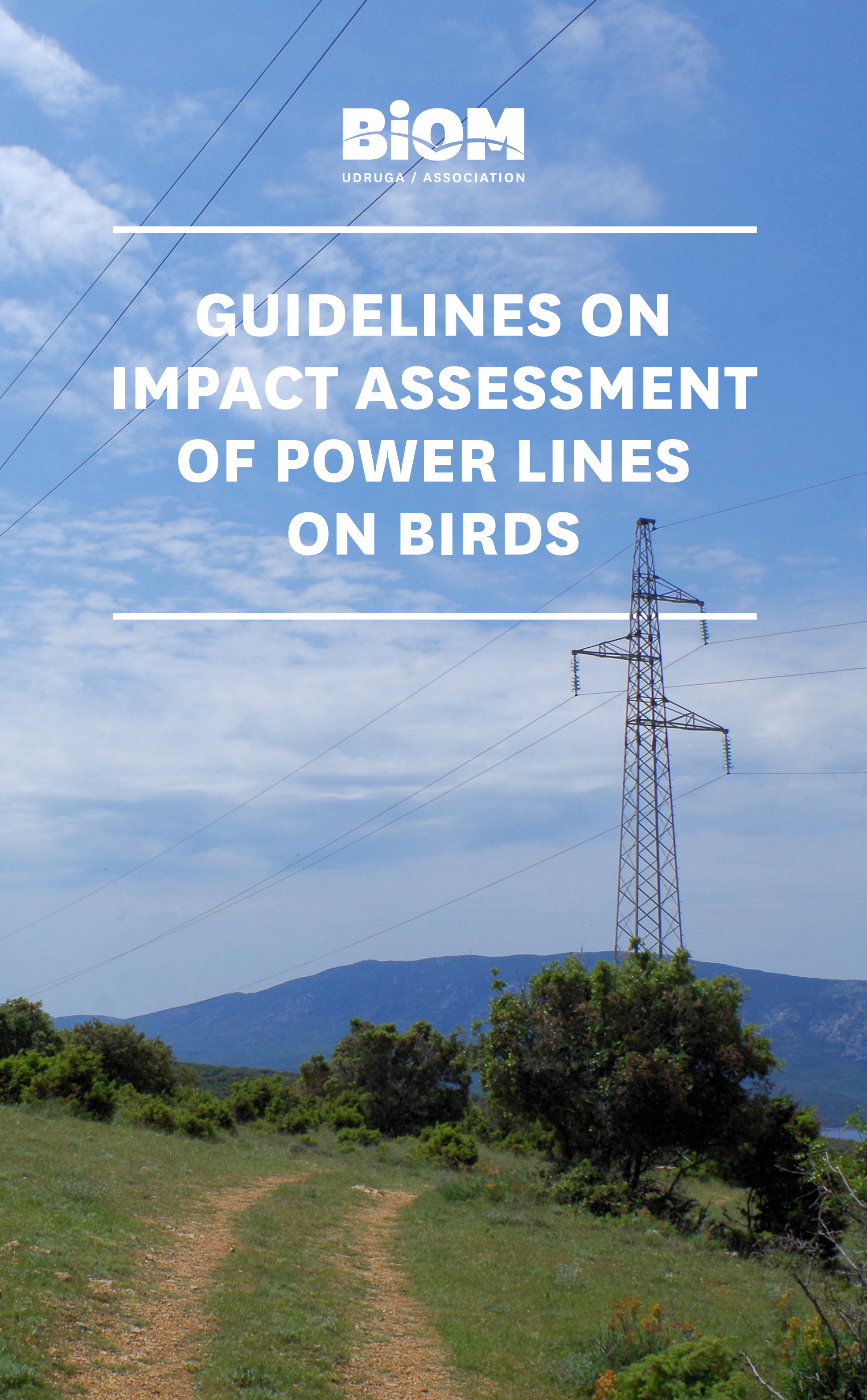
