Secretariat provided by the
United Nations Environment Programme (UNEP)

Doc StC Inf. 7.9
Agenda item 20
15 November 2011

7th MEETING OF THE AEWA STANDING COMMITTEE
26 – 27 November 2011, Bergen, Norway

The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
and
The Convention on the Conservation of Migratory Species of Wild Animals (CMS)

AEWA/CMS Technical Series No. XX

Review of the Conflict between Migratory Birds and Electricity Power Grids in the African-Eurasian Region

Funded by AEWA's cooperation-partner, RWE RR NSG, which has developed the method for fitting bird protection markings to overhead lines by helicopter.

VORWEG GEHEN

Produced by
Bureau Waardenburg
Boere Conservation Consultancy
STRIX Ambiente e Inovação
Endangered Wildlife Trust – Wildlife & Energy Program

Compiled by: Hein Prinsen[1], Gerard Boere[2], Nadine Píres[3] & Jon Smallie[4].

1. Bureau Waardenburg bv, Culemborg, the Netherlands, h.prinsen@buwa.nl, www.buwa.nl
2. Boere Conservation Consultancy, Gorssel, the Netherlands, gcboere@planet.nl
3. STRIX Ambiente e Inovação, Porto Salvo, Portugal, nadine.pires@strix.pt, www.strix.pt
4. Endangered Wildlife Trust (Wildlife & Energy Program), Modderfontein, South Africa, wep@ewt.org.za, www.ewt.org.za

Milestones in the production of this review
First draft: September 2011, presented to the CMS Scientific Council through correspondence and to the 10th meeting of the AEWA Technical Committee, 12-16 September 2011, Naivasha, Kenya.
Second draft: November 2011, submitted to the 17th meeting of the CMS Scientific Council on 17-18 November 2011 in Bergen, Norway, the 10th Conference of the Parties to CMS on 20-25 November 2011 in Bergen, Norway and the 5th Meeting of the Parties to AEWA on 14-18 May 2012 in La Rochelle, France.

Contributors:
Besides the authors listed above, the following persons contributed to (parts of) this review:
Bureau Waardenburg: Jonne Hartman, Abel Gyimesi, Angela van Bergeijk, Mark Collier, and Jan van der Winden;
STRIX: Filipe Canario, Ricardo Tomé;
EWT-WEP: Megan Diamond.

Recommended citation: Prinsen, H.A.M., G.C. Boere, N. Píres & J.J. Smallie (Compilers), 2011. Review of the conflict between migratory birds and electricity power grids in the African-Eurasian region. CMS Technical Series No. XX, AEWA Technical Series No. XX. Bonn, Germany.

Acknowledgements:
Thanks go to the UNEP/AEWA Secretariat and UNEP/CMS Secretariat, Aline Kuehl, Borja Heredia, Sergey Dereliev and Florian Keil for helpful comments on this review. We thank the CMS and AEWA Focal Points of the following countries for the information they provided: Algeria, Benin, Bulgaria, Canada, Denmark, Ethiopia, European Union, Germany, Ghana, Hungary, Israel, Kenya, Liechtenstein, FYR of Macedonia, Monaco, Montenegro, Mozambique, Namibia, Nigeria, Portugal, Romania, Republic of Serbia, Slovakia, South Africa, Sudan, Switzerland, Togo, Uganda, and United Kingdom. Furthermore, we like to thank the following persons for providing information or help in compiling the review report and these guidelines: Ivaylo Angelov, Miklós Antal, Sherif Baha El Din, Boris Barov, Julieta Costa, Chang-Yong Choi, Nick Davidson, Damijan Denac, Tasos Dimalexis, Margus Ellermaa, George Eshiamwata, Richard Grimmett, Dieter Haas, Rick Harness, David Horal, Roger Jaensch, Helmut Jaklitsch, Vicky Jones, Frans Koops, Dražen Kotrošan, Aleksi Lehikoinen, João Loureiro, Alexander Matsyna, Guillam McIvor, Taej Mundkur, Markus Nipkow, Derek Pomeroy, Dave Pritchard, Alice Ramsay, Borut Rubinič, Mike & Ann Scott, Ivan Scrase, Svetoslav Spasov, Elchin Sultanov, Lukas Viktora, Roland van der Vliet, Tatyana Yassievich, Leo Zwarts.

Picture on the cover: Blue Crane (*Anthropoides paradisea*), collision victim of transmission line in South Africa. © EWT-WEP.

CONTENTS

Executive Summary

Power lines constitute one of the major causes of unnatural deaths for birds in large parts of the African-Eurasian region, with an estimated many millions of victims each year. The main causes of death are from electrocution and collisions, each of which affects different species.

Electrocution of a bird occurs when it bridges the gap between two energized components or an energized and an earthed (also called 'grounded') component of the pole structure. This results in a short circuit, with current flowing through the bird's body, and electrocution. Electrocution mainly involves larger species that perch or nest on wires or poles, with low to medium voltage lines posing the greatest risk; this is due to the close spacing of the structures. Consequently, large birds of prey and storks, particularly in habitats where perches and nest sites are limited, are at most risk. Most incidences occur during the breeding season and in the months proceeding, when young birds are most affected.

A bird collision occurs when a flying bird physically collides with an overhead cable. The bird is typically killed by the impact with the cable, the subsequent impact with the ground, or dies from the resulting injuries. Collisions can occur at all above ground lines, although most commonly at high voltage lines; this is due to the relative abundance of wires in multiple vertical layers. Fast-flying species with poor manoeuvrability and poor forward vision are thought to be the most frequent victims. Furthermore, collision risk is highest during periods of limited visibility, such as twilight or at night.

In addition to direct mortality resulting from electrocution and collision, power lines can influence birds through disturbance and habitat loss. In contrast, structures associated with power lines may provide benefits to birds through providing nesting and perching sites, particularly in open habitats. These effects, however, are minor in comparison to the negative effects of electrocution and collision.

The exact numbers of birds killed through electrocution or collisions with power lines is difficult to estimate, although, depending on the size of the grid and species present, up to 10,000 electrocutions and many 100,000s collisions are thought to occur per country in the African-Eurasian region each year.

Although a large number of studies, including previous reviews, have been published, inconsistencies between studies, difficulties in accessing reports and the anecdotal character of much of the information are the main factors limiting better estimates of the scale of the problem. The same applies for the solutions to avoid electrocution and various measures to mitigate collisions.

In order to address the current uncertainty as to the extent of the problem of power line related bird mortality in the African-Eurasian region, the secretariats of the Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (UNEP/AEWA) commissioned a review covering all aspects of the conflict between migratory birds and electricity power grids, and guidelines for mitigating and avoiding this conflict within the African-Eurasian region.

This review aims to present an up-to-date overview of the nature, scale and impact of the electrocution and collision of birds across the African-Eurasian region, including a summary of the aspects involved and gaps in knowledge. It also includes recommendations for actions to reduce the level of bird mortality. Technical and legislative solutions as well as suggestions for evaluating and monitoring the effectiveness of mitigation and preventative measures are covered in the separate guidelines document 'Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region'.

This review includes information gathered through a questionnaire, which was sent to a range of parties across the African-Eurasian region, and through literature searches of both published and non-

published material. Combining the information available with the extent of above ground power line networks in the region, large gaps in the knowledge become apparent. In particular, much is still unknown, or at least not readily available, on the extent of bird mortality through electrocution and collision and its impact on bird populations in Asia and Africa. Although more information exists for Europe, this is often based on anecdotal reports or poorly designed studies with limited temporal or spatial effort and a lack of control for biases. Furthermore, information is largely limited to rare or large, conspicuous species.

Few international conservation instruments have specific recommendations and actions formulated for their Parties on the problems of bird electrocution and collision in relation to the construction of new power lines or existing power line transects. The texts that do exist contain only general aspects of conservation, although some Action Plans, Resolutions and Recommendations and information documents distributed among Parties and others, give special attention to the problems of electrocution and collision. These, however, often focus on specific habitats or species. Almost all countries have legislation that brings the construction of power lines under a regime of an Environmental Impact Assessment (EIA), which should take into account existing habitat and wildlife conservation legislation, including for birds. Specific mention of the problems of electrocution or collision is rare.

Actions to reduce the level of power line mortality have included routing all low to medium voltage power lines underground, avoiding key areas for birds, avoiding routes that transect major or key flyways, the removal of redundant power lines and, for existing power lines, the use of preventative and mitigation measures.

Preventative and mitigation measures have proven to be effective in reducing the level of mortality from both electrocution and collisions. The insulation of cables close to poles, replacement of dangerous structures with bird-safe designs and the addition of safe perches, at a safe distance from energized structures, can prevent electrocutions. Similarly, measures such as using line configurations with wires in a small number of planes and no ground wires or the addition of high contrast, reflective or moving markers have been shown to lessen the risk of collision.

The sheer extent of the region’s power line networks renders it impossible to mitigate the impact on birds along its full length, or even at the national level. Therefore, a strategic approach is recommended, which prioritizes potentially problematic sections of power lines using priority lists of areas and species of conservation concern. In order to ensure consistency with this approach, standardized protocols for research and monitoring should be established.

Existing power lines should be examined on their risks for bird electrocution and collision using standardized protocols and wherever possible appropriate mitigation measures should be put into place.

In the first instance, voluntary arrangements between government agencies, NGOs and electricity companies aimed at reducing the impact of power lines on bird populations, should be established. This could lead to Memoranda of Understanding (MoU), and possibly later policy and actions, aimed at reducing the level of mortality resulting from electrocution and collision. National Working Groups should be established to review the national situation, and discuss priority actions for mitigation measures.

Finally, in order to provide Parties with the most up-to-date information on the best possible mitigation techniques and measures, it is recommended to produce an update on this Review report and Guidelines in the near future.

1. Introduction

Background

Because of their size and prominence, above ground electrical infrastructures represent important risks for birds if certain precautionary measures are not taken. Most above ground power lines (both medium voltage distribution lines and medium to high voltage transmission lines) present potentially fatal risks for birds through risks of collision with overhead wires and the risk of electrocution. A bird collision occurs when a flying bird physically collides with an overhead cable. The bird is typically killed by the impact with the cable, the subsequent impact with the ground, or dies from the resulting injuries. Electrocution of a bird occurs when it bridges the gap between two energised components or an energised and an earthed (also called 'grounded') component of the pole structure. This results in a short circuit, with current flowing through the bird's body, and electrocution, often accompanied by an outage of the electricity supply.

Power lines are one of the major causes of unnatural deaths for birds in a large part of the African-Eurasian Flyways with, for example, an estimated many millions of collision victims each year in Germany alone (Hoerschelman *et al.*, 1988). In several European countries a relative high proportion of collision victims involve endangered species of Appendix I of the Birds Directive, *e.g.* Eurasian Spoonbill (*Platalea leucorodia*) and Black-tailed Godwit (*Limosa limosa*) in the Netherlands, and several bustard and eagle species in Spain and Portugal. The problem is also believed to be serious in Africa. In South Africa, for example, the survival of several IUCN Red Listed species, such as Blue Crane (*Anthropoides paradise*) and Ludwig's Bustard (*Neotis ludwigii*), is believed to be severely threatened due to collisions with power lines. Unfortunately, for most of the continent concrete data are missing.

Although nowadays electrocution is not much of a problem in Northwest Europe, where most of the lower voltage lines have been placed underground, there are still many countries, both in Europe and elsewhere along the African-Eurasian Flyways, where low and medium voltage lines have not been equipped with proper mitigating measures. In these countries electrocution poses a serious threat to a number of populations, in particular storks and raptors that build their nests on the electricity poles or use the poles as perches. There are indications that for certain bird species, particularly larger species, electrocution may be the most serious cause of death; even more than road traffic (Haas *et al*., 2005). Electrocution of birds is not just a conservation issue, it also has serious economic and financial consequences due to the disruption to power supplies and thereby presents a cause for concern among electricity distribution companies.

Unfortunately, many electricity companies are not aware of, or are reluctant to apply, state-of-the-art bird safety provisions. Sensible changes to the routing of the power lines and changes to the structures (both marking overhead wires and modifications to avoid electrocution) can effectively reduce the risk posed to birds by 50 percent or more.

A large number of studies, including previous reviews, have been published on the issues involved. However, the information is scattered, not always easily accessible (much in internal reports and 'grey literature'), much is of anecdotal character and an overview of the magnitude of the conflict between birds and electricity power grids at the scale of the African-Eurasian region is lacking. The same applies for the solutions to avoid electrocution and various measures to mitigate collisions. Therefore, the secretariats of the Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (UNEP/AEWA) commissioned a review of all aspects of the conflict between migratory birds and electricity power grids, and guidelines for mitigating and avoiding this conflict within the African-Eurasian region.
Because of the extensive information collated, the review at hand has been published as a separate background report to the guidelines document, published as AEWA/CMS Technical Series No. XX titled 'Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in

the African-Eurasian region' (Prinsen *et al*., 2011). The focus of this review is to present an up-to-date overview of the nature, scale and impact of the electrocution and collision problem for birds from the wider area of the African-Eurasian region, including an overview of the aspects involved and gaps in knowledge on the the extent of bird fatalities. It includes recommendations for appropriate actions. The separate guidelines document, on the other hand, summarises the state-of-the-art mitigation/avoiding measures and solutions, both technical and legislative, as well as suggestions for evaluation and monitoring.

Sources of Information

This review is based on three main sources of information.

Firstly, information on the bird-power line conflict was directly sought from the Range States within the AEWA region through a questionnaire. For this purpose the UNEP/AEWA and UNEP/CMS Secreatariats provided a list with 175 Focal Points and/or CMS Raptor MoU Contact Points within the African-Eurasian region. Together with an introductory letter, provided by the UNEP/AEWA and UNEP/CMS Secretariats, each of these contacts was sent a questionnaire by email in February 2011. The questionnaire contained questions on national policy, solutions undertaken, status of technical standards, successes and bottlenecks and status of scientific work and research on the topic of interactions between birds and the electricity grid in the country (Appendix 1). In spring 2011, up to four follow-up requests by email or telephone were carried out to remind the contact persons of the questionnaire. Nevertheless, in the end only a small number of enquiries (from less than 25% of the Range States) was returned, mostly from Europe and less so from Asia and Africa (Appendix 2). For the latter two regions, this possibly reflects the fact that information available on the subject of bird-power line interactions is genuinely limited and/or possibly that the topic is just not on the agendas of governmental agencies. A full list of persons, institutes and organisations contacted and their responses is available from the UNEP/AEWA Secretariat.

Secondly, in summer 2011 the same questionnaire was sent to a number of Non-governmental Organisations (NGOs) and researchers in especially Asia and Africa, regions for which scant information on the topic was received thusfar. These included, amongst others, BirdLife International offices, national BirdLife partners, Wetlands International offices, and Partnership for the East Asian - Australasian Flyway, as well as researchers in, for example, Morocco, Sudan, Azerbaijan, the Russian Federation, and Mongolia. Through these contacts some additional unpublished information was received that has been included in this review.

Finally, existing information was obtained from scientific and other publications, including review papers, and regional reports, as well as non-published information from 'grey' reports. For this we searched internet databases ISI Web of Knowledge, Zoological Record and JSTOR for scientific studies on bird-power line interactions and internet search engine Google™ for other publications and reports. Also the authors requested unpublished reports from utility companies, consultancies and private persons. The reference lists in this first set of material was further perused for any outstanding publications and reports and this procedure was repeated until no new relevant studies were encountered. Literally hunderds of publications and 'grey' reports are available on the topic of bird-power line interactions. In order to keep focus, the review has been limited to those publications and reports that present results from studies specifically directed at establishing number of casualties, underlying causes and/or solutions as well as studies on behaviour of birds near power lines. Numerous publications that report on incidents of electrocution or collision with a high anecdotal character have not been included.

Appendix 2 presents an overview of the amount of information available on the topic of bird electrocution and collision in the different Range States. Unfortunately, almost no information was retrieved from large parts of Asia (including the Russian Federation and Range States in the former Soviet Union) or the Middle East, and the amount of information available in these countries is unclear. From this region the only questionnaires returned were from Azerbijan and Israel, from which additional information was used. From other Range States in Asia and the Middle East no information was received from Focal Points, NGOs or researchers we contacted with our request for information. Publications in languages other than English, German or French (or without an abstract in one of these languages) were probably overlooked in our searches of internet databases. Searching for publications in, for example, Russian or cyrrilic, was outside the available scope of this project. The same applies to a lesser extent for Range States in Africa. However, based on the information received in the enquiries returned (see Appendix 2) and through our network of contacts on the continent, we believe that the little information presented in this report from this region truly reflects what is available.

Outline

The following chapters present an overview of the nature, scale and impact of the electrocution (**chapter 2**) and collision (**chapter 3**) problem for birds. Each of these chapters contain a general introduction dealing with contributing factors and causes, which is followed by an overview of species involved and magnitude and conclude with a regional overview of the electrocution respectively collision conflict. **Chapter 4** describes effects of disturbance and habitat loss resulting from power lines, while **chapter 5** presents a number of positive side effects of power lines for birds. **Chapter 6** presents an overview of some of the legal and semi-legal obligations as laid down in international conventions, treaties, Memoranda of Understanding, and national legislation. **Chapter 7** presents the conclusions of this review, summing up the most important gaps in the knowledge. Finally, **chapter 8** lists recommendations for appropriate actions on how to solve the conflicts between birds and power lines.

2. Electrocution

2.1. Introduction

Electrocution of birds

There are millions of kilometers of power lines throughout the world constructed with minimal consideration of the environmental impact. Power line electrocution causes annually the deaths of tens of thousands of birds around the world (Bevanger, 1994; Bayle, 1999). In some areas it is considered the main reason for the decline of endangered species (Ferrer *et al.*, 1991; Real and Mañosa, 1997; Bevanger and Overskaug, 1998). Electrocution normally results in the death of the bird and can cause a power outage with the potential to affect many customers. Electrocution may take place when a bird simultaneously touches two energised phase conductors or a phase and grounded hardware. This may occur when birds are landing or taking off and the wings bridge the gap between the energised wires of different voltages, causing a short-circuit. On the other hand, a bird perched on a cross-arm may even be killed by touching only one conductor (Janss, 2001). Another type of electrocution (often called a flashover) occurs when the bird or nesting material bridges the gap between the wires and the grounded power pole, causing a ground-fault (Haas & Nipkow, 2006). In the breeding period electric companies generally experience more flashovers, due to nesting material or prey falling out of the nests touching the conductors (Bevanger, 1994).

Scientific interest

The problem of bird electrocutions was first addressed in the early 1970s, when thousands of raptors were found to be killed in North America due to this reason (APLIC, 2006). Since then, extensive research has been conducted on the problem of bird electrocutions, especially in North America, Western Europe and South Africa (Lehman *et al.*, 2007; Manville, 2005). Appendix 2 presents an indication of the amount of information available for each range state within the African-Eurasian region.

Much research on the topic was often conservation related, but frequently also motivated by the financial losses that energy suppliers suffered due to the power interruptions and reparations caused by bird electrocutions. For example, Antal (2010) estimates that in Hungary at least US$ 7 million is

spent annually in retrofitting existing power poles to mitigate electrocution. There are indications that for certain bird species electrocutions may be the most serious cause of mortality representing, for large birds, an even higher risk than road traffic (Haas *et al.*, 2005). In certain cases it can have important negative effects on the local scale or even at the population level, such as has been documented for Saker Falcon (*Falco cherrug*) (Harness *et al.*, 2008), Golden Eagle (*Aquila chrysaetos*) (Lasch *et al.*, 2010; Manville, 2005) and Eagle Owl (Bevanger & Overskaug, 1998; Rubolini *et al.*, 2005). Appendix 3 presents an overview of the severity of impacts on bird populations due to electrocution with power lines for different bird families in Eurasia and Africa.
In Europe a wide variety of raptors, storks, owls, corvids, and other passerines of all sizes are reported to suffer electrocution on power lines (Bevanger, 1998; Negro *et al*., 1989; Janss, 2000; Moleon *et al.*, 2007), and electrocution may pose a serious threat to certain endangered species such as the Spanish Imperial Eagle (*Aquila adalberti*) (Ferrer *et al.*, 1991; Ferrer & Hiraldo, 1992; González *et al.*, 2007) and the Bonelli's Eagle (*Aquila fasciata*) (Real *et al.*, 1997, 2001).

2.2. Contributing Factors and Causes

Electrocution risk is influenced by multiple factors within a bird's environment. Bird electrocutions on power lines result from three main aspects: biological, technical and topographical (or environmental). These aspects are linked together and are not easily separated. The problem is complex because of the diversity of topographical aspects and diversity in electrical installations and equipment, as well as bird species with individual traits and behaviour.

2.2.1. Technical Issues

The most obvious factors contributing to electrocution are power line type and configuration of electrical hardware on support structures. The spacing between the wires and the pole, the cross-arms or other energised parts explains to a large extent the number of casualties and are considered a key factor (Figure 1). In order for electrocution to occur, contact must typically be made with fleshy parts of the bird, such as the skin, feet, or bill. Large birds are more commonly affected because they can more easily touch two cables or charged parts of a power line structure at once. Consequently, most electrocutions are of large birds, such as eagles, hawks, and ravens (APLIC, 2006). Most casualties occur at power poles of medium voltage distribution lines (1kV to 60 kV), which is due to the close spacing of the different parts (Haas & Nipkow, 2006). Low voltage wires (below 1 kV) seem not to cause casualties, while at higher voltages (mostly transmission or transportation lines) the wires are generally placed far enough apart to prevent birds spanning the wires (Janss, 2001). However, victims may occur even at the highest tensions as raptors and other species frequently use towers for nesting purposes (Bevanger, 1994).

The basic shape of poles and pylons used to support above ground power lines are very similar worldwide (*i.e*., T-shape poles and Delta-shape pylons), but many different types exist, even differing from company to company within one country. In Europe, nearly all utility structures, including cross-arms, are constructed of steel or steel-reinforced concrete and are conductive and grounded by design (Bayle, 1999; Janss, 2000). A bird perched on a cross-arm can be killed by making contact with just one conductor (Janss & Ferrer, 1999); consequently, mortality levels can be extremely high. Adamec (2004) reported annual mortalities in Slovakia exceeding 10,000 birds. Given such losses, Bayle (1999) suggested the only reliable solution is to place virtually all medium voltage power lines on the continent underground. The idea has been taken into account and Belgium, the United Kingdom, Denmark, Germany and Austria, are working towards that goal, while in the Netherlands, the process has already been completed (Lehman *et al.*, 2007).

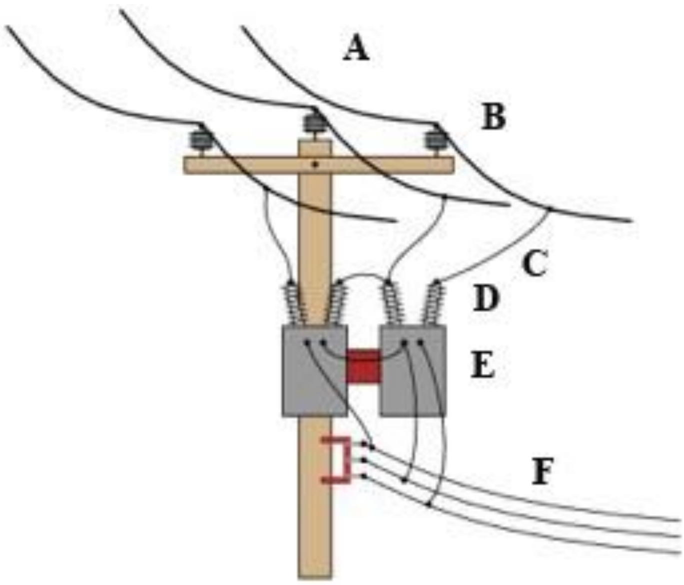


Figure 1. An example of a pole-mounted transformer (source: www.allaboutcircuits.com). This kind of construction is especially dangerous to birds because of the short distances between energised parts and between energised and grounded parts. In this case, the three energised phase conductors (A) are mounted on top of the pole, using short upright insulators (B) and are connected to a pole-mounted grounded transformer (E), using bare jumper wires (C) and exposed bushings (D), all key elements of a problem construction. The lowest wires are low voltage utility lines (F) that generally are not considered to be dangerous to birds because of the relatively low voltage and high electric resistance of birds (Haas et al., 2005).

In South Africa, most electrocutions (up to 95%) occur on four types of power line structures: 22 kV wooden T-structures, 88 kV steel kite transmission towers, terminal H-frame wood structures and Delta suspension structures (Kruger, 1999). Unfortunately, no specific information on technical specifications of power line design has been received from other areas within the African-Eurasian region. From the literature it is however clear that problem poles (constructed from wood, concrete or steel) with high electrocution risk exist throughout the region (see examples in paragraph 2.5).

2.2.2. Biological aspects

The main biological aspects regarding electrocution are linked to bird morphology and behavioural patterns (Bevanger, 1994). Biological and topographical aspects that influence electrocution risk include: body size, habitat, prey availability, behavioural patterns, age, season and weather.

Body size is one of the most important characteristics related to bird electrocution. In general, large birds are more affected, this is simply because the conductors and ground/earth wires or earthed devices are placed too far apart for smaller birds to touch them simultaneously (Janss & Ferrer, 1999). However, because utility structures, including cross-arms and poles, are commonly constructed of steel or steel-reinforced concrete, and are conductive and grounded in design, size seems to be relatively less important in Europe than in other continents (Bayle, 1999; Janss, 2000). As a consequence, all species of bird are theoretically at risk.

In general, the chances of electrocution are enlarged when the feathers are wet, during periods of high humidity or when the bird defecates on the wires (Haas & Nipkow, 2006; Lehman *et al.*, 2007). However, skin-to-skin contacts (*e.g.* at the carpal joint, the leading edge of ventral wing surfaces) seemed to be even more dangerous (Lehman *et al.*, 2007). The prevailing wind direction also plays a role in shaping the rate of electrocution casualties. In this aspect, winds parallel or diagonal to the cross-arms are the most detrimental, due to enhancing difficulties during landing or take-off. In addition, more casualties seem to occur in the breeding period. In particular, carrying nest material or prey to feed the chicks increases the effective span, resulting in higher chances of touching conductors (Lehman *et al.*, 2007).

Generally, juvenile and sub-adult individuals seem to suffer higher losses than adults. This is likely to be caused by inexperience in landing and taking off or in hunting methods. On the other hand, this phenomenon might occur simply due to the higher percentage of young birds in a population and due to the often more gregarious behaviour of this age group (Bevanger, 1998). Most casualties are reported from late summer, from the period of fledging or post-fledging (Bayle, 1999; Bevanger, 1998; Lasch *et al.*, 2010; Lehman *et al.*, 2007; Manville, 2005). Ferrer & Hiraldo (1992) observed age and gender influences in the Spanish Imperial Eagle: 88% of all deaths were immature birds and 78% of all deaths were females; the high mortality rate in females being attributed to their larger size.

Landscape factors may also contribute to attract raptors or concentrate birds in the vicinity of power lines (Hunting, 2002). These may include vegetation structure and composition, prey density and perch availability. Power lines, poles and towers may be of benefit to raptors, owls and corvids in areas where trees for nesting or roosting are rare, such as on plains, in deserts and intermontane basins (APLIC, 2006). In South Africa, vultures often occur in open habitats lacking natural perches. Furthermore, Cape Vultures (*Gyps coprotheres*) and African White-backed Vultures (*Gyps africanus*) are highly gregarious and often gather on power line structures in large numbers. In these settings, crowding and competition for perches can lead to numerous electrocutions (Lehman *et al.*, 2007). The use of power poles and wires as hunting perches, roosting or nesting sites is a key factor in the analysis of electrocution problems (Bevanger, 1994; APLIC, 2006).

As birds prefer perching on power poles that provide the best field of view, a considerable proportion of the electrocutions (especially of raptors and owls) occur at the highest poles in the surroundings (Lehman *et al.*, 2007; Manville, 2005). In many newly established power poles, the lines are attached to upright insulators mounted on the top of the cross-arms (Figure 1). Large birds landing on these so-called “killer pole” constructions can easily be electrocuted by touching the energised wires (Haas & Nipkow, 2006). These birds (*e.g.* the thermal soarers: hawks, eagles, vultures, storks) are generally more prone to electrocution than other species (Bevanger, 1998; Demerdzhiev *et al.*, 2009). In that sense, ground-nesting species (*e.g.* cranes) are less vulnerable than tree-nesting species. Furthermore, in contrast to species breeding in forests, the rate of electrocution can be considerably higher in species breeding in open landscapes (*e.g.* wetlands, grasslands), where natural perches or nesting places are scarcer (Haas *et al.*, 2005; Lehman *et al.*, 2007).

2.3. Species Involved and Magnitude

Species differences are extremely important in understanding the dynamics of electrocutions. Some species are prone to electrocution because they are large, and can easily span distances between energised or grounded components of power poles, and others are susceptible because they live in areas lacking natural perches (Olendorff *et al.*, 1981; Janss and Ferrer, 1999). The species reported to most often fall victim to electrocution belong to Ciconiiformes, Falconiformes, Strigiformes and Passeriformes (Bevanger, 1998; Rubolini *et al.*, 2005). Species in this latter group are often not large-bodied, but fly or roost in dense flocks, and may also cause short-circuits, due to the electric current passing through several individuals (Bevanger, 1998). Appendices 3 and 4 present an overview of the main species groups involved in the conflict between birds and power lines and give an indication to what extent electrocution mortality impacts bird populations.
In Europe, raptors most often found below power poles include the Common Buzzard (*Buteo buteo*), Black Kite (*Milvus migrans*), Red Kite (*Milvus milvus*), and Common Kestrel (*Falco tinnunculus*) (Lehman *et al.*, 2007). Of the 37 raptor and owl species breeding or wintering in Western Europe, 30 (*i.e.* 81%) have been shown from various studies in the 1970s – 1990s to regularly become victim to electrocution (Bayle, 1999). Altogether 42 of the species found to become victim are listed as rare or vulnerable, of which 22 are mentioned as endangered in the Appendices I and II of CMS (Bevanger, 1998; Haas & Nipkow, 2006; Manville, 2005). Electrocution mortality rates appear to be species-

specific and are not always a major cause of death for the species as a whole. For instance, out of 627 recorded causes of death of Barn Owls (*Tyto alba*) throughout Britain during 1963-1989 only 0,3% were attributed to electrocution (Newton *et al.*, 1991), while in Hungary 1,3% was found for the same species based on 252 individuals (Matics, 2000). However, many of the affected species are relatively rare, slowly reproducing and often without natural predators, and hence electrocution contributes relatively to a large extent to the cumulative mortality. In order to ensure sustainable populations such unnecessary and relatively easy-to-avoid death casualties should be avoided (Bevanger, 1998).

