity

overhead line indicates the potentially significant impact only. However, it does not specify the realistically existing threats, their scope and significance.

It is obvious that the biggest possible impact of the high voltage electricity overhead line on birds is possible and probable in the SPAs designated to protect areas of waterfowl concentrations and areas of flyway bottlenecks. However, in other SPAs high voltage overhead lines may also cause deaths of protected bird species including protected target ones. As in most cases their populations are not numerous it is very difficult to collect information concerning individual death cases of rare protected species and to evaluate their scope and the potential impact on the population in a specific area. Targeted permanent investigation is required to assess rarely registered death cases of protected rare bird species.

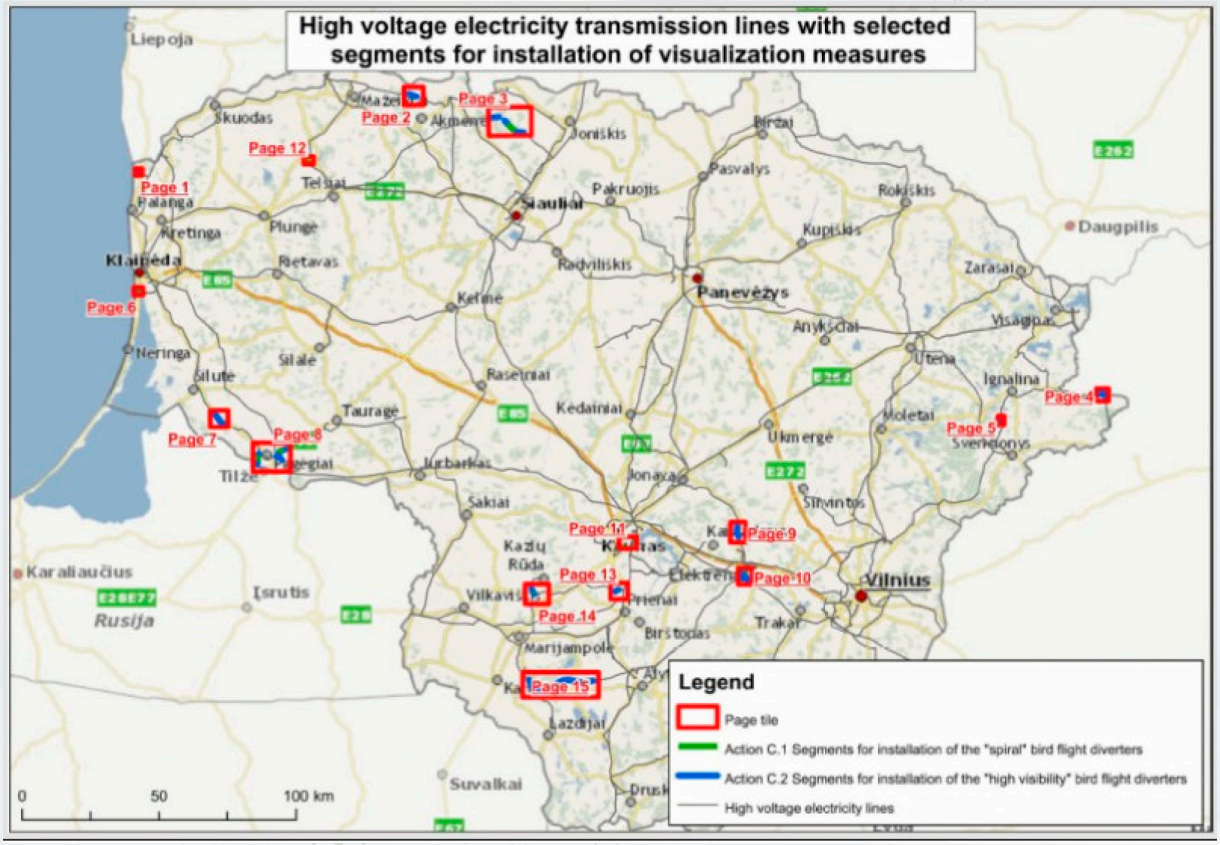

Fig. 7.1. *The most dangerous places for various birds (red) identified within the Project implementation and installation of visualization measures (blue and green)*

8. Results of monitoring of bird deaths under high voltage wires carried out during the Project implementation

During the Project implementation period in all months of the year beneath high voltage electricity wires 852 km were monitored walking on foot, including 320 km beneath the lines without installation of visual measures and 521 km beneath the lines with visual measures installed in the Project implementation.

In 2014 – 2018 the Project staff found 254 bird victims within the 852 km segment of high voltage electricity transmission lines in different parts of Lithuania. Among them 112 were swans directly frightened by people in different wintering places in Kaunas that collided with wires over the Nemunas river. However, the aforementioned figure was not used in further analysis of bird deaths because of different registration methodology of bird death cases. The site has been known for a long time as a highly dangerous site for waterfowl and because of this reason during the project implementation in Kaunas 3 overhead lines extending over the Kaunas Ornithological Reserve situated below the Kaunas HPP were visualized. The implemented measures significantly reduced here the scope of collisions with wires of regularly flying here waterfowl, but the visualization has not produced the expected impact, as the birds are frightened and ascend continually in numerous flocks. A case of this nature was registered during the canoeing event devoted to the celebration of February 16, 2017. Then, just in 20 minutes 10 collisions of flying mute swans with wires were registered. It happens because solely the front birds flying in the flock manage to notice the electricity wires on time and avoid them, and those in the middle or back of the flock sometimes react too late and fail to avoid collision, thus suffering serious injuries or death. Carrying out records in different areas of Lithuania 142 bird victims were found beneath the electricity lines (Table 2); among them the biggest number of thrushes (31), European robins (14), Northern lapwings (16), Eurasian skylarks (14), European golden plovers (14). The biggest share of the bird victims accounted for bird species migrating at night and feeding on the cultivated fields in daylight, or birds forming large concentrations in migration periods stopping off and feeding there. Death cases of grey partridges caused by collisions with high voltage wires were unexpected – 4 dead individuals were found in winter. It shows that when these birds fly longer distances sometimes they reach bigger heights and do not avoid collisions with obstacles, like wires of high voltage electricity lines.