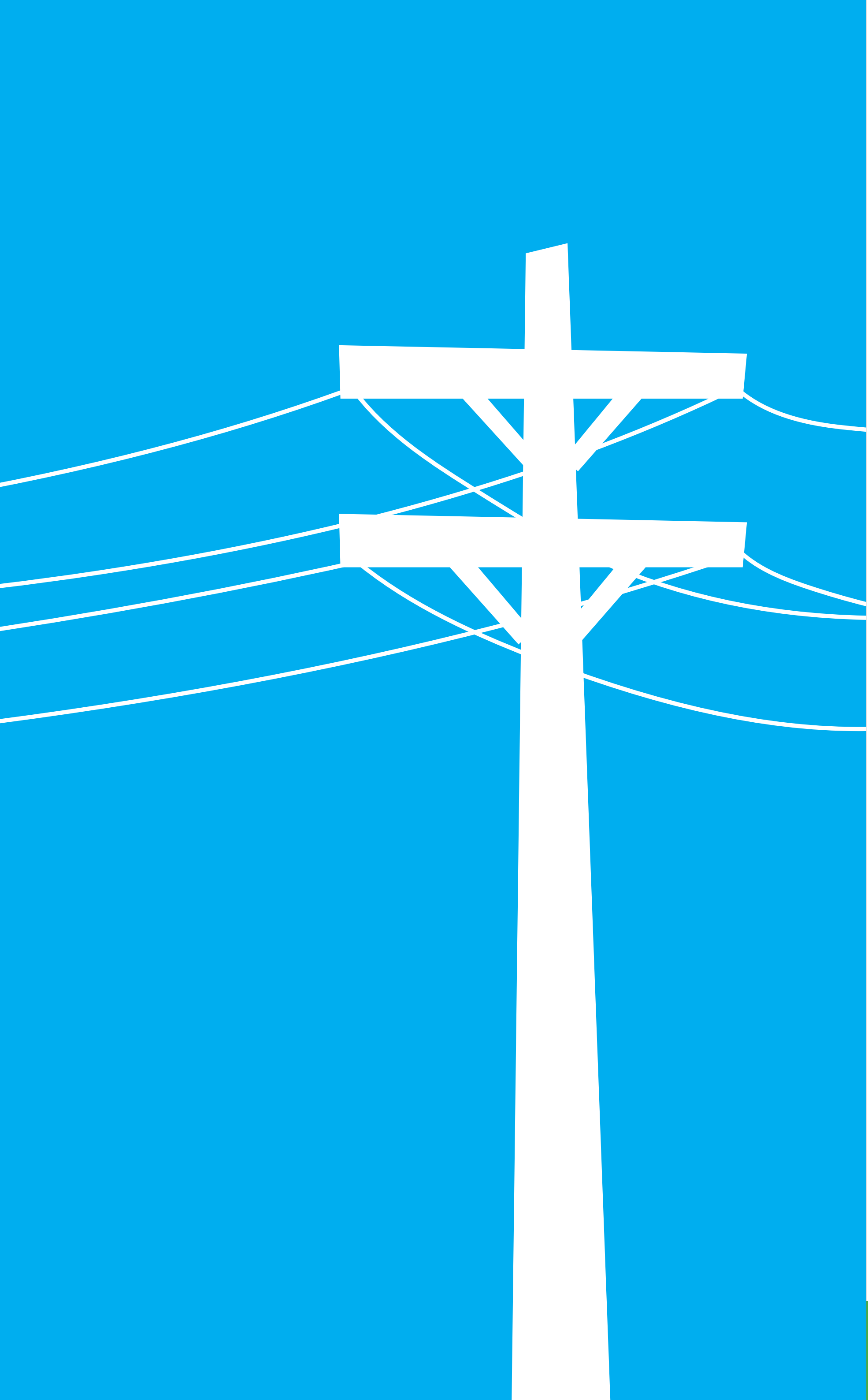
BIOM
UDRUGA / ASSOCIATION