Electrocution is probably the main cause of declines in Bonelli's Eagle in Spain and France (Real *et al.*, 1996; Real & Manõsa, 1997), and in the Eurasian Eagle Owl (*Bubo bubo*) in France (Bayle, 1999) and Italy (Rubolini *et al.*, 2001). According to the European Union's action plan for the Bonelli's Eagle, reduction of electrocution mortality is likely to be critical to the survival of the species (Arroyo and Ferreiro, 1998). Resolving electrocution issues has already been critical to the survival of the Spanish Imperial Eagle, one of the most endangered raptors in the world (Janss & Ferrer, 1999).

In South Africa, at least 14 species of diurnal raptor and five owl species have been found electrocuted on power facilities (Smallie *et al*., 2009). Two species, the Cape Vulture and the African White-backed Vulture, have appeared in electrocution records in large numbers since studies began in the early 1970s (Markus, 1972; Ledger & Annegarn, 1981; Kruger, 1999).

2.4. Regional Overview of Electrocution Conflict

There is a large difference in the amount of (quantitative) information available between countries and regions. In some countries the problem of electrocution of birds with power lines has been extensively studied (Appendix 2). However, in most countries the scale and nature of the problem is still unknown. An unknown amount of the existing information is also published in grey literature, which tends to be difficult to access and not subjected to peer-review.

The interpretation and comparison of studies is a challenging task. Comparison of results (even from one and the same country) is often very difficult or practically impossible, due to the large differences in study areas (habitat, climate), species, duration of the studies, seasons, types of power line (voltage, configuration) and the applied methodologies, including the application of several correction factors (search efficiency, disappearance rate, crippling bias, etc.). Documentation of the magnitude of the problem uses different units (*e.g.*, % of total mortality, casualties/km or per pole), which also hinders comparison. Finally, there is also a large number of studies in which the distinction between victims of electrocution and collision is not (or only partly) made, often because it can be difficult to determine the cause of death.

With this in mind, below we summarize the current knowledge per region, with special attention to the most vulnerable taxa and the most dangerous electricity configurations. The review relies on peer-reviewed literature, unpublished studies and reports as well as answers to the questionnaire sent to 175 Focal Points and/or CMS Raptor MoU Contact Points within the African-Eurasian region in February 2011 (see chapter 1). The paragraphs below present information on the three main regions of the African-Eurasian region, namely: Europe, Asia and Africa. Based on regional similarities, Europe has been further divided into five sub-regions: Western Europe, Northern Europe, Central Europe, Eastern Europe and Southern Europe, while Africa has been divided in the sub-regions Northern Africa, Central and Western Africa, Eastern Africa and Southern Africa.

2.4.1. Europe

2.4.1.1. Northern Europe

In Northern Europe nearly all raptor and owl species were indicated as being vulnerable to electrocution. An analysis of the Finnish Ringing Centre revealed that 46% of all ringed birds (*n*=479) that died of electrocution in the period 1980 – 2003 were Eagle Owls, 22% Ural Owls (*Strix uralensis*) and another 11% Tawny Owls (*Strix aluco*), and thus these three species comprise 79% of all recorded electrocutions of ringed birds (information from returned questionnaire Finland; M. Ellermaa, BirdLife Finland, *in litt*.). A questionnaire answered by 175 Norwegian power companies revealed that the most dangerous constructions frequently causing bird electrocutions in the region can be classified in three main groups: (1) top-mounted pin insulators, (2) steel cross-arms and (3) pole-mounted transformers (see Figure 1 for typical location on a pole). Pole-mounted transformers (Figure 1) or equipment connected to them (such as poles where overhead wires are disbranched into underground cables) were believed to be responsible for 68% of the bird electrocutions (Bevanger, 1994).

In Northern Europe, Eagle Owl casualties are the most frequently mentioned and electrocution is considered to be the most important mortality factor for this species and possibly the main reason for the decline of the population (Bayle, 1999; Bevanger & Overskaug, 1998). Although most research has been carried out in Norway, power lines were reported to be responsible for 22.6% of identified cases of mortality of Eagle Owls in Sweden and Finland, and for 32.5% in Germany (Bayle, 1999 and references within). According to records of the Finnish Ringing Centre, 10.3% of the Eagle Owls ringed in Finland with a known cause of death in the period 1980-2003 (n=2,153) died of electrocution (information from returned questionnaire Finland; M. Ellermaa *in litt*.). In Norway, of 27 juvenile, artificially reared and radio-tagged Eagle Owls, 22 were reported killed following their release, of which 12 were electrocuted (Larsen and Stensrud, 1988). In the Norwegian county of Nordland, of a population of 40-50 Eagle Owl pairs, 30-40 adults were killed by utility structures in the last twenty years. Of these 90% were killed by electrocution (Bevanger *et al.*, 2009).

In Finland Ural Owls are also known to be at risk from electrocution. Based on data of the Finnish Ringing Centre, 7% of deaths of this species appear to be due to electrocution. Other species found as regular electrocution victims in Finland in the period 1980-2003, were: White-tailed Eagle (*Haliaeetus albicilla*) (n=9), Osprey (*Pandion haliaetus*), Northern Goshawk (*Accipiter gentilis*) (n=35), Kestrel and Jackdaw (*Corvus monedula*) (n=10) (information from returned questionnaire Finland; M. Ellermaa *in litt*.). In the archipelago of Åland the most dangerous poles are often on the shore where sea cables come ashore and the first terrestrial pole is present. These poles seem to be attractive for perching White-tailed Eagles and Eagle Owls and consequently killed relatively large numbers of these species prior to retrofitting in 2006 (Stjernberg *et al*., 2007).

In Sweden, species at risk of electrocution include the Eagle Owl in particular, as well as, White-tailed Eagle, Golden Eagle and Ural Owl (Schürenberg *et al.*, 2010). In Iceland, the number of bird species at risk from electrocution is relatively small, but comprises species such as the White-tailed Eagle, Gyrfalcon (*Falco rusticolus*) and Merlin (*Falco columbarius*), as well as waders, like Whimbrel (*Numenius phaeopus*) and Curlew (*Numenius arquata*) as well as large gulls (Schürenberg *et al.*, 2010).

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**
Clear-felled areas in forests / forest edges / mountainsides	Eagle Owl, Ural Owl	20 - 45% of death casualties for Eagle Owl and 7% for Ural Owl	Problem decreases after insulating conducting parts and using closed transformer kiosks

Summary of information on electrocution retrieved from Northern Europe: mostly from Norway and Finland but also applicable to Sweden.

2.4.1.2. Western Europe

In Western Europe, the process of putting medium voltage distribution lines underground has been completed in the Netherlands and is being carried out in Belgium, the United Kingdom, Denmark, and

Germany. Hence, the problem of bird electrocutions appears to be uncommon or reducing in this region (Tucker *et al.*, 2008).

2.4.1.3. Central and Eastern Europe

<u>Central Europe</u>
Except for Austria, where a large percentage of the medium-tension power lines is already placed underground, storks, raptors and owls seem to be largely affected by electrocutions in Central Europe. In Hungary, 877 electrocuted birds of 46 species were found under 6,500 medium voltage electric poles, which represents only 1% of the total number of medium voltage electric poles of the country (Kovacs *et al.*, 2008). The annual number of bird casualties on power lines throughout the country may exceed 30,000 (Demeter, 2004). Relating the number of electrocution casualties between 2003 and 2008 to the size of the bird populations in Hungary revealed that the most vulnerable species was the Golden Eagle, followed by the Common Kestrel, the Saker Falcon and the European Roller (*Coracias garrulus*) in a decreasing order of vulnerability (Horvath *et al.*, 2008). Interestingly, based on this analysis, the Imperial Eagle (*Aquila heliaca*), the Eagle Owl, the White Stork (*Ciconia ciconia*) and the Black Stork (*Ciconia nigra*) were considered to be relatively less vulnerable, comparable to the Red-footed Falcon (*Falco vespertinus*) and the Common Buzzard. Furthermore, the White-tailed Eagle and the Peregrine Falcon (*Falco peregrinus*) seemed to be less sensitive to the problem (Horvath *et al.*, 2008). The most detrimental pylon types appeared to be strain poles (Figure 2), followed by switch towers and transformer stations. Common support poles, which make up around 70% of all pylon types, seemed to be relatively less harmful (Horvath *et al.*, 2011).

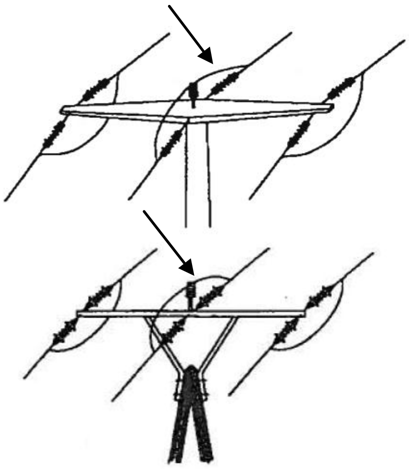


Figure 2. Examples of a strain pole (source: Haas & Nipkow, 2006). Dangerous to landing and perching raptors because of close distance between energised conductor wires and energised jumper wire (arrow) across top of pole.

In Central Europe, electrocution is a major cause of death in White Storks and Eagle Owls and consequently these species are the most thoroughly studied (Janss, 2001; Marti, 1998). In Switzerland, among 1,130 White Stork recoveries with a known cause of death, 46% had died of electrocution or collision with power lines (Moritzi *et al.*, 2001). In Hungary, 94% of all known White Stork casualties between 1941 and 1994 were related to power lines (Lovaszi, 1998). In Poland, the annual loss of White Storks due to electrocution is estimated at approximately 510 individuals (Schürenberg *et al.*, 2010). In the case of Eagle Owls, electrocution accounted for 24% of all fatalities in the northwestern part of Switzerland, and it have been suggested that the elimination of this mortality source could result in a population increase of 17% (Schaub *et al.*, 2010). In Germany, out of 1,583 Eagle Owl corpses found between 1965 and 2005, 26% had died due to electrocution (Breuer, 2007).

Habitat type	Taxa known to be susceptible	Documented magnitude of problem	Remarks
Clear-felled	Eagle Owl,	Largest publ. mortality	

areas in forests / forest edges	Golden Eagle	factor: > 20% of mortality	
Lowlands without trees	Imperial Eagle, Peregrine Falcon, Saker Falcon, Common Kestrel, European Roller	Largest publ. mortality factor: 0,5 - 1,5% annual mortality of total population	Deterrents and barriers, suspended insulators and cross-arm covers are good remedies. Burying cables locally carried out.
Wetlands	White Stork	Largest publ. mortality factor: > 40% of mortality related to electricity	Placing elevated nest platforms is commonly done

Summary of information on electrocution retrieved from Central Europe: most data available from Hungary, Switzerland and Germany, with further information used from Poland, Slovakia and the Czech Republic.

Eastern Europe

In Eastern Europe, in Bulgaria, Stoychev & Karafeizov (2003) analysed the Bulgarian power line network and judged a significant portion of the 20 kV lines to present an electrocution hazard. It was estimated that only 5% of the existing network is avian-safe. There is about 45,000 kilometres of distribution power lines that presents an electrocution hazard for birds. In a quantitative study of 105 bird carcasses (of which 77% died of electrocution) found under 140 kilometres of investigated power lines, representing 22 species, diurnal raptors, storks and crows were reported to form 53% of all electrocution fatalities (Demerdzhiev *et al.*, 2009). In a similar study, 66% of victims found under power lines (n=44) were suspected to be victims of electrocution and consisted mostly of diurnal raptors and corvids (together accounting for 62% of all electrocutions) together with a high percentage of storks (*i.e.* 21%) (Gerdzhikov & Demerdzhiev, 2009). A study carried out by BirdLife Bulgaria (BSPB) on the bird mortality in six SPAs in 2008-2009 as part of a EU LIFE project, confirmed similar mortality proportions among these species groups (Demerdzhiev, 2010). Of 292 registered electrocution victims, 29% were from the family Corvidae, 27% of the order Ciconiiformes and 21% of diurnal raptors, together amounting for 77% of all victims. The species showing the highest mortality rate due to electrocution was the White Stork (25%). Surveys and activities for reducing the effect of power lines on raptors are further implemented under the projects of Green Balkans Federation of nature conservation Non-Governmental Organisations, including studies on Lesser Kestrel (*Falco naumanni*), Eurasian Black Vulture (*Aegypius monachus*), and Imperial Eagle in their main habitats in Bulgaria.

In Bulgaria, metal towers with jumper wires (the short connecting wire, *e.g.* across the top of a pole, Figure 2) proved to be the most dangerous, accounting for 54% of all electrocution victims, followed by concrete poles with pin-type insulators mounted upward or sideways, parallel to the wires. Metal and concrete towers with suspended and/or downward fixed insulators seemed to pose a smaller risk. Electrocution was mainly affecting bird populations of open grasslands and cultivated lands, such as pastures, vineyards and arable lands, with no victims in forested areas (Demerdzhiev, 2010; Demerdzhiev *et al.*, 2009; Gerdzhikov & Demerdzhiev, 2009).

In Romania, there has been no systematic data collection for the whole of Romania, but the data that are available creates great concern. Studies report bird casualty rates of 0.045 - 0.07 birds/pylon/year, with storks and raptors being the most affected (information from returned questionnaire Romania; T. Papp *in litt*.). In Serbia, it has been estimated that between 10,000-100,000 birds died of electrocution or collision each year with *ca.* 70,000 kilometres medium voltage distribution power lines (information from returned questionnaire Serbia; M. Mladenovic, Ministry of Environment, Mining and Spatial Planning of Republic of Serbia, *in litt*.).

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**
Agricultural areas	Imperial Eagle, possibly also	Unknown	Mostly at metal

and grasslands without trees	Saker Falcon, Lesser Kestrel, Eurasian Black Vulture, corvids		towers with jumper wires
Wetlands	White Stork	0.01 birds/ pole/ year	Mostly during migration

Summary of information on electrocution retrieved from Eastern Europe: most data available from Bulgaria, with further information used from Romania.

2.4.1.4. Southern Europe

In the Southern Europe region, storks and raptors are the species groups most affected by electrocution.

In France, 96,5% of raptors found dead under power lines (*n*=649), were found under medium voltage power lines (Sériot & Rocamora 1992 in Bayle, 1999). Of all the raptors found, 93.5% were electrocuted (the remaining collided against electric wires). Another study, refered to in Schürenberg *et al*. (2010), reported 1,348 raptor casualties of power lines between 1982 and 2002. In both studies the species most affected were the Common Buzzard and the Common Kestrel. In another study in the Plain de Crau Important Bird Areas (IBA), 100 birds were found electrocuted; the groups of species most affected were corvids (45%), raptors (40%) and storks (6%). The Black Kite was the most affected raptor although endangered birds such as Bonelli's Eagles were also found dead (Bayle, 1999). Cheylan *et al.* (1996) reported that, out of 20 ringed juvenile Bonelli's Eagles found dead, 85% of them were electrocuted.
Kabouche *et al.* (2006) reported that electrocution was found to be the main cause of mortality of the Black Kite, the Griffon Vulture (*Gyps fulvus*) and the Short-toed Eagle (*Circaetus gallicus*) in Southern France. It was also considered a major cause of mortality for Bonelli's Eagles.

In Italy, a review of 11 bird mortality surveys was performed by Rubolini *et al.* (2005). Over 1,300 casualties were reported in power lines, involving 95 bird species. Raptors (especially Common Buzzard, Common Kestrel, Griffon Vulture, Osprey and Eurasian Sparrowhawk (*Accipiter nisus*)), flamingos, herons and storks were highly affected. Even though a distinction between electrocution and collision as the cause of mortality was not always available, the application of a statistical model allowed to conclude that raptors and corvids were mostly affected by electrocution, while herons, flamingos and small passerines died more frequently from collisions.
In the Alps and Apennines, electrocution was one of the major causes of death in the Eagle Owl, with 17% of fledglings estimated to be lost due this cause (Sergio *et al.*, 2004).

In Slovenia several cases of electrocutions of Eagle Owls and White Storks have been recorded. In the last 10 years, 42 Eagle Owls died of electrocution on medium voltage power lines, mostly on concrete electric poles (Milhelic *et al.*, 2011).
During the White Stork census in Slovenia carried out between 1999 and 2010, 45 dead White Storks were found. Of these, 78% (35 individuals) died due to electrocution, the majority in medium voltage lines (20kV transformers; Milhelic *et al.*, 2011).
From Greece there is a report of one electrocution event in August 2009 in which at least 85 White Storks (mostly immatures) were killed when a flock of 300 birds came in to roost at the SPA site of Sounion south of Athens. The utility company has since then retrofitted all the dangerous poles in the area where the event took place (T. Dimalexis, Nature Conservation Consultants, *in litt*.).

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**
Agricultural areas/ wetlands	Mainly raptors (Black Kite, Bonelli's Eagle, Common Buzzard, Common Kestrel)	Out of 649 birds killed by power lines, 93.5% were found electrocuted in France	Most common species electrocuted were Common Buzzard and Common Kestrel. Also important cause of mortality for Griffon Vulture, Short-toed Eagle and Bonelli's Eagle in Southern France

	White Stork	35 victims between 1999 and 2010 in Slovenia	
	Eagle Owl	42 victims between 1999 and 2010 in Slovenia	
	Corvids	45 victims in one IBA area in Southern France	

Summary of information on electrocution retrieved from France and Italy, with further information used from Slovenia.

In Portugal, nearly 900 kilometres of power lines (and 5258 pylons) were surveyed for dead birds between 2003 and 2005. A total of 945 birds were found dead from electrocutions, which represented 49% of the mortality caused by power lines (Infante *et al.* 2005). The most sensitive areas were steppe areas. The White Stork was the most affected species (137 electrocuted storks), especially during breeding and post breeding dispersal movements. Most of the casualties involved young birds and nest building adults. Threatened species were also affected, including, Osprey (1 individual), Golden Eagle (2), Griffon Vulture (12), Eurasian Black Vulture (*Aegypius monachus*) (1), Short-toed Eagle (32), Bonelli's Eagle (9), Montagu's Harrier (*Circus pygargus*) (6) and Lesser Kestrel (16). The most affected raptor was the Common Buzzard (146).

In a different study, a sample of 275 kilometres of medium and high voltage power lines were prospected mainly on protected Natura 2000 sites and IBA at a national level (including lines crossing habitats that were under-represented in previous sampling, such as scrublands and wetlands). Results indicated an estimated mortality of 153.52 birds due to electrocution, corresponding to a mortality rate of 0.25 birds/pylon/year. Differences were found for electrocution rates in different pole types: 1.52 ± 1.57 birds/pylon/year for triangular configuration (pin insulators) with tappings and 0.80 ± 1.35 birds/pylon/year for transformer stations (Infante & Neves, 2009).
In the Portuguese Islands of the Azores, a total of 1,765 power poles were patrolled systematically between July 2007 and November 2008. This sample represents about 19% of the total extent of power lines in the Azores. A total of 137 dead birds were identified as victims of electrocution corresponding to a mortality rate of 0.224 birds/pole/year (Sampaio, 2009). The most common victim due to electrocution was the endemic subspecies of the Common Buzzard (*Buteo buteo rothschildi*).

In Madeira, a total of 19 kilometres of power line was studied in four different seasons (only representing 1,3% of the total power lines in Madeira Island) between January 2007 and December 2008. Monitoring of power and transmission lines in Madeira is difficult due to topographical features and extremely dense forests. In these two years only two birds were identified as electrocution victims, corresponding to a mortality rate of 0.08 birds/pole/year. The habitats with the highest estimated mortality are "Coastal open areas" and "Agro-forestry mosaic" (Fagundes, 2009).

In Spain, a detailed review is available on bird electrocution studies carried out since the 1980s in various regions. As in other Southern European countries, raptors and storks were the most affected species groups. Some threatened species affected included the Spanish Imperial Eagle, the Bonelli's Eagle, the Eagle Owl, the Eurasian Black Vulture, the Griffon Vulture, the Egyptian Vulture (*Neophron percnopterus*), the Red Kite, the Short-toed Eagle, the White Stork, the Black Stork and the Northern Goshawk (Martínez, 2003; Palacios, 2003).

In Catalonia (Northeastern Spain), approximately 3,000 birds were estimated to fall victim to electrocutions every year (Mañosa, 1995). In a seven-year study (1999-2006) in the same region, 3,869 pylons were inspected for carcasses of electrocuted birds (Tintó *et al.* 2005, 2010). A total of 141 carcasses were found below 98 of the pylons (2.5%). The average electrocution rate was estimated at 0.036 carcasses/pylon. Carcasses involved 21 species, with diurnal raptors (33.3%), corvids (31.2%) and owls (12.1%) being the most common victims. The remaining 23.4% of the carcasses included doves, pigeons, small passerines, storks, cormorants, gulls and woodpeckers. Pylon design was the main factor making pylons potentially dangerous for birds. The safest designs were unearthed pylons with suspended pin-insulators or jumpers, alternate cross-arm configurations, and no connector wires. Pylons with a dominant position in the landscape, especially those placed on hilltops and surrounded by low vegetation cover (scrubland), had higher electrocution rates. These pylons were probably chosen by territorial bird species, such as raptors, as perching points from which they could detect potential prey items.

In the Doñana National Park, in Southern Spain, a sample of 100 kilometres of medium-tension power lines (16 kV) was surveyed during a two-year period (1982-1983) (Ferrer *et al.*, 2001). A total of 778 dead birds were found, of which 233 were electrocuted raptors and owls, including Griffon Vulture (14 individuals), Spanish Imperial Eagle (3), Short-toed Eagle (8), Booted Eagle (*Aquila pennata*) (9), Red Kite (15), Black Kite (82), Common Buzzard (35), Northern Goshawk (1), Common Kestrel (10), Peregrine Falcon (1), Kite species Milvus spp. (36), Falconiforme species (7), Tawny Owl (*Strix aluco*) (3), Barn Owl (7) and Little Owl (*Athene noctua*) (2).
Following a carcass-removal experiment, an estimation of 400 electrocuted raptors was obtained for the same 100 kilometres stretch of power lines, which would mean that 1,200 raptors died annually in the 300 kilometres extension of power lines present in and along the borders of the park (Ferrer *et al.*, 1991). Both pylon design and habitat had significant effects on the detected raptor mortality. Ferrer *et al.* (1991) recommended that only pylons with suspended insulators should be adopted, pylons with an exposed loop of wire above the insulators should never be used and power lines should be built along roadsides.

Another comprehensive study on the effects of power lines was conducted in southern Spain, in Sierra Morena oriental and Campo de Montiel, during an eight-year period (1988-1996) (Guzmán & Castaño, 1998). In this study, where a sample of 10 power lines (69 kilometres of lines and 1,629 poles) was surveyed, 274 raptors, belonging to 14 species, were found electrocuted. This included Eurasian Black Vultures (2 individuals), Griffon Vultures (1), Golden Eagles (23), Spanish Imperial Eagle (14), Bonelli's Eagles (17), Short-toed Eagles (9), Osprey (1), Red Kites (4), Black Kites (3), Common Buzzards (33), Northern Goshawks (71), Peregrine Falcons (7), Common Kestrels (7) and Eagle Owls (21). A Black Stork and a Raven (*Corvus corax*) were also found. The type of pylons used greatly influenced the probability of electrocution, with pylons with suspended insulators being considered safer.

Electrocution seems to be particularly hazardous to some species, such as the Spanish Imperial Eagle and the Bonelli's Eagle. In a 16-year period (1989-2004), more than half (50,2%) of the non-natural mortality of Spanish Imperial Eagles was related to the transmission of electricity (González *et al.*, 2007). Out of 241 individuals for which the mortality cause was known, 115 had died from electrocution. No differences were found between sexes, although sub-adults were electrocuted more frequently than expected. Electrocution was the most common cause of death in dispersal areas, but not in breeding areas. In a more recent review, 39.87% of the Spanish Imperial Eagle mortality recorded since 1974 (*n*=158) was assigned to electrocution (López-López *et al.*, 2011). However, electrocutions decreased considerably since 1990, when a mandatory regulation was approved, which resulted in the substitution of 6,560 dangerous pylons (López-López *et al.*, 2011).
In the case of Bonelli's Eagle a survey study of three power lines located in the species' dispersal areas resulted in the finding of 16 dead individuals (Moleón *et al.*, 2007). Other 92 raptors (of 15 species) were found electrocuted, mostly Common Buzzards and Eagle Owls.

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**

Wetlands/agricultural / steppe areas	White Storks, Common Buzzard,	Average mortlaity rate: 0.25 birds/pylon/year (Portugal); 1.52 ± 1.57 birds/pylon/year for triangular configuration	Raptor species most frequently electrocuted is Common Buzzard
Agricultural areas/ mountainous areas	Raptors, corvids and owls	Average electrocution rate:0.036 carcasses/pylon (Spain)	Pylon design and habitat had significant effects on raptor mortality.
	Bonelli's Eagles, Spanish Imperial Eagle, Eagle Owl	39.87% of Spanish Imperial Eagle mortality (*n*=158) was caused by electrocution	Large diversity of raptor species affected, including some highly threatened species

Summary of information on electrocution retrieved from Spain and Portugal.

2.4.2. Asia (including Middle East)

Asia

In the steppes of Kazakhstan larger raptors are most affected by electrocution. Together with crows and gulls, they account for 93% of all electrocution casualties (Lasch *et al.*, 2010). Within just one month, 200 Common Kestrels, 48 Steppe Eagles (*Aquila nipalensis*), two Imperial Eagles, one White-tailed Eagle and one Eurasian Black Vulture (*Aegypius monachus*) were killed by electrocution over a 11 kilometre long transect of medium voltage power line (Haas & Nipkow, 2006). In a four-year study of a 288 kilometres power line segment, 223 electrocuted raptors (73% of all victims) were found (Karyakin, 2008). Based on these figures, around 58,000 raptors may be killed annually during spring migration along 9,478 kilometres of power lines. In another study, 409 casualties of 34 different species were found in less than six months under a 45 kilometre long section of power lines (Lasch *et al.*, 2010). Here, falcons especially were affected (54% of all cases). During the summer period, a distinct increase in the number of casualties and the proportion of raptors involved occurred; especially due to high numbers of Common/Lesser Kestrels. This increase in numbers can probably be attributed to the dispersal of juveniles as well as to migration movements. Immature birds seem to be especially prone to electrocution. As there was no difference in pole construction (and thus also in the potential danger) it was suggested that the total number of casualties depended here upon the surrounding habitat quality (Lasch *et al.*, 2010).

Electrocution seems to be hazardous to all locally occurring eagle species, namely White-tailed Eagle, Golden Eagle, Greater Spotted Eagle (*Aquila clanga*) and the Short-toed Eagle (Karyakin, 2008). However, Steppe Eagles dominated the bird victims, providing 50% of all records in a study conducted in Central and Western Kazakhstan, and together with the Long-legged Buzzard (*Buteo rufinus*), 80 - 90% in Western Kazakhstan; mostly breeding birds (Karyakin, 2008; Karyakin & Novikova, 2006). According to estimates, the annual mortality resulting from electrocution amounts to almost 8% of the total population and has caused a clear population decline in Kazakhstan (Karyakin & Novikova, 2006; Lasch *et al.*, 2010). In Central Kazakhstan, Golden Eagles and Short-toed Eagles are more frequent victims, with Imperial Eagles seemingly more capable of avoiding dangerous electric poles (Karyakin, 2008). However, unsuccessful breeding attempts in this species were related to the electrocution of one the breeding adults in 29% of cases (Karyakin *et al.*, 2006).

Also in Mongolia, more than 60% of the electrocuted birds found under a total of 1,427 inspected power poles were raptors. In particular, the Saker Falcon seems to suffer considerable losses due to electrocution. In addition, Common Kestrel, Lesser Kestrel, Long-legged Buzzard, Upland Buzzard (*Buteo hemilasius*), Steppe Eagle, Golden Eagle, Northern Goshawk and Little Owl were found. Concrete poles were generally more dangerous than wooden poles, although lateral wood configurations (serving train stations or radio towers) were also more problematic than tangent wood poles because they included closely spaced electrical equipment (Harness & Gombobaatar, 2008; Harness *et al.*, 2008).

In the Russian Federation, the total extension of above ground medium voltage power lines is estimated at 1,500,000 kilometres, of which only 0.5% is equipped with isolated cables or modern facilities for bird protection. This causes the death of an estimated 10 million birds of 100 species annually (Matsyna & Matsyna, 2011). Species found the most often in the Altai region were Black Kite, Common Kestrel, Northern Goshawk and buzzards (buteo species). However, the proportion of raptors electrocuted is heavily dependent on the region: in the Nizhny-Novgorod region only 12% of victims are raptors, whereas in the Samara region this is 31% and the Kalmykia region 81% (Matsyna & Matsyna, 2011).

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**
Steppes / open grasslands /semi-deserts	Steppe Eagle, Golden Eagle, Short-toed Eagle, Northern Goshawk, Common Buzzard, Long-legged Buzzard, Black Kite, Common Kestrel, Saker Falcon	Steppe Eagle: 8% yearly mortality of total population Saker Falcon: 54% of adult mortality, carcass rate 0.74 birds/km	Several critically endangered species

Summary of information on electrocution retrieved from Asia: most data available from Kazakhstan and Mongolia, with further information used from the Russian Federation.

<u>Middle East</u>
For this region the only questionnaire returned was from Israel. No published information on the topic could be found for other countries in the region.

In Israel, Bahat (1997) estimated that on average 20 Griffon Vultures (approximately 5% of this species' population in the country), 20 other large raptors, 50 White Storks and Black Storks and 60 White Pelicans (*Pelecanus onocrotalus*) are electrocuted every year (Bahat, 1997). Recent data suggests that the annual number of documented electrocution and collision events is about 150 (information from returned questionnaire Israel; O. Hatzofe, Israel Nature & Parks Authority, *in litt*.). The most commonly electrocuted species are Black Kite (*ca.* 30 cases /year) and White Storks (20-60 cases/year). Both species are regularly found dead below power lines near garbage dumps, while lines near fish ponds seemed to constitute particularly hazardous areas for the electrocutions of Black Kites and Ospreys. Most cases of Eagle Owls electrocutions occur in pylon transformers. Most electrocutions of Common Kestrels and Barn Owls apparently occur within settlements (information from returned questionnaire Israel; O. Hatzofe *in litt*.). Total known electrocutions (all species involved) were reduced from 111, 90, and 109, in the years 2007 to 2009, to 79 in 2010, probably as a consequence of pylon insulating near garbage dumps.