The biggest share of bird victims was found beneath the high voltage overhead lines without increased visibility (without markers) whereas their number beneath the marked lines was lower (Table 1). Based on the total number of bird victims found calculated according to the monitored relative high voltage overhead electricity line unit, it was established that wire markers on these lines reduced death casualties among thrushes, lapwings, European robins, European golden plovers, larks, gulls, mallards (Fig. 1). However, no positive impact of the installed measures increasing visibility of wires on many species was not noticed due to small numbers of found bird victims (too

Table 2. *Bird victims found beneath different high voltage overhead electricity lines in Lithuania (with and without installations of visualization measures), 2014-2018*

Bird species	Number of individuals beneath marked electricity lines			
	Unmarked	Pendants / Spirals	Spirals	Total
Duck sp. (Aythia sp.)			1	1
Redwing (Turdus iliacus)		1		1
Greater White-fronted goose (Anser albifrons)	1	1		2
White Stork (Ciconia ciconia)	3			3
Common Redpoll (Carduelis flammea)	1			1
Common Linnet (Carduelis cannabina)	1			1
Mallard (Anas platyrhynchos)	2		1	3
European Golden Plover (Pluvialis apricaria)	12	1	1	14
Eurasian Skylark (Alauda arvensis)	8	2	3	13
Swan sp. (Cygnus sp.)	3			3
Whooper Swan (Cygnus cygnus)		1		1
Eurasian Blackcap (Sylvia atricapilla)	1			1
Common Blackbird (Turdus merula)	1			1
Pigeon sp. (Columba sp.)	1			1
Wood Pigeon (Columba palumbus)	2	2		4
Common Chaffinch (Fringila coelebs)	1			1
Gull sp. (Larus sp.)	1		1	2
Common Goldeneye (Bucephala clangula)			2	2
Rook (Corvus frugilegus)	1			1
Northern Wheatear (Oenanthe oenanthe)		1		1
Western Jackdaw (Corvus monedula)	1			1
Grey Partridge (Perdix perdix)	1		3	4
European Robin (Erithacus rubecula)	10	4		14
Goldcrest (Regulus regulus)	1			1
Common Buzzard (Buteo buteo)	1			1
Common Redstart (Phoenicurus phoenicurus)			1	1

Common Kestrel (Falco tinnuculus)		1		1
Northern Lapwing (Vanellus Vanellus)	15		1	16
Hooded Crow (Corvus cornix)	1			1
Black-headed Gull (Larus ridibunds)		1	1	2
Eurasian Woodcock (Scolopax rusticola)	2			2
Thrush sp. (Turdus sp.)	4	1		5
Song Thrush (Turdus philomelos)	19	3	2	24
Rough-legged Buzzard (Buteo lagopus)	1			1
Stock Dove (Columba oeanas)			1	1
Common Starling (Sturnus vulgaris)	2			2
Goose sp. (Anser sp.)			1	1
Unidentified	4	1	2	7
*Mute swan (Cygnus olor)**	4	108		
Total number of bird victims found (excluding mute swans)	101	20	21	142
Total number of bird victims found	105	128	21	254

** Death cases of mute swans caused by collision with electrical wires (frightened by people) in the city of Kaunas; not used in the analysis below.*

small statistical sampling) or occurrence of individual species solely beneath one category of lines. Some species, such as common linnet, common goldeneye, greater white-fronted goose, grey partridge, common starling, Eurasian woodcock and others were found only beneath the unmarked lines and no victims were found beneath the lines with increased visibility installations. And vice versa, some species were found only beneath the marked lines (the wheatear, gold crest, Western jackdaw, common kestrel, etc.). However, in both cases occurrence of solitary instances of bird victims does not allow to state that marking lines increases or decreases the probability of collision of these species with wires in high voltage electricity lines. For analysis of statistical parameters of death rate of individual species in high voltage electricity grids with marked or unmarked the data of ten species and genuses were used[1]. It was established that marking reduced bird death mortality statistically significantly (non-parametric Wilcoxon signed-rank test for dependent samplings[2], n=10, Z=2.59, *p<0,05*).

[1] Ten species used to compare: song thrush, lapwing, European golden plover, European robin, Eurasian skylark, thrushes, mallard, gulls, redpoll, Eurasian blackcap. For comparison the white stork was not used, though their death level increased beneath the marked lines (Fig. 2); in our opinion it is not related to the marking.

[2] Applying the statistical comparisonsolely to the species found beneath the marked and non-marked lines, excluding the number of white storks' victims.