GUIDELINES ON IMPACT ASSESSMENT OF POWER LINES ON BIRDS





CONTENT

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INTRODUCTION

Power lines constitute one of the major causes of unnatural mortality for birds in large parts of the African-Eurasian region, with estimates going as high as millions of victims each year. The main causes of death on power lines are from electrocution and collision, each of which affects different species (Prinsen et al. 2012).

Electrocution happens when a bird bridges the gap between two live (energized) components or a live and an earthed (grounded) component of the pole structure. Low to medium voltage lines pose the greatest risk because of the close spacing of the structures. Large birds of prey and storks are most at risk.

A bird collision occurs when a flying bird physically collides with an overhead power line. Collisions can occur at all above ground lines, but they are mostly recorded on high voltage lines due to the abundance of wires in multiple vertical layers. Species which fly fast and have poor maneuverability and forward vision are the most frequent victims.

Mitigation/prevention measures have proven to be effective in reducing the mortality from electrocutions and collisions. Measures include the insulation of cables close to poles, replacement of dangerous structures with bird-safe designs, the addition of safe perches at a safe distance from energized structures, line configurations, markers etc.

The purpose of these guidelines is to assist in environmental impact assessment procedures related to power lines. This includes designing bird surveys to assess impacts, proposing mitigation measures, as well as designing monitoring programs. Since this is the first version of guidelines for power lines impact assessment in Croatia, it presents fundamental principles to be followed, but still leaves some questions to be answered, hopefully in the next version of these guidelines.

STRATEGIC PLANNING

To exclude possible negative impacts on bird populations, it is of most importance to have plans for grid development which are aligned with nature conservation legislation. This means that plans for energy infrastructure development should be assessed through the strategic environmental impact assessment (SEA) procedure.

The SEA procedure should result in sensitivity maps and no-go zones which consider important bird areas, including the presence of susceptible species and major flyway routes (in Croatia this is the Adriatic flyway). When planning new corridors, it is important to consider biological characteristics (flight behavior, season, habitat, and habitat use) as well as landscape features (e.g., topographical elements). When planning power line routes, features that are traditional flight corridors (mountain ridges, river valleys, and shorelines) should be considered (Avian Power Line Interaction Committee 2012).

To have a better strategic overview, nature protection authorities should develop scientifically based databases and spatial datasets on the presence of key bird areas and presence of susceptible bird species, including flight routes of these species between breeding, feeding and resting areas as well as important migration corridors.

ENVIRONMENTAL IMPACT ASSESSMENT

Direct impacts on birds are primarily associated with medium (10-35 kV) and high voltage lines (>100 kV).

Higher collision risk in high voltage lines is associated with the thin earth (shield) wire, which is positioned above the thicker conductor wires. Medium and low voltage power lines are more likely to result in electrocution, due to birds making a connection between two live components (Birdlife International 2015).

The severity of the population-level impact of the losses due to electrocution and collision for the different families of bird species are shown in the table below. The following classifications are used (BirdLife International (on behalf of the Bern Convention) 2003):

- o — no casualties reported
- I — casualties reported, but no apparent threat to the bird population
- II — regionally or locally high casualties; but with no significant impact on the overall species population
- III — casualties are a major mortality factor; threatening a species with extinction, regionally or on a larger scale.

Table 1 The severity of the impact on populations of the losses due to electrocution and/or collision (BirdLife International (on behalf of the Bern Convention) 2003)

Bird family	Electrocution	Collision
Loons (*Gaviidae*) and Grebes (*Podicipedidae*)	o	II
Shearwaters, Petrels (*Procellariidae*)	o	I - II
Cormorants (*Phalacrocoracidae*)	I	II
Herons, Bitterns (*Ardeidae*)	I	II
Storks (*Ciconidae*)	III	III
Ibisses (*Threskiornithidae*)	I	II
Ducks, Geese, Swans, Mergansers (*Anatidae*)	o	II
Raptors (*Accipitriformes* and *Falconiformes*)	II - III	I - II
Partridges, Quails, Grouses (*Galliformes*)	o	II- III
Rails, Gallinules, Coots (*Rallidae*)	o	II - III
Cranes (*Gruidae*)	o	II - III
Shorebirds / Waders (*Charadriidae + Scolopacidae*)	I	II - III
Gulls (*Laridae*)	I	II
Terns (*Sternidae*)	o - I	II
Pigeons, Doves (*Columbidae*)	II	II
Cuckoos (*Cuculidae*)	o	II
Owls (*Strigiformes*)	I - II	II - III
Nightjars (*Caprimulgidae*) and Swifts (*Apodidae*)	o	II
Hoopoes (*Upudidae*) and Kingfishers (*Alcedinidae*)	I	II
Bee-eaters (*Meropidae*)	o - I	II
Rollers (*Coraciidae*)	I	II
Woodpeckers (*Picidae*)	I	II
Ravens, Crows, Jays (*Corvidae*)	II - III	I - II
Medium-sized and small songbirds (*Passeriformes*)	I	II

Electrocution

As previously mentioned, bird electrocution occurs mainly on utility poles of medium voltage lines, which is due to the close spacing of live (conducting) elements. However, victims may occur even on high voltage network elements as raptors and other large species frequently use towers for nesting purposes (Prinsen et al. 2012).