Habitat type	**Taxa known to be susceptible**	**Documented magnitude of problem**	**Remarks**
Steppes / semi-deserts	Black Kite, White Storks	Black Kite (*ca.* 30 cases/year) and White Storks (20-60 cases/year) mainly near garbage dumps.	Known electrocutions were reduced from 111, 90, and 109 each year (2007-2009) to 79 in 2010.

Summary of information on electrocution retrieved from Israel

2.4.3. Africa

Africa can be divided broadly into Northern, Western, Central, Eastern and Southern Africa. Generally this coincides with arid or desert, forest, woodland and woodland/semi-desert vegetation types respectively. Vegetation type has two main implications for bird electrocutions, aside from obviously influencing which species occur in an area. Firstly, it is believed that natural perch availability affects the extent to which perching birds such as raptors will use artificial perches such as power lines, thereby placing themselves at risk of electrocution. Where numerous natural perches exist (trees) that are sufficiently sturdy and an appropriate height, there is less need to perch on power lines. Secondly, vegetation type affects the chance of detection of bird carcasses under power lines, thereby identifying an electrocution problem in an area. The more open the vegetation, the more likely carcass detection is.

2.4.3.1. Northern Africa

In Northern Africa, some quantitative information exists for the Sudan and Ethiopia. This is a region predominantly classified as desert, semi-desert and woodland. One would expect power lines to be frequently used for perching, in the absence of other taller vegetation.

In Sudan, 17 Egyptian Vulture carcasses (all suspected electrocution victims) were found under a 31 kilometre section of line between Port Sudan and Khor Arba on the western Red Sea coast in September 2010 (Angelov *et al.*, 2011). The pole structures involved were a steel t-type structure and a concrete staggered vertical type structure. Earlier surveys of this section of line in 1982 and 1983 (Niklaus 1984), had found 50 and two carcasses respectively. Angelov *et al.* (2011) speculate that based on that line being 50 years old, 5,000 vultures could have died at that site during the lines life span, and that this mortality could atleast partially explain population declines in this species in the Middle East (probably the origin of the Sudan birds).

In Ethiopia nesting and roosting of migratory bird species in the rift valley system places them at risk of mortality through electrocution (but possibly also collision). Poles are utilised as perches more frequently due to the general degraded nature of surrounding area (information from returned questionnaire Ethiopia; Dr. K. Argaw *in litt*.). At Lake Kokadam, two African Fish Eagles (*Haliaeetus vocifer*) and a Marabou Stork (*Leptoptilos crumeniferus*) were found electrocuted at one pole (Haas, 2011). Newly built unsafe poles structures were observed east of Shashemene, on the main road to the Bale National Park (Haas, 2011). Unsafe t-pole structures also reported built across the Simien Mountains National Park (Rushworth, Ezemvelo KwaZulu-Natal Wildlife Senior Ecologist, *pers. comm*.). Older power lines are still electrocuting birds, but data are not available (information from returned questionnaire Ethiopia; Dr. K. Argaw *in litt*.).

Furthermore, in Egypt electrocution is believed to represent a great conservation problem, with many kilometres of low voltage power lines with short insulators and steel lattice towers found in and near migration bottlenecks, such as the Gulf of Suez and localities where birds of prey, such as Steppe Buzzard (*Buteo buteo vulpinus*) are tempted to land (like sewage ponds, irrigation pipes, garbage dumps, etc.) (Dr. S. Baha El Din *in litt*.).

2.4.3.2. Central and Western Africa

Much of this region is classified as forest by White (1983). Since forest is the tallest vegetation type, one could surmise that perching on power lines would be reduced in those areas (although it is probably not as simple as this). Secondly, detection of electrocution victims (bird carcasses) is less likely in forest vegetation. No information on bird electrocutions in this region was received or found in the literature.

2.4.3.3. Eastern Africa

A rapid risk assessment of the interactions between Kenya’s large birds and electrical infrastructure was conducted in the Magadi and Naivasha areas during January 2009 (Smallie & Virani, 2010). Preliminary findings from these areas have relevance nationally. The majority (six out of seven or 86%) of distribution and transmission (<132 kV) pole designs assessed pose an electrocution risk to medium to large birds. Of approximately 24 relevant bird species of conservation concern in Kenya, 17 (71%) face a high risk of direct interactions with electrical infrastructure. Priority species for attention are the Egyptian Vulture, White-headed Vulture (*Trigonoceps occipitalis*), Lappet-faced Vulture (*Torgos tracheliotos*), Grey Crowned Crane (*Balearica regulorum*), Lesser Flamingo

(*Phoenicopterus minor*), African White-backed Vulture, Rüppell's Vulture (*Gyps rueppellii*), Martial Eagle (*Polemaetus bellicosus*), White Stork, Secretary Bird (*Sagittarius serpentarius*), and various sit-and-wait raptors. Smallie & Virani (2010) present a number of recommendations for a national response to this matter. The Augur Buzzard (*Buteo augur*) has already shown a 55% decline at Lake Naivasha, with electrocution being a suspected contributing factor (Virani, 2006).

2.4.3.4. Southern Africa

Parts of South Africa are classified as semi-desert (the Karoo), but have been altered through the creation of artificial dams and reservoirs by farmers, which allow more species to occur there than would otherwise have been the case.

In Lesotho, Jenkins *et al.* (2009) surveyed 56 kilometres of 22-132 kV power line but found no signs of any raptor fatalities, despite evidence of poles being used as perches. Jenkins *et al.* (2009) postulate that the relative lack of mortalities detected was confounded by a very high human scavenge rate of collision and electrocution victims, possibly exacerbated by the high prices paid for raptor and vulture parts by traders in traditional medicine, a factor which may affect this type of work elsewhere in Africa. We have only encountered one report of an electrocuted bird in Lesotho; a Spotted Eagle Owl (*Bubo africanus*) was found electrocuted below a pole structure near Katse Dam (S.Makhubu *pers comm*.).

In Namibia, the electricity company Nampower suffers huge losses because of power outages caused by bird incidents (information from returned questionnaire Namibia; K. Uiseb *in litt*.), one could assume that at least some of these incidents refer to electrocutions. In addition, data obtained from the Namibia Nature Foundation – Nampower Strategic Partnership on incidents to date, includes seven eagle, 13 vulture, and five owl mortalities, all of which could be assumed to be electrocution casualties.

In South Africa, data on reported bird mortalities on power lines is collated and managed by the Eskom-EWT Strategic Partnership in its' Central Incident Register. During the period August 1996 to May 2011, a total of 1,504 electrocuted birds have been reported. Those species for which five or more fatalities have been reported are shown in Figure 3.

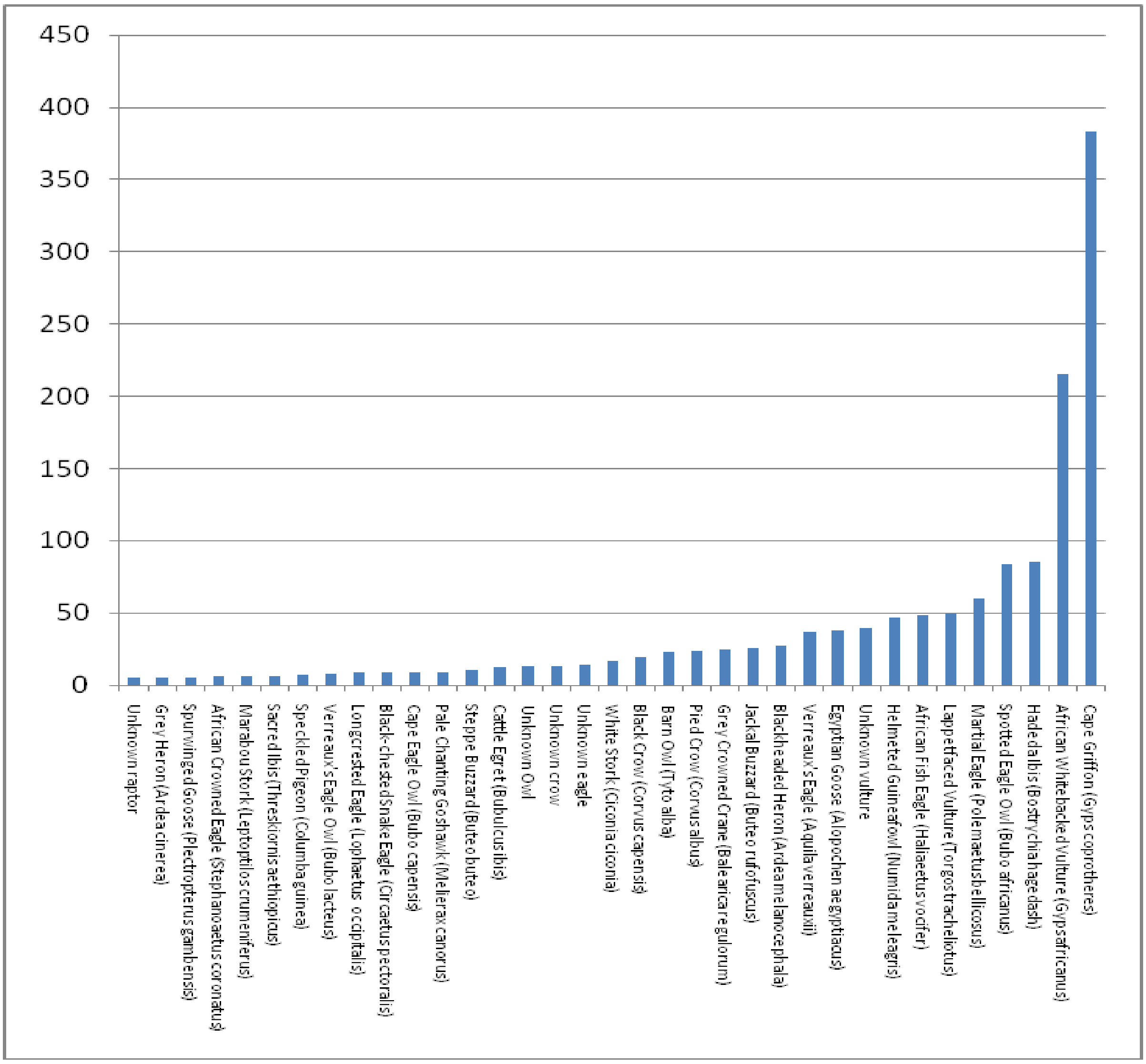


Figure 3. Data on reported bird electrocutions in South Africa in the period August 1996 – May 2011, for those species with five or more electrocutions (Eskom-EWT Strategic Partnership – Central Incident Register).

Physically large species dominate the data, as expected, since electrocution requires a bird to physically bridge critical clearances. Vultures and eagles have been particularly prevalent in the reported data in South Africa. Interestingly, Helmeted Guineafowl (*Numida meleagris*) appears highly affected although a physically smaller species. This is due to its habit of roosting communally on power lines, and multiple birds bridging critical clearances. Also worth mentioning is the Grey Crowned Crane, for which a number of electrocutions have been recorded. The Grey Crowned Crane is the only one of the 15 crane species that is morphologically adapted to perching and roosting in trees, hence the adaptation to roosting on power lines. This species has a wide distribution throughout much of sub-Saharan Africa.

The Central Incident Register is however the product of chance detection and reporting of electrocutions and is recognised to suffer from several biases, in addition to underrepresenting the actual number of fatalities. A more systematic study conducted in South Africa in order to deal with this data problem is described in the following paragraph:

The global population of the Cape Vulture, a threatened southern African endemic, is known to be impacted by electrocutions and collisions on power line infrastructure. Boshoff *et al.* (2011) estimated an adjusted mean annual mortality rate from power line-related mortality (*i.e.* electrocutions and collisions) of around 80 vultures per year in the Eastern Cape population of this species. For a number of reasons, the adjusted estimated mean annual mortality rate is considered to under-represent the true situation, and must therefore be considered as a minimum value. A simple model was constructed and run to investigate the potential impact of the mortality rate from electrocution on the study population. The resident population in those areas where this threat is high is predicted to crash to extinction, from electrocution mortality alone, within a 20-35 year period. The regional (Eastern Cape) population is predicted to show positive growth over the 50 year period. However, for a number of reasons that relate to the nature of certain parameters used in the model, the simulations must be considered to be conservative, at best.

2.4.3.5. Bird/ Power Line Interactions in Africa, additional Remarks

Since relatively little information exists on bird – power line interactions in Africa, and few responses were received to the questionnaire, which had been sent to a large number of governmental and Non-Governmental Organisations in Africa (see chapter 1 and appendix 2), it is necessary to extrapolate our knowledge from those countries where data does exist. Smallie *et al.* (2009) state that the reason that power line/bird interactions have not been more evident in other African countries to date could include the following reasons:

- the relative lack of power lines in these landscapes to date (but see below);
- the relatively low awareness of these interactions amongst the electrical, conservation and public sectors;
- the low likelihood of detecting bird carcasses in some habitats.

Sub-Saharan Africa currently has some of the lowest rates of access to electricity amongst its population (*e.g.* average of 20% amongst Southern African Development Community states – ABS 2011). The region is comprised of four regional power pools, the Central African Power Pool (CAPP), West African Power Pool (WAPP), East African Power Pool (EAPP) and Southern African Power Pool (SAPP). The vast majority of generation capacity (72%) sits in the SAPP. Numerous plans exist for transmission interconnection between these pools and their member states. As of the end of 2010, 70.5 million kilometres of line (64.7 million distribution, and 5.8 million transmission) was installed globally, and this is predicted to increase to 76.2 by end of 2015 (ABS, 2011). Of this, China has 13.5 million kilometres, the United States 11 million kilometres, and India 6.1 million kilometres of line. Information on the length of line installed in Africa is not comprehensive. ABS (2011) reports data for only 12 sub-Saharan countries, and this information appears a little incomplete. Table 1 below summarises this information (from ABS, 2011), and includes South Africa for which good data exists from Eskom. A total of approximately 482,918 kilometres of line across these 13 countries can be accounted for. Given that South Africa alone accounts for approximately 80% of this line, it would seem reasonable to estimate that no more than 700,000 kilometres of line exists in total in sub-Saharan Africa as of 2010.

Feedback through the enquiries from the Sudan mentions growing electrification as a result of dam construction, possibly resulting in greater threat to birds. In Uganda it is believed that government emphasis on rural electrification will result in increased collision and electrocution.
Smallie *et al.* (2009) further state that all of the families of birds that have proven to be vulnerable to electrical infrastructure in South Africa are well represented across much of the African continent, as demonstrated by overlaying species distribution with likely future electrification. Since power line design and construction is very similar within the region, similar impacts can be expected to occur.

Table 1. Approximate length of transmission and distribution overhead power line in sub-Saharan African countries (ABS 2011, and Eskom). For some countries no information is available on the function (transmission or distribution) of existing power lines, these are presented as ‘unknown’.

Country	Transmission km	Distribution km	Unknown	Source
Burundi		792		ABS
Cameroon	2,120			ABS

Central African Republic			560	ABS
Democratic Republic of the Congo	5,207			ABS
Cote d Ivoire	4,485		33,768	ABS
Gabon	1,881	Approx. 15,000		ABS
Ghana			4,000	ABS
Mauritius	118			ABS
Rwanda	392	741		ABS
Senegal	366	19 850		ABS
South Africa	29,000	351,000		Eskom
Uganda		9,000		ABS
Zambia	4,638			ABS
Total	48,207	396,383	38,328	

The relative lack of electrical infrastructure across sub-Saharan Africa to date provides an opportunity to avoid the mistakes made elsewhere when new infrastructure is constructed. In this respect, this region probably is most in need of guidelines, which provides a good opportunity for guidelines to make a significant conservation impact.

2.5. Mitigation and Prevention of Electrocution

The major measures for preventing electrocution are the same as those recommended for dealing with the collision problem (see paragraph 3.5): route planning, underground cabling, removal of earth wires (and earthing modifications), line and tower design modifications and tower marking[1]. As with collision mitigation, underground cabling is the best solution to eliminate electrocution.

The separate guidelines document (Prinsen *et al*., 2011) provides a detailed stepwise approach and guidelines on how to avoid, minimise and mitigate electrocution of birds, both for new and existing power lines. We refer to that document for more (technical) information on this topic. In summary, the most important electrocution mitigation measures include:

i) substitute upright insulators on cross-arms with hanging insulators or put insulating caps of the newest generation on the upright insulators,
ii) place the power lines (conductors) below the cross-arms,
iii) use insulating chains at least 70 cm in length,
iv) insulation of powerlines at least on 70 cm of both sides of the cross-arm,
v) insulation of all other energised parts which are closer than 70 cm to a possible perch.

Below we present a number of examples in the way problems of electrocution have been prevented or mitigated in various countries within the African-Eurasian region, mainly from Europe and Africa.

2.5.1. Examples of Electrocution Mitigation in Europe and Asia

Northern and Western Europe

In Northern Europe most casualties were of Eagle Owls that perched on transformers. Therefore, in Sweden phase conductors and other conducting parts of transformers were insulated (Bevanger, 1994).

[1] Tower marking comprises visual and acoustical scaring methods. Visual deterrents have been trialled in the past, such as the use of raptor silhouettes placed on pylons as deterrents to reduce bird flights over lines (Janss *et al*., 1999) but have proven to be ineffective. These devices almost certainly suffer from bird habituation. Audio or acoustic deterrents have potential, although no literature on their effectiveness is available. It is anticipated that habituation could be a challenge with this approach. All these techniques cannot be applied over long distances other than at high costs and they will over time lose their effect. Permanent solutions (line design and insulation) as illustrated above are much better and much more cost effective.

In Norway, previously open transformer poles and towers have now been largely replaced with small and closed, bird safe kiosks on ground. In addition, more and more low voltage overhead power lines are being replaced with ground cables (Lislevand, 2004).

In Germany, the construction of new "killer poles" became generally prohibited, and all existing power poles were agreed to be made safe by 2012 (see chapter 6). The technical measures (regionally) taken in accordance with the technical standards formulated in the Bird Protection Clause of the German Industry Norm in 1985 have already had significant effects; the populations of endangered species of large birds, such as White Stork, Black Stork, White-tailed Eagle, Osprey, Red Kite and Eagle Owls have started to recover or have at least stabilised (Haas *et al.*, 2005). The application of insulating hoods over upright (pin-type) insulators on concrete and metal power poles has proven to be the most effective mitigation method in Germany (Schürenberg *et al*., 2010).

All low utility and medium voltage distribution lines have been placed underground in the Netherlands and this process is being carried out in Belgium, the United Kingdom, Norway, Denmark and Germany. The electrocution problem is therefore absent or has been strongly reduced in these countries.

<u>Eastern and Central Europe</u>
In Poland, over 100 electricity poles in breeding areas for White Storks have been modified since 1998 to include a stork nest platform (Tryjanowski *et al.*, 2009). In addition, above ground power lines are being replaced by underground ones. Birds also have been protected from electrocution as a result of sitting directly on power pylons by the installation of special platforms over the insulators (Dolata, 2006).

The Czech Republic already started with mitigation measures in the 1980s, by placing artificial perches 0.5 metres above the upright insulators, and insulating hoods. During 1998 to 2001 approximately 8,000 power poles were retrofitted in the main regions for Peregrine and Saker Falcon. This occurred with special types of hoods on consoles, which almost exclude injuries, or with suspended insulators (DCCNH, 2010). In 2009, the largest energy supplier agreed to retrofit the power lines in the Important Bird Areas of the Natura 2000 network and other hotspots at a length of approximately 3,300 kilometres in total (Schürenberg *et al.*, 2010).

In the Slovakian part of the Carpathian basin, conservation efforts to protect Imperial Eagles included activities of monitoring the mortality of birds along dangerous power lines and the installation of deterrents and barriers to prevent the electrocution of the birds (information retrieved from returned questionnaire Slovakia, Z. Cudrakova, Ministry of the Environment of the Slovak Republic, *in litt*.).

In Hungary more than 50,000 medium voltage power poles were retrofitted using cross-arm covers until 2004 (Figure 4). However, as the total amount of medium voltage power lines of the country exceeds 50,000 kilometres, which corresponds to more than 600,000 poles (Demeter, 2004), the process has slowed and in twenty years only 10% of all the pylons in Hungary could be covered this way (Demeter, 2004; Horvath *et al.*, 2011). The safety of electricity poles as nest support structures for White Storks is made safer by raised nest platforms (Lovaszi, 1998).

Figure 4. Cross-arm insulation carried out in Hungary (source: Horvath et al., 2011).

In Bulgaria, poles identified as dangerous within a five kilometre radius of Imperial Eagle nests will be insulated in the next two years in collaboration with an electricity company. A LIFE project launched by BSPB/BirdLife Bulgaria in 2010 includes actions to mitigate collisions and electrocutes of birds in the area of Bourgas wetlands. Project activities include identification of dangerous power lines within one kilometre of the lakes and insulation of dangerous poles. Surveys and activities for reducing the effect of the power lines on the raptors are implemented under the projects of Green Balkans Federation of nature conservation Non-Governmental Organisations, within the framework of the project 'Conservation measures for target species of the EU Birds Directive – Lesser Kestrel (*Falco naumanni*), Eurasian Black Vulture (*Aegypius monachus*), and Imperial Eagle (*Aquila heliaca*) in their main habitats in Bulgaria' (information from returned questionnaire Bulgaria; Y. Velina, *in litt.*).

In Serbia, medium voltage distribution power lines (and their poles) are present in about 70,000 kilometres all around Serbia and they are particularly dangerous for birds. Some evaluations estimated that between 10,000-100,000 birds died from electrocution or collision each year (information from returned questionnaire Serbia; M. Mladenovic, Ministry of Environment, Mining and Spatial Planning of Republic of Serbia, *in litt*.). Moreover, malfunctioning of high voltage power grid lines caused by accidents involving birds occurs very often. In 2005, the Electro Economy Company of Serbia (EPS) accepted to modify existing power line poles and to design new poles, especially concerning the grid of medium and low voltage power lines (information from returned questionnaire Serbia; M. Mladenovic, *in litt.*). Most efforts in this country have been concentrated on providing safe nesting platforms for White Storks and for the endangered Saker Falcon.

<u>Southern Europe</u>

Mitigation measures in Southern Europe are very similar to those adopted elsewhere in Europe. Burial of medium voltage distribution lines has only been applied to a limited extent and in a few countries, such as France, Monaco, Italy, Spain and Portugal. In the southern region there are large differences between countries regarding the application of mitigation measures and the current available information. In fact, while mitigation measures are taken well into account in some countries (see below), few efforts were made to address this issue in other.

Currently, most countries in Southern Europe have regulations regarding power line mitigation. For example, in Montenegro and in Bosnia and Herzegovina legislation states that all poles and technical components of power lines should be manufactured/constructed in a way that is safe for birds and protects them from electric shocks (Schürenberg *et al.*, 2010).

In Spain a lot of effort has been done to reduce bird mortality due to electrocution. Many studies have been carried out to determine the most effective method to reduce bird electrocution. Regidor *et al.*

(1988) performed an experiment in which they modified electric pylons in an abandoned power line in Doñana National Park. They used control (unmodified) pylons and three experimental types of pylons: with elevated perches, with diverters (also called perch guards) and with both elevated perches and diverters. They concluded that for the Black Kite pylon modifications were not effective in reducing the number of birds perched in high-risk locations. Also, artificial perches increased electrocution risk for the Common Kestrel, while diverters reduced that risk.

Specific studies and mitigation measures have also been carried out for endangered species, such as the Spanish Imperial Eagle. These included the identification of mortality hotspots, construction of new pylons with suspended insulators, avoidance of the use of pylons with an exposed loop of wire ('jumper wire') above the insulator, and ensuring that new power lines were located away from both breeding areas and of temporal settlement areas for juvenile eagles. The number of electrocuted eagles was reduced since the implementation of these measures, even though the power line network has been increasing. The species population size has also increased since these measures started to be implemented (López-López, 2011). Another example is the study by Gil (2009) that proposed the correction of 138 electricity lines (1,127 kilometres) and 4804 supports, as a result of a Recovery Plan for the Bearded Vulture (*Gypaetus barbatus*) in Aragon region.

In Portugal, the implementation of measures to mitigate electrocution in new medium and high voltage power lines at a national level has been identified as a strategic objective, meant to be fully implemented in the years to come. The main problem related with the mitigation measures for electrocution is the degradation of the insulating material with time. The search for long lasting materials is an on going activity by EDP – Distribuição (Portuguese Electricity Distributor). The effectiveness of correction measures on medium and high voltage power lines to reduce bird mortality has been evaluated through the monitoring of 64 kilometres of power lines (information from returned questionnaire Portugal; J. Loureiro, Instituto da Conservação da Natureza e da Biodiversidade, *in litt*.). Depending on electric pylon configuration, a 60%-89% reduction of electrocution rate was found after mitigation measures were implemented. Some of the mitigation measures used in Portugal were: insulation of live phase conductors; insulation of tension clamps, pin insulators and bushings; the use of insulating materials for suspension clamps and other overhead line fittings; the installation of perching and nesting dissuasion devices (usually effective to keep storks from building their nests on top of poles and electrical associated structures) (Figure 5). Another generally applied measure is the construction of dedicated nesting poles that White Storks can use to build their nests nearby existing electric poles (Figure 5) (information from returned questionnaire Portugal; J. Loureiro, ICNB, *in litt*.).

Figure 5. Distribution pole with symmetric chevron (arrow) on top as bird exclusion device (Photo: EDP-Distribution, Portugal) and dedicated nesting pole for White Stork next to distribution pole with bird exclusion device (Photo: Carlos Tiago).

2.5.2. Examples of electrocution mitigation in North Africa and the Middle East

In Israel, there is no legislation demanding for the insulation of pylons or for the adoption of prevention measures against electrocution and collision with power lines. However, the Israeli Electric

Company (IEC), the only producer and distributor of electricity in Israel, in cooperation with the Israeli Nature and Parks Authority (INPA), assumed the compromise of insulating hundreds of dangerous high voltage 22-33 kV pylons. Consequently, since 1996 over 2,500 pylons have been insulated. When planning new lines, IEC follows the INPA demands for “safe construction” near IBAs, garbage dumps and nature reserves. This includes underground lines, routing away from potential conflict hotspots and insulation. Every year, the INPA submit to the IEC a previous year report on electrocution events and collisions and an agreed list of pylons for insulation is set. Priorities are set according to species sensitivity (in regard to conservation status, both globally and locally) and repetition of events. Currently, there is a voluntary based campaign to raise awareness of this conflict, but no legislation has yet been set (information from returned questionnaire Israel; O. Hatzofe, Israel Nature & Parks Authority, *in litt.*).

In Algeria, the only mitigation measures known have been taken in Wilaya (province) of Annaba and El Tarf. In this area, special platforms were built on poles and electricity pylons in order to reduce the mortality of White Storks by electrocution. There are currently nearly 300 nests of this species on such platforms on electricity constructions in this area (information from returned questionnaire Algeria; S. Hamida, Head of Wetlands Office, General Direction of Forests, Algeria, *in litt*.).

3. Collisions

3.1. Introduction

Each year millions of birds die worldwide as a result of collisions with above ground power lines. The first reports on collisions of birds with overhead wires date from the late 19th century, when several authors in the United States reported findings of collision victims (*i.e*. many tens of Horned Larks (*Eremophila alpestris*) and 14 Grey Phalaropes (*Phalaropus fulicarius*)) with telegraph lines (references in Aplic, 2006). Bird collisions with power lines were noted as early as 1904, when collisions of several shorebird species and a Black Rail (*Laterallus jamiacensis*) with electricity wires in the San Francisco Bay area (United States) were reported by Emerson (reference in Aplic, 2006). In Europe, Beadnell (1937) may have been one of the first to write about the conflict in a European context. He reckoned the problem to be only temporary since birds would get used to the overhead wires. However, the impact and scale of this type of mortality has rapidly increased and still increases, following the rapid growth of the electricity grid, especially in developing countries. The total length of transmission and distribution lines in the world are forecast to rise from their extent of 70.5 million kilometres at the end of 2010 to 76.2 million kilometres in 2015 (ABS, 2011). For many countries the problem of collisions might be of the same, or an even higher, order of magnitude (nationwide many tens of thousands or hundreds of thousands bird casualties per year) as the problem of electrocution.

Bird collisions with power lines have been the subject of research in many different countries, mainly in North America, Europe and South Africa. However, there are also large parts of the world, such as large parts of Asia and Africa, where the problem is generally unexamined. The studies performed in the last decades have focused on the underlying causes and the species involved, and have examined many different mitigating measures. Despite this large research effort, the impact of the mortality caused by collisions with power lines on bird populations remains largely unknown. Many authors state that on the larger scale, collision fatalities on their own will not influence populations. However, together with other human-related mortality factors (traffic, electrocution, wind turbines, buildings and window collisions, domestic cats, hunting, oil spills, etc.), it is in some areas a significant factor of concern. Moreover, it is known that on a local scale, mortality due to collisions with power lines can be an important factor causing populations of certain vulnerable species to decline. In particular long-lived species with a low reproductive rate, limited geographic distribution and low numbers, such as some species of bustards, cranes and raptors, are vulnerable to the effect of additional mortality due to collisions with power lines (APLIC, 1994; Rubolini *et al.*, 2005; Drewitt & Langston, 2008).

Appendix 3 presents an overview of the severity of impacts on bird populations of mortality due to collision with power lines for different bird families in Eurasia and Africa.

3.2. Contributing Factors and Causes

Birds can collide with power lines in a range of situations and locations. However, the existence and interaction of several meteorological, technical, topographical and biological factors can dramatically increase the number of collision victims (APLIC, 1994; Bevanger, 1994). The following paragraphs describe the nature and existence of several abiotic and biotic factors, which are known to influence the collision rate.

3.2.1. Weather Conditions

Besides darkness and low visibility at twilight, environmental conditions like fog, dense clouds and several types of precipitation, reduce the visibility of power lines, which increases the collision risk for birds. Despite the fact that most birds avoid flying under these conditions, Heijnis (1976) found an increase in the number of collision victims in periods with fog and precipitation. He also found a large amount of collision victims after a sudden hailstorm. Litzbarski & Watzke (2007) specifically mention the frequent bad visibility due to thick fog in the winter in the Ukraine as an important factor for the relatively high collision mortality of Great Bustards (*Otis tarda*) there. The impact of fog and precipitation may be enlarged by the fact that birds tend to lower their flight height in reaction to those conditions (Bevanger, 1994). The same holds for strong headwinds, which places nocturnal migrants under especially great risk of collision (APPLIC, 1994; Drewitt & Langston, 2008). In addition, heavy winds and storms lead to a reduction in flight control. Especially gulls are known to be vulnerable in stormy conditions, under which they are often more active than other species groups and when they are more easily blown into the wires. Thus, Scott *et al.* (1972) found that gale-force winds often resulted in an increase in gull casualties. Most birds will avoid flying under harsh weather conditions, but when they do take flight or when they encounter these conditions unexpectedly, they may experience a large chance of collision with power lines.