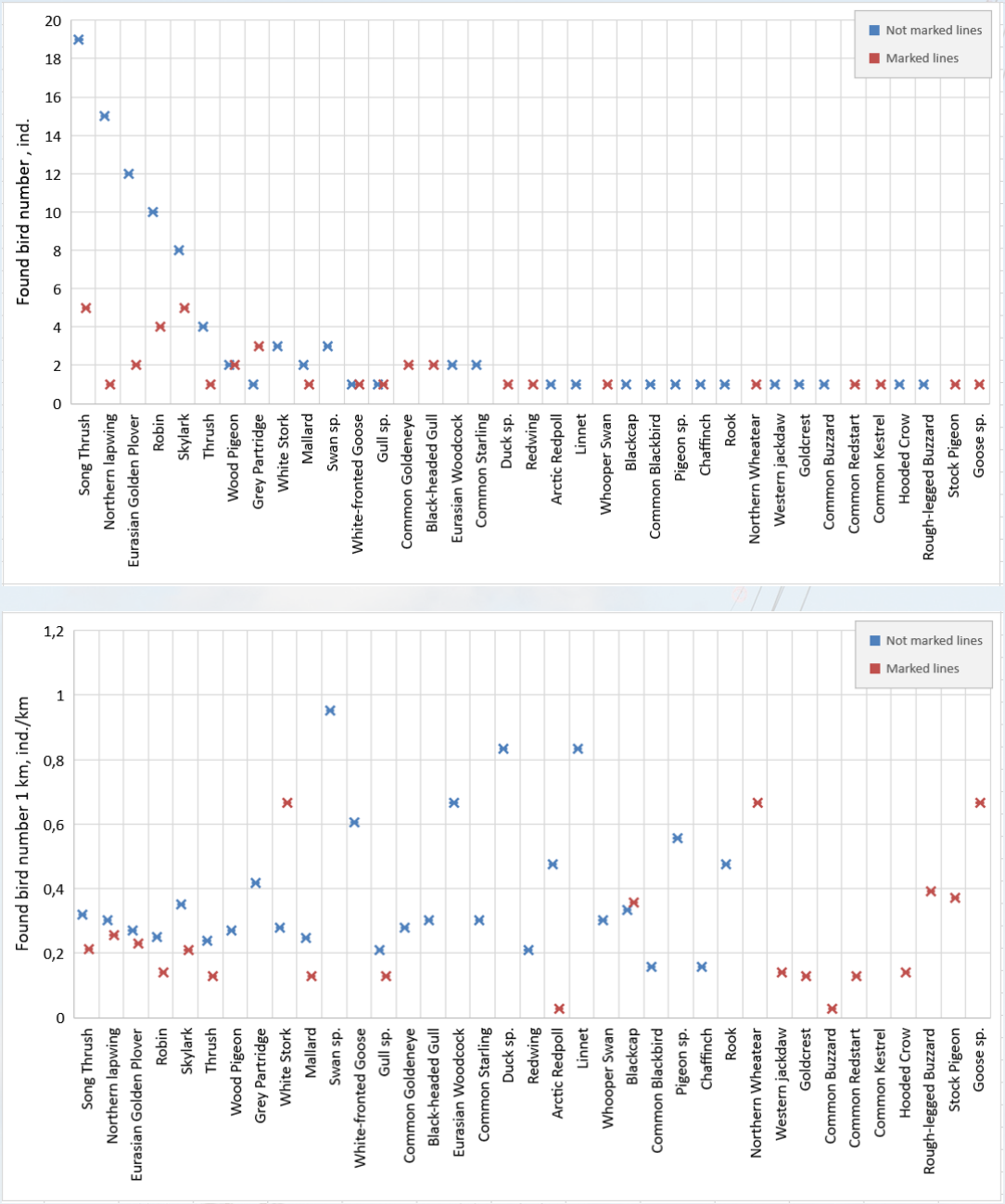

Fig. 8.1. *Abundance of bird victims found beneath the lines with non-marked and marked wires: at the top – the total number of birds, at the bottom – the number of birds per kilometre in the checked segment*

Search of birds beneath the electricity lines were carried out in months January-November. Having applied non-parametric Wilcoxon signed-rank test for dependent samplings, the statistically significant increase of bird death cases was established (n=11, Z=2.13, *p<0,05)* in individual months; approximately from 1 to 6,4 (average 2,5) times less bird victims of all species were found in different months beneath the lines with markers compared to the lines without markers (Fig. 8.1).

Analysis of the number of bird victims found in different months established that the highest rate of bird deaths beneath the lines without markers (77 percent of all registered) and with

markers (59 percent of all registered) occurred in April, March, September and October – the most intensive migration periods in Lithuania (Fig. 8.2).

Using the data concerning the bird mortality rate in different months the number of bird victims in different lines throughout Lithuania were assessed. Aiming at the overall figure of bird victims activity of predators has to be taken into account. Similar researches concerning bird or mammal deaths beneath wind power plants established that the major share (ca. 90 percent) of bird victims were consumed by predators within 5 days. Thus, bird carcasses beneath the electricity transmission lines would stay no longer than 5 days. It is considered that the minimum number of bird victims complies with the number of individuals found by the fieldworkers (searchers); whereas the potential maximum number of bird victims is significantly higher (according to preliminary assessment – 6 times higher) taking into account the impact of predators (Fig. 8.2).