Species Involved and Magnitude

The species reported as vulnerable to electrocution belong to Ciconiiformes, Falconiformes, Strigiformes and Passeriformes. Species in this latter group fly or roost in dense flocks, and may also cause short-circuits, due to the electric current passing through several individuals.

In Europe, raptors most often found below utility poles include the Common Buzzard (*Buteo buteo*), Black Kite (*Milvus migrans*), Red Kite (*Milvus milvus*), and Common Kestrel (*Falco tinnunculus*) (Prinsen et al. 2012).

In Northern Europe nearly all raptor and owl species were indicated as being vulnerable to electrocution (Prinsen et al. 2011).

In Central Europe, storks, raptors, and owls seem to be largely affected by electrocutions (Prinsen et al. 2011).

A study in Eastern Europe (Bulgaria) found that 53% of all bird electrocution fatalities were diurnal raptors, storks and crows. (Prinsen et al. 2011).

In addition to this, in Croatia vultures, eagles, buzzards, owls, gulls and ravens have been found as electrocution victims.

Collision

Fog, dense clouds, and several types of precipitation reduce the visibility of power lines, which increases the collision risk for birds. Even though most birds avoid flying in these conditions, studies have found an increase in the number of bird collisions in periods with fog and precipitation, or after a sudden hailstorm (Prinsen et al. 2011).

The topography is also an important factor because, for example, rivers, shorelines or mountain valleys concentrate birds into certain flight routes. To avoid severe impacts, new lines should be placed parallel to such landscape features when possible.

Susceptibility of Birds to Collision

It is often observed and described that soaring, less agile birds, like herons, cranes, swans and pelicans, are vulnerable to collisions (Prinsen et al. 2011).

The detectability of power lines for birds depends on the visibility of the wires as well as on the species' vision: for example, certain species such as vultures tend to look downwards during foraging flight. Additionally, for species like filter-feeding ducks or tactile probing shorebirds, the very narrow (±5°) binocular field in the direction of travel might also limit the perception of obstacles in the open air (Prinsen et al. 2011).

Behavior also influences the susceptibility of species to collision. Birds which fly in large flocks (ducks, pigeons and starlings) are at higher risk of colliding with obstacles. Also, some behaviors make birds unaware of obstacles, such as display flights, mating displays, and chasing away of predators or competition. If these flights are performed in the proximity of a power line there is an increased risk of collision (Prinsen et al. 2011).

Another important factor is flight altitude. Migration often occurs at higher altitudes, above the height of power lines, so collision risk for migrating birds is expected to be lower. However, the collision risk of migrating birds increases with bad weather conditions which force them to fly at lower altitudes (especially at night), or if birds stop-over near a power line. On the other hand, resident birds often have more interaction with power lines due to regular movement between foraging areas and roosting or nesting sites. Based on a case study in Hungary, species which cover large distances during their everyday movements between their foraging areas and breeding/roosting sites have a larger chance of colliding with overhead lines, especially if the sites are close to each other and birds fly between those areas at low altitude (Pigniczki et al. 2019).

Several studies have shown that inexperienced juveniles more often collide with power lines than adult birds; however, there is also a number of studies that showed no difference in collision of juvenile and adult birds (Prinsen et al. 2011).

It is accepted that bird species that regularly fly at night or in twilight are at higher risk of collision with a power line than species that mostly fly during the day. Through multiple searches during the day, it was shown that most collision victims in a Dutch grassland polder occurred during the night (33% between 11 PM and 4 AM) and twilight period (23% between 4 AM and 8 AM and 29% between 6 PM and 11 PM). In a study in Germany 61% of the collision victims belonged to species that mostly fly at night (Prinsen et al. 2011).

Bird Survey Design

Desk-based Review

The first step in preparing a bird survey should be a thorough search for already available data followed by a visit to the site to validate the collected information. Bird data can be obtained from the Institute for Environment and Nature (Ministry of Economy and Sustainable Development). Other members of the ornithological community in Croatia (The Institute for Ornithology at the Croatian Academy of Sciences and Arts, non-governmental organizations which work in nature protection with emphasis on birds) can be contacted regarding the necessary data.

Bird data

Reviewing existing bird data of the study area should include the following aspects of the relevant bird species:

— Which species occur in the study area
— Location of migration routes
— Local movement patterns
— Habitat requirements
— Foraging habits
— Conservation status of the species
— Sensitivity of species to collision or electrocution (table 1 on page 2).