3.2.2. Line Configuration

Many authors refer to the possible effects of the configuration of power lines on the collision risk and the associated number of collision victims, but little research has been conducted to support these assumptions. There are however some basic principles that are widely accepted:

1) Birds are believed to collide most often with the ground wire (also called neutral, earth or shield wire). This wire is a thin, single wire, attached above the conductors (the actual power lines) (Figure 6). Through these characteristics, the ground wire is harder to detect and poses a greater risk to passing birds than phase conductors. For example, Faanes (1987) observed a total of 109 collisions of birds with power lines in prairie habitats in the United States, of which 102 birds collided with the ground wire. Accordingly, a construction without ground wires would be preferable. This has been shown to be effective in protecting birds as varied in size and biology as cranes and grouse (Jenkins *et al.*, 2010). However, as these wires are used to protect the infrastructure from lightning, removal of the ground wires reduces the reliability of the system and is, therefore, often maintained;
2) Bundling of the wires improves their visibility and thereby reduces the collision risk. The complementary use of spacers (Figure 6) to prevent contact between the conductor wires increases the visibility even more. Bundling or the use of spacers is technically only needed in high-tension power lines (150 kV or more);
3) High-tension power lines configured in a horizontal plane are preferred over a predominantly vertical configuration of the lines, which enlarges the (vertical) plane with

which birds can collide. Renssen (1977) monitored the effect of a lowered portal construction close to Muiden in the Netherlands (Figure 7). At this site the three conductors were placed in a horizontal plane, approximately 10 metres above the ground, reducing also the distance between pylons. These measures resulted in a reduction of the number of collision victims from 0.51 birds/km/day at the control transect to 0.14 birds/km/day at the lowered portal construction;

4) Putting different power lines close together or combining lines is advised in situations where several lines cross an area. As the resulting network of wires is confined to a smaller area and is more visible birds only have to make a single ascent and descent to cross a series of lines in this arrangement (Thompson, 1978 as in APLIC, 1994). However, again the distribution of wires in the vertical plane should be minimised (Bevanger, 1994).

Figure 6. High voltage (380 kV) transmission line with spacers (arrow) to keep individual energised phase conductors in each bundle apart. The single thin wire in the top left corner of the photo is the ground wire (also called neutral or earth wire) that is mostly positioned above the phase conductors. In this case the ground wire has been equipped with small spirals (so called pig tails, see inset) to make this wire better visible to birds (Photo: Bureau Waardenburg).

Figure 7. A 380 kV line, with lowered conductor wires hanging from portals in one horizontal plane to minimise collision risk for Great Cormorant (Phalacrocorax carbo), Eurasian Spoonbill (Platalea leucorodia) and Purple Heron (Ardea purpurea) daily passing this stretch of line while commuting between the breeding colony and foraging areas, Muiden, the Netherlands (Photo: Bureau Waardenburg).

3.2.3. Line Routing

Concerning the routing of power lines there are four main issues: proximity to areas rich in birds, vegetation type, topography and disturbance (APLIC, 1994). Note that the information below is only partly based on sound scientific studies. A large part of this knowledge is based on the observations of collisions which are scarce and are always of a similar descriptive nature.

Proximity

The proximity to areas where many birds forage, land and take-off, is an important factor to take into consideration when planning the location of a new power line. Protected areas, wetlands and agricultural grounds can attract large numbers of birds (often depending on the season). The routing of a power line directly inbetween areas intensively used by birds for foraging and roosting can lead to a high number of collision victims as a result of a high daily passage frequency. For example, Murphy *et al*. (2009) studied collisions of Sandhill Cranes (*Grus canadensis*) with two 69 kV power lines located in the near proximity of a major night roost of the species on the Platte River in South-Central Nebraska. Each year dozens of Sandhill Cranes died after colliding with one of the lines. They showed that most collisions occurred when flocks of more then 1,000 cranes suddenly flushed from their roost within 500 metres of the power line after dusk. Additionally, Koops & de Jong (1982) related the uneven distribution of collision victims of Oystercatcher (*Haematopus ostralegus*), Lapwing (*Vanellus vanellus*), Golden Plover (*Pluvialis apricaria*), Black-tailed Godwit (*Limosa limosa*), Whimbrel (*Numenius phaeopus*), Black-headed Gull (*Larus ridibundus*) and Starling (*Sturnus vulgaris*) across the studied line sections to the distribution of important foraging and roosting sites of these species along the power line. For each of these species they found more collision victims in the proximity of the foraging or roosting areas important to these species.

Vegetation height

Secondly, the presence of high vegetation (trees) forces birds to increase their flight height. When wires are situated just below the canopy, the trees prevent many birds from colliding with the power line. A study in Northern Japan, Shimada (2001) showed that a significantly greater proportion of Greater White-fronted Geese (*Anser albifrons*) leaving their roosting sites, passed the power lines positioned in the woods (indirect route between roosting and foraging sites) compared to the

proportion of geese passing the power lines in the open rice fields (direct route). In other words, to some extend these Greater White-fronted Geese avoided passing the power lines in the open rice fields.
Additionally, Bevanger & Brøseth (2004) found that in Norway the probability of grouse to collide with power lines depended on the height of the trees. Collision hotspots tended to be in places with low trees.

Topography
The topography is the third important factor that should be taken into account. Certain characteristics of the landscape, such as rivers, shorelines or mountain valleys, concentrate birds into certain flight routes (Drewitt & Langston 2008). Preferably, the routing of new power lines should occur parallel to these landscape features. Placing a power line perpendicular on important flight routes can result in a higher number of collision victims. This is illustrated by the results of Renssen (1977) who found a collision rate of 1.37 birds/km/day at a power line placed perpendicular to a migration route along the shore of Lake IJsselmeer in the Netherlands. This result is three times as high as the collision rate of 0.46 birds/km/day he found at a power line placed parallel to the same migration route. Stumberger (2008) argues that the channel width and height of vegetation (notably trees) on the river bank are two important micro-topographic features that may influence the collision risk for power lines that cross a river valley perpendicularly. Power lines crossing narrow rivers bordered by trees taller than the height of the power line have a lower collision risk than broad rivers because most birds will fly over the tree tops and cross the valley way above the power line.

Disturbance
Finally, the placement of a power line close to areas where large numbers of birds congregate can lead to a higher collision risk when disturbance of these birds regularly occurs. Disturbed and panicking birds, such as geese and flocks of waders, taking flight close to a power line have frequently been observed to fly into the wires. For instance, Hartman *et al.* (2010) report of a group of approximately 90 geese that foraged in the proximity of a 150 kV power line that was disturbed by a small, low-flying aeroplane. The flock of geese panicked and took flight straight into the wires after which one Greater White-fronted Goose and one Greylag Goose (*Anser anser*) were seen to collide with the wires and collapsed to the ground. Also Heijnis (1976) witnessed an event in which seven Northern Shovelers (*Anas clypeata*) took flight after being disturbed by a farmer, of which one flew against a conductor.

3.2.4. Susceptibility of Birds to Collision

Different species experience different collision rates. The vulnerability of a species to collision with power lines is defined by the combination of the exposure to collision risk and the susceptibility of the species to collision (Jenkins *et al.*, 2010). The exposure to collision risk depends on the time species spend in the air, the height on which species tend to fly and the location of foraging and roosting areas relative to the position of the power line. This paragraph describes the biological factors, which influence the susceptibility of a species to collision.

3.2.4.1. Morphology

Several morphological characteristics are known to increase the susceptibility of a bird species to collision. Many of these characteristics are in a way connected to each other and influence birds flight performance. Species that regularly are found as collision victim are often called ‘poor flyers’, following the classification made by Rayner (1988) (cited in Bevanger, 1998). Those poor flyers include, for instance, species groups like rails and grouse. The poor flyers are characterised by rapid flight and the combination of heavy body and small wings obviously restricts swift reactions to unexpected obstacles (Bevanger, 1998). Apart from Rayner’s classification, it is often observed and described that especially large, less manoeuvrable birds, like herons, cranes, swans and pelicans, are vulnerable for collisions (APLIC, 1994; Manville, 2005). Janss (2000) specifically studied avian mortality from power lines using a morphologic approach by studying the composition of the local bird community and the collisions of birds with three different sections power lines in Extremadura, Central West Spain. Results revealed that large, heavy birds with a high wing loading (ratio of body weight to wing area) and low aspect (ratio of wing span squared to wing area) appeared to experience the highest collision risk. Of the species found dead under the power lines in this study, the following were classified as being vulnerable to collision (and not to electrocution): Mallard (*Anas platyrhynchos*), Common Moorhen (*Gallinula chloropus*), Great Bustard (*Otis tarda*), Little Bustard (*Tetrax tetrax*) and Woodpigeon (*Columba palumbus*).

3.2.4.2. Vision

The detectability of power lines for birds depends on the visibility of the wires as well as on the characteristics of the vision of birds. In contrast to us humans, the frontal vision of many species of birds is not high-resolution vision and many species mainly use their lateral vision to detect details (Martin, 2011). Next to that, birds may often tend to look downwards in flight (*e.g.*, to look for conspecifics or food) by which (for some species) the direction of flight falls completely inside their blind zone (Martin & Shaw, 2010; Martin, 2011). Recently, it was shown for Kori Bustard (*Ardeotis kori*) and Blue Crane (*Anthropoides paradisea*), two collision prone species in Southern Africa, that they have an extensive blind zone above their head that makes them unable to see objects ahead in case they bend their heads downward in flight for only more than 25-35° (Martin & Shaw, 2010). The lack of vision above the head may also explain why some species collide with the ground wire (which is mostly above the conductors) while avoiding collision with the conductors below. The ground wire may simply fade away in the blind zone. Additionally, for species like filter-feeding ducks or tactile probing shorebirds, the very narrow (±5°) binocular field (area that can be seen with both eyes) in the direction of travel might also limit the perception of obstacles in the open air. However, in this respect the possible unimportance of binocular vision for birds to control locomotion with respect to distant objects should be kept in mind (Martin & Shaw, 2010).

3.2.4.3. Behaviour

Apart from the morphology of birds, behaviour also largely influences the susceptibility of species to collision. An important factor is the habit of some bird species such as ducks, pigeons and starlings, to fly in (large) flocks, which increases the chance to collide with obstacles especially for the birds in the back of the group. Due to the obstruction of their vision by the birds in front, those birds often notice the wires too late to be able to avoid collision. Another risk is formed by types of behaviour, through which birds are distracted in such a way that they do not notice overhead wires. Examples of such behaviour are display flights of wader species, the pursuit of mates, competitors for prey and the chasing away of predators.

Some wader species, such as Lapwings, Black-tailed Godwits and Common Snipe (*Gallinago gallinago*), are particularly known for their display flights. If these flights are performed in the proximity of a power line there is a large risk of collision. For example, analysing the collision victims found in 17 different collision victim searches in Dutch grassland areas rich in breeding waders, Koops (1987) found that most collision victims were found in April. This corresponds with the start of the breeding season and the high number of display flights during this time.

A bird species that is known to often fly in persuit of mates is the Mallard. In spring, groups of male Mallards can often be observed in pursuit of a single female. The focus of these birds is likely to be primarily on the female and consequently have a perceived increased risk of collision.

As an example of the risk of chasing away predators, Heijnis (1976) witnessed a Lapwing defending its territory against a Herring Gull (*Larus argentatus*) during which the Lapwing collided with one of the conductors.

3.2.4.4. Local or Migrant

An important factor controlling the collision susceptibility of species is the flight height. Migration often occurs at higher altitudes, way above the height of power lines. Therefore, migrating birds will experience a lower collision risk than local birds that regularly perform flights between foraging and roosting sites at the height of power lines. However, the collision risk of migrating birds increases when weather conditions (precipitation, fog or strong headwind) forces them to fly at lower altitudes (especially at night). The same holds for migrating birds that stop over in the vicinity of a power line. Migratory birds are less familiar with the landscape and the presence of obstacles than local birds.

This increases their susceptibility to collision. Heijnis (1976) described how most collision victims of Water Rails (*Rallus aquaticus*) in an area of the Netherlands were found in October and November, the period in which Water Rails migrate through the area. On the other hand, local birds often have more interaction with power lines in their breeding and/or wintering territory when they daily commute between breeding or resting areas and feeding locations. Henderson *et al.* (1996) showed that adult birds of Common Terns (*Sterna hirundo*), which performed frequent foraging flights during chick rearing, were more susceptible to collision in the chick rearing period than outside that period, because they regularly crossed and flew close to power lines that were situated between the nests and main feeding areas.

3.2.4.5. Age

The influence of age on collision susceptibility appears to be species specific. A number of studies have shown that inexperienced juveniles more often collide with power lines than adult birds. For instance, Renssen (1977) found that in June and July the collision victims of Lapwing and Black-tailed Godwit mainly consisted of first-year birds. Additionally, Mathiasson (1993) showed that in Sweden 43.1% of the collision victims of ringed Mute Swans (*Cygnus olor*) were juvenile swans, a higher percentage than to be expected from the population structure. Furthermore, Grey Herons (*Ardea cinerea*) were more likely to collide with power lines between August and December, a period when first-year birds represent more than 71% of the recorded mortality (Rose & Baillie 1989 as cited in APLIC, 1994). There are, however, also a number of studies that found no difference in collision risks between adult and juvenile birds (*e.g.*, Koops & de Jong, 1982; APLIC, 1994).

3.2.4.6. Nocturnal or Diurnal

Generally, it is accepted that bird species that regularly fly at night or in twilight are more susceptible to collision than species that mostly fly during the day. At night, power lines are less visible to birds, increasing the liklihood of collision for birds that fly at the ‘critical height’, such as foraging ducks. Through multiple searches during the day, Heijnis (1980) found that most collision victims in a Dutch grassland polder occurred during the night (33% between 23.00h and 04.00h) and twilight period (23% between 04.00h and 08.00h and 29% between 18.00h and 23.00h). Also, Scott *et al.* (1972), who conducted a study at the South coast of England, mainly found nocturnal migrants (mainly thrushes) as collision victims. In a study in Germany by Hoerschelmann *et al.* (1988), 61% of the collision victims belonged to species that mostly fly at night. In Nebraska, Murphy *et al.* (2009) installed sensors, so-called Bird Strike Indicators (Figure 8), on the wires of a 69 kV power line to determine the number of collisions, mainly of Sandhill Cranes. Approximately half of the collisions registered occurred during the evening and nearly all the rest of the collisions occurred during the remaining part of the night.

Figure 8. Bird Strike Indicator (BSI) attached to a power line. BSIs are relatively small devices that can be attached to a single wire of a power line and automatically register bird collisions based on the vibration of the wire.

3.3. Species Involved and Magnitude of Problem

3.3.1. Collision-prone Species

The risk of a species to collision with power lines is a result of the combination of the level of exposure to the risk and the susceptibility of the species to collision. Consequently, certain species (or species groups) are more often found as collision victims than others. The species involved differ between locations, both between countries and even between sites within countries. Unfortunately, the intensity of research differs between regions and countries and for many species insufficient data are available to assess their susceptibility to collisions with power lines. The data that are available, however, provide a valuable insight into the species (and species groups) that are prone to collisions, as well as those that are rarely found as collision victims. Appendix 3 presents an overview of the main species groups involved in the conflict between birds and power lines and gives an indication if collision mortality impacts bird populations.

Most of the collision-prone species possess one or more of the general morphological characteristics found to enlarge the susceptibility of a species to collision, like being large, heavy bodied and less manoeuvrable in flight. Paragraph 3.4 describes examples of collision events for these and other species groups and presents regional differences within the African-Eurasian Flyways.

Some species groups appear to be relatively non-susceptible to collisions with power lines, most prominently the raptors. Note, however, that this species group is highly susceptible to electrocution (see chapter 2). Generally, low numbers of collision victims are also found for corvids and small passerines. In the case of small passerines this may result from the fact that they are easily overlooked in collision victim searches and are very quickly removed by scavengers (Ponce *et al.*, 2010).

3.3.2. Magnitude of the Problem

Ideally, this paragraph would present clear national or even worldwide figures on the number of birds that are annually killed by collisions with power lines. However, several factors limit the use of figures that have been published so far.

Firstly, good quantitative studies, which could be used to extrapolate the number of collision victims/km/year to a national (or even larger) scale, are scarce. Also, most of these studies have focused on areas where the collision rate was expected to be high due to factors like the local abundance of collision-prone species or the routing of the power line inbetween important foraging and roosting sites or perpendicular to an important migration route. Consequently, extrapolation of data from these studies to a larger scale would lead to a gross overestimation of the number of birds that are annually killed by collisions with power lines.

Secondly, there are several factors that result in the total number of collision victims from collision victim searches being underestimated. Some of the well-known factors that cause this bias are the removal of collision victims by scavengers, the limited search efficiency of the observers, which is highly influenced by experience, and the fact that wounded birds can disperse out of the search area. In some studies the site-specific estimate of victims/km/year includes corrections for these factors. However, in most studies at least one of the factors is not taken into account, which ultimately leads to an underestimation of the collision rate.

Finally, large differences exist between studies in the number of collision victims/km/year, ranging from only a few (one or two) to several hundreds of birds (Drewitt & Langston 2008). Often information is lacking or insufficient to understand why the results from these studies are so different. When such differing results were derived from one country or region it hampers the extrapolation of the data to a national or larger scale.

Despite all these difficulties there are some authors who have attempted to estimate the annual number of collision victims on a national scale (table 2). These numbers should be seen as very rough estimates and consequently treated with care. Nevertheless, these are the only quantitative data available to help us understand the global impact of collisions with power lines on birds.

Table 2. Estimates of the annual number of collision victims with above ground transmission lines (excluding distribution lines) for three different countries. Due to limitations described above, the following estimates should be considered as crude.

Country	**Estimation of the annual number of collision victims**	**Source**
The Netherlands	750,000 – 1,000,000	Renssen, 1977; Koops, 1987
Germany	30,000,000	Hoerschelmann *et al.*, 1988
United States	130,000,000	Erickson *et al.*, 2005

In the Netherlands, Renssen (1977) and Koops (1987) calculated that 750,000 to 1,000,000 birds are annually killed by collisions with power lines. In Germany, Hoerschellman *et al.* (1988) extrapolated the number of collision victims they found at a study site near the river Elbe to the national scale and came up with a figure of 30 million birds colliding with high-tension power lines each year (excluding distribution lines). For the United States, Erickson *et al.* (2005) estimated the annual avian mortality of several human-related causes of death. Based on the study from Koops (1987) they estimated for the United States a total annual amount of 130 million collision victims (excluding distribution lines).

To put these figures of collisions with power lines in perspective, knowledge is needed on the relative size of this specific type of mortality compared with other types of human-related mortality as well as the natural mortality rate of birds. Erickson *et al.* (2005) estimated the relative importance of several human-related causes of death including collisions with buildings, power lines, traffic, communication towers and aeroplanes and other threats like cats, pesticides and oil spills (table 3). After collisions with buildings/windows, collisions with power lines appeared to be the second most important human-related cause of death for birds in the United States. APLIC (2006) presents a similar ranking, but a figure of 174 million collision victims for the United States. From this latter study it becomes clear that power line collisions annually result in much more bird deaths in the United States than electrocutions (thousands of birds annually).

Few studies compare the species-specific mortality caused by collisions with power lines to other human-related sources of mortality. Bevanger (1995) estimated that in Norway every year 20,000 Capercaillies (*Tetrao urogallus*), 26,000 Black Grouse (*Tetrao tetrix*) and 50,000 Willow Grouse (*Lagopus lagopus*) die following collisions with power lines, which is respectively 90%, 47% and 9% of the annual hunting harvest of these species (*e.g.*, in comparison the annual hunting harvest of Capercaillie is 22,200). This is a cause for concern as there is evidence that hunting mortality alone can be additive to natural mortality among grouse (Bergerud 1985 as in Drewitt & Langston, 2008).

Table 3. Summary of predicted annual avian mortality in the United States (extracted from Erickson et al., 2005).

Mortality source	**Annual mortality estimate**
Buildings (including collisions with windows)	550,000,000
Power lines	130,000,000
Cats	100,000,000
Automobiles	80,000,000
Pesticides	67,000,000
Communication towers	4,500,000
Wind turbines	28,500
Aeroplanes	25,000
Other sources (oil spills, oil seeps, fishing by-catch, etc.)	Not calculated

3.3.3. Effects on Population Level

To be able to judge the possible effects of power line collisions on population level, we need to know which part of the (local, regional, national or global) population is killed annually by collisions with power lines. Additionally, knowledge is needed on the ability of populations to compensate for these losses (including all other factors of mortality). Because such information is largely unavailable, little is known as to the effects of power line collisions on the population levels of birds. It is to be expected that the effects on population levels are greatest for long-lived species with a low reproductive strategy, which often breed only after their second or third year or possibly later. This is because these species are unable to react to increased mortality levels by a sufficient increase in their reproductive rate (Winkelman *et al.*, 2008) and have a higher lifetime reproduction per individual than short-lived species.

Several authors state that, taken in isolation, power line mortality will not negatively influence national bird populations (Koops, 1987; Drewitt & Langston, 2008). However, in cumulation with other human-caused mortality factors it may become a factor of concern. Collisions are, for instance, thought to be an influential factor in the ongoing population declines of several species of cranes, bustards and diurnal raptors (Jenkins *et al.*, 2010). Moreover, collision mortality might significantly effect local populations of (endangered) species, particularly in cases of small populations. Considering the collision rates that were measured for Blue Crane and Ludwig's Bustard (*Neotus ludwigii*) in a representative area of the Eastern Karoo, collision mortality might significantly affect the total population of both these threatened species if the measured levels of mortality are sustained over a broader area (Jenkins *et al.*, 2010).

There is at least one case where collision with power lines has caused significant mortality of a globally threatened and declining species. At least 49 Dalmatian Pelicans (*Pelecanus crispus*) were found as collision victims in Northern Greece, a major wintering location for the species. The mortality due to power lines was estimated to represent 2.4 to 3.5% of the total number of breeding pairs in the area. The authors suggest that this mortality, combined with the effects of illegal shooting, may be responsible for the lack of an increase in the size of breeding colonies in Northern Greece (Crivelli *et al.*, 1988).

3.3.4. Overview per Species Group

Below a brief overview is presented of the species groups susceptible to collide with above ground power lines. Appendix 3 presents an overview of the main species groups involved in the conflict between birds and power lines and gives an indication to what extent collision mortality impacts bird populations.

<u>Colonial breeding birds</u>
From the overview for the Netherlands presented by Koops (1987), it becomes clear that between 1960 and 1985, almost all colonial breeding species were found as collision victims in the Netherlands. The collision risk for **cormorant** species is assumed to be relatively low and accordingly, Koops (1987) reported very low numbers of Great Cormorant (*Phalacrocorax carbo*) being found as collision victims.

Herons are quite regularly found as collision victim and are, therefore, seen as a species group of intermediate susceptibility to collision. Two heron species that regularly collide with power lines in Western Europe are the Purple Heron (*Ardea purpurea*) and the Grey Heron. For these two species it is often found that juveniles are more susceptible to collision with power lines than adult birds (Osieck & de Miranda, 1972; Rose & Baillie 1989 as cited in APLIC, 1994). It is relevant that between 1960 and 1985 the number of collision victims of Purple Heron in the Netherlands was almost equal to the number of Grey Herons, while the first species was 10 times as scarce (Koops, 1987). Most Purple Herons were found in a study of a power line located south of a colony of Purple Herons at 'Het Naardermeer' in the Netherlands. Within a three year period, 36 dead Purple Herons were found under approximately 2.7 kilometres of power line. The herons from the colony at 'Het Naardermeer' regularly passed the power line on their way to and from foraging areas (Osieck & de Miranda, 1972). In Germany, Gutschmiedl & Troschke (1997) studied the effects of a new 110 kV power line on a colony of Grey Herons located approximately 500 metres from the line. Their findings indicated no adverse effects of the power line on the Grey Heron colony. No collisions were observed nor any collision victims found during the breeding period.

Eurasian **Spoonbill** (*Platalea leucorodia*) is also regularly found as collision victim. Koops (1987) reports a total of 17 collision victims that were found under power lines in the Netherlands between 1960 and 1985. Regarding data from the Dutch Centre for Avian Migration & Demography of 57 recovered ringed Eurasian Spoonbills with a known cause of death, 14% were killed through collision with a power line. These data are of concern because of the (locally) scarce status of the species. In the species action plan for the conservation of the Eurasian Spoonbill (AEWA, 2008), collision with power lines is marked as a low to medium threat for migrating and breeding individuals of the species (especially in wetlands near highly industrialised areas). A factor of low threat is defined as a factor causing or likely to cause population fluctuations and a factor of medium threat is a factor causing or likely to cause relatively slow, but significant, declines (10-20% over 10 years).

Pelicans are also known to collide with power lines. In Northern Greece, for example, important numbers of Dalmatian Pelicans have been found as collision victims (see above), while in Israel several tens of White Pelicans (*Pelecanus onocrotalus*) collide annually during the autumn migration.

In Southern Europe **flamingos** are also regularly found as collision victim. In Southeastern France, between 1988 and 1993, a total of 122 victims of Greater Flamingos (*Phoenicopterus roseus*) were found dead after colliding with high voltage power lines, which constituted 14.1% of the total number of collision victims found (Bayle, 1999). In Italy, Rubolini *et al*. (2005) also reported that Greater Flamingos were highly affected by collisions.

<u>Wildfowl</u>
Almost all wildfowl species are found as collision victims, but there are differences between the collision rates across species (groups). In general, it can be assumed that **swans** are at medium risk of collisions with power lines. Most information is derived from Northwest Europe, where (especially in the United Kingdom) occasionally relatively large numbers of swans have been found as collision victims. For instance, Frost (2008) found 21 and nine dead Mute Swans under approximately 1.5 kilometres of power line over two consecutive springs respectively. Additional information is mainly available from recoveries of ringed birds and these data are inevitably biased toward deaths that occur from human action or around human habitation (APLIC, 2006). Thus, Rees (2006) reports that 25% of recovered Bewick's Swans (*Cygnus columbianus*) ringed in the United Kingdom with a known cause of death were killed through collision with obstacles, such as power lines. In contrast, in the Netherlands, where approximately 65% of the European population winters, the species has only been found as collision victim in very low numbers. For instance, in a study during two winters in a Dutch grassland polder, used as foraging area by circa 200 Bewick's Swans throughout each winter, only three Bewick's Swans were found as collision victim below a stretch of four kilometres of a 150 kV power line (Hartman *et al.*, 2010).

Geese are also regularly found as collision victims, but the numbers are generally low. Koops (1987) mentions six geese species as collision victims between 1960 and 1985 in the Netherlands, including nine Barnacle Geese (*Branta leucopsis*), two Brent Geese (*Branta bernicla*), 25 Greylag Geese, 72 Greater White-fronted Geese, 11 Bean Geese (*Anser fabalis*) and one Pink-footed Goose (*Anser brachyrynchus*). In Germany, a number of studies focused especially on collisions of geese with power lines. Also these studies found that the numbers of collisions victims were relatively low. Haack (1997) witnessed 27 collisions of Greater White-fronted Geese with a power line in a period of three years at the lower Niederrhein, and Sudmann *et al*. (2000) witnessed 11 collisions of geese in one winter at a power line close to Reeser Meer. The relative abundance of geese in collision victim counts in areas where large number of geese winter is also low. For instance, geese represent 3.8% of the victims found by Hartman *et al.* (2010), 4.5% of the victims found by Brauneis *et al.* (2003) and 0.3% of the victims found by Hoerschelmann *et al.* (1988).

Compared to swans and geese, **ducks** are more regularly found as collision victims and are, therefore, regarded as a highly susceptible species group. For instance, of the 320 collision victims found in a Dutch grassland polder by Hartman *et al.* (2010), 28% consisted of ducks, mainly Mallard and Eurasian Wigeon (*Anas penelope*). Koops (1987) mentions a total of 2,251 ducks found as collision victim in the Netherlands between 1960 and 1985 (14% of the total number of collisions victims). In particular, the Mallard is often reported as collision victim in European collision victim searches, often in relatively large numbers (Beijersbergen, 1975; Hoerschelmann *et al.*, 1988; Janss & Ferrer, 1998; Marti, 1998; Rubolini *et al.*, 2005).

<u>Raptors & owls</u>
In contrast to their high susceptibility to electrocution, **raptors** and **owls** are rarely found as collision victims in Europe, possibly due to their good forward vision. A few extensive and long-term collision victim studies have reported some victims (mostly one or two) of raptors or owls, but large numbers of casualties have not been observed (Hoerschelmann *et al.*, 1988; Alonso *et al.*, 1994; Bayle, 1999). Koops (1987) reports that 42 raptors that were found as collision victim in the Netherlands between 1960 and 1985, of which 32 were Common Kestrels (*Falco tinnunculus*) as well as several Marsh Harriers (*Circus aeruginosus*), Common Buzzards (*Buteo buteo*) and Eurasian Sparrowhawks (*Accipiter nisus*). A total of 16 owls were also found, including 13 Long-eared Owls (*Asio otus*).

In Southeastern France (Plain de Crau and surroundings) between 1988 and 1993, only two raptor species were found dead (Eurasian Sparrowhawk and Long-eared Owl) out of 865 birds found, after colliding with high voltage distribution lines (Bayle, 1999). In Spain and France, between 1979 and 2008, 18 Bearded Vultures (*Gypaetus barbatus*) died from electrocution (33.3 %) and collision (66.7 %) with power lines in the Pyrenees mountains, comprising the third-highest cause of non-natural mortality in this species (Margalida *et al*., 2008).

Also in Africa, numbers of collision victims with raptors and owls are many times lower than the number of electrocution victims (compare Figure 3 with Figures 9 and 10 for the same species of raptors).

<u>Rails</u>
Rails are reported as collision victims in almost every available collision victim studie from Europe. Because of their poor flight abilities, their habit to fly at relatively low heights and the fact that they migrate at night, rails are highly susceptible to collisions with power lines. Osieck & de Miranda (1972) relate events at which large numbers of rails were killed in the Netherlands to migration triggered by periods of frost. Common Coot (*Fulica atra*), Common Moorhen and Water Rail are often encountered as collision victims in European studies, frequently with dozens of victims being reported (Scott *et al.*, 1972; Hoerschelmann *et al.*, 1988; Hartman *et al.*, 2010). Corncrake (*Crex crex*) is occasionally reported as collision victim, but always in low numbers, which reflects its very rare status (Scott *et al.*, 1972; Koops, 1987; Hoerschelmann *et al.*, 1988).