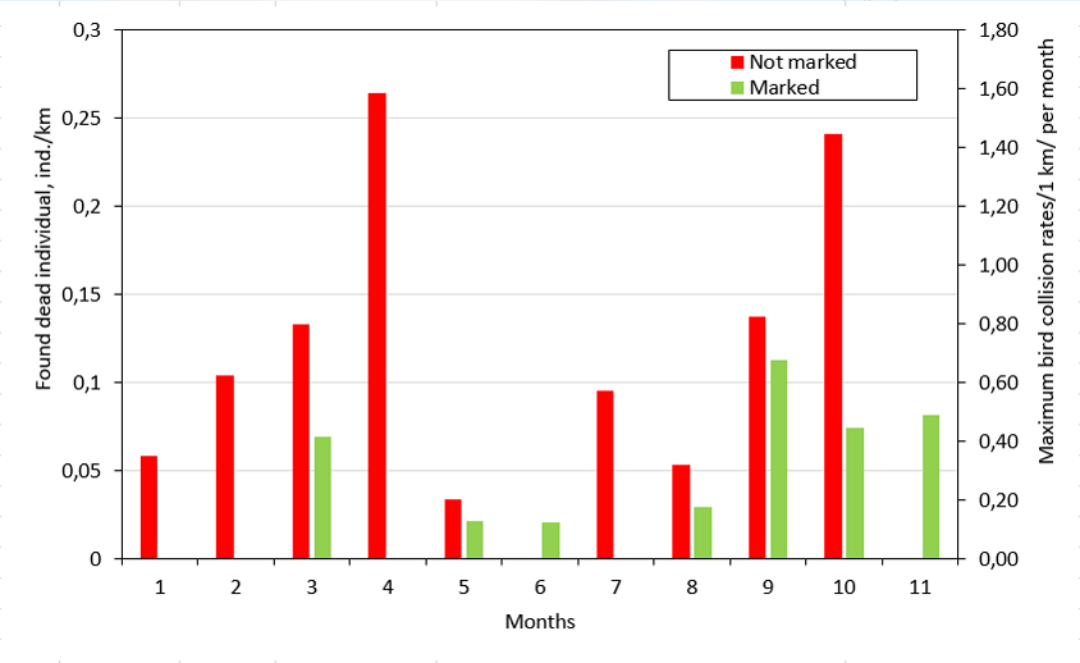

Fig. 8.2. *Variation of the number of bird victims found and the maximum number of bird victims in different months*

Aiming at assessment of the annual level of bird deaths caused by collisions with wires of the high voltage electricity lines in Lithuania, a minimum number of bird victims found beneath different lines each month (the actual figure) and the implicit maximum number of bird victims were calculated (with application of index 6 due to the actions of predators). As in December no survey activities were carried out (because birds are scarce in this month), for assessment of the latter month the survey figures of the previous and following months were used: for the unmarked lines – of January and for the marked lines – of November. Using this methodology statistical calculations were made that in Lithuania 43 858 individuals are killed due to the unmarked lines extending across open habitats (3 927 km), including 33 675 individuals within the migration period (March, April, September and October). In the average 11,1 bird deaths occur per 1 km of

the unmarked line monthly. In 123 km marked lines 437 bird deaths could occur, including 253 within the migration period (58 percent of all birds). In the marked lines in the average 3,6 bird death cases occur per 1 km.

In Lithuania, up to 44 295 death cases of various bird species could occur beneath the high voltage overhead lines annually. Having marked 123 km of high voltage overhead lines in compliance with the Project activities 1 374 bird death cases per year were avoided. Furthermore, taking into account that the improved visibility introduced within the Project implementation period will continue to serve for the future it may be stated that a similar quantity of birds will be preserved each year. Based on our assessment, each year 13 962 bird death cases (including 8 079 death cases in migration period) could be averted if wires of all high voltage electricity lines were installed with visibility improvement measures.

In the course of the observation activities planned by the Project, bird victims were searched beneath the high voltage electricity lines with wires marked by two methods/measures (140,8 km marked with both pendant and spiral type bird diverters were checked, including 398,2 km marked only with spiral type bird diverters). The lengths of the searched segments marked with different marking measures were different, so the number of bird victims found were divided by the length of the searched segments (Table 3). It became obvious that the bird death rate was reduced most effectively by spirals (0,054 individuals per km). Effectiveness of the marking measures was established comparing the number of bird victims per kilometre to the same number beneath the unmarked line (Table 3).

Assessment of the total number of bird victims per year showed installation of spiral markers reduced the bird death rate by 2,6 times, and pendants together with spirals – by 2,2 times.

Table 3. *Summary of effectiveness of marking measures*

Type of marking	Bird victims found, individuals	Length of searched segments, km	Bird victims (individuals) found per km
Pendants / spirals	20	140,8	0,142
Spirals	21	389,2	0,054
Unmarked	101	320,3	0,315
Type	142	852	-

The Project identified 4 segments of the high voltage overhead electricity line highly dangerous for birds which had not been known before. Another example is the high voltage overhead electricity line in the district of Biržai. Monitoring this relatively short (200 m) segment without installation of the visibility improvement measures in the field, between two wood massifs 11

bird victims were found, including 6 European golden plovers (*Pluvialis apricaria*). Such finding of the Project discloses that even relatively short segments of high voltage electricity lines may be highly threatening if they extend across migration corridors of birds. Bird protection measures were taken urgently and already in 2018 the visibility increasing measures were introduced on the wires of the electricity lines.

The most important results of the monitoring of bird deaths:

- **852** km of high voltage overhead electricity transmission lines were surveyed by the fieldworkers walking beneath the electricity lines;

- **254** bird victims (112 mute swans in the Nemunas river in Kaunas in winter, 142 birds of different species monitoring other high voltage electricity lines) were found caused by collision with the wires;

- In Lithuania, the annual toll of up to **44 295** bird deaths caused by collisions with the high voltage electricity lines occurs;

- The annual toll of 11,1 bird deaths per 1 km of the high voltage overhead electricity lines without installation of visibility increasing measures occurs;

- The annual toll of up to 3,6 bird deaths per 1 km of the high voltage overhead electricity lines with installation of visibility increasing measures occurs;

- Beneath the lines with installation of visibility increasing measures introduced in the Project implementation the rate of birth deaths reduced in different months from 1,2 to 4 times, compared to the lines the visibility of which had not been improved;

- Having implemented protection measures 1 374 bird deaths are avoided in the high voltage overhead electricity lines extending 123 km;

- Installing spiral bird flight diverters on electricity lines is one of the most effective methods to reduce bird deaths in open habitats in Lithuania.

9. Bird protection measures introduced in the Project implementation in Lithuania

On the existing overhead transmission lines measures to reduce bird deaths were installed, i.e. spiral and pendant type bird diverters. Also, on pylons of high voltage electricity lines measures to reduce bird deaths caused by electrocution were installed, i.e. wishbone and saucer type bird diverters.