Geospatial analyses can facilitate the identification of critical areas/conflict hotspots (areas inhabited/visited by species sensitive to power line impacts) in the vicinity of planned power lines. This can be made by producing a sensitivity map which would show the range (nesting territory, foraging area, migration route) for the species concerned (Birdlife International 2015).

If bird presence data are not available, identifying conflict hotspots should rely on local ecological or landscape characteristics that influence the number of birds using the area (Birdlife International 2015).

Survey Area

The survey area should cover the entire development (with ancillary structures, access tracks etc.), and extend to a suitable distance beyond it.

Electrocution hotspots

Electrocution hotspots can be identified through sensitivity mapping and field visits that focus on site characteristics and the absence/presence of natural perches. Power lines and poles close to important feeding sites are likely to be used as perches, especially if tree cover is absent in the surroundings. An inventory of already existing roosts can help to identify locations where newly erected utility poles may also be used for roosting (Birdlife International 2015).

Collision hotspots

Vantage point surveys should be carried out at hotspot locations identified through sensitivity mapping. Depending on the scale of the development, it may not be necessary to undertake vantage point watches along the whole length of the route corridor (Scottish Natural Heritage 2016). Vantage point observations should focus on sensitive sites (known or expected nest, roost or foraging site, migration route) and areas used by species prone to electrocution/collision.

Vantage point surveys should take place during the parts of the year when sensitive species (to electrocution/collision) are present at the survey area. As the principles of vantage point surveys for assessing power line impacts are similar to those set out in Guidelines on Assessing the Impact of Wind Farms on Birds, this document should be advised when designing vantage point watch surveys.

Vantage point surveys conducted by field observers should establish:

- Flight intensity (number of birds/space unit/time interval, e.g. number/crossing a virtual km line/hour)
- Flight height during different weather conditions (this is important because flight behavior changes in conditions of fog, dense clouds, precipitation, wind, etc.), and
- Flight routes at the local scale.

If an existing power line is present in the area it should be used as a reference for determining flight height.

A detailed topographical map should be used to record flight routes. The following information should be recorded (Table 2):

- Species
- Number of birds
- Flight height (it is important to be as precise as possible when determining flight height; identifying flight intensity at power line height, below the height of the lowest power lines, and above power line height)
- Type of flight (feeding, going to nest/roost, migrating).

Table 2 An example of a form to record flight patterns in the field (Source: Birdlife International 2015)

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Datum:
Mjesto promatranja:
Početak:
Završetak:
Izlazak sunca / zalazak sunca:
Promatrači:</td><td colspan="4">Temperatura:
Smjer/brzina vjetra:
Oblaci:
Padaline (vrsta i trajanje):
Sunce (%)
Vidljivost (km):
Razdoblje tame:</td></tr>
<tr><td>Vrijeme (po 5 min)</td><td>Vrsta</td><td>Broj ptica</td><td>Ruta leta na karti*</td><td>Sletjela (da/ne)</td><td>Nastavila letjeti migracijskom rutom</td><td>Visina leta</td><td>Napomene (vrsta leta, promjene vremenskih uvjeta, uznemiravanje)</td></tr>
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* U područjima velike gustoće ptica može se zabilježiti

— From which direction in relation to the researcher the bird was observed
— In which direction the bird is flying
— Flight height
— Did the bird cross the power line.

Other survey methods

Noćne vrste Nocturnal activity may pose greater risks due to low visibility of the exposed elements of power lines, particularly for collision. It is important to analyze impacts on nesting birds (owls and nightjars) and migratory birds (cranes, herons).

Point count method For collecting data on songbirds, we recommend using the point count method. The method is well suited for relatively small study sites with diverse habitat types.

Transect method Like point counts, linear walking transects are used to investigate songbird communities. Transects are suitable in extensive, open, and uniform habitats, or areas with low bird density.

Using control sites to analyze impacts

One approach to evaluating the human-induced impacts on ecosystems is defining a control site and implementing a bird survey (as well as later monitoring) at the same time as on the impacted location. Before-After-Control-Impact (BACI) design is suggested as optimal for this type of analysis. There it must be added that concerns have been raised when it comes to the ability to determine causation by human impact even with a control site. Caution should be taken when interpreting results from a BACI design in an environmental impact study, but it is still stated that a well-designed BACI remains one of the best models for monitoring impacts (Smokorowski and Randall 2017).