<u>Cranes & storks</u>
In a large part of the world, but especially in Southern Europe, Africa, Asia and the United States, **cranes** are known to be highly susceptible to collisions with power lines. For instance, Janss & Ferrer (1998) found 13 Common Cranes (*Grus grus*), Janss (2000) found eight Common Cranes and Alonso *et al.* (1994) found seven Common Cranes, representing 8.7%, 15.4% and 6.5% of the total amount of collision victims found in these Spanish studies respectively. In the United States, Faanes (1987) found 62 Sandhill Cranes under power lines, which made it the third-most recorded species after wildfowl and gulls species. In another study in the United States it was found that dozens of Sandhill Cranes were killed every year at a 69 kV power line close to a major night roost of the species (Murphy *et al.*, 2009). In India, Sundar & Choudhury (2005) studied the mortality of Sarus Cranes (*Grus antigone*) due to electricity wires and they found that each year approximately 1% of the total

Sarus Crane population was killed due to accidents with power lines. In South Africa, Shaw *et al.* (2010) estimated that approximately 12% (5–23%) of the total Blue Crane population within the Overberg area of the Western Cape could be killed annually in power line collisions.
Storks are also found dead under power lines in relatively large numbers, but most of these victims are the result of electrocution accidents rather than collisions (Marti, 1998). For example, Janss (2000) found 41 White Storks (*Ciconia ciconia*) under approximately 16 kilometres of power line, of which only five were thought to be collision victims. Many of these accidents are related to food availability. Garrido & Fernández-Cruz (2003) reported that more than 70% of the collisions occurred at less than one kilometre away from the nearest rubbish dump.

<u>Bustards</u>
Another group of species that is also known to be highly susceptible to power line collisions is the bustards. From Central Europe there are few reports of Great Bustards that were found as collision victim (Reiter, 2000). In the Ukraine, Andryushchenko *et al*. (2002) reported 19 collision victims from the period 1992 - 2002. In addition to this, they found 11 dead Great Bustards during a survey devoted to the problem below two stretches of 10 kilometer power line in winter 2001/2002 in the south of Ukraine and received three further reports of collided victims below other power lines in the area. Watzke (2007) reports six collision victims from the Saratov region in Russia, five of which were found in the immediate vicinity of the display lek in one of survey areas.
In Southern Europe and Africa relatively large numbers of collision victims of bustards have been recorded. For example, Alonso *et al.* (1994) found five Little Bustards and five Great Bustards, Janss & Ferrer (1998) found 26 Little Bustards and 23 Great Bustards and Janss (2000) found 10 Little Bustards and 13 Great Bustards. Altogether the bustards represented 27.5% of all collision victims found in these three Spanish studies. In Portugal, Marques (2009) compiled information on bustard mortality in distribution lines available from distinct monitoring schemes. These results showed that 202 kilometres of nine different power lines caused the death of 143 bustards (58 Great Bustards and 85 Little Bustards). Recent published information showed that transmission power lines are avoided by Little Bustards, being the most important factor determining breeding densities in sites with suitable habitat for the species (Silva, 2010; Silva *et al*., 2010). The status of the Great Bustard on the IUCN Red List is 'vulnerable' and the status of the Little Bustard is 'near threatened', which means that large numbers of collision victims of these species raises concern.
Jenkins *et al.* (*in press*) have begun study of the Ludwig's Bustard (*Neotis ludwigii*), a near-endemic to Southern Africa, which is extremely susceptible to collisions with power lines, and was uplisted on the IUCN Red List to Endangered in 2010 based on the anticipated population decline stemming from such mortality. Preliminary results suggest that 11-15% of the population could be killed annually on high voltage transmission lines through collisions. Shaw (reference in Barrientos *et al*., 2011) estimated in 2009 that in South Africa 30% of Denham's Bustard (*Neotis denhami*) are killed annually by collisions with power lines.

<u>Waders</u>
Waders are relatively well represented in most collision victim studies, indicating that a number of wader species are also highly susceptible to collisions with power lines. For example, 22.2% of the victims found by Hartman *et al.* (2010), 19.1% of the victims found by Hoerschelmann *et al.* (1988), 24.3% of the victims found by Alonso *et al.* (1994) and 33.0% of all collision victims found in the Netherlands between 1960 and 1985 (Koops 1987) consisted of waders. In contrast, Scott *et al.* (1972) only found 12 waders among a total of 1,285 collision victims in a study at the coast of England.

The range of wader species that is found in a single study can be relatively large, but often one or two species dominate in numbers. In Southern and Western Europe, the Lapwing is the most commonly found wader species in collision studies (Hoerschelmann *et al*., 1988; Alonso *et al*., 1994; Janss & Ferrer 1998; Marques *et al*. 2008; Hartman *et al*., 2010), with lower numbers of, *e.g*., Eurasian Curlew, Golden Plover and Common Snipe (*Gallinago gallinago*). According to the overview of Koops (1987), Lapwing was the most abundant collision victim in the Netherlands between 1960 and 1985 (1,743 birds). Koops (1987) also reported relatively large numbers of collision victims of 891 Black-tailed Godwits, which nowadays has the status 'near threatened' on the IUCN Red List, 393

Ruff (*Philomachus pugnax*) and 381 Common Snipes. Most of these species are nowadays scarce or rare breeding birds in the Netherlands and also much scarcer on migration than in 1960s, 1970s and 1980s. Therefore, modern numbers of collisions for these species may look very different although recent data on collision victims is lacking.

<u>Gulls & terns</u>
Gulls are highly susceptible to collisions with power lines and are often found as collision victims in large numbers, perhaps because they spend relatively a lot of time in the air, often very dense flocks and also during windy conditions. Gulls made up 5.5% of the victims found by Hoerschelmann *et al.* (1988), 5% of the victims found by Hartman *et al.* (2010), 10.6% of the victims found by Scott *et al.* (1972), 14.5% of the victims found by Marti (1998), 23% of the victims found by Faanes (1987), and even 61.6% (more than 530 gulls and tern victims) in a study in Southeastern France by Bayle (1999). Koops (1987) reports of 1,629 gulls found as collision victims in the Netherlands between 1960 and 1985. The species that is most often found in Western European inland studies is the Black-headed Gull, but next to that almost all locally common gull species have been found as collision victims.

Compared to gulls, **terns** appear to be relatively less susceptible to collisions with power lines. Hoerschelmann *et al.* 1988 only found one tern (*Sterna spp.*) and Koops (1987) reports not more than 13 collision victims of Black Terns (*Chlidonias niger*), 27 Common Tern and two other tern victims in the Netherlands between 1960 and 1985. Janss & Ferrer (1998) report an event at which 15 Black Terns where killed on a single occasion at one specific location, but the cause for this remarkably high number of casualties is unknown.

<u>Nocturnal migrants</u>
Nocturnal migrants can be at high risk of colliding with power lines during periods with adverse weather conditions, which often forces migrants to fly at lower altitudes, coupled with the difficulty of seeing power lines in darkness (see also paragraph 3.1.4 and 3.1.6). In several studies at locations where power lines cross a major migration route, nocturnal migrants were found as collision victims in relatively large numbers. For instance, Scott *et al.* (1972), who studied collisions of birds with a power line at the South coast of England where many migrants enter and leave the mainland, found a lot of nocturnal migrants including many rails, **thrushes** and **warblers**. The thrushes represented 16.7% of all collision victims found during this study. Also Marti (1998) and Hoerschelmann *et al.* (1988) found that thrushes accounted for 21.8% and 17.6% of all collision victims respectively. Additionally, 40% of the collision victims found by Andersen-Harild & Bloch (1973) in a study in Denmark, consisted of nocturnal migrants. These percentages include some of the species groups mentioned before, such as ducks and rails, for which it is not always possible to make a clear distinction between local birds and migrants. The number of collision victims for small passerines, such as warblers, might be underestimated because carcasses of these species are easily overlooked in collision victim searches and are quickly removed by scavengers (Ponce *et al.*, 2010).

3.4. Regional Overview of Collision Conflict

There is a large difference in the amount of (quantitative) information available between countries and regions. In some countries the problem of collisions of birds with power lines has been extensively studied (Appendix 2). However, in most countries the scale and nature of the problem is still unknown.

Paragraph 2.4 describes the difficulties surrounding the interpretation and comparison of results of bird electrocution studies. This also applies to collision studies. Despite these difficulties it remains valuable to summarise the available information per region in an attempt to identify the (potential) bottlenecks and collision hotspots. Below we summarise the current knowledge per region, with special attention to the most vulnerable taxa and the most dangerous electricity configurations. The review relies on peer-reviewed literature, unpublished studies and reports as well as answers to the questionnaire sent to 175 Focal Points and CMS Raptor MoU Contact Points within the African-

Eurasian region in February 2011 (see chapter 1). The paragraphs below present information on the three main regions of the African-Eurasian region, namely: Europe, Asia and Africa. Based on regional similarities, Europe has been further divided into five sub-regions: Western Europe, Northern Europe, Central Europe, Eastern Europe and Southern Europe, while Africa has been divided in the sub-regions Northern Africa, Central and Western Africa, Eastern Africa and Southern Africa. For every (sub-) region the main habitats are listed in which collisions of birds with power lines were studied, including the main species involved. If available, for every (sub-) region one or more extensive studies (long term / involving different habitat types) are highlighted and some other complementing and/or interesting results are described. For a full overview of existing information, we refer to the reference list at the end of the report.

3.4.1. Europe

3.4.1.1. Northern Europe

Most information available for Northern Europe is from Norway where different studies have focused on collisions of birds with power lines in low alpine birch forests mixed with small bogs (Bevanger, 1993; Bevanger, 1995; Bevanger & Brøseth, 2004). In these studies species belonging to the grouse were most often found as collisions victims. Examples of species are Willow Grouse, Black Grouse and Capercaillie. The high number of grouse victims in Northern Europe is probably caused by a combination of factors including the relatively high abundance (locally) and behaviour (typical gliding flight behaviour in winter and dispay flights in spring). Of the available studies, Bevanger & Broseth (2004) performed the most extensive study with a duration of six years in which approximately 4,000 kilometres of power lines were patrolled. The study area was located in subalpine habitats dominated by boreal birch forest mixed with small mires. In this study almost 400 collision victims were found, of which approximately 80% were grouse (*Lagopus spp.*), which are considered to be ‘poor’ fliers (see paragraph 3.2.4.1). On average the minimum collision rate of *Lagopus spp.* was found to be 5,3 birds/km/year. An interesting result from this research was that collisions tended to occur at places with low trees in the area surrounding the power line.

For Northern Europe there are almost no complementary (quantitative) information on the impact of collisions with power lines for other species groups like wildfowl, waders, raptors or passerines. The only available quantitative information is from Sweden, where Mathiasson (1993) found that 19-38% of the Swedish ringed Mute Swans died due to collision with power lines. The fact that all other studies in Northern Europe focused on grouse *spp.*, indicates that in certain areas (subalpine birch forests) a relatively large number of birds of these species die from collisions with power lines. However, in other habitats power lines might still pose a great risk to other bird species *e.g.*, waterbirds in coastal areas or migrants funneled through mountain valleys. Bevanger (1994) states that theoretically collision frequency should increase with latitude following the deterioration of light conditions. Unfortunately there are no data available to support this theory.

In Finland there has been a bird collision risk assessment of part of the transmission grid (110-400 kV). In this study they classified sites on a point scale according to the bird collision risk. A total of 191 sites were suggested as having a (relatively) high bird collision risk. The author recommends marking of the wires at those sites (Piironen, 1997).

Habitat	**Species**	**Remarks**
Subalpine birch forest (mixed with small bogs)	grouse *spp.*	In specific areas the number of grouse killed by overhead wires (collision) are almost as high or even higher as the number of grouse killed by hunting

Summary of information on collision retrieved: mostly from Norway (but also applicable to other Scandinavian countries). Further reading: Bevanger & Overskaug, 1998; Bevanger & Brøseth, 2001; Bevanger *et al.*, 2009.

3.4.1.2. Western Europe

Most available information for the Western European sub-region is derived from the Netherlands, the United Kingdom and Germany. Substantial research has been performed in agricultural areas and wetlands and many studies involve both habitat types (Andersen-Harild & Block, 1973; Heijnis, 1976; Koops & de Jong, 1982; Hoerschelmann *et al.*, 1988). Two of the available studies were performed in coastal areas (Scott *et al.*, 1972; Beijersbergen, 1975). It is remarkable that the species or species groups that are found most as collision victims in Western European agricultural areas and wetlands are highly comparable between studies. The species groups most frequently found are ducks, waders, rails, gulls, pigeons and passerines (mostly Starling and thrushes). In coastal areas the local presence or absence of channeled migration largely influences the species spectrum and the number of collision victims (Scott *et al.* 1972).

To illustrate the general bottlenecks for the Western European region, three extensive studies are discussed in more detail, including a study from the Netherlands (Koops 1987), Germany (Hoerschelmann *et al.*, 1988) and the United Kingdom (Scott *et al.*, 1972). Koops (1987) reviewed all Dutch quantitative studies of collisions of birds with power lines for the period from 1960 to 1985 and has prepared an overview of the species that were found as collision victims. He reports the same species groups as being prone to collision as many other studies from Western Europe, namely waders, ducks, rails, gulls, pigeons and large passerines. The five species that were found most in the Netherlands between 1960 and 1985 (excluding the Domestic Pigeon (*Columba livia f. domestica*)) are Lapwing, Starling, Common Coot, Mallard and Black-headed Gull. There are also some nationally scarce species that are found relatively often as collision victims, like Purple Heron, Eurasian Spoonbill, Garganey (*Anas querquedula*), Ruff, Black-tailed Godwit and Common Snipe. There are also some species (groups) that, despite their regular presence close to power lines, are hardly ever found as collision victim. Examples are the Great Cormorant, corvids and raptors. Small passerines are also rarely found as collision victims but this might partly be caused by the fact that they are easily overseen in collision victim searches and are very quickly (completely) removed by scavengers (Ponce *et al.*, 2010). Averaging the data from all different studies, Koops (1987) calculated an average collision rate for the Netherlands of 113 ± 58 birds/km/year.

Hoerschelmann *et al.* (1988) conducted an intensive study in Germany. They studied collisions of birds with a high-tension power line crossing an agricultural area next to the Elbe, which was classified as wetland habitat. The study included four migration periods and searches were carried out along approximately 4.5 kilometres of line. They mostly found ducks, rails (mainly Common Coot), waders, gulls, pigeons, and passerines (including many thrushes). The five most commonly found species were Lapwing, Domestic Pigeon, Woodpigeon, Starling and Mallard. Hoerschelmann *et al.* (1988) calculated a minimum collision rate for the area concerned of 390 birds/km/year. This number is clearly higher than mentioned above by Koops (1987) for the Netherlands, which can be explained by differences in study areas (many different areas in the Netherlands versus one small study area in a bird-rich river valley, period of research, species involved and possibly differences in study protocols).

The most extensive, and most frequently cited, study from the Western European region in a coastal area is Scott *et al.* (1972). They searched for collision victims for six years under *ca.* 2.1 kilometres of a 400 kV power line in Dungenes, the United Kingdom. Many of the victims they found were nocturnal migrants like rails (mainly Common Moorhen, Common Coot and Water Rail), thrushes and warblers, the latter species group reflecting the importance of the site as a migrant hotspot. Next to that they also found a lot of Starlings, pigeons and gulls. Among the most frequent found collision victims were Starling, Song Thrush (*Turdus philomelos*), Turtle Dove (*Streptopelia turtur*), Redwing (*Turdus iliacus*), Blackbird (*Turdus merula*), Great Black-backed Gull (*Larus marinus*) and Woodpigeon. Compared to the results from agricultural areas, the collision victims included many migrant species, which enter or leave the mainland at this site on the south coast of the United Kingdom, at which point the power line was placed perpendicular to the main route of migration.

In addition there is also a relatively large amount of information on large numbers of swans colliding with power lines in the United Kingdom. Unfortunately most of this information consists of short references to unavailable qualitative research. For instance in APLIC (1994) they refer to Beer and Ogilvie (1972) who found that in Kent 30% of the resident population of Mute Swans was killed in two months along 400 metres of power line. Additionally, from an analysis of ringed birds Rose and

Baillie (1989, as cited in Tucker *et al.*, 2008) found that the Mute Swan was one of the most vulnerable species in the United Kingdom concerning deaths caused by power lines. Frost (2008) found 21 and nine Mute Swans under a high-tension power line at the Abberton Reservoir, Essex, England, over two springs respectively. Finally, Robinson *et al.* (2004) state that the main causes of death of Whooper Swan (*Cygnus cygnus*) in Britain and Ireland are flying accidents. The question remains if the swans are really highly collision prone species in the United Kingdom or that this species group just received an exceptional amount of attention because it is easily found and monitored.

Habitat	**Species**	**Remarks**
Open water	Swans (Mute Swan and Bewick Swan)	Several studies from UK detailing relatively large losses through collision
Agricultural area / wetland	Wildfowl (especially ducks), waders (meadow birds), rails, gulls, pigeons and large passerines (mainly Starling and thrushes)	Many studies involve both habitats and the species (groups) found as collision victim are highly comparable for both habitats
Coastal area / wetland	Waders (shorebirds), gulls, ducks, rails, pigeons and passerines (nocturnal migrants)	Species (groups) highly dependant on local populations combined with the possible presence of channeled migration, which is often an issue in coastal areas

Summary of information on collision retrieved from the Netherlands, Germany, United Kingdom, Denmark. Further reading: Anonymus *ca.* 1970; Heijnis, 1980; Brauneis *et al.*, 2003; Vlas & Butter, 2003; Bernshausen & Kreuziger, 2009; Hartman *et al.*, 2010.

3.4.1.3. Central and Eastern Europe

The amount of available information from Central and Eastern Europe concerning bird collisions with power lines is very limited. There is only limited information available from a few countries, while for most other countries the scale and nature of the problem is still unknown. There are two available studies in which the habitats and species involved were specified, one from Switzerland (Marti, 1998) and one from Bulgaria (Gerdzhikov & Demerdzhiev, 2009).

Marti (1998) studied bird collisions for three periods of two months at two power lines (approximately 1,5 kilometres) in an agricultural area next to a wetland. The collision victims mainly consisted of ducks, gulls and thrushes. The four most found species were Blackbird, Song Thrush, Gull spec. (*Larus spp.*) and Mallard. For the two separate studied power lines Marti (1998) calculated collision rates of respectively 292 (60 kV) and 328 (125 kV) birds/km/year. Gerdzhikov & Demerdhiev (2009) studied the combined mortality of birds by electrocution and collision for 15 months at 44,6 kilometres of power line (20 kV). Most of the victims they found were located close to the poles and were therefore seen as electrocution victims. Only 34% of the victims were found under the conductors and were therefore seen as collision victims (15 individuals). These victims mainly included storks (Ciconia spp.), Common Buzzards (*Buteo buteo*), Ravens (*Corvus corax*) and passerines (one Blackbird, one Linnet (*Carduelis cannabina*), one Yellowhammer (*Emberiza citrinella*) and one unidentified passerine). Only one Common Moorhen, one pigeon (Columbidae) and one Long-eared Owl were found as collision victim.

We know of two other field studies in the Central and Eastern European region. Jaklitsch *et al.* (2011) studied the collision of birds with a marked power line in an agricultural area in Austria. They found six victims including five passerines and one duck. In Bulgaria a study was performed in four IBAs (Demerdzhiev *et al.*, 2009). The collision victims they found consisted mainly of small passerines (59%). Zohmann *et al.* (2010) studied collisions of several grouse species with wires (mainly wires of ski-lifts). They concluded that for the grouse species, wire mortality sometimes results in considerable local losses.

The remaining available information mainly reports about power line casualties of some specific species. Several authors state that the mortality of White Storks caused by power lines is high (Marti, 1998; Schaub & Pradel, 2004; Mihelic & Denac, 2011). Most of these studies do not distinguish between electrocution and collision victims. However, the studies that separate the causes show that the main threat for the White Stork is posed by electrocution. Marti (1998) refers to a study of Kaiser (1993) in which he showed that 21,6% of the registered dead Mute Swans died following a collision with a high-tension power line. Reiter (2000) points at the additional mortality of the Great Bustard due to collision with power lines in Austria. The Great Bustard is well known as a collision prone species and is more extensively studied in Southern Europe (see below).

There is no quantitative information on the numbers of collision victims or the species involved from Romania . However, two potential collision hot-spots are the Danube Delta and Dobrogea, where large flocks of pelicans, geese and swans are present, and the Western Plain near the Hungarian border, where the last Romanian Great Bustard population exists and also large numbers of geese winter (T. Papp *in litt.*).

Habitat	**Species**	**Remarks**
Agricultural area / wetland	Mainly ducks, gulls and thrushes	Single study from Switzerland
Agricultural area / steppe	Mainly storks, Common Buzzard, Raven and passerines	Single study from Bulgaria

Summary of information on collision retrieved from Switzerland & Bulgaria

3.4.1.4 Southern Europe

Most available information on bird collision in the Southern European sub-region was obtained from Spain, France and Portugal. There have been several studies addressing the subject, including papers published in peer reviewed journals. However, plenty of information is included in unpublished reports. In the Southern European region, most collision victims belonged to species groups like raptors, waders, herons, storks, bustards, gulls and terns. Much of the research in this region has been performed in inland open areas (mainly agricultural or steppe), wetlands or coastal areas.

In France and Italy waterbirds including Greater Flamingos (*Phoenicopterus roseus*), seem to be the main victims as well as some raptors and owls (*e.g.*, Bayle, 1999; Rubolini *et al.*, 2005; Kabouche *et al.*, 2006). In Southeastern France (Plain de Crau and surroundings) 865 birds were found dead between 1988-1993, after colliding with high voltage transmission lines. The species most affected were gulls and terns (61.6%) and Greater Flamingo (14,.1%). Only two raptor species, Eurasian Sparrowhawk and Long-eared Owl, were killed (Bayle, 1999). A different study conducted in France in 1992 showed that, out of 649 raptors found dead under power lines, 6.5% collided with electric wires (the remaining were electrocuted). Most of the raptors (96.5%) were found under medium voltage power lines (Sériot & Rocamora, 1992 in Bayle, 1999). The most affected species were the Common Buzzard and the Common Kestrel.
A review of 11 bird mortality surveys was performed in Italy by Rubolini *et al.* (2005). Over 1,300 casualties were reported under power lines, involving 95 species. Once again, raptors (especially Common Buzzard, Common Kestrel, Griffon Vulture (*Gyps fulvus*), Osprey (*Pandion haliaetus*) and Eurasian Sparrowhawk, flamingos, herons and storks were highly affected. Even though a distinction between electrocution and collision as the cause of mortality was not always available, the application of a statistical model allowed the conclusion that raptors and corvids were mostly affected by electrocution, while herons, flamingos and small passerines died more frequently from collisions. Rubolini *et al.* (2001) reviewed the impact of power lines on the Eagle Owl (*Bubo bubo*) mortality in the Italian Alps. A total of 92 owls were found dead, 52% of which due to power lines (no distinction between collisions and electrocution).

While in Southeastern Europe there is much less information available, Dalmatian Pelicans are known to be affected at least in Greece (Crivelli *et al.*, 1988). In contrast, several studies and information are available from the Iberian Peninsula. In this region, bird collisions with power lines threaten mostly steppe birds, such as the Great Bustard and Little Bustard (*e.g.*, Alonso *et al.*, 1994; Marques *et al.*, 2008; Silva *et al.*, 2010). Waterbirds are also affected and, to some extent, raptors (especially young birds), including the globally threatened Spanish Imperial Eagle (*Aquila adalberti*), Bonelli's Eagle (*Aquila fasciata*) and Bearded Vulture (*Gypaetus barbatus*).

In a detailed study carried out in Portugal between 2003 and 2005, nearly 900 kilometres of power lines were surveyed for dead birds, mainly on Natura 2000 sites and IBAs (Important Bird Areas) (Infante *et al.*, 2005). 1,599 birds were found dead from collisions, which represented 51% of the whole mortality caused by power lines. The estimated number of collisions per kilometre of power line per year was 3.45. Two groups of areas were found to be especially susceptible to bird mortality from collisions: coastal wetlands (up to 9.4 casualties/km/year) and steppe areas (up to 6.57 collisions/km/year). Gruiformes and Charadriiformes were two of the bird groups most affected. Casualties included eight Great Bustards, 32 Little Bustards and raptors such as one Bonelli's Eagle and five Montagu's Harrier (*Circus pygargus*). Lines constructed on portal support and delta configurations registered higher values of collision mortality.

In another study, nearly 206 kilometres of transmission lines were surveyed throughout the Portuguese territory, again mainly on Natura 2000 sites and IBAs (Neves *et al.*, 2005). 575 birds were found dead (no distinction between collisions and electrocution), belonging to 72 species. Passerines were the most common victims (27%), followed by Ciconiiformes (16%). 19% of the species had national or international protection status, including seven species listed as SPEC 1 and SPEC 2 categories (Tucker & Heath, 1994; BirdLife International, 2004): Lesser Kestrel (*Falco naumanni*), Great Bustard, Little Bustard, White Stork, Red-legged Partridge (*Alectoris rufa*), Lapwing and Woodchat Shrike (*Lanius senator*). The most affected species was the White Stork, especially young birds while leaving the nest or dispersing. Casualties included also 13 Great Bustards, 33 Little Bustards, three Common Cranes and one Lesser Kestrel. In this study, the total estimated collision mortality rate was 13.92 birds/km/year. Cereal steppe areas revealed the highest mortality rates (16.31 birds/km/year). Most corpses were found more than 50 metres away from the pylons and more than 50 metres away from the middle of the line corridor. No differences were found in collision rates regarding to the type of pylon, but there was a positive correlation between cable height and mortality in the cereal steppe habitat. Cable diameter was also related to mortality, being higher in 14.6 mm cables, in comparison to thinner (11.7 mm) and thicker (15.5 mm) cables.

A different study was carried out in Portugal to study bird mortality associated with power lines in a cereal steppe area (Marques *et al.*, 2008). In this study, 50 kilometres of distribution and transmission lines were surveyed and revealed a collision rate of 3.42 birds/km/year. Lines installed with portal configuration produced more casualties. Most affected species were the Corn Bunting (*Miliaria calandra*), Cattle Egret (*Bubulcus ibis*), Lapwing and Quail (*Coturnix coturnix*). Five Great Bustards were found dead (collision rate of 0.1 birds/km/year), corresponding to 1.93-2.76% of the local population. In addition, 15 Little Bustards were found dead (collision rate of 0.3 birds/km/year), corresponding to 1.03% of the local population. In a different study, Marques (2009) compiled the information on both Little and Great Bustard mortality in distribution lines available from distinct monitoring schemes in Portugal. These results showed that 143 bustards (58 Great Bustards and 85 Little Bustards) died along 202 kilometres of nine lines. The influence of the distribution of transmission lines on Little Bustard populations has also been studied in Portugal. Recent published information showed that transmission power lines are avoided by Little Bustards, being the most important factor determining breeding densities in sites with suitable habitat for the species (Silva, 2010; Silva *et al.*, 2010).
Finally, a recent survey involving 202 kilometres of power lines located mainly on Natura 2000/IBA areas reported a collision rate of 0.63 birds/km/year (Costa & Infante, 2010). In this case, mortality was higher during the autumn migration period.

In the Portuguese Islands of the Azores, between July 2007 and November 2008, 237 sections of 1 kilometre length were surveyed for dead birds. This sample represents about 19% of the total extent of power lines in the Azores. A total of 315 dead birds were found due to collisions, corresponding to a mortality rate of 11.1 birds/km/year. The most common collision victims included pigeons (*Columba* spp.), gulls (*Larus* spp.), Eurasian Woodcock (*Scolopax rusticola*) and Common snipe (*Gallinago gallinago*).

In Madeira, between January 2007 and December 2008, a total of 19 km power lines were patrolled systematically in four different seasons. This only represents 1.3% of the total power lines in Madeira Island. Monitoring of distribution and transmission lines in Madeira is difficult due to topographical features and extremely dense forests. During the examination of ten different power lines in seven different areas (mainly in Protected Areas, SPA and IBA), 17 dead birds were found due to collisions during these two years. After the application of all correction factors, the mortality rate estimated was 14 birds/km/year. The birds more susceptible to die from collision are Bulwer's Petrel (*Bulweria bulwerii*), Madeiran Storm-petrel (*Oceanodroma castro*) and Eurasian Woodcock (*Scolopax rusticola*). Collision frequency was higher in "Coastal open areas" and "High altitude open areas" (Fagundes, 2009).

Since 2003, three collision victims and one (possible) electrocution victim of Spanish Imperial Eagle have been found in Portugal (information from returned questionnaire Portugal; J. Loureiro, Instituto da Conservação da Natureza e da Biodiversidade, *in litt*.). This mortality is highly relevant considering the unfavourable conservation status of this species.

In Spain, Alonso & Alonso (1999) estimated a collision rate of 2.95 birds/km/year in nine areas representing the most typical habitats of the Iberian Peninsula. A study sponsored by some of Spain's most important electricity distributer companies (Compania Sevillana de Electricidad, Iberdrola & REE, 1995), revealed that the species most affected by collisions were the Great Bustard, the Little Bustard and the Common Crane.

In a four-year study (1991-1995) surveying a sample of power lines in Spain 150 collision casualties, involving 26 bird species, were found. Gruiformes were the most common victims - Great Bustard (23 individuals found dead), Little Bustard (26), Common Crane (13), Common Coot (1) and Common Moorhen (1) -, followed by Charadriiformes – Black Tern (15), Lapwing (10), other species (8) -, Passeriformes (14), Anseriformes (12), Ciconiiformes (8), Phoenicopteriformes (6), Columbiformes (5) and Falconiformes (1) (Janss & Ferrer, 1998).

During a nine-year study in Extremadura (Southwest Spain), 3,228 birds of 98 species were found dead. The bird species that suffered the most from collisions with power lines were the Common Crane and the Great Bustard (Palacios, 2003; Palacios & García-Baquero, 2003). In a three-year study (1992-1995), Janss and Ferrer (2000) estimated collision rates (number of birds hitting a power line/number of birds crossing a power line) at 3.93×10^{-5} for Common Cranes and 6.34×10^{-3} for Great Bustards. Lane *et al.* (2001) studied habitat preference of Great Bustards in Central Spain, concluding that this species avoids power lines, which contributes to the non-use of otherwise potentially suitable areas.