In Lithuania, measures reducing bird collisions with wires of the electricity transmission lines were installed in bird staging areas of importance and posing most threats to them. In the Project implementation 6 464 spiral type and 2 890 pendant type bird diverters that significantly increased visibility of the wires were installed in the segments of the high voltage transmission lines (mostly on thinner lightning protection cables) selected in advance.

Other equally important bird protection measures (wishbone type markers and isolators of sauce type disc of bigger diameters) reducing the probability of electrocution were installed on pylons of the high voltage transmission grid. In the Project implementation 10 800 wishbone type and 6 900 saucer type installations were introduced. Having introduced these measures the probability of deaths caused by electrocution of white storks and other large birds reduced significantly.

Before installation of bird protection measures against electrocution (wishbone and saucer type) on high voltage electricity transmission lines in the areas of pre-migratory concentrations important for white storks, each year up to 50 deaths of the species were registered. Analysis of later years shows that in the segments of the high voltage electricity transmission grid solely 12 power outages due to the impact of birds were registered, including only 2 cases in the segments where protection measures were installed in the Project implementation. It shows effectiveness of the measures.

10. What bird protection measures to avert electrocution are used in high and medium voltage grids in Lithuania and other countries, their effectiveness registrations

Installation of underground electricity lines (cabling) is the most efficient measure to avert bird deaths caused by collisions with wires and electrocutions in low and medium voltage electricity lines. Currently, this measure is widely implemented in North and North-West Europe, the Netherlands , in particular, also in Belgium, the United Kingdom, Denmark, Germany and Norway. However, for high voltage electricity transmission grids it is not a widely used practice in Western Europe, so far.

The existing high voltage overhead electricity lines may be marked using measures which increase visual visibility by birds. Different models of wire marking measures are chosen taking into consideration numerous factors: their visualization effectiveness (visibility level), fixing particularities, climatic conditions (wind intensity, icing expectancy, etc.), fixing points (on ground or voltage wires), fixing conditions (whether it is possible to reach from the ground or only from the air, or using the wires), etc. Thus, different models of wire marking measures are implemented in the country taking into consideration specifics of the high voltage overhead line or even its segments. The survey established that installation of the spiral measures reduced the bird death rate by 90 percent. The survey was carried out in 2002-2005 in high voltage overhead electricity lines, 12 200 km. Bird deaths caused by collisions with wires were surveyed in segments of 110 kV voltage overhead electricity transmission lines in Bernburg and Susigke (Germany).The survey established that in the unmarked segments of overhead electricity transmission lines 156 bird victims were found. In the overhead electricity transmission lines marked with 40 m spacing 56 bird victims were found. In the overhead electricity transmission lines marked with 20 m spacing 1 bird victim was found. In the United Kingdom, marking of electricity transmission lines with spirals the rate of bird collisions with wires reduced by 57-89 percent depending on the size of markers and spacing. Bigger sizes of markers and smaller spacing between the markers reduced the probability of bird collisions. In most cases 10 cm spirals fixed at 5 m intervals, or 10 cm red color spirals fixed at 10 m intervals are used. In such cases it was established that the rate of bird collisions with wires in high voltage transmission lines reduces about 60 percent. In France, earhing cables of the high voltage transmission lines were marked. The bird death rate was stated to reduce by 61 percent. Thus, many reseachers and environmental experts recommend, that seeking to avert bird collisions with wires and avoid bird deaths in new overhead electricity transmission lines under construction, to mark wires using effective visualization measures.

Customary visualization measures are related to a lower scope of markings on electricity wires, mainly using spiral type markers. In this case the visualization measures are installed only on part (usually in the middle) of the segment (the section between two next pylons) of high voltage overhead electricity lines making the optimum density of the individual measures depending on the visualization measure/pattern used. Commonly, spiral type markers are installed in a pattern of a higher density compared to the pendant type pattern, though spacing between individual pendants depends on their size as it is directly related to their visibility. Sumarising it may be stated that for customary visualization wire marking measures may be described as follows: a. selected in many cases possess poorer visibility features (however, possessing other positive features, i.e. durability, lower prices, etc.); b. wire markers are installed within bigger distances between them; c. markers mostly are installed not on the full length of the wires (on 30-60 percent of the line); d. wire markers are installed solely on the lightning protection cable or the solitary electricity transmission wire.

Measures of higher visualization, primarily, are related to their increased visibility to be achieved using hanging, coloured, bigger size marking measures installing them at a higher density, i.e. with a smaller spacing between individual visibility markers. However, the same (or similar) effect may be achieved also using the aforementioned spiral measures but of bigger diameter, installing with a higher density on high voltage overhead electricity lines, also placing them on a bigger part/section of high voltage overhead electricity lines. Furthermore, the spiral type wire markers due to incurred smaller corona also may be installed on the cable of high voltage overhead electricity lines, as the pendant type markers, of metal construction, in particular, cannot be installed on 110 kV lines because of the highest degree of corona. Customary or higher visualization measures should be selected individually for each case taking into account climatic conditions, technical characteristics of the high voltage overhead electricity line, the nature protection status of the area, also the species of bird victims and their protection status, Thus, collisions of birds with wires and, respectively, the death probability are related to many reasons including, primarily, the named bird species. In each case it should be examined what type of visualization wires of the high voltage overhead electricity lines require, and later to choose respective wire markers and their installation technical characteristics taking into consideration other features of the high voltage overhead electricity line and its environment.