These guidelines recommend having a control site, but still leave it to EIA consultants to choose whether this type of analysis would be beneficial for impact assessment, having in mind the location and project characteristics. Also, it must be kept in mind that limitations to this approach could be the need for additional resources (including the duration of the pre-construction survey and post-construction monitoring).

Risk Assessment

To estimate possible future mortality, BirdLife International 2015 recommends a modeling approach.

The knowledge of modeling mortality by electrocution on already existing power lines can also be applied to new power lines. Tinto et al. (2010) gave an example of quantitative modeling of electrocution risk on existing power lines (BirdLife International 2015).

Collision risk modeling should be based on appropriate habitat mapping and empirical bird survey data. If a modeling approach proves to be unsuitable, the best solution is to monitor mortality at already existing power lines in the vicinity in order to estimate expected mortality rates at new power lines (BirdLife International, 2015).

On the other hand, Scottish Natural Heritage (2016) does not advise using a generic modeling approach, and they further state that "collisions are usually site-, season- and species-specific, and a generic collision risk model is unlikely to accurately predict levels of mortality". Their recommendation is to put effort on mitigation where surveys have indicated potential conflicts. For cases with potentially severe impacts, where mitigation may not reduce this sufficiently, models could be useful if they are based on the best available data (site characteristics and species concerned).

We hope that the authorities, EIA consultants, ornithological community will work together on the best solution for this topic in the next version of these guidelines.

Cumulative Impact Assessment

The cumulative impact assessment should cover planned projects which are currently in the process of obtaining permits, projects which already have permits but are still not constructed, and constructed projects.

The coverage of the cumulative impact assessment (area of assessment) should be determined depending on the bird species present at the planned power line area. For example, if there are Griffon vultures present, then the cumulative assessment should cover an area big enough to involve all routes/areas used by the Griffon vulture (colony site, foraging site etc.). For SPA sites, cumulative assessment should cover the entire SPA area.

Avoiding or Mitigating Impacts

Measures proposed in these guidelines are derived from Prinsen et al. 2012.

ELECTROCUTION

Line design or configuration	The technical design of utility pole tops can take one or a combination of two approaches: either to ensure that the likely preferred perching space for a bird on the pole top is well clear of dangerous components; or to ensure that the dangerous components are sufficiently separated by space to ensure that the bird cannot touch them. This latter option can result in significantly larger pole tops with consequent significantly increased costs, which is why a combination of the two approaches is often employed.
Insulation	Where poles, pylons or substation hardware pose a risk of electrocution to birds due to insufficient clearances between critical hardware, it is possible to rectify the situation with add-on mitigation. This usually takes the form of insulating materials that are fitted onto conductive elements of the structure. In some cases this insulation takes the form of custom-designed products for insulating certain components, while in other cases a more universal, generic material is used, which can be adapted on site to insulate varying components.Retrofitting (polymer) insulation may be carried out on ground wires, phase conductors, crossarms and jumper wires, both at tap and dead-end locations, especially where bare energized wires connect transformers.
Perch management techniques	Cross-arms, insulators and other parts of the power lines can be constructed so that there is no space for birds to perch where they can be close to energized wires.
Podzemni kabeli	Placing overhead lines underground is the most efficient measure for preventing electrocution. It must be stated that this is a highly costly and sometimes technically challenging option.

SUDAR

Oblikovanje ili konfiguracija vodova	Although different bird species fly at different heights above the ground, there is consensus that the lower the power line cables are to the ground, the better they prevent bird collision. There is also consensus that less 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. Since bird collisions have been recorded with the guy or stay wires of towers, the construction of self-supporting towers, which do not require stay wires, is preferred.
Line marking	Since the assumption is that birds collide with overhead wires because they cannot see them, fitting the cables with devices in order to make them more visible to birds in flight is a preferred mitigation option worldwide. Besides thickening, coating or coloring the often least visible thin ground wires, a wide range of potential line marking devices

has evolved over the years, including: spheres, spiral vibration dampers, swan flight diverters, bird flappers, ribbons, flags, aviation balls, crossed bands. Spuštanje nadzemnih vodova ispod zemlje najučinkovitija je mjera i za sprječavanje sudara. Kao što smo već naveli, to je iznimno skupa, a nekada i tehnički zahtjevna opcija.