Also in Spain, a shorter-term study (1999-2000) involved the monthly survey of 12 different power line sections and 129 steel power poles aiming the assessment of White Storks mortality (Garrido & Fernández-Cruz, 2003). Very few storks died during the breeding season, but near 1% of the present population died on power lines during post-breeding migration and 7% during pre-breeding migration and wintering season. Estimated mortality rates were 3.9 birds/km/year for collisions and 0,39 birds/pylon/year for electrocutions. More than 70% of the collisions occurred at less than one kilometre away from the nearest rubbish dump (Garrido & Fernández-Cruz, 2003).
Bearded Vultures are also affected negatively by power lines in Spain and France. In the period between 1979 and 2008, 18 Bearded Vultures died from electrocution (33.3%) and collision (66.7%)

with power lines in the Pyrenees mountains, comprising the third cause of non-natural mortality in this species (Margalida *et al.*, 2008).

Habitat	**Species**	**Remarks**
Coastal area / wetland / forest	Raptors, herons, gulls, terns, waders, flamingos and passerines	France, large numbers found under medium voltage power lines. Affecting mostly common species (Common Buzzard and Common Kestrel). Italy, most affected groups are herons and passerines.
Wetland	Dalmatian Pelicans	Single study from Greece
Agricultural area (mainly cereal steppe)	Mainly Great and Little Bustards and Cranes and White Storks; also threatened raptors, including Spanish Imperial Eagle, Bonelli's Eagle and Bearded Vulture	Yearly mortality of Great Bustard and Little Bustard in Portugal is equivalent to around 2% and 1% of the population respectively on their core distribution area. Highly threatened raptors in Spain and Portugal

Summary of information on collision retrieved mainly from Spain, Portugal and France. Further reading on bird collisions in Portugal: Neves & Infante, 2008; Sampaio, 2009. Further reading on collisions in Spain: Alonso *et al.*, 1994; Fernández García, 1998; Janss, 2000; Mañosa & Real, 2001; GaNGOso & Palacios, 2002; González *et al.*, 2007; Rollan *et al.*, 2010).

3.4.2. Asia (including Middle East)

Information on collisions of birds with power lines from Asia is extremely scarce.

Only one study from India on the mortality of Sarus Cranes due to electricity wires is available (Sundar & Choudhury, 2005). The most striking result is that each year approximately 1% of the local Sarus Crane population dies due to electrocution or collision. During the study, wire-related mortality was the main cause of death for both fledged young and adult Sarus Cranes in territories (67% of 52 deaths). Mishra (2009) also states that power lines are a main threat for this endangered species.

Yoo *et al.* (2010) showed that for the Red-crowned Crane (*Grus japonensis*) and the White-naped Crane (*Grus vipio*), collisions with power lines is the second most important type of mortality (after poisoning) in the Cheorwon area in Korea. Based on the results of this study, the Eco-Star Project of the Center for Aquatic Ecosystem Restoration, funded by the Korea Ministry of Environment (MOE), developed a prototype of wire markings to increase the visibility of the wires. No results on the efficiency of these markers are yet available (Dr. Chang-Yong Choi *in litt*.). Elsewhere in Korea, the local government of Suncheon City successfully implemented the Hooded Crane (*Grus monacha*) conservation action plan by putting above ground power lines within an important wintering reserve for the species below ground, preventing collisions with these lines (Dr. Chang-Yong Choi *in litt*.).

In Ukraine, Andryushchenko *et al*. (2002) found 11 collision victims of Great Bustard during a survey below two stretches of 10 kilometer power line in winter 2001/2002 in the south of Ukraine. They further report on 22 other collision victims of this species in the same area in the period 1992-2002. During the same survey they also found remains of 46 other collision victims, including a Hen Harrier (*Circus cyaneus*), two Grey Partridges (*Perdix perdix*), six Calandra Larks (*Melanocorypha calandra*), and 11 corvids.

There is almost no additional information concerning collisions of birds available for this region, so there is a large gap in the knowledge available for Asia. The only other available information is coming from two countries, Mongolia and Azerbaijan, and is highly anecdotal. Harness *et al.* communicated on the internet that in Mongolia in 2008 a large number of Pallas' Sandgrouse (*Syrrhaptes paradoxus*) were killed after colliding with wires during an unusual seasonal movement. In Azerbaijan, Sultanov (1991) estimated the high-tension power line and communication line related bird mortality in the southeastern part of the country. During wintering and spring migration, wire related mortality was highest for waterbirds like ducks. In the breeding season most victims belonged to the songbirds and other land birds. They also found victims of rare and threatened birds like Little Bustard and the Dalmatian Pelican. In addition, Sultanov *et al.* (1991) state that communication lines and medium-tension power lines are most dangerous for birds and that most victims occur close to waterbodies.

Most of the research in Asia so far has focused on the electrocution of birds at power lines and poles. It is to be expected that also in Asia many birds also die due to collisions with power lines, however, much research needs to be done to determine the scale and nature of the problem and point out the bottlenecks and potential collision hot-spots.

<u>Middle East</u>
In Israel, documented information on electrocution and collision events suggests an average number of near 150 events per year (information from returned questionnaire Israel; O. Hatzofe, Israel Nature & Parks Authority, *in litt*.). The majority of collisions involve White Pelicans (*Pelecanus onocrotalus*) (up to 60 cases in 2008 but usually less than 20) and White Storks during the autumn migration.

Habitat	**Species**	**Remarks**
Urban area / agricultural area	White Pelican, White Stork Gulls and Raptors	20-60 cases/year Most collisions occur during migration or near garbage dumps

Summary of information on collision retrieved from Israel

3.4.3. Africa

Africa can be divided loosely into Northern, Western, Central, Eastern and Southern Africa. Generally this coincides with arid or desert, forest, forest, woodland and woodland/semi-desert vegetation types respectively. Below a summary is presented of the little information that was found on bird collisions with power lines in Africa. Additionally, in paragraph 2.4.3.5 an effort is made to extrapolate the knowledge from the few African countries where data does exist to the larger African region.

3.4.3.1. Northern Africa

In North Africa and sub-Saharan Northern Africa there is an almost total absence of published data on the subject of bird collisions with power lines. One exception is a review on the main man-induced mortality of the highly threatened population of Great Bustards in Morocco (less than 100 birds), that showed that collision with power lines represented 23.3% of the mortality calculated (n = 30) (Alonso *et al.*, 2005).

In Egypt, bird collisions are probably mainly a local phenomenon, concerning riskful locations in and near migration bottlenecks, such as the Gulf of Suez and South Sinai (Dr. S. Baha El Din *in litt*.).

3.4.3.2. Central and Western Africa

Much of this region is classified as forest by White (1983). Since forest is the tallest vegetation type, one could surmise that collisions may be less frequent since the tall vegetation may shield certain parts of the power distribution lines. Secondly, detection of collision victims (bird carcasses) is likely to be less likely in forest vegetation. No information on bird collision in this region was received or found in the literature.

3.4.3.3. Eastern Africa

An important feature of this region, relevant to bird collision, is the presence of the Rift Valley and its lakes. These lakes are home most importantly to flamingos, which are extremely vulnerable to power line collision, partly due to their habit of flying at night.

A rapid risk assessment of the interactions between Kenya's large birds and electrical infrastructure was conducted in the Magadi and Naivasha areas during January 2009 (Smallie & Virani, 2010). Several sites of high bird collision risk were observed. Of approximately 24 relevant bird species of conservation concern in Kenya, 17 (71%) face a high risk of direct interactions with electrical infrastructure. Priority species for attention are the Lesser Flamingo (*Phoenicopterus minor*), Egyptian Vulture (*Neophron percnopterus*), White-headed Vulture (*Trigonoceps occipitalis*), Lappet-faced Vulture (*Torgos tracheliotos*), African White-backed Vulture (*Gyps africanus*), Rüppell's Vulture (*Gyps rueppellii*), Martial Eagle (*Polemaetus bellicosus*), Grey Crowned Crane (*Balearica regulorum*),White Stork, and Secretary Bird (*Sagittarius serpentarius*). Smallie & Virani (2010) present several recommendations for a national response to this matter.

In Uganda dead Marabou Storks (*Leptoptilos crumeniferus*) have been found below transmission lines near Lake Katwe and in Queen Elizabeth National Park, presumed collision victims since those lines are poorly sited, crossing regular Flyways (Pomeroy *pers. comm.*).

3.4.3.4. Southern Africa

Parts of South Africa are classified as semi desert (the Karoo), but have been altered through the creation of artificial dams and reservoirs by farmers, which allow more species to occur there than would have been the case.

In Lesotho, Jenkins *et al.* (2009) surveyed 56 kilometres of 22-132 kV power line and found two small passerines, one Grey-winged Francolin (*Francolinus africanus*), one Ground Woodpecker (*Geocolaptes olivaceus*) and one Southern Bald Ibis (*Geronticus calvus*), all victims of collision. They postulate that the relative lack of fatalities detected was confounded by a very high human scavenge rate of collision and electrocution victims, possibly exacerbated by the high prices paid for raptor and vulture parts by traders in traditional medicine, a factor which may affect this type of work elsewhere in Africa. Allan (2001) recorded the remains of two juvenile Jackal Buzzards (*Buteo rufofuscus*) and one juvenile Lanner Falcon (*Falco biarmicus*), these having apparently been killed in collisions with the Leribe-Katse power line (five surveys between 1996 & 2000). In May 2010, a Bearded Vulture fitted with satellite transmitter was found collided with a 132 kV delta structure power line near Mokhotlong (Van der Westhuysen pers comm.).

Data obtained from the Namibia Nature Foundation – Nampower Strategic Partnership on incidents to date, includes 23 bustard, 32 flamingo, two game birds, two Secretary Birds, two species of waterbird, and three passerine fatalities, all of which can be assumed to be collision casualties.

In South Africa, data on reported bird mortalities on power lines is collated and managed by the Eskom-EWT Strategic Partnership in its Central Incident Register. During the period August 1996 to May 2011, a total of 1,808 collided birds were reported below distribution and transmission lines of 132 kV and lower voltage and 486 collided birds were reported below transmission lines of > 132 kV. Those species for which five or more fatalities were reported are shown in figures 9 and 10.

As with electrocution, physically large species dominate the data. This may be due to their greater vulnerability to collision as discussed elsewhere in this report, and/or the greater likelihood of larger carcasses being detected and reported. Bustards, cranes, storks and flamingos have been particularly affected in South Africa. A number of taxa mentioned in Annex 2 of AEWA are represented in this data (Appendix 4).

The Central Incident Register is, however, the product of chance detection and reporting of collisions and is recognised to suffer from several biases, in addition to underrepresenting the actual number of mortalities. More systematic studies conducted in South Africa in order to deal with this data problem include the following:

Shaw *et al.* (2010) surveyed 199 kilometres of transmission and distribution lines in the Overberg of the Western Cape. Blue Cranes were the most commonly killed birds found (54% of all carcasses). Counts of 'recent carcasses' were used to estimate a Blue Crane collision rate, corrected for sample biases, of 0.31 birds/kilometer of power line per year (95% CI 0.13–0.59⁄km⁄year), which means that approximately 12% (5–23%) of the total Blue Crane population within the Overberg study area could be killed annually in power line collisions. This represents a possibly unsustainable source of mortality, and highlights the urgent need for further research into risk factors. On the 199 kilometres surveyed, 123 birds of at least 18 species were found. Collisions were more common than electrocutions, apparently killing 88% of the birds found on distribution lines. Large terrestrial birds were the most numerous victims, with large numbers of Blue Cranes and Denham's Bustards killed.

Jenkins *et al.* (*in press*) have begun study of the Ludwig's Bustard (*Neotis ludwigii*), a near-endemic to Southern Africa, which is extremely susceptible to collisions with power lines. Preliminary collision rates averaged at least 0.63±0.12 fatal collisions per kilometre of transmission line per year. Extrapolating these rates across the species' range suggests that 11-15% of the population could be killed annually on high voltage transmission lines. Actual mortality on overhead lines probably is much greater given biases in carcass detection (injured birds moving and dying outside of the seach area, scavenge and habitat biases), as well as the fact that their estimate excludes mortality on lower voltage utility lines, medium voltage distribution lines and telephone wires. Given an estimated global population of 56-81,000 birds in the late 1980s, the demographic invariant method suggests that such mortality is unsustainable.

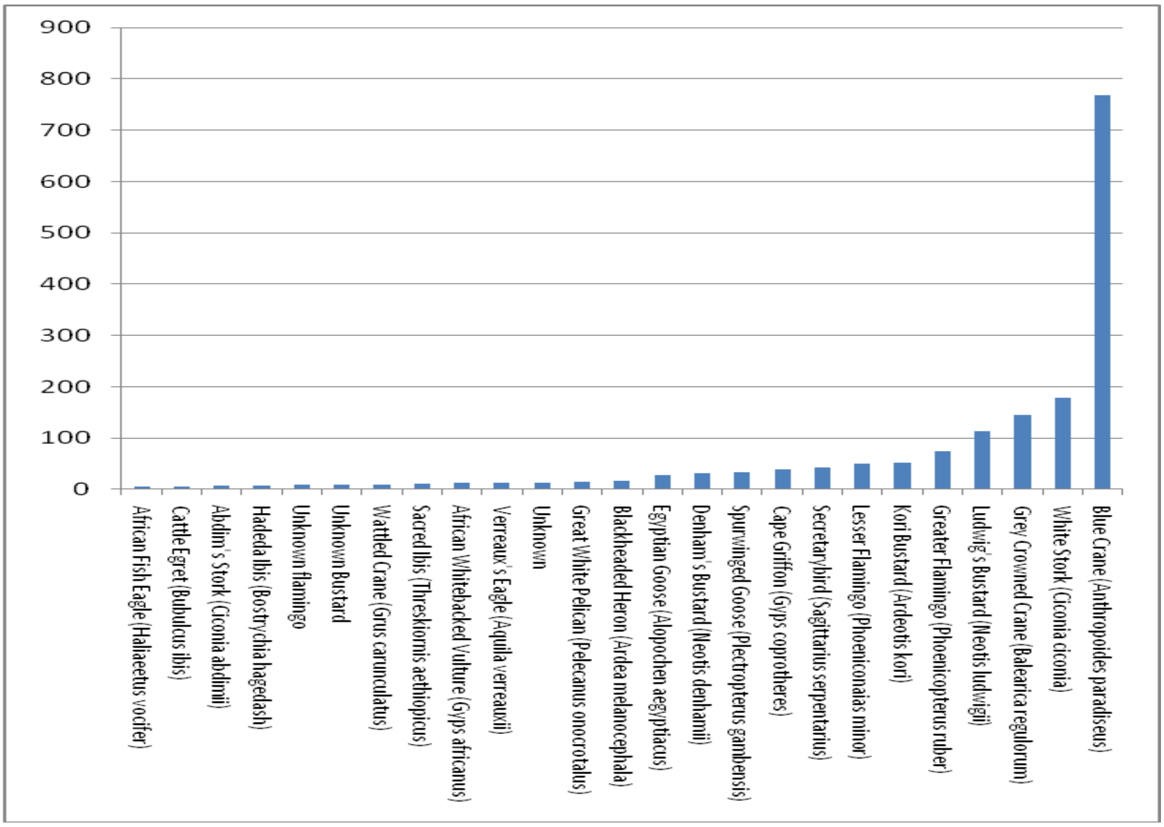


Figure 9. Number of reported bird collisions on distribution and transmission power lines (132 kV and lower) in South Africa in the period August 1996 – May 2011, for those species with five or more collisions reported (Eskom-EWT Strategic Partnership – Central Incident Register).

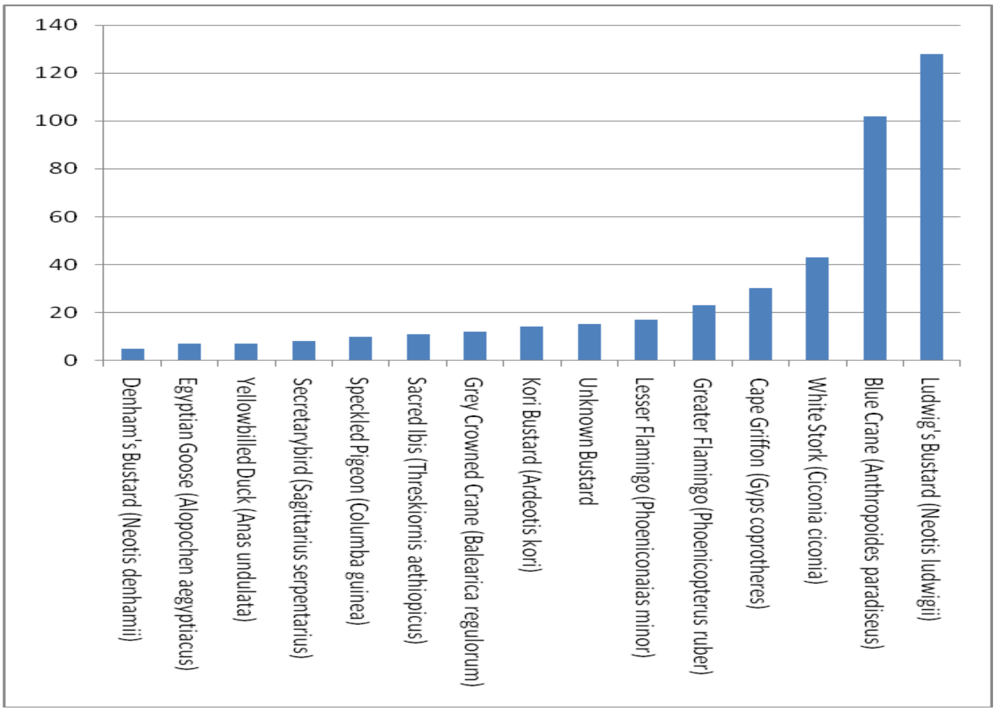


Figure 10. Number of reported bird collisions on transmission power lines (higher than 132 kV) in South Africa in the period August 1996 – May 2011, for those species with five or more collisions reported (Eskom-EWT Strategic Partnership – Central Incident Register).

3.5. Mitigation and Prevention of Collisions

The main measures for preventing collision are: route planning, underground cabling, removal of ground/earth wires (and earthing modifications), and line modification. The modification of power lines can take several forms, which can be broadly divided into measures that make power lines present less of a 'obstacle' for birds to collide with, those that keep birds away from the power line and those that make the power line more visible. As with electrocution mitigation, underground cabling is the best solution to eliminate collision, but because of costs fitting the cables with devices (so called bird flight diverters) in order to make them more visible to birds in flight has become the preferred mitigation option worldwide (Figure 11). In Hungary, for example, laying cables underground is estimated to be 20 times more expensive (approximately US$ 54,000/km) than the use of wire markers (Antal, 2010).

Figure 11. Various line marking devices (not comprehensive) that are placed at regular intervals on conductor and/or ground wires to make these lines more visible to birds in flight. In each photo a pen (circa 14 cm length) is placed to provide scale (Photo: EWT-WEP).

The separate guidelines document (Prinsen *et al*., 2011) provides a detailed stepwise approach and related guidelines on how to avoid, minimise and mitigate collision of birds, both for new and existing power lines. We refer to that document for more (technical) information on this topic. Below we present a few examples on how collision has been prevented or mitigated in various countries within the African-Eurasian region, mainly in Europe and Africa.

3.5.1. Examples of Collision Mitigation in Europe

Northern and Western Europe

In Scandinavia grouse *spp*. are most often found as collisions victims. Bevanger & Brøseth (2001) found a 50% decrease of casualties after the ground wire had been removed.

A large number of publications present results from studies that have investigated the efficiency of marking devices to mitigate bird collisions in Western Europe. Most of these studies, carried out in the period between 1970 and 1990, report reductions in mortality of between 50-90% and have been reviewed elsewhere (*e.g.*, Jenkins *et al*., 2010; Barrientos *et al*. 2011). Here we report on results of some recent studies in Western Europe that were not yet included in aforementioned reviews.

Between 2002 and 2005, the German electricity company RWE constructed a new type of marking devices consisting of 50 cm long hard plastic black and white strips constructed on an aluminium clamp (Figure 12). Since summer 2005 more than 13,000 of these so-called ‘bird flappers’ have been installed on ground wires of high-tension power lines in Germany and the Netherlands, using a specially retooled helicopter to guarantee rapid installation advancement without impairing the power supply. Bernshausen & Kreuziger (2009) demonstrated a collision reduction of more than 90% for gulls at a power line section near a large gull roost that had been retrofitted with these bird flappers. More recently, in a study in the Netherlands, Hartman *et al*. (2010) also found a significant reduction of 80% in the nocturnal collisions of ducks (Mallard and Eurasian Wigeon) on a four kilometre long stretch of 150 kV power line through bird-rich grassland polders fitted with these bird flappers (Figure 18). However, for Coot, of which also many tens of collision victims were found and were also believed to have collided at night, the reduction in collision victims was negligible. For species that collided during the day (*e.g*., gulls, waders, pigeons) the statistically significant reduction amounted to 67%, but the number of victims per species was too low to calculate species-specific reductions.

Studies with similar type of 'flappers' were carried out by Sudmann *et al*. (2000) and Brauneis *et al*. (2003) in different parts of Germany. Both studies also found a large reduction of collision mortality, mainly involving species of wildfowl.

In the United Kingdom, Frost (2008) found a 95% reduction in collisions of Mute Swans after large red spirals had been attached as bird flight diverters in a 132 kV power line previously known to cause locally important losses to this species.

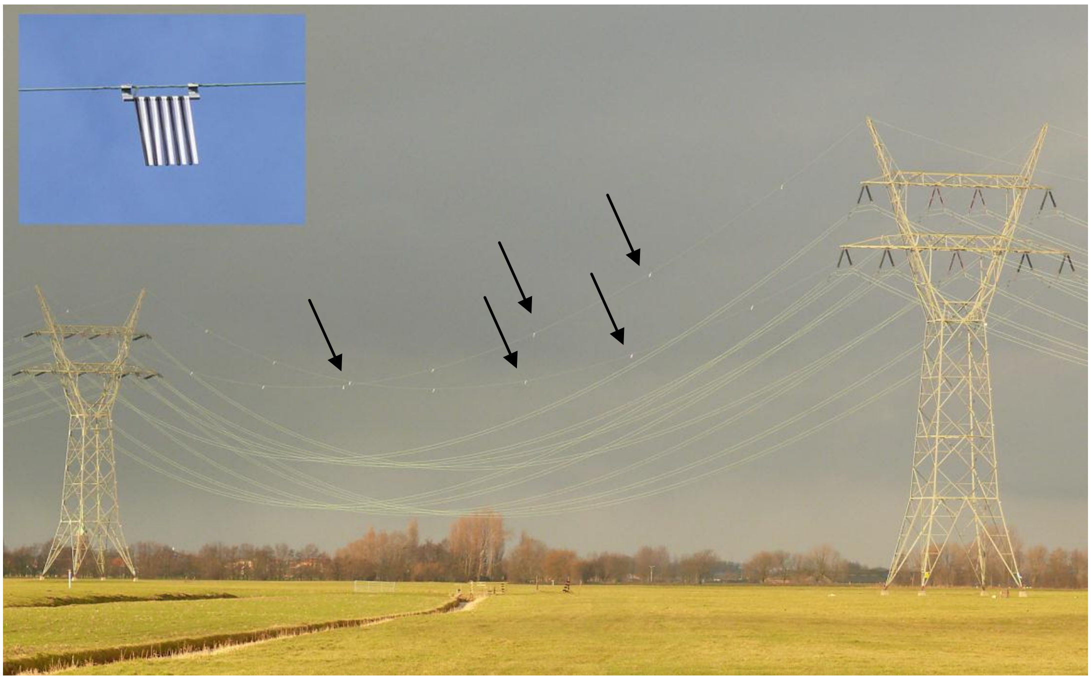


Figure 12. High-tension (150 kV) power line in the Netherlands with bird flappers (inset) (see arrows) placed at regular intervals in both ground wires as bird flight diverters, see also Box 1 (Photo: Bureau Waardenburg).

Southern Europe

Mitigation measures in Southern Europe are very similar to those adopted elsewhere in Europe. Burial of medium voltage distribution lines has only been applied to a limited extent and in a few countries, such as France, Monaco, Italy, Spain and Portugal. In the southern region there are large differences between countries regarding the application of mitigation measures and the current available information. In fact, while mitigation measures are taken well into account in some countries (see below), in others few efforts were made to address this issue. In Greece, for example, awareness of the need of bird safety measures in relation to power lines is scarce and few studies on this subject have been carried out. Even in Important Bird Areas (IBAs), the only measures reported are bundling and insulation of the phase conductors on medium voltage lines. This makes these lines thicker, and therefore more visible, with the aim of preventing bird collisions (Schürenberg *et al*., 2010).

In 2008, the Italian Ministry of the Environment, Land and Sea issued a report called "Guidelines for mitigation of impact of power lines on birds" ("Linee guida per la mitigazione dell'impatto delle linee elettriche sull'avifauna"). This report includes practical and illustrated solutions to mitigate collisions and electrocution risks in operation lines (including safe pylons, insulators and cables, to be applied, especially in new lines) and indicated procedures to reduce casualties in operational and planned lines. Some of these guidelines were implemented during the execution of the LIFE project "Improvement of Bird Habitats and Renewal of Electricity Network", that started in July 2001. This was the first and most substantial project in Italy aiming to reduce the dangers created by the power lines in a region of great natural significance: the Po Delta Regional Park, in Emilia-Romagna. In this area, approximately 110 kilometres of power lines were gradually replaced by new facilities that both safeguarded the ecological needs of birds using the Delta and ensured full efficiency of the electricity supply system. The project focused on 340 kilometres of high and medium voltage power lines implemented at the Po Delta Park, 35% of this line extension was located in critical areas for birds. Some of the mitigation measures included the erection of artificial nesting platforms (for White Storks and Ospreys) and the installation of white and red spirals (placed 18-20 metres apart) along the wires to make them more visible for flying birds. Of the 26 on-site actions planned, 14 involved the complete or partial burial of the line.

In Spain, the main mitigation measure implemented to avoid collisions consists of the placement of bird flight diverters (Murillo, 2003; Gil del Pozo & Roig, 2003; Palacios & García-Baquero, 2003). To a lesser extent cables have been burried in areas with high risks for birds or the number of collision planes has been reduced by the reduction of the number of conductors placed vertically (Compañia Sevillana de Electricidad, Iberdrola & REE, 1995; Palacios & García-Baquero, 2003). Some experiments have been performed to determine which measures are most effective, focussing on those bird species most vulnerable to collisions.

An experiment using raptor models (realistic Golden Eagle statue and *Accipiter* silhouettes) placed on top of utility towers was carried out to test the effect of such models on bird flight behaviour (and on collision risk). The number of flocks, number of crossings and flight heights were not affected by the models. Potential collision victims such as waterbirds, storks and lapwings were indifferent to the models. Raptors frequently attacked the models, increasing their collision risk (Janss *et al*., 1999). Alonso *et al*. (1993, 1994) evaluated the effectiveness of ground wire marking as a method of reducing bird mortality through collision at a transmission line in Southern Spain. Flight intensity and collision frequency decreased by 60% both at marked spans compared to the same spans prior to marking. After marking, the frequency of birds flying between the cables decreased, while that of birds flying above the line increased.

Janss & Ferrer (1998) tested the efficiency of three different marker types by comparing mortality below marked spans to unmarked spans along the same power line. A spiral (30 x 30 cm) reduced collisions by 81%, but not significantly for Common Crane. Black crossed bands (35 x 5 cm) were also effective (76% reduction), but not for Great Bustard. The third marker, consisting of thin black stripes (70 x 0.8 cm) did not reduce mortality.

Also in Portugal, mitigation of bird collisions mainly involves placing marking devices in power line sections in areas with high collision risk for birds. When it is no option to relocate power lines from important or critical bird areas, these lines are subjected to the enforcement of mitigation measures, such as the reduction of number of collision planes (number of conductors placed vertically) or the use of technologies that increase the visibility of the conductors. For example, conductor visibility can be increased by applying bird flight diverters, such as "large spirals" every seven m in medium voltage power lines or every five m in high and very high voltage power lines. Currently, different devices are being compared and tested for their efficiency. The preliminary results confirm that small static bird flight diverters or spirals (so called 'pig tails') are the less efficient devices, whilst dynamic 'swinging plates' or 'flappers' with luminescent plates, so-called FireFly BFDs (Figure 17), show the greatest effectiveness. The use of the low efficient spirals is currently under revision and stakeholders involved in the abovementioned protocols consider its abandonment (information from returned questionnaire Portugal; J. Loureiro, ICNB, *in litt*.).

In Israel, bird flight diverters have been used to prevent collisions from White Storks and White Pelicans, but results are not known. For more information about mitigation measures in Israel, see paragraph 2.5.2.

3.5.2 Examples of Collision Mitigation in Africa

In South Africa, Anderson (2002) reported 67% reduction in overall collision rate, mainly involving Blue Crane and Ludwig's Bustard, after attaching 30 cm long bird flight diverters at every 10 m on both ground wires of a 132 kV line in the Karoo region. After this line was additionally fitted with rotating 'flappers' on the most problematic sections, the overall reduction rate increased to >80%. A 400 kV section of line marked with 90 cm long bird flight diverters however showed a 42% higher casualty rate than a nearby umarked line. It was concluded that wire marking may not be effective in reducing Ludwig's Bustard fatalities and that the variability in presence and abundance of bustards and cranes in such semi-arid areas severly hindered the testing of wire marking devices efficiency for these species.

4. Disturbance and Loss of Habitat

Apart from the clear adverse effects of power lines on birds, resulting from electrocution and collision, power lines have the potential to have a negative influence on birds through disturbance and habitat loss. Disturbance may result from noise generated by the conductors, the effects of magnetic and electrical fields, the increased risk of predation and the barriers formed by the presence of the power line, which can effectively result in habitat loss (Altemüller and Reich, 1997). These factors influence breeding, foraging and roosting birds.
Despite the range of potential effects of disturbance on birds, few studies have quanitified the effects of disturbance of power lines on birds. The studies that are available focus mainly on specific species or species groups, which suggests that there is a lack of general knowledge concerning disturbance of birds by power lines. The complexity of the issue is illustrated by the fact that some attempts to study the disturbance of birds by power lines did not lead to clear results or conclusions, due to issues with the study design caused by the large number of variables that determine and influence bird behaviour and distribution (Niemi and Hanowski, 1984). Accordingly, many of the existing questions in this area of research are yet to be answered.