The measures protecting birds against death caused by electrocution. In this case attempts are made to protect birds against death caused by electrocution, and that is important for larger birds (storks, eagles) perching on support structures above insulators of electricity lines, or to protect birds (white storks, Northern ravens, falcons) in the nests of breeding birds erected above the insulators supporting wires of electricity lines. In both cases it is pursued that birds would avoid or not choose places to sit or breed, the presence in which due to various reasons (a big wingspan, droppings, conductible nest material) could lead to electrocution causing deaths of the birds or their young, or disruption of work of the high voltage electricity grids. Large birds (in Lithuania, mainly these are white storks) like to perch on pylon traverses of overhead electricity transmission lines above insulators supporting wires and their abundant droppings lead to electrocution caus-

ing death of the birds and disruptions of power supplies. For their nests made above the insulators supporting electricity wires or very close to them, the birds often use electrically conductive materials, such as wires and others. If a piece of the material is long it may cause electrocution resulting in death of the birds and their young and electricity transmission disruptions. Taking these aspects into account it is necessary to produce unfavourable conditions for birds to sit and/or nest above and close to the insulators supporting the wires. Such bird diverters as wishbones and flippers may be applied and practices show these two measures are effective. Another protection measure that may be used on a large scale is installation of saucer type casing above the insulator supporting wires. Its main function would be to protect the insulator and wires against climatic conditions and also to protect overhead electricity transmission lines against electrocution caused by abundant droppings of large birds. The aforementioned measures are not popular in the EU countries but they are widely used in Belarus, the Ukraine, in some Balkan countries, for example Macedonia and others. These measures produced beneficial results in Lithuania enjoying a big population of white storks.

11. Improvement of breeding conditions for rare birds breeding on pylons of high voltage overhead electricity lines, effectiveness of achieved results and technical measures used, safety ensurance for maintenance of the measures

Pylons of overhead transmission lines create artificial conditions to breed for birds making nests in natural environment. Ravens often make nests in metal pylons and each year renovate their structure placing a new layer on the nest, so each year the nest becomes bigger and heavier. Ravens usually nest in the upper or middle part of the metal pylon. Ravens start breeding in early spring and in May the young leave their nests. Common kestrels, protected and endangered species in Lithuania, often use such nests. They do not make nests by themselves and use the existing "infrastructure". Unfortunately, the nests of ravens upon completion of their breeding season should be removed in compliance with the effective maintenance regulations for electricity lines. Next year ravens make new nests but common kestrels become deprived of suitable breeding conditions. In many foreign countries operators engaged in maintenance of power lines implement alternative breeding places for protected bird species, for example kestrels or other falcons. Special semi-open nest-boxes for falcons (Fig. 11,1) installed on pylons of electricity transmission lines are a common scenery. In some countries Western ospreys make their nests on such pylons, and their nests should be protected. In Lithuania, Western ospreys do not make their nests on pylons of high voltage electricity grids, though in neighbouring Belarus such cases occurred.

Furthermore, numerous bird species constantly use wires or pylons of high voltage electricity transmission grids as places of roosting, hunt observations or overnight stay. There are typical places for raptors, corvids, pigeons, starlings or the white storks.

In the implementation of the Project *Installation of the Bird Protection Measures on the High Voltage Electricity Transmission Grid in Lithuania* by the Lithuanian Ornithological Society, funded by the EU LIFE+ Programme, installation of nest-boxes for kestrels was started in spring 2015. Within the Project implementation period by the end of 2018, on high voltage electricity transmission pylons 580 nest-boxes for common kestrels were erected. The nest-boxes were erected taking into consideration plans for renovation works in the high voltage electricity transmission lines. Taking into consideration peculiarities of the area and distribution of common kestrels, the long term plan for renovation of the overhead lines, from 20 to 120 nest-boxes were erected annually. Each year the number of installed nest-boxes grew. Occupancy of nest-boxes grew re-

Fig. 11.1. *Nest-box sketch, measurements 50 × 30 × 30 cm*

spectfully too. The first kestrels could occupy and start breeding in newly introduced nest-boxes in 2015. Then the nests were occupied in the districts of Alytus and Vilnius – 3 pairs of kestrels bred in the nest-boxes in 2015. Later, having installed nest-boxes two more districts (of Klaipėda and Kaunas) the number of breeding kestrels started to grow and 35 new breeding pairs were observed in 2016. In 2017, in the nests erected on pylons 64 pairs bred their chicks; in 2018 – 87 pairs. Currently, kestrels breeding in nests on pylons account for a big share of the entire population nationally - 150-300 pairs of these birds breed in Lithuania including 40 percent of them - in the artificial nests. In the Project implementation in total 189 breeding cases of common kestrels in erected nest-boxes (Table 4) were registered. The average number of the young per pair varied from 3,5–4,2 in one nest-box. The highest occupancy rate of nest-boxes by kestrels was in the districts of Klaipėda, Kaunas, Vilnius and Alytus, also the comfortable nest-boxes homed birds turned out of the towns by renovation. It was noticed that when kestrels occupy a nest-box next year more nearby nest-boxes became occupied. Within 4 years kestrels bred over 700 chicks. The share of unoccupied erected nest-boxes accounted for less than 1/3. However, the potential of nest-boxes exists for kestrels to breed. It is expected that beyond accomplishment of the Project implemented by the Lithuanian Ornithological Society the population of common kestrels in Lithuania should further increase.

Table 4. *Occupancy of nest-boxes by common kestrels, in 2015-2018*

Municipality	Year				Total number of breedings
	2015	2016	2017	2018	
Akmenė district				1	1
Alytus district	1	7	12	15	35
Jonava district				1	1
Jurbarkas district			1	2	3
Kaunas district		3	5	5	13
Kėdainiai district		1		2	3
Klaipėda city		6	21	16	43
Klaipėda district		8	13	24	45
Kretinga district		3	3	10	16
Marijampolė district				1	1
Palanga town		1	1	2	4
Prienai district			1	2	3
Šiauliai district				1	1
Šilutė district				1	1
Trakai district		1	1	2	4
Ukmergė district			2		2
Vilnius city		4	4		8
Vilnius district	2	1		2	5
Total:	3	35	64	87	189

12. The assessment methodology for negative impact of overhead lines on birds and bats before and after installation. Assessment principles and methodology for bird deaths

International legislation obliges the countries subordinate to them to ensure adequate protection of birds in all sectors including the energy branch. The European Commission underlines that decline and loss of biological diversity determines considerable environmental, economic and social consequences at the European Union (EU) scale and globally. Furthermore, the ecosystems provide numerous services directly or indirectly contributing to well-being of people delivering food, fresh water, clean air, recreational and medical services to us, reduce the probability of natural calamities, pests of farming lands and support climate stability. Therefore, in 2011 the EU countries adopted the large scope ambitious Strategy to 2020 seeking to halt biodiversity loss and degradation of ecosystem services in the EU.