Underground cabling	Placing overhead lines underground is the most efficient measure for preventing collision. As stated above, this is a highly costly and sometimes technically challenging option.

MONITORING PROGRAM

There are two types of effects to monitor: mortality and flight behavior. Post-construction monitoring should follow the same principles as pre-construction monitoring.

Monitoring fieldwork should cover those parts of the power line corridor which were identified as risky (in terms of possible electrocution/collision) during the EIA phase (areas with most bird activity/density, migration routes, foraging sites, roosts, and nesting sites etc.).

Mortality Monitoring

Spatial and temporal coverage for mortality monitoring

Most collision victims are found within a 50 meter distance from the power line but, if feasible, larger distances from the line should be incorporated in the search protocol in order to ensure that those victims that have fallen to the ground further away are included (BirdLife International, 2015).

Most electrocution victims fall close to the base of the pole, so a search radius of 10 meters around poles and pylons is sufficient for electrocution monitoring.

The frequency of searches will depend on the expected bird species. The smaller the bird, the more frequent searches are required. For most soaring birds a search intensity of once a week is likely to provide good results. When only large conspicuous birds (storks, vultures, eagles and cranes) are searched for, fortnightly searches may be sufficient (BirdLife International, 2015). The period of carcass searches must cover the period in which the species identified during EIA phase use the area (breeding season, migration season (spring and autumn), as well as wintering period).

Correction for biases

Searcher detection efficiency experiments

In searcher detection experiments, "test" carcasses are placed in areas unknown to the researchers. Based on the percentage of carcasses found from the known number of test carcasses laid out, the searcher detection bias can be determined (Birdlife International, 2015).

Scavenger removal experiments

Scavenger removal experiments are conducted to correct the number of carcasses that are removed by scavengers before searchers could find them. This can take place with carcasses found during the regular searches, but also with carcasses used for the searcher detection experiments. It is important not to put out too many carcasses at once, because this may give scavengers more than they can remove and process (Birdlife International 2015).

Test carcasses for both experiments should be similar in size and color to the species identified in the EIA study. It is also important to consider palatability, as gallinaceous birds will be more attractive to scavengers. This recommendation will depend on the permitting authority. Also, we are aware that finding adequate bird species for these trials is not an easy task. Still, the recommendation remains, but it is not an obligation which must be followed.

Crippling bias

Researchers should be aware of the existence of the so-called crippling bias. This accounts for birds that get injured due to collision or electrocution but can still move on, eventually to die outside the search zone of the carcass searches (Birdlife International 2015).

Habitat bias

Habitat bias represents the accessibility of sites under power lines for effective prospecting. Habitat bias is quantified by determining the area of the site that cannot be searched by observers (Bornel et al. 2017).

Flight Behavior Monitoring

The monitoring of live bird movement is less commonly conducted than dead bird searches, but if we do not estimate how many birds crossed the line in flight, the collision rates calculated through dead bird searches are less meaningful.

Since this would consume a lot of time and resources, remote techniques such as radar can be used to obtain data. In some countries, bird conservation and research organization volunteers assist in these surveys as additional manpower (Prinsen et al. 2012).