Most of the existing studies on disturbance of birds by power lines have been carried out in Germany. The diversity of the species, locations and time periods involved, makes it difficult to draw any general conclusions. Nevertheless, the individual results provide valuable information. Already in 1976, Heijnis published a report in which he states that waders breeding in cultivated grassland polders (Lapwing, Black-tailed Godwit, Common Redshank, Common Snipe and Ruff) avoid to breed in the proximity of power lines. For all those species he found a lower density of breeding pairs within 100 metres of the line. An exception was the Oystercatcher (*Haematopus ostralegus*), which often bred in the proximity of power lines. Heijnis also pointed out the possible importance of the higher risk of predation close to power lines, caused by the higher density of predators in the proximity of power lines attracted by the regular presence of collision victims. Altemüller and Reich (1997) also studied the influence of high-tension power lines on breeding birds in cultivated grasslands and their results partly contradict the results of Heijnis. They studied three specific species: Lapwing, Eurasian Curlew (*Numenius arquata*) and Skylark (*Alauda arvensis*). The results provided no evidence to assume that the presence of the power line had any effect on Lapwing and Eurasian Curlew. However, for the Skylark the results showed that the density of singing males was lower within 100m of the power line.

Gutsmiedl and Troschke (1997) showed that the erection of a 110 kV power line, approximately 500m from a colony of Grey Herons (*Ardea cinerea*), did not lead to any adverse effects on the number of breeding pairs or the hatching success in the colony.

Balassus and Sossinka (1997) studied the effects of high-tension power lines on the use of the area by overwintering geese. For power lines of low height (<60m) they found that the grazing density increases with distance to the power line. Next to that they also showed that the grazing density was generally reduced at small areas that were 'cut off' by a power line from large ones. They hypothesised that this last effect might be explained by the flight behaviour and phenologic characteristics of overwintering groups of geese. In summary, they conclude that the presence of power lines causes habitat loss additional to the habitat occupied by the power line itself.

Raab *et al.* (2010) showed that the presence of a power line influenced the flight direction of Great Bustards after take-off. They found that "up to a distance of 800 metres from the nearest power line, mean flight direction of Great Bustards after take-off deviated significantly from a random distribution". The influence of the distribution of transmission lines on Little Bustard (*Tetrax tetrax*) populations has been studied in Portugal. Recent published information showed that transmission power lines are avoided by Little Bustards, being the most important factor determining breeding densities in sites with suitable habitat for the species (Silva, 2010; Silva *et al.*, 2010).
One of the more specific possible disturbing effects of power lines on birds is formed by the presence of the electrical and magnetic fields. The strength of these electric and magnetic fields depend on the voltage of the line, the distance to the source and the configuration of the line (Fernie & Reynolds, 2005; Foster & Repacholi, 2002). Many speculations exist as to the possible effects of electromagnetic fields on birds; however, hardly any quantitative studies have been carried out. Fernie and Reynolds (2005) reviewed the issue and state that most studies that were performed indicate that exposure of birds to electromagnetic fields: "generally changes, but not always consistently in effect or in direction, their behaviour, reproductive success, growth and development, physiology and endocrinology, and oxidative stress". It is clear that the presence of electromagnetic fields influence (some) bird species, however, there is still a lot of uncertainty about the nature, direction and impact of these effects. In a recent study, Dell'Omo *et al.* (2009) found that the magnetic field produced by power lines, does not influence the growth curves, melatonin level, leukocyte counts and fledging success of nestlings of Common Kestrels, nesting on high voltage transmission line towers. Besides the ongoing discussions on the possible effects of electromagnetic field on birds it is also largely unknown if and how birds detect these fields (Ballasus & Sossinka, 1997; Altemüller & Reich, 1997). Fernie and Reynolds (2005) even suggest that birds might detect electromagnetic fields as light, which might lead to changes in seasonal patterns.

In summary, it is clear that for some species the presence of a power line can lead to disturbance and subsequent habitat loss. However, it is also evident that much additional research is needed in order to determine the importance, impact and species- and location-specific nature of these effects.

5. Positive Side Effects of Power Lines for Birds

5.1. Introduction

Power lines, poles and towers may be of benefit to birds, such as storks, raptors and corvids, for nesting, roosting or perching, especially in areas where suitable natural nest sites and roosting substrates are rare, such as in cultivated areas, plains, semi-deserts or deserts. In heavily forested regions, such as in Northern Europe, electricity installations are rarely used for nesting or roosting by birds, with exception of Osprey (*Pandion haliaetus*). Thus, in Norway, few birds nest on pylons, except for parts of the Finnmark area. Mass roosting in pylons is also rare and has not been reported from the rest of Scandinavia (Bevanger, 1994).
There are numerous reports of species using power line pylons as nesting sites, hunting posts or perches. APLIC (2006) gives a detailed overview, mainly focusing on the situation in North America. Here a brief overview is given for the African-Eurasian region.

5.2. Storks

White Storks (*Ciconia ciconia*) commonly use electricity poles and pylons as bases on which to nest throughout the region, especially in Eastern and Southern Europe. In Western Europe, where many artificial nest platforms are provided on wooden poles and roofs, storks are less attracted to electricity installations. For example, in the Netherlands of ca. 750 breeding pairs in 2009, less than 15 are known to have bred on electricity installations. This may also results from the fact that most low voltage utility lines and medium voltage distribution lines in Northwest Europe (including the Netherlands) have been buried underground, providing fewer nesting opportunities than in other parts of Europe.

In Hungary, the number of stork nests built on electricity poles has increased exponentially since the 1970s (Boldogh, 1998; Rekasi and Jakab, 1984). By 1994, almost 80% of the Hungarian stork population nested on poles (Lovaszi, 1998). However, storks at traditional nest sites (chimneys, trees) seem to have higher breeding success, and older birds seem to prefer these over the modern equivalents at electricity poles (Boldogh, 1998).

Similarly, in Poland approximately 60%, and regionally even 80%, of the White Storks breed on power poles (Dolata, 2006; Schürenberg *et al.*, 2010). The number of nests on electricity poles has increased between 1983-2006, but the breeding success here was found not to differ from other nesting sites. There was also no difference in breeding performance between nests on electricity poles with and without artificial platforms (Tryjanowski *et al.*, 2009).

In Ukraine, White Storks have been using electricity poles for nesting since the late 1950s. The number of nests has also grown quickly and nowadays it is the most commonly used nest site, with more than 60% of nests being on poles in some regions (Grishchenko, 2008).

In Portugal, during the 2004 White Stork national census, Rosa *et al.* (2005) found that 24.3% of nests in Portugal (n = 7,681) were placed on power line pylons and in some regions, this induced a local population increase.

In Spain, a total of 4,336 poles were sampled on five different designs. Nesting rate was almost 5%. The White Stork was by far the most frequent nesting species using the structures with 79.2% of total bird nests. At the same time, crows and ravens (*Corvus corone* and *Corvus corax*) and raptors occupied 15.7% respectively 4.6% of the nests on poles. Nests on poles of all bird species were especially common near irrigated agricultural land or wooded grasslands by all bird species (Infante & Peris, 2003).

5.3. Raptors

Power line structures provide raptors with perches for hunting and nesting substrate. In open areas without natural vantage points, such as trees and shrubs, power poles, pylons and conductor wires are readily used as alternative hunting posts, often offering the highest point for miles around from where raptors can scan the surrounding terrain. Raptors also use power poles as roost sites. Roosts in pylons may be selected for protection from inclement weather and predators or for their proximity to food sources. Examples from literature of raptor roosts in electricity installations for the African-Eurasian region are scarce. Arevalo *et al.* (2004) describe the importance of transmission substations for summer roosts of Lesser Kestrel (*Falco naumanni*) in Northern Spain. These substations are used for roosting, only during the summer months, where large concentrations of pre-migratory birds take refuge. These substations are important in the conservation of this declining species and do not seem to pose a risk to the species or change the normal operation of these facilities (REE, 2005).

In Southern Africa, vultures (mostly African White-backed Vultures *Gyps africanus*) are found to roost in large numbers on transmission towers (Ledger and Hobbs, 1999), and also nest on transmission towers (Anderson & Hohne, 2007). Cape Vultures have been found to roost in large numbers on transmission towers (Smallie & Strugnell, 2011).

Nesting raptors on power poles and in pylons and other electricity installations have been well documented in the literature. Some studies have found higher nest success and productivity in these man-made structures than at natural locations, for example for Osprey in Germany (Meyburg *et al.*,

1996). The pylons of transmission lines may provide more secure nesting substrate than natural nesting sites and offer protection from mammalian predators, heat stress (through wind and shade) as well as range fires (Steenhof *et al.*, 1993). Most raptors use poles and pylons for nesting because of the absence of suitable natural nest sites in the area where they prefer to hunt. Therefore, utility companies can easily enhance raptor nesting opportunities by providing stable nest substrate in the form of artificial platforms or nestboxes and thus help raptor populations increase and ranges expand. Historically, utility companies have combated bird nesting on their lines through direct nest removal, but often without much success. Managing where raptors nest on utility structures is a more sustainable solution and has already solved many operational problems. Moreover, it also resulted in positive publicity for many line operators.
Well-constructed platforms protect nests from wind damage and are positioned in such a way that nest material, prey remains and excrements that drop down from the nest cannot lead to outages or pollution of insulators. APLIC (2006) presents a number of bird- and power utility safe constructions. Artificial platforms have been successfully used in Germany, where the absence of suitable nest trees has lead more than 75% of nesting Ospreys to use power poles and pylons for nesting (Meyburg *et al.*, 1996) (Figure 13). Similarly, in Finland 46% of 951 studied nest sites of Osprey were located on artificial structures, with even up to 90% so in Southern Finland (Saurola 1997).

Figure 13. Nesting Osprey on artificial platform in medium voltage transmission line, Muritz National Park, Germany (Photo; Bureau Waardenburg).

A number of falcon species, amongst others Saker Falcon (*Falco cherrug*), Peregrine Falcon (*Falco peregrinus*), Common Kestrel (*Falco tinnunculus*) and Hobby (*Falco subbuteo*), are known to regularly nest in electricity pylons, often in old nests of corvids, but also in nest boxes. So far, in Hungary, 396 nest boxes for Saker Falcon have been placed in 132 kV supporting pylons. Nowadays, every other Saker Falcon pair in Hungary breeds in such a nest box (Biro, 2011; Podonyi, 2011). Bagyura *et al.* (2004) concluded that the increase in the number of breeding Saker Falcon in Hungary since the early 1990s has been aided partly by the provision of many artificial nest sites in trees and on electricity pylons.

Currently, several programs are active to provide save nesting opportunities in power utilities for Saker Falcon in several Eastern European countries. In the steppe zone of Mongolia, Dixon (2009) found breeding densities of Saker Falcon of 5.27 bp/100 km of transmission line and 2.94 bp/100 km of distribution line based on surveys of 171 kilometres and 102 kilometres line, respectively. Dixon

(2009) estimated that 400-500 pairs of Saker Falcons breed on electricity power lines in Mongolia, which equals 10-20% of the total estimated breeding population for the country.
Peregrine Falcon, Common Kestrel and Hobby are also known to use old nests of corvids in power utilities (see below).

In Serbia (Vojvodina), Saker Falcons occurring in deforested agricultural areas, also nest predominantly in old corvid nests located on power line poles, since no natural nest sites are available. This species also benefits from power lines, by kleptoparasitising other falcons, such as Common Kestrels and Hobbys, that regularly perch on the line and nest on its poles, corvids such as Hooded Crows (*Corvus cornix*) and Jackdaws (*Corvus monedula*), and other raptors such as Marsh Harriers (*Circus aeruginosus*) and Hen Harriers (*Circus cyaneus*) (Puzovic, 2008).

In a study performed in the Northeast of Italy, 57% of the nests (n = 49) of a Common Kestrel population were located in old corvid nests on medium and high-tension electrical transmission line pylons. These nest sites were chosen over other (natural) available nest sites. The productivity of these sites was similar to other successful sites, though they were more prone to nest collapse (Krueger, Jr., 1998). In another Common Kestrel population, nest boxes were provided in power line poles, and were rapidly used by the birds immediately after their installation, suggesting scarcity of natural sites in the area. This population showed an increase in the number of breeding pairs after this procedure (Dell'Omo *et al.*, 2005).

In Spain, even though power lines are an important cause of mortality in the Bonelli's Eagle (*Aquila fasciata*), this species sometimes uses power line poles as a nest platform (0.5% of nests) in Spain (Del Moral, 2006).

In Northern Africa available information on positive impacts is limited. However, in southern Africa, large eagles such as Martial Eagle *(Polemaetus bellicosus)*, Tawny Eagle (*Aquila rapax*), and Verreaux's Eagle (*Aquila verrauxii)* have all been found to nest extensively and successfully on transmission towers in the Karoo region of South Africa (Jenkins, 2007). Other raptors known to nest on power line structures in South Africa include Lanner Falcon, Greater Kestrel (*Falco rupicoloides*), and Spotted Eagle Owl (Smallie, *pers. obs*.). Of course, whilst for the species nesting this may be considered a positive effect, a more in depth look at broader avifauna in the area may reveal that increased presence of these predators in the area has impacted on population of prey species, a secondary effect.

In Europe and Asia there is limited information available for breeding *buteo spp*. and eagles in pylons. T. Papp (*in litt*.) reports breeding Long-legged Buzzard (*Buteo rufinus*) in Romania in pylons and S. Dereliev *(in litt*.) has observed breeding Imperial Eagles in pylons in FYR of Macedonia, but quantitative information is lacking.

5.4. Other Species

Many other bird species use electricity installations, such as poles, pylons and conductors, for perching and/or hunting. In many open steppe and semi-desert areas, shrikes and wheatears often hunt from poles and wires of distribution lines, while the same holds true for kingfishers in wetland areas where they can perch-hunt from conductor wires when these overhang ditches, pools, etc. Many songbirds from open agricultural and semi-natural areas also use these structures for advertising their territory by song. Finally, flocking birds, such as swallows and Common Starling (*Sturnus vulgaris*), often use power lines for perching, for example during pre-roost gathering.

Cormorants and corvids are well known to use pylons for roosting. For example, in the Netherlands, several large roosts of Great Cormorant (*Phalacrocorax carbo*) are situated in pylons of high voltage power lines where these lines cross water bodies in which the cormorants feed during the day. Such roosts can hold up to many hundreds of birds in one pylon.

Nesting in electricity utilities has been documented for a variety of bird species. Other than the ones mentioned previously, the nesting of herons and Egyptian Goose (*Alopochen aegyptiacus*) in pylons (references in APLIC 2006) is worth mentioning in the context of this report. Also nesting by corvids is relevant, as these nests can later be used by raptor species that do not readily build their own nest, such as several falcon species. Nesting of Common Raven in high-tension line towers has been well documented for North-America (APLIC, 2006), but examples can also be found in the Eurasian region. According to references cited in Agić (2006), Common Ravens nesting in high voltage pylons were already observed in the 1960s in the European part of the Russian Federation and in following decades also in United Kingdom, Germany, former Yugoslavia and Poland. In Croatia, 93 breeding pairs of Common Ravens were nesting on pylons over the 380 kilometres length of transmission lines under observation in the period between 1995-2001. The breeding population increased over this period to a population density of 2.45 pairs per 10 kilometres of line, which is reportedly the highest recorded in the world for Common Ravens breeding on electricity pylons (Agić, 2006). Results of a study in Poland indicates that ravens are faithful to once-chosen pylons. Among 175 pylons occupied by Common Ravens in the years 1996-1998, 44% of the nests were occupied for all three years (in five cases 11 to 13 years), and in 38% the nests were built not only on the same pylon, but on exactly the same spot. In Poland the most common reason for birds leaving pylons unoccupied in a following year was human disturbance caused by placing bird scaring devices and renovation works on those pylons (Bednorz 2000 in Agić, 2006).

In Romania, several species of corvids, *e.g.*, Common Raven and Hooded Crow, are regularly breeding in pylons, and Common Kestrel and Hobby are using these nests in subsequent years. In some areas in Romania even rookeries can be found in pylons of high voltage power lines (information from returned questionnaire Romania; T. Papp, Milvus Group, *in litt*.).
In southern France, Kabouche *et al.* (2006) reviewed the cases of birds nesting on power line pylons. These included White Stork, Common Kestrel, Magpie (*Pica pica*) and Carrion Crow (*Corvus corone*).

Finally, woodpeckers have been reported to make nest holes in wooden electricity poles in, for example, Sweden, Finland, the Czech Republic, Hungary and Japan. Commonly, the genus of spotted woodpeckers *Dendrocopus* is involved, but also Black (*Dryocopus martius*), Green (*Picus viridis*) and Grey-headed Woodpeckers (*Picus canus*) are known to make nest holes in electricity poles (Turcek, 1960 and references within). Several species of hole nesting birds (*e.g.*, tits) may use these holes for nesting. In South Africa, a countrywide survey was conducted in 2004 to assess the extent of woodpecker and/or barbet damage on wooden poles and cross-arms. The survey provided a means of identifying geographical hotspots of this problem in this country. Results have shown that the Northern region and the Eastern region are the most affected regions in the country (Matshikiza *et al*., 2004).

6. Legislation overview

This chapter presents an overview of some of the legal and semi-legal obligations as laid down in international conventions, treaties, Memoranda of Understanding, etc., as well as those present in national legislation to stimulate electricity companies to reduce bird electrocution and collision through appropriate mitigation measures presented in the previous chapters and described more extensively in the accompanying guidelines document (Prinsen *et al*., 2011).

6.1. Introduction

This review report shows the great loss of bird biodiversity as a direct result of electrocution and collision of birds with power lines, affecting many millions of birds annually (for example, see tables 2 and 3 and discussion in paragraph 3.3). The technical sections of this report also show that the

problem of electrocution and collision of migratory birds with electricity power grid has only recently received more serious attention. There is much more (more or less anecdotal) local and regional literature describing individual cases than systematic research on the problem.
Given the fact that it has been a well-known phenomenon from the moment that power lines came into use and from the anecdotal literature, it is surprising that little has been arranged towards good research and monitoring of the extend of the problem and that in a legal sense not much has been done to stimulate companies to reduce bird electrocution and collision through appropriate mitigation measures. This has not only been the case at national levels, but also at an international level.

Indirect measures to be taken are more common. For instance, from the returned questionnaires it has become clear that almost all countries over the years have developed legislation that brings the building of power lines under a regime of an Environmental Impact Assessment (EIA) that should take into account existing habitat and wildlife conservation legislation, which may include birds (see Appendix 5). Such an EIA procedure aims to find and develop the right siting of power lines to reduce the impact on landscape and biodiversity (in the broadest sense) to the minimum.

The AEWA Guideline 11: '*Guideline on how to avoid, minimise or mitigate impact of infrastructural developments and related disturbance affecting waterbirds*' (Tucker & Treweek, 2008) pays much attention to the general aspects of planning infrastructure (roads, power lines, etc.). It is a helpful and practical document taking you step-by-step through everything necessary for planning and the application of Strategic Environmental Assessment (SEAs) and Environmental Impact Assessment (EIAs). Annex B of AEWA Guideline 11, lists international conventions and other legislation that requires impact assessments with related guidance in information documents. Some of that information is repeated below.

The same applies at the international level, where the application of a well-designed and detailed EIA is widely promoted through *e.g.* international treaties, together with the 'precautionary principle', which has sometimes encountered difficulty in adoption. There is, however, not much international legislation, through formal treaties, that is specifically dealing with migratory birds and power lines and ways to reduce the impact. Actually only the Bern Convention and CMS have paid attention to this issue by adopting resolutions and guidance documents how to best reduce the negative impact on birds, focussing in the first instance on the problem of electrocution more than on collision issues.

Below a brief overview is presented of the most relevant obligations (both 'hard' and 'soft ' law) in international and national legal arrangements, such as treaties, conventions, resolutions of conventions, national legislation (mainly based on replies to the questionnaire as summarised in Appendix 5) and informal declarations, for instance of conferences. On the national level, reference is made as well if informal arrangements exist like MoU's (if this information has been provided by the countries).

This report only makes reference to more general and important statements on biodiversity conservation by conventions if they are of relevance for the issues dealt with in this report. It is not meant to repeat all international obligations countries have already (repeatedly) made regarding the conservation of biodiversity in general through various treaties, most notably the Convention on Biodiversity or, for EU Member States, to the EU Biodiversity Strategy to 2020 (EU 2011).

6.2. Convention on Biological Diversity (CBD)

The CBD has not developed specific recommendations or guidelines regarding the issues of migratory birds and power lines. Already at an early stage of developing implementation policies under CBD, it was agreed that issues related to migratory species should in the first place be dealt with in the framework of CMS and only thereafter under the CBD, taking into account the wider biodiversity aspects.

However, much of the more general policy guidelines on keeping and restoring biodiversity in general have implications for migratory species as well. The CBD strongly supports and requires that Parties apply thorough assessment procedures (SEA and EIA) if it comes to the planning of activities with an impact on biodiversity; see CoP Decision VIII/28 (March 2006; see also CBD Technical Series number 26: http://www.cbd.int/doc/publications/cbd-ts-26-en.pdf). These procedures under SEA and EIA include also guidance to look for alternative energy sources for which power lines may not be needed or which reduces it to a minimum.

Applying the ecosystem approach and also taking into account possible trans-boundary effects are both promoted under CBD. Trans-boundary effects are certainly an issue if it comes to assessing the impact of power line construction on migratory birds. That is not just a matter of bilateral agreements, but often of multilateral arrangements as power line systems are often connected and can cross several national borders as do migratory birds.

The latest call on biodiversity conservation are the Aichi Biodiversity Targets (CBD 2011), many of them have a general value and application of them on power line and bird conservation issues has great value. The Aichi Biodiversity Targets addresses priority issues such as addressing underlying causes of the loss of biodiversity; reduction of direct pressure on biodiversity; safeguarding ecosystems, species and genetic diversity and participatory planning to enhance implementation of biodiversity conservation.

They all have their value in the case of power lines and bird conservation through all stages: from planning to mitigation measures for existing lines.

6.3. Convention on Wetlands of International Importance, especially as Waterbird Habitat (Ramsar Convention)

In the long history of the Ramsar Convention (above specifically mentioned by its original name as waterbirds are often victim of power lines), with its many Resolutions and Recommendations, there are no specific guidance documents referring to power lines and wetlands conservation or the issues of electrocution and collision of waterbirds.

There are many documents and guidelines on the importance of wetlands, how to operate EIA procedures in relation to possible threats to wetlands, guidelines for wise use and many more. There is nothing specific about power lines in these guidelines. However, the obligations for Parties to the Ramsar Convention to protect all wetlands in general should be an important criteria in the assessment for the transect of a power line across or near wetlands. This is even more important if a wetland has been designated a formal Ramsar site of international importance. Frequently this is based on its importance for large numbers of waterbirds and waterbirds are susceptible for collision with power lines (see paragraph 3.3). In case a power line is planned to cross a designated Ramsar site this may be notified by the authorities or NGOs to the Ramsar Convention Secretariat. This could be the start of further guidance from the Ramsar Secretariat under a Ramsar Advisory Mission (http://www.ramsar.org/cda/en/ramsar-activities-advisory/main/ramsar) how to possibly reduce the impact or to find alternatives.
For obvious reasons of a more easy construction (and thus lower costs), power lines more often cross open areas, including wetlands, than forested areas. The latter requires much higher costs to construct the line.

A detailed inventory on how the Ramsar Convention has dealt with issues like EIA etc., is available in the *'Key Concept Index to Ramsar Decisions and the Strategic Plan"* on the Ramsar Convention website. The index refers to the convention text, strategic plans, guidelines and all decisions as laid down in resolutions and recommendations including those on SEA, EIA procedures, wise-use principles, maintaining the ecological characteristics of a wetland, etc., all of them relevant for

wetland and migratory waterbird conservation and to be applied if it comes to the planning of power line transects which would possibly cross wetland areas.
In addition to this, the Ramsar Convention, in line with its full name, pays attention to the conservation of migratory waterbirds. That was the case, for instance, with CoP10 adopting Resolution X.22 on 'Promoting international flyway cooperation for the conservation of waterbird Flyways', which:

"URGES Parties to identify and designate as Ramsar sites all internationally important wetlands for waterbirds on migratory Flyways that meet the Criteria in the *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance* (Resolution VII.11, as amended), in line with the long-term targets established for these Criteria;"

Finally, it should be mentioned that the Ramsar Convention has further guidance in preparation ('Framework for Avoidance, Mitigation and Compensation for wetland losses"; document *in prep*; *pers*. *comm*. by the Ramsar Secretariat) on possible human-induced change or likely change of wetlands to be addressed by Ramsar Parties. This is important for every Ramsar Party in planning power line transects that may cross or seriously influences wetlands. It may not directly result in loss of wetlands habitat (or just small areas for the pylons) but it will certainly influence waterbird behaviour and movements.

6.4. Convention on the Conservation of Migratory Species of Wild Animals (CMS)

6.4.1. General Arrangements

The Convention on the Conservation of Migratory Species of Wild Animals, CMS or Bonn Convention is the most appropriate instrument to deal with the conservation of migratory species, birds as a point in case, in all aspects. That includes policy and guidelines development for the problems caused by man-made structures.

The text of the Convention emphasises this in various articles, where it requires from Range States/Parties *e.g.* special attention for actions for species in an unfavourable conservation status and to take measures to avoid migratory species from becoming endangered (Art II, par. 1 and 2). CMS also requires from Parties to endeavour to prevent, remove etc. the adverse effects of not only activities but also of obstacles that seriously impede or prevent the migration of migratory species (Art. III, par. 4b and 4c).

It is also important to highlight the specific arrangements in the Convention on essential research in relation to migratory birds (Art. II; 3a). Such a specific article with a clear research requirement is not in that way present in other conventions. It applies to all issues important for migratory species, but it certainly applies to the problems with man-made structures, including power lines.

At CMS/CoP7 (2002) Res. 7.2 on Impact Assessment and Migratory Species was accepted, requesting Parties to apply appropriate SEA and EIA procedures arrangements. This is certainly most appropriate to address the increasing problem of migratory birds collision and electrocution with power line systems. The more so as the problem affects many large and vulnerable species, such as bustards, cranes, storks and birds of prey; a substantial number of them are already endangered. Careful assessment of the need for a power line and, if that is the case, careful assessment of its routing and construction can substantially avoid the problem with electrocution and collision.

6.4.2. Specific Arrangements on Power Lines and Migratory Birds

With regards to migratory birds and electricity power-grids, CoP 7 (Bonn, September 2002) adopted a resolution (UNEP/CMS/Res. 7.4) that specifically paid attention to the problems with electrocution, be it in one paragraph, that also mentioned the negative effects of collision.

The resolution, among other things, calls upon the Parties to pay attention to electrocution and to apply mitigation measures that have proven to reduce the killing of birds. That should in the first place be done when new power lines are constructed. The resolution also calls upon the Parties to take measures to neutralise existing towers and pylons, etc., and transmission lines to protect migratory birds against electrocution. Finally, the resolution calls upon Parties to put mitigation measures into their national legislation to minimise electrocution and collision of migratory birds.

The resolution was accompanied by a practical information document (UNEP/CMS/ Inf.7.21), outlining a number of technical solutions to prevent electrocution. That information document is a joint publication of the German conservation NGO: NABU and the German Ministry of Environment, Nature Conservation and Nuclear Safety (BMU).

6.5. Agreement on the Conservation of African Eurasian Migratory Waterbird (AEWA)

This Agreement developed in the framework of CMS, in force since November 1999, is meant to bring the 119 Range States of the AEWA region together in a common policy to protect migratory waterbirds in the entire flyway from the Arctic to southern Africa. The text of the Agreement contains a number of obligations (see below) that are relevant for the problems related to migratory waterbirds and power lines. To assist Parties in implementing the general conservation measures AEWA has so far published 12 practical guidelines on how to deal with conservation issues influencing the status of migratory waterbirds. The most relevant guideline for migratory birds and power lines is Guideline 11 as mentioned in the introduction:

"*Guideline on how to avoid, minimise or mitigate impact of infrastructural developments and related disturbance affecting waterbirds"* (Tucker & Treweek, 2008)

Tucker and Treweek (2008) have already summarised the most important AEWA requirements and obligations (Agreement text and Action Plan) to consider impacts and mitigation of human activities in general, which can be applied and implemented on the issue of waterbirds and power lines as well. Their summary is repeated below:

<u>Citation from Tucker and Treweek (2008)</u>
The fundamental principles of AEWA, as given in Article II, state that: "*1. Parties shall take coordinated measures to maintain migratory waterbird species in a favourable conservation status or to restore them to such a status*". To achieve this they shall implement General Conservation Measures (as described in Article III) together with the specific actions determined in the AEWA Action Plan. Furthermore, in implementing the measures, "*Parties should take into account the precautionary principle*".

Of the General Conservation Measures listed in Article III, 2e is of particular relevance to actions relating to infrastructure developments and impact assessment. This states that Parties shall: "*investigate problems that are posed or are likely to be posed by human activities and endeavour to implement remedial measures, including habitat rehabilitation and restoration, and compensatory measures for loss of habitat*". Impact assessment measures would also support actions 2c and 2d with respect to the identification, protection and management of sites and networks of habitats of particular importance to waterbirds.

Section 4 of the AEWA Action Plan addresses the management of human activities and includes several measures that must be taken by Parties that are of relevance to infrastructure impacts, including disturbance. In particular, action 4.3.1 relates to impact assessments and states that: "*Parties shall assess the impact of proposed projects which are likely to lead to conflicts between populations listed in Table 1* [Migratory Waterbirds] *that are in the areas referred to in paragraph 3.2* [Conservation Areas] *and human interests, and shall make the results of the assessment publicly available*".

Other measures that relate to infrastructure impacts include 4.3.5, which states that:
"*Parties shall, as far as possible, promote high environmental standards in the planning and construction of structures to minimise their impact on populations listed in Table 1. They should consider steps to minimise the impact of structures already in existence where it becomes evident that they constitute a negative impact for the populations concerned*".

Action 4.3.6 relates to disturbance impacts, which can arise from infrastructure developments, amongst others, and states that: "*In cases where human disturbance threatens the conservation status of waterbird populations listed in Table 1, Parties should endeavour to take measures to limit the level of threat. Appropriate measures might include, inter alia, the establishment of disturbance-free zones in protected areas where public access is not permitted.*"
End of citation.

AEWA pays much attention to the issue of migratory waterbirds and human induced obstacles such as power lines. Waterbirds are, generally speaking, larger birds and frequent open habitats as steppe, wetlands, meadows, etc., both provide a higher risk for collision and electrocution. Monitoring and research evidence have shown that indeed waterbirds are more frequently found as collision victims (see elsewhere in this report).