The European Council Convention of European Wildlife and Natural Habitats (Bern Convention), ratified by Lithuania in 1994, in 2004 adopted 110 recommendations on minimising adverse effects of above-ground electricity transmission facilities (power lines) on birds. They advise the contracting parties to implement measures averting threats of electrocution and collisions. In 2011, Budapest Declaration on Bird Protection and Power lines was adopted calling on the EU institutions and national governments by 2020 to implement action plans of the agreement averting threats to birds caused by power lines.

Planning new overhead transmission lines it is necessary to assess the ornithological situation in such areas and to indentify a negative impact on birds. If an overhead line is designed to cross a Natura 2000 site or extends near it a potential negative impact on protected birds in it should be assessed. It is necessary to assess this impact if an overhead line extends over a water body, an area of flyway bottlenecks, a river valley or any other areas attractive to birds where abundant flocks gather or particularly rare and endangered bird species breed. In such areas observations of passing birds are needed in order to produce more exact impact of the lines on birds, protected and endangered species, in particular. It is recommended to carry out observations in the most intensive period of bird migration: March–May in spring, August – late October/early November in autumn. When planning observations certain posts enabling to observe all potentially dangerous places for birds. In migration seasons observations in each post ought to last from 100 to 120 hours per year. Observations are carried out in the most intensive flying time of birds: 4 hours in the morning after sunrise and 2 hours in the evening before sunset. If the area is sensitive in terms of potential impact on raptors observations may be carried out from 10 a.m. in the morning to 3-4 p.m. in the afternoon, when these birds are most active. When observing, the following parameters should be taken into account: height and direction of the bird flight, composition of

species and the most intensive flying times in twenty-four hours. Besides, in the planned area for a high voltage electricity transmission line records of bird concentrations should be carried out, abundance of individuals counted, most often used feeding or resting sites identified. In the most dangerous stopover areas where birds gather most often and abundantly (usually around water bodies or feeding places, over farming lands or rivers, etc.) electricity lines should be marked using measures increasing wire visibility, such as light reflective pendant or spiral type markers. The easiest way to mark is when overhead lines are being built as wires are not tightened yet, or together with planned technical maintenance works.

Having built new electricity transmission lines assessment of effectiveness of implemented bird protection measures ought to be carried out. Monitoring should continue at least two years after construction of new lines aiming at collection of needful inceptive information for further monitoring. Monitoring should monitor the same parameters as before installations of the new electricity line, also monitoring of bird deaths should be performed. Monitoring activities of bird deaths should be carried out every 5 days. Depending on the area it should be performed in autumn, spring, summer and winter. It depends in what season the area is important for bird protection. For monitoring of bird deaths it is necessary to assess error of impact of predators on bird searches, and bird searcher effectiveness in the area. Aiming at assessment of bird searcher efficiency tests with 20 baits conforming a small bird (10 units), like a wren or tit, and a large bird (10 units), like a common wood pigeon or bigger ones, have to be conducted. The baits should be put in a place unknown to the searcher in his searching zone before his regular searching activity. Later the result of found and unfound baits has to be assessed. To assess impact of predators on bird victims' search placed baits should be marked and regularly checked on a daily basis through to the next search, i.e. 5 days after placement in this case. Only knowing what percentage of dead birds is collected by natural predators and what are detected by the monitoring searcher the real number of bird deaths caused by collisions with wires can be assessed.

13. Recommendations how to reduce bird collision mortality in high voltage overhead electricity transmission lines

The most effective way to reduce their negative impact on birds (bird mortality caused by collision with wires or electrocution) is installing high voltage overhead electricity transmission lines underground (cabling). Another rather effective way seeking to reduce bird collision mortality is to objectively plan installation of new overhead electricity transmission lines. For planning, it is necessary to take into consideration location of areas important for birds, also bird wintering or staging areas (for stopover, feeding, overnight stay). Existing high voltage overhead electricity transmission lines should be equipped with markers increasing visibility of wires – various types of moving pendants or static spirals. The most efficient and effective pattern is to install measures increasing wire visualization covering at least 40 percent of the electrical wire length, i.e. to leave 60 percent of the wire length without the aforementioned visibility increasing measures. About 1/3 of the wires in the electricity line, measuring from each nearest pylon of the line, are left without visualization measures. Thus, about 2/3 of the length of wires in the electricity line, from the sides of pylons, remain without the aforementioned measures. Spacing between two spiral bird diverters is 5 m.

Selecting visualization measures and seeking their durability the below recommendations should be taken into consideration:

- metal parts of bird diverters made from stainless steel;

- plastic parts made from PVC or other materials resistant to climatic conditions, exposed to UV radiation do not quickly lose their characteristics, comply with flammability safety regulation;

- attaching mechanics should not allow the devices to move along electricity transmission or ground wires;

- markers installed on electricity transmission lines to increase visibility of their wires mustn‘t cause corona, i.e. formation of electromagnetic field.