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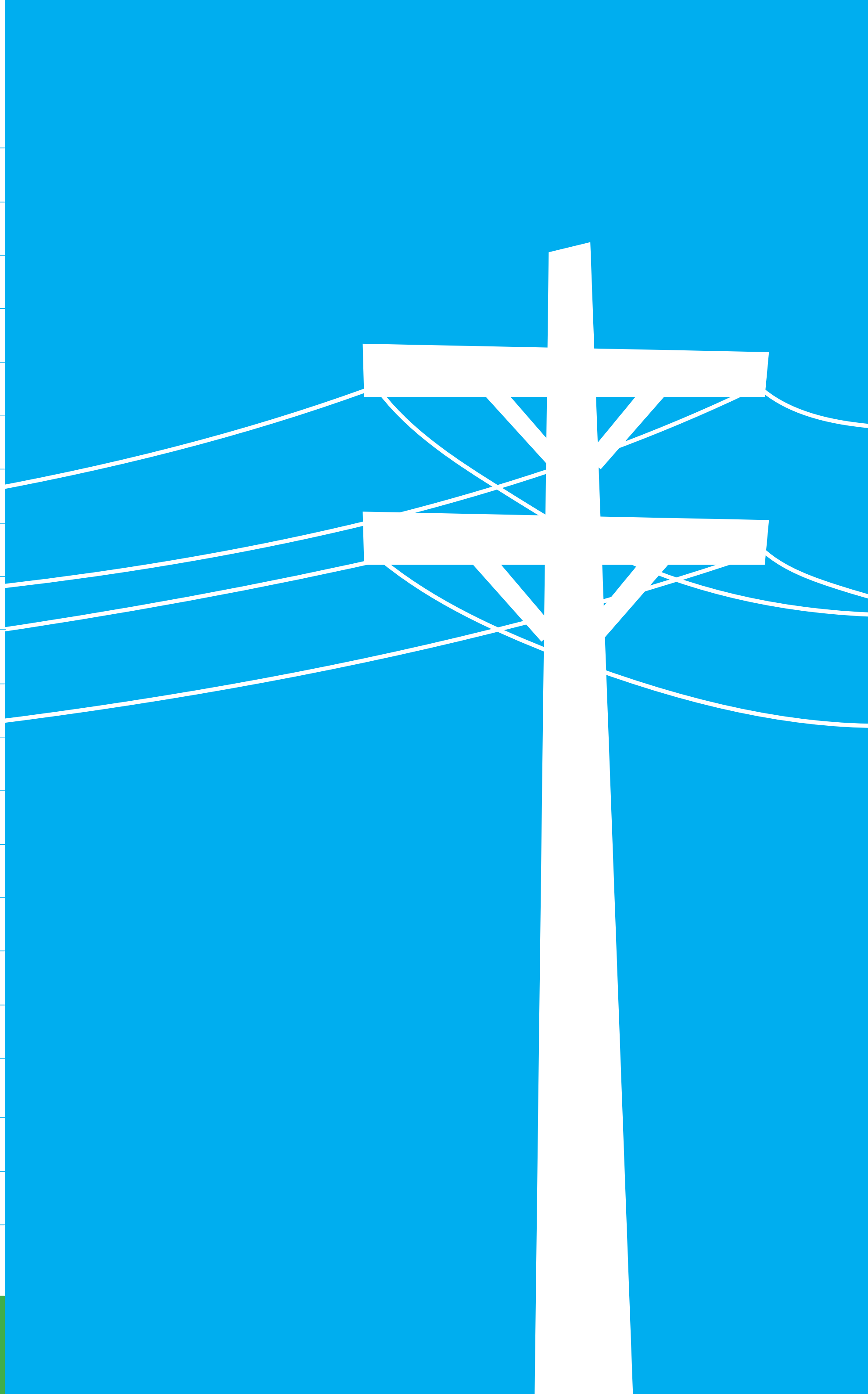
APPENDIX

Protocol Measuring mortality rates	Standard	Possible variation
Search area	40-50 m both sides of the line; 10 m around poles.	For extremely high lines, this may need to be increased to cover the extent of the area where birds could land. Similarly, for extremely low lines this area could be reduced.
Search intensity	Carried out on foot.	Searches in open, flat terrain with sparse vegetation and for large species can be from car or motorbike.
Search frequency	1 x per week.	For areas with high predation, high carcass removal or small species search two or three times a week. For large species and no carcass removal, every two weeks may be sufficient.
Searcher efficiency experiments	1x per season/ period.	Not more than every month to reduce predator attraction.
Scavenger removal experiments	1x per season/ period.	Not more than every month to reduce predator attraction.

Appendix 1 Example of protocol for fieldwork aimed at gathering information (Source: Birdlife International, 2015.)

Appendix 2
An example of a form to record collision victims in the field
(Source: Birdlife International, 2015.)

Location: Date: Start: End: Observers:				Temperature: Wind direction/speed: Clouds: Precipitation (type and duration): Sun (% period) Ground coverage:							
Line section	ID	Waypoint	Photo code	Species	Plumage (M/F)	Cause of death	Injuries	How long dead	Remains	Predation	Comments



Association Biom is a civil society organization committed to the conservation, promotion and popularization of nature. The association is dedicated to monitoring and combating direct threats to birds, such as collisions, electrocution, poisoning or illegal killing. The association collects data on the extent of these threats and informs the public about them. Biom advocates for the improvement and effective implementation of existing regulations on nature protection, and encourages dialogue between key stakeholders in the field of bird protection.

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