14. Strategy for building new overhead lines

Planning to build new high voltage overhead electricity lines should avoid that they crossed staging areas of wintering, migrating or breeding birds, open areas of productive water bodies or flooded meadows. In Lithuania, development of new high voltage overhead electricity lines should not be planned in areas of flyway bottlenecks, next to breeding sites of white-tailed eagles, black storks, whooper swans, Eurasian eagle owls. Besides, it is proposed to combine with the infrastructure of the existing lines, already built new high voltage overhead electricity lines, in particular, as the opinion is shared that negative impact of two side-by-side (as close to each other as possible) overhead lines would be significantly smaller compared to two separately built lines. If the distance between side-by-side high voltage overhead electricity lines is big (several km) negative impact may strengthen, thus designing high voltage overhead electricity lines is very important. In Lithuania, this principle is observed through its implementation within the framework of procedures of the Strategic Environmental Impact Assessment (SEIA) and Environmental Impact Assessment (EIA). However, issues concerning improvement of bird protection in the existing high voltage overhead electricity lines require adequate attention. In this case opportunities to apply additional bird protection measures exist, taking into consideration the status of the object in natural environment, ornithological situation of a particular area and nature conservation significance.

Project partners

The Lithuanian Ornithological Society (LOD), a non-governmental organisation, uniting Lithuanian people concerned with wildlife protection, who take care of and watch birds and their environment, engage in its preservation and public ecological education, also take civic part in policy making for protection of environment and biodiversity. Since 1994, the LOD represents in our country BirdLife International, a global partnership of over 100 conservation organisations, seeking to conserve birds and their habitats. We believe joint efforts, knowledge and experience will facilitate more efficient protection of birds and the entire wildlife around us, and its status will improve.

Litgrid, the Lithuanian electricity transmission operator, maintains stable operation of the national electricity system, manages electricity flows and enables competition in the open domestic electricity market. Litgrid is responsible for integrating the national power system into the European infrastructure and common electricity market.

Litgrid being the electricity transmission system operator is responsible for the national electricity system management, sound operations of the national electricity system, lines and other electricity facilities, their technical maintenance and development. The Lithuanian 330–110 kV voltage electricity transmission grid includes 6 687 km electricity transmission lines.

We work to ensure transmission grid operation of good quality, sound and not harmful to the environment in Lithuania.

Bibliography

Allinson, T., 2017. Introducing a new avian sensitivity mapping tool to support the siting of wind farms and power lines in the Middle East and northeast Africa. In Wind Energy and Wildlife Interactions (pp. 207-218). Springer, Cham.

Bagyura, J., Lovászi, P., Nagy, K., Kovács, A. and Horváth, M., 2004. Mediumvoltage power lines and bird mortality in Hungary. Experience, nature conservation requirements and suggestions. MME BirdLife-Hungary, p.30.

Bevanger, K., 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. Biological conservation, 86(1), pp.67-76.

Biro, G., 2011. Bird protection on high voltage transmission system. Presentation at International Conference on Electricity Distribution.

Daan, S., Dijkstra, C., Drent, R. and Meijer, T., 1988. Food supply and the annual timing of avian reproduction. In Proceedings of the International Ornithological Congress (Vol. 19, pp. 392-407). Ottawa: University of Ottawa Press.

Fargallo, J. A., Blanco, Guillermo Potti, Jaime and Viñuela, Javier, 2001. Nestbox provisioning in a rural population of Eurasian Kestrels: breeding performance, nest predation and parasitism. Bird Study, 48(2), pp. 236-244.

Frost, D., 2008. The use of 'flight diverters' reduces mute swan Cygnus olor collision with power lines at Abberton Reservoir, Essex, England. Conservation Evidence, 5, pp.83-91.

Garrido, J.R. and Fernández-Cruz, M., 2003. Effects of power lines on a White Stork (*Ciconia ciconia*) population in central Spain. Ardeola, 50(2), pp.191-200.

Gil-Delgado, J.A., Verdejo, J. and Barba, E., 1995. Eurasian Kestrels (*Falco tinnunculus*) in. Raptor Res, 29(4), pp.240-244.

Gockel, P.N.M., 2009. Steady-state voltage profile and reactive power balance for EHV AC cable systems in the Randstad 380 project.

Hanso H. Vaike Vain power line – a great fanger to staging and migrating waterfowl. 6th International Swan symposium 16-19 October 2018 Tartu, Estonia. Abstract Book

Horvath, M., Nagy, K., Demeter, I., Kovacs, A., Bagyura, J., Toth, P., Solt, S. and Halmos, G., 2011, April. Birds and power lines in Hungary: Mitigation planning, monitoring and research. In Presentation at International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary.

Hurst, N., 2004. Corona Testing of Devices Used to Mitigate Bird Collisions. EDM International, Fort Collins, Colorado.

Janss, G.F., 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biological Conservation, 95(3), pp.353-359.

Jenkins, A.R., Smallie, J.J. and Diamond, M., 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conservation International, 20(3), pp.263-278.

Kaługa, I., Sparks, T.H. and Tryjanowski, P., 2011. Reducing death by electrocution of the white stork Ciconia ciconia. Conservation Letters, 4(6), pp.483-487.

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

Morkūnas J., Raudonikis L., Monkuvienė V. Overlap of electricity grid and swan staging in areas in Lithuania, 6th International Swan symposium 16-19 October 2018 Tartu, Estonia.

Raudonikis R., Liaudanskytė (Mažulė) J. Bird protection in 110-330 kV voltage electricity transmission lines. Study, Lithuanian Ornithological Society, 2014

Rubolini, D., Gustin, M., Bogliani, G. and Garavaglia, R., 2005. Birds and powerlines in Italy: an assessment. Bird Conservation International, 15(2), pp.131-145.

Wiehn, J. and Korpimäki, E., 1997. Food limitation on brood size: experimental evidence in the Eurasian kestrel. Ecology, 78(7), pp.2043-2050.

View on Energy Sector Nr.10 (31). Litgrid publication

Webs *http://www.litgrid.eu/*.

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