6.6. MoU on the Conservation of Migratory Birds of Prey in Africa and Eurasia

This Memorandum of Understanding (MoU) was concluded in October 2008 and the Secretariat is based in Abu Dhabi since 2009. The Action Plan for this MoU contains a few activities with specific references to power lines, migratory birds of prey and *e.g.* electrocution more than collision. For example, in Annex 3 to the MoU, which is the Action Plan, table 2 mentions the following activities that are of relevance in relation to power lines and quoted below in full:

"*1.4 Review relevant legislation and take steps where possible to make sure that it requires all new power lines to be designed to avoid bird of prey electrocution*

2.3 Conduct risk analysis at important sites (including those listed in Table 3) to identify and address actual or potential causes of significant incidental mortality from human causes (including fire, laying poisons, pesticide use, power lines, wind turbines)

2.4 Conduct Strategic Environmental Assessments of planned significant infrastructure developments within major flyways to identify key risk areas

3.2 Where feasible, take necessary actions to ensure that existing power lines that pose the greatest risk to birds of prey are modified to avoid bird of prey electrocution"

For part of the geographical region included in the Birds of Prey MoU, a UNEP/GEF funded flyway project is in place which started in 2009 and is implemented by BirdLife International (www.BirdLife.org/regional/africa/pdfs/Factsheet-MSBs-Updated.pdf). This BirdLife project on the conservation of migratory soaring birds pays attention to the problems of electrocution and collision by/with power line transects, thus implementing some elements of the Action Plan.

6.7. MoU on the Conservation and Management of the Middle-European Population of the Great Bustard

This MoU became effective in 2001 and is aiming at the conservation of the Great Bustard populations in Middle Europe, for instance in Hungary, but also in other countries in the region.

The Action Plan Part 1 (General) has a specific action point on power lines, which states in 2.3.2. of the Action Plan: "*Existing lines which cross Great Bustard areas should be buried or marked prominently. New lines should not be built across Great Bustard areas*".

Various projects, some funded by the EU/LIFE program, successfully addresses the problems of power lines and the Great Bustard *e.g.*, by installing mitigation measures on existing lines.

6.8. Bern Convention

The Convention on the Conservation of European Wildlife and Natural Habitats or Bern Convention (concluded in 1979) as administered by the Council of Europe has in its text the usual general arrangements for conservation, protection of species and habitats as well as obligations for the assessment of human impact on habitats, landscapes and species.

Art 2. of the Bern Convention requires Parties to take measures to maintain populations of wild fauna at a level which *" corresponds in particular to ecological, scientific and cultural requirements, while taking into account of economic requirements."*

It is interesting to see that in this case economic aspects are included in the text of the convention.

In its long history the Bern Convention has often paid attention to specific conservation problems and that includes birds and power lines. That was the case in 2003 and 2004. In 2003 the Bern Convention has published the report "*Protecting Birds from Powerlines: a practical guide on the risks to birds from electricity transmission facilities and how to minimise any such adverse effects."*(T-PVS/Inf (2003) 15; BirdLife International with support from NABU).
The substance of the report is similar to the report submitted by NABU and the German Government to CMS/CoP/7 in 2002 in Bonn.

The discussion by the Bern Convention Parties of the above report was followed in 2004 by the adoption of Recommendation 110 (3 December 2004) of the Standing Committee of the Bern Convention (in fact the Conference of the Parties*) "on minimising adverse effects of above ground electricity transmission facilities (power lines) on birds"*.

This Recommendation asks the Parties to take "*appropriate cost-effective measures to reduce bird mortality from electric transmission facilities"* and it makes a reference to CMS res. 7.4. The Recommendation also requests the Parties to *"apply as far as possible the measures for bird safety as suggested by the report mentioned"* (that is the above cited report: T-VS/Inf (2003) 15). The Recommendation includes a table with groups of bird species indicating if they are more sensitive to electrocution or collision. It further specifies a number of technical aspects in relation to tower and line constructions and mitigation techniques.

The above means that Bern Convention Parties, mainly European countries, but also a few African countries, have agreed to take appropriate measures to address the problem, specifically electrocution, of power lines and birds.

In 2010, The Bern Convention published a report (T-PVS/Files (2010) 11) with the title: *"Implementation of Recommendation No 110/2004 on minimising adverse effects of above ground* *electricity transmission facilities (power lines) on birds. Report by the Governments"*. This contains a total of 14 reports from Bern Convention Parties on how they have dealt with the recommendations as requested for in 2004. This means that less than half of the Bern Convention Parties reacted in time.

The questionnaire circulated in the framework of the present project to CMS and AEWA Parties contains similar questions and replies contain similar information or slightly updated. Where relevant both sources have been used for the chapter on national legislation and Appendix 5 listing replies from individual countries.

6.9. EU Directives

The EU has a number of legislative instruments to deal with migratory birds and power lines. At the species level it concerns the Bird Directive (79/409/EEC) and the Habitat Directives (92/43/EEC) with its articles on preventive measures and assessments of plans and projects in the light of the aims of both Directives.

Furthermore, the EU has agreed on a number of Directives dealing with EIA and SEA procedures and when and how to implement these; these are also directly relevant for power line construction. The EIA Directive includes a specific obligation for overhead electric power lines of 220 KV (or more) and longer than 15 kilometres. Both EU assessment procedures ask for special attention if power line construction would affect Natura 2000 sites and areas of special conservation concern (SPAs).

Through the LIFE project funding instrument, the EU supports a number of projects aiming at the reduction of the killing of endangered birds (often larger species, such as the Great Bustard which is covered by a CMS MoU, which has benefited from such a LIFE project in Austria, Slovakia and Hungary) as a result of electrocution or collision by/with power lines. LIFE also funded the costs of technical equipment to solve some of these problems in certain EU member states.

6.10. National legislation

Information has been provided by a limited number of only 33 countries (including EU) through the questionnaire (Appendix 2). Additional information from another five countries was available from the Bern Convention report T-PVS/Files (2010) 11 with the title "*Implementation of Recommendation No 110/2004 on minimising adverse effects of above ground electricity transmission facilities (power lines) on birds. Report by the Governments*".

The available information is briefly summarised in Appendix 5. It is somewhat biased since the majority of the information comes from European countries and a few African countries. Information from, for instance, the Russian Federation, Middle East and Asia (the area included in the CMS Raptor MoU) became hardly available through the questionnaire and literature sources were difficult to assess or very scarce.

It is apparent that there is limited specific national legislation regarding the issue of power lines and birds. In almost all countries the issue of powerlines and birds is dealt with through SEA and EIA procedures when the construction of new power lines are planned. This is done in combination with existing national and international legislation or obligations (*e.g.*, when a country is a Party to a convention or EU Member) on wildlife and habitat conservation. It is, however, not clear from the available information if countries have obligations in their national EIA procedures to carry out bird surveys within the area of a planned power line or to use best available bird information to identify potential risk areas/routes of power lines in relation to bird electrocution and collision.

It therefore depends on how strict the national wildlife legislation can be applied to even prevent the construction of power lines. National legislation is often focussing on maximum protection of species/individuals, especially of species that are internationally endangered (IUCN Red lists; CMS and AEWA Annexes, *etc*.) or have a strict protection status at the national level. Such a strict protection, by its nature, is conflicting with the construction of infrastructure in general and specifically with the construction of power lines when the risk of bird killings by electrocution and collission is known to exist.

The information provided by the countries shows different policies to deal with and reduce the problems of powerlines and birds. All low utility and medium voltage distribution lines have been placed underground in the Netherlands and this proces is being carried out in Belgium, the United Kingdom, Norway, Denmark, and Germany. The electrocution and collision problem is therefore absent or has been strongly reduced in these countries. A few European countries, *e.g*., Denmark and Switzerland are working on putting even some parts of the high voltage power lines underground, which is a technically challenging operation with high costs. Some countries also apply mitigation measures against both electrocution and collision from the very beginning of a construction.

It is also interesting to see that a number of countries have not worked towards legislation to avoid bird killing by power lines, but instead developed voluntary arrangements between the electricity companies, governmental authorities and NGOs. These voluntary arrangements aim to develop a practical policy to reduce the damage (APLIC, 2005; Antal, 2010). They often include practical guidelines how to monitor the problem, assist in research, and prioritise power line sections for mitigation measures.

6.11. Declarations from international meetings, conferences, NGOs, etc.

There is a wealth of so-called “declarations”, “statements”, “messages of international meetings and conferences” dealing with the topic of power lines and birds. Declarations of such meetings have no formal status and are not legally binding for the countries participating in them. Nonetheless, they can be important to continuously motivate governments to undertake actions and they often contain up-to-date information. Some of these relevant declarations have later been formally adopted in full by countries through resolutions at the CoP of, for instance, the Ramsar Convention and CMS.

The latter was the case with the Edinburgh Declaration as endorsed by the international conference: “Waterbirds around the World”, held in Edinburgh in April 2004. This declaration requests a number of global actions on conservation, research, sustainable management, *etc*. of waterbirds in all Flyways. Many of the required actions, if applied, could also be beneficial for the problem of migratory birds and power lines.
The Edinburgh Declaration received formal recognition as an attachment to resolutions from both the Ramsar Convention (Resolution X.22: “Promoting international cooperation for the conservation of waterbird flyways”, in 2008) and AEWA (Resolution 3.7: “Implementing the conclusions of the Waterbirds Around the World Conference”, in 2005) and mentioned in CMS (Resolution 9.2: “Priorities for CMS Agreements”, in 2008). With this formal adoption Parties accepted the requested actions and are bound to handle accordingly. The Edinburgh Declaration itself does not contain specific items related to problem with power lines.

A number of recent declarations from the European region are: Message from Athens (2009); The Hague Statement (2010); Cibeles Priorities (EU) (2010); UNESCO Biodiversity Science Policy Conference (2010). Generally, they strongly focus on the common biodiversity targets as agreed under CBD.

A recent much more specific case is the Budapest Declaration (2011), which has been adopted after a special European Conference on power lines and bird mortality (see box 1).

For migratory (water)birds the The Hague Statement: “Flyway Conservation in action” is of importance as it was agreed at the end of the symposium celebrating the 15th Anniversary of AEWA in June 2010, The Hague, the Netherlands. It reconfirms many of the agreed activities as laid down in the Edinburgh Declaration, at the same time emphasising sustainable use, local community involvement and the integration of migratory species aspects into other aspects of society such as national planning and development cooperation. That certainly applies to power line construction and bird problems.

None of these documents, except the Budapest Declaration, specifically mention the issue of migratory birds and power lines. But it is important to note that these declarations and statements represents strong moral obligations and in that sense are good instruments to continuously remind countries on their obligations under formal instruments such as conventions to which they are a Party or to the Directives for EU Member States.

Within this category you can also place the equator principles (EPs). This is a voluntary set of standards to determine, assess and manage the social and environmental risks with project funding in general. This means that certainly donors would like recipients to take these into account and apply also their own national legislation on nature and wildlife conservation. This may be a way to address issues of birds and power lines, but so far they are not specifically included and it is unknown if it has ever been applied in the case of a power line construction.

If it comes to the involvement of international NGOs there is the **Position Statement on Birds and Power Lines** by BirdLife International from 2007. Although not a legal and binding document it is a clear statement on the issue and it takes relevant existing national and international legislation into account. The position statement suggests a number of practical mitigation measures and suggests what further research and monitoring should be undertaken. It is important to mention this Position Statement as it is supported by all National BirdLife partners; they are always one of the stakeholders if it comes to joint efforts on the national level with the electricity companies and governments agencies to reduce the killing of birds by power lines. Finally, we would like to point to the publication of the BirdLife Europe report ‘Meeting Europe’s renewable energy targets in harmony with nature”, foreseen in November 2011. The report sets out how policy makers can help to make the renewables revolution truly ‘green’ and includes a section on the conservation risks of power lines for birds (BirdLife Europe, 2011).

BOX 1. Budapest Declaration

The Budapest Declaration on bird protection and power lines was adopted by the Conference ***"Power lines and bird mortality in Europe"*** *(Budapest, Hungary, 13 April 2011) and was co-organised by BirdLife Hungary, the Ministry of Rural Development of Hungary and BirdLife Europe and was kindly hosted by MAVIR (the Hungarian Transmission System Operator Company Ltd.), as part of the official programme of the Hungarian EU Presidency in 2011. It was attended by 123 participants from 29 European and Central Asian countries, the European Commission, UNEP-AEWA, six energy and utility companies, experts, consultancies and NGOs.*

The participants of the Conference adopted a Declaration in which they called on the European Institutions (Commission and Parliament) and national governments to, for instance, 'reconcile energy generation, transmission and distribution with the protection of wild birds within and beyond protected areas' as a general policy.

The declaration refers to the resolutions as adopted by the Bern Convention (2004) and CMS (2002) and, for the EU Member States, to the regulations within the framework of the EU Bird Directive. It is also highlighted to strictly apply the SEA and EIA procedures if it comes to the planning of new power lines The conference called on all interested parties to undertake all possible actions which can lead to minimise the effect of power lines on bird mortality and formulated a number of actions and activities among them are:

- *to set up groups of experts on bird safety on power lines in each country and at the international level to review and consolidate and distribute the available technical standards for bird safety on power lines*
- *to develop national and European programmes for prevention and mitigation of bird electrocution and collision;*
- *to facilitate exchange of technical, biological and managerial experience and support implementation of such programmes.*
- *to develop internationally standardized monitoring protocols; to expedite a Pan-European movement towards improving bird safety on power lines, including research as well as communication projects and voluntary cooperation between industry, public administration and civil society.*
- *Support ongoing exchange of experience between EU and non-EU countries to reduce and eliminate bird electrocution and collision on power lines.*
- *to priorities power lines for mitigation in accordance with bird distribution data and in consultation with relevant government, industry, academic and NGO experts.*
- *Promote and support financially internationally standardised monitoring of the impacts of power lines on birds, including the necessary evaluation of the effectiveness of mitigation measures.*

For the complete text of the declaration and the presentations at the conference see:
http://www.mme.hu/termeszetvedelem/budapest-conference-13-04-2011

6.12. General conclusions on international and national legal arrangements

There are just a few international conservation instruments that have specific recommendations and actions formulated for their Parties on the problems of (migratory) bird electrocution and collision in relation to the construction of new power lines or existing power line transects. Not surprisingly, these are the instruments which, more than others, are dealing with the conservation of migratory birds such as CMS with three of its more specific arrangements: AEWA, Great Bustard MoU and MoU on Birds of Prey.

The texts of these instruments only contain general conservation aspects to be applied, but in Action Plans and later on in Resolutions and Recommendations adopted by the CoPs as well as in information documents distributed among Parties and others, special attention was given to the electrocution and collision problems.

All other international important conservation instruments have obligations that ask for well applied standardised SEA and EIA procedures, including the application of the precautionary principle, for infrastructure development. However, these obligations are very general and given the extent of the problem it would be good if, for example, also CBD could more specifically pay attention to the problem of bird-power line interactions, which occur worldwide.

At the national level a similar policy, using SEA and EIA procedures, is being applied by government agencies. This means that the construction of power lines is almost always subject to EIA procedures (or beforehand the need to construct one is subject of a SEA procedure), in which conservation aspects, including migratory birds, have to be taken into account. These conservation aspects are often based on other national legislation dealing with the conservation of habitat and wildlife. It is a matter of how strict that conservation legislation is, for the overriding influence it has on:

- the way power lines are placed in the landscape;
- what mitigation measures are applied;
- the decision that no power lines at all can be constructed at certain places because of overriding conservation interests;
- the requirement to spend much higher costs in bringing the power lines underground.

That as such should, in the opinion of most countries, be enough to prevent, or at least minimise, the problem of electrocution and collision. Specific legislation on birds and power lines is very rare or part of other conservation legislation.

There is the legal issue of the ‘***precautionary principle***’ to be applied. This is something that almost all international conventions have either in the text itself or laid down as an obligation in decisions that were taken later. Applying this principle when planning the construction of power lines, knowing what it may cause on wildlife in general but especially (migratory) birds, should be a standard procedure as part of SEA and EI procedures.

What is much more common are arrangements, on a voluntary basis or under slight pressure of existing legislation, between the conservation authorities and NGOs and the (electricity) companies responsible for the construction and maintenance of the power lines.
They can also be agreed on just the governmental level between the authorities on wildlife conservation (including migratory birds) and those responsible for the energy sector to agree and assure that migratory birds conservation is taken into account. An example is the MoU of 2006 between the US Fish and Wildlife Service and the US Department of Energy, which details each other responsibilities as Federal Agencies to Protect Migratory Birds in detail. A similar one was arranged in 2011 between US Federal Energy Regulatory Commission (FERC) and the US Fish and Wildlife Service to also implement the “ Responsibilities of Federal Agencies to Protect Migratory Birds”.

The United States pay much attention to the problems of power lines and migratory birds with the national Avian Power Line Interaction Committee (APLIC) as an organisation to provide much technical expertise on this issue coming from the electricity utilities. APLIC also has a long-standing cooperation with the US Fish and Wildlife Service on power lines and migratory birds, publishing important joint guidelines for Avian Protection Plans (APPs; *e.g.* one in 2005).

Arrangements, often by way of a Memorandum of Understanding between all stakeholders, are in place in an increasing number of countries and have been helpful in reducing the negative impacts of power lines (Antal, 2010). This is a good way forward but it does not fully replace the need for legislation.

7. Conclusions

Power lines are one of the major causes of unnatural deaths for birds in a large part of the African-Eurasian region; exact numbers are unknown but annually tens of millions birds are killed. This review highlights previous findings that the two major impacts of power lines on birds, electrocution and collision, show important differences in a number of temporal and spatial aspects as well as in the bird groups affected and the number of casualties.

Electrocution

Electrocution most commonly occurs at medium voltage distribution lines (1 kV to 60 kV), due to the close spacing of the structures. It often involves large perching bird species, such as storks, birds of prey and corvids, which can easily bridge the gap between two cables, or the charged parts and the power line structure.

Electrocution mainly occurs in open habitats (*e.g.*, deserts, plains, steppes, grasslands, and wetlands) lacking natural perches or trees for nesting or roosting. It especially affects birds during the breeding season, when nest building, hunting and territorial behavior put adult birds of *e.g.*, White Storks, Eurasian Eagle Owls, and eagles at risk. In summer, post-breeding dispersal of juveniles and the start of migration also result in an increase in electrocution casualties.

Few studies have estimated the total number of electrocution victims at the national level, but in general annual totals are expected to be in the order of 1,000s of birds per country at the most, seldom 10,000s. For the Iberian Peninsula, average electrocution rates between 0.04 victims/pole (in Catalonia, Spain) and 1.52 victims/pole/year (in Portugal) have been published.

Although electrocution affects less bird species and the number of casualties is much lower than for collision, many of the affected species are relatively rare, have long generation times and low annual reproduction rates and, therefore, electrocution can be a major cause of mortality for these populations, possibly leading to population decline and/or local or regional extinction.

Collision

Collision can occur at all above ground power lines, although more so with high voltage power lines than low or medium voltage lines. This is because the high voltage power lines often consist of multiple sets of vertically placed phase conductors and a separate thin ground wire or neutral above these phase conductors. Low to medium voltage lines mostly have the phase conductors placed in the same horizontal plane, with the ground wire, if present, positioned slightly above them. Furthermore, high voltage lines are generally larger constructions with tall pylons (35 m or higher for 150 kV or more) and thus the wires cover a larger vertical area.

Bird collisions with power lines occur in every habitat type in the African-Eurasian region, from the densely forested areas of Scandinavia, intensively cultivated areas in Western Europe, mountain ridges in the Alps to the deserts of Africa and steppes of Asia. Collisions also involve a vast range of bird species.

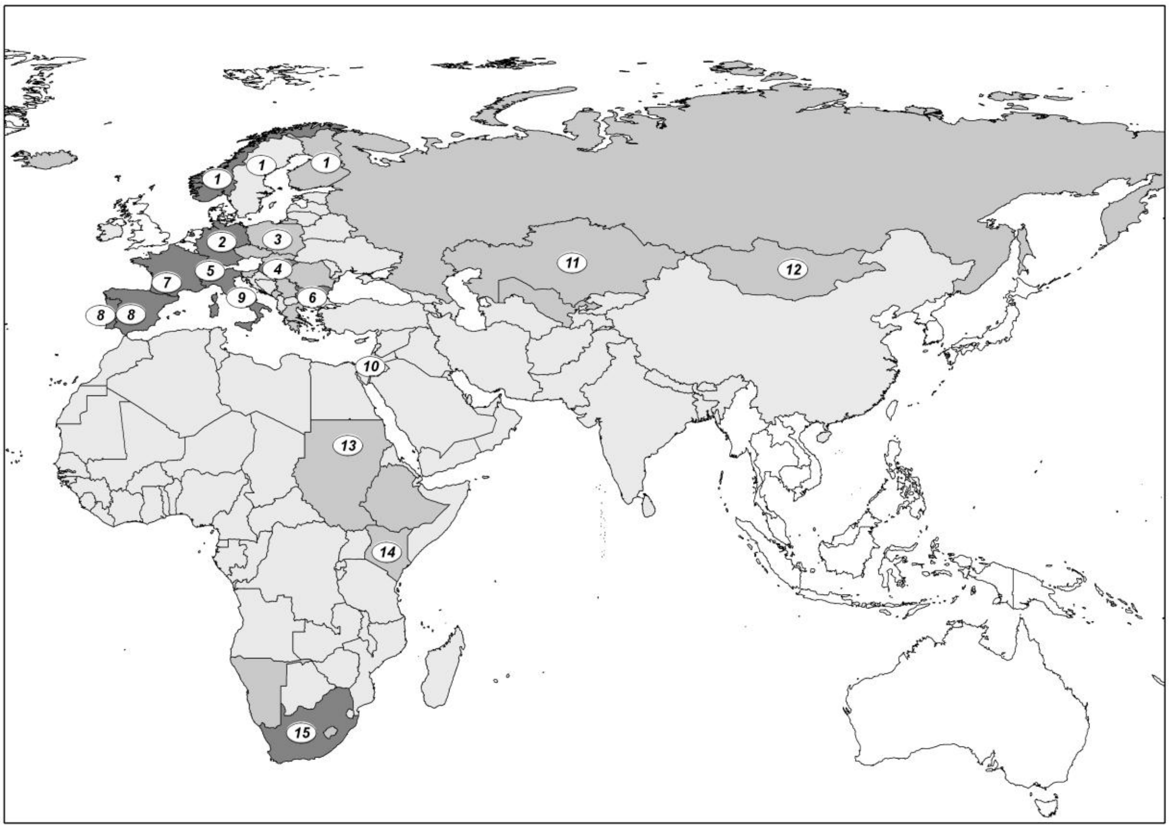
Generally speaking, all flying species of bird are at risk of collision with above ground power lines, although the exposure to the risk (frequency of crossings), environmental conditions (habitat, time of day, *etc.*) and species traits (size, visual ability, *etc.*) influences the risk to individual species. Those species that regularly breed, rest or forage in the vicinity of an above ground power line are at most risk of collision. Visibility also influences the level of risk with most collisions ocuring during twilight and at night, when visibility is less. Furthermore, studies show that large, heavy, less manoeuvrable birds (often species with short, round wings), as well as species with rapid flight, have the highest collision risk. This includes a number of species groups that are rarely found as electrocution victims, such as pelicans, flamingos, ducks, rails, grouse, cranes, bustards, waders and gulls. Species such as thrushes, finches and other small bird species are less found as collision victims, but it is not clear if this is caused by less detectability or indeed a lower risk of collision.

On the other hand, collision is less of a problem to birds of prey and storks than electrocution in large parts of the African-Eurasian region. Collision is also much more of a year-round problem than electrocution, but seasonality plays a role at many locations such as those close to congregations of wintering birds or those on important migration routes.

For many countries in the region, the annual number of collision victims with above ground power lines will be in the order of 100,000s of birds, or higher; this is of course dependent on the length of the total electricity network and the numbers of birds present. This ranks collision within the major human-related causes of death for birds in many parts of the African-Eurasian region; together with traffic, collision with windows and predation by domestic cats. Published average collision rates vary widely, with 2.95 birds/km/year in nine areas representing the most typical habitats of the Iberian Peninsula, to 113 bird/km/year for a wide range of habitats in the Netherlands and 390 birds/km/year for a German wetland area.

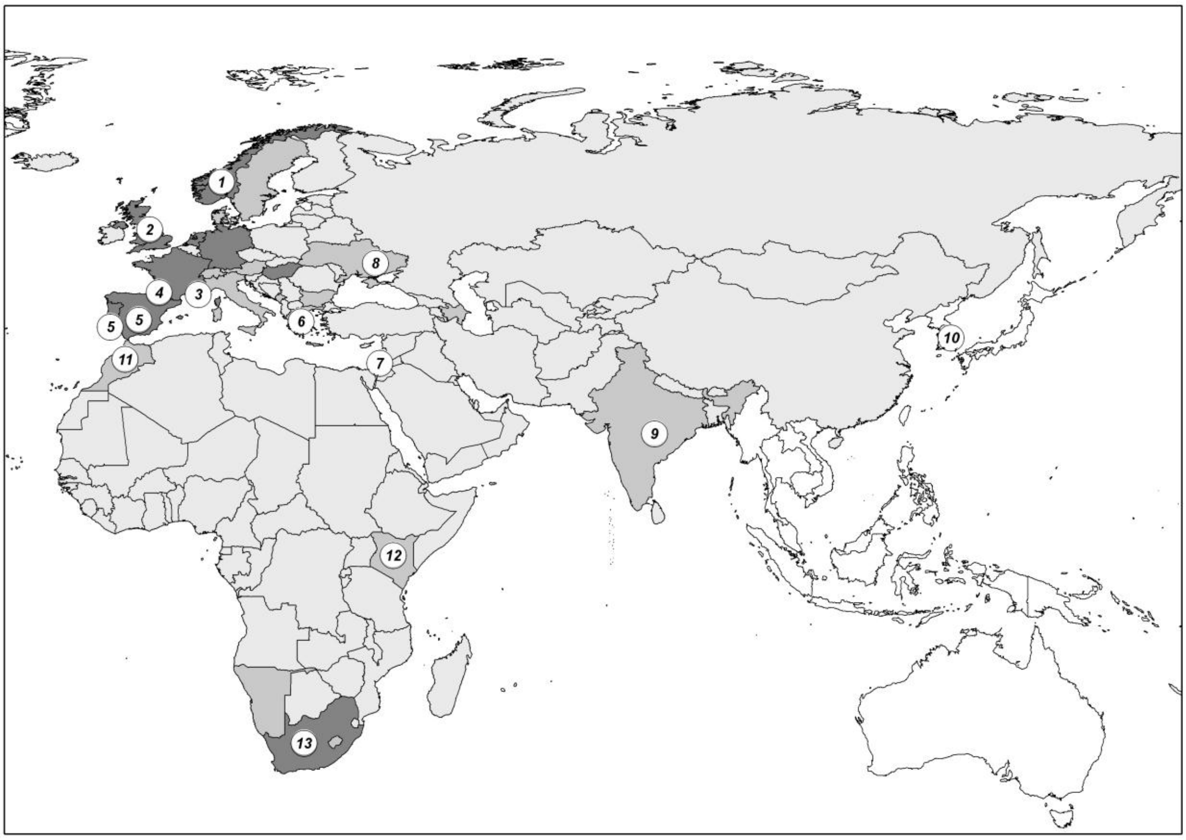
Conflict Hotspots

From the information made available for this review it is not possible to construct detailed maps of conflict 'hotspots'. It is possible however, to generalise some of the findings to the extent that certain species groups are more susceptible to electrocution or collision than others. This information has been summarised in Appendices 3 and 4. If one or more of these species groups occur in the areas of planned or existing power lines, problems for the species in question are likely to occur if no mitigation measures are applied. The extent of the problem depends on the number of birds involved, their behaviour (*i.e.* regularly perching on poles, many flight movements passing the power line transect) and layout of the power line and its components. The information reviewed in this report contains a number of documented conflict hotspots; locations or areas where relatively large numbers of birds have been found as victims of power lines, resulting in a possible impact on regional, national or international populations of these species. These are summarised in the maps below with published conflict hotspots for electrocution (Figure 14) and collisions (Figure 15). To be more precise on hotspots at a greater detailed geographical scale much more in depth analyses are needed than was possible in the framework of this review.



Hotspot	Range State	Species (group)	Magnitude
1	Norway, Sweden, Finland	Eurasian Eagle Owl Ural Owl	20-45% of known death 7% of known death
2	Germany	Eurasian Eagle Owl	26% of known death
3	Poland	White Stork	annually 510 victims
4	Hungary	Golden Eagle, Saker Falcon, Roller	0.5-1.5% annual mortality of total population
5	Switzerland	White Stork Eagle Owl	>40% of known death 24% of all fatalities in NW part
6	Bulgaria	Imperial Eagle, Saker Falcon, Lesser Kestrel, Eurasian Black Vulture White Stork	under study 25% of mortality rate
7	France	Bonelli's Eagle	of 20 found dead 85% was electrocuted, mayor cause of mortality
8	Spain/Portugal	White Stork Bonelli's Eagle Spanish Imperial Eagle	137 victims in three years time in Portugal 9, 16 and 17 victims reported in three studies ~40% of total mortality
9	Italy	Eurasian Eagle Owl	17% of fledlings in Alps and Apennines
10	Israel	Griffon Vulture	yearly 5% of population
11	Kazakhstan	Steppe Eagle	48 victims in one month time at 11 km of power line; 8% yearly mortality of total population
12	Mongolia	Saker Falcon	54% of adult mortality
13	Sudan	Egyptian Vulture	several tens annually at 31 km of power line
14	Kenya	a.o. vulture *spp*., Martial Eagle, Augur Buzzard	risk assessment, no collision searches
15	South Africa	Cape Vulture	up to 80 victims per year, Eastern Cape population

Figure 14. Summary of known conflict hotspots (numbers in figure and in table) for electrocution in the African-Eurasian region based on the information collected and made available for this review. Grey colours depict amount of information (made) available on this topic (legend see Appendix 2).



Hotspot	Range State	Species (group)	Magnitude
1	Norway	grouse spp.	>300 victims in six years time
2	United Kingdom	Mute Swan Bewick's Swan	high numbers of victims 25% of victims with known cause of death
3	France (Camargue)	Greater Flamingo	122 victims in five years time
4	France (Pyrenees)	Bearded Vulture	12 victims in 1979-2008
5	Spain/Portugal	Common Crane Great Bustard, Little Bustard Bonelli's - & Spanish Imperial Eagle	common victim in core wintering area in Extremadura 2% resp. 1% of population in core area several victims found
6	Greece	Dalmatian Pelican	ca. 3% of local breeding population (49 victims)
7	Israel	White Pelican	20-60 victims/year
8	Ukraine	Great Bustard	33 victims reported in 10 year time in core area
9	India	Sarus Crane	1% of local population (35 victims)
10	South Korea	Red-crowned- & White-naped Crane	after poisoning, most important cause of additional mortality
11	Morocco	Great Bustard	23.3% of total mortality
12	Kenya	a.o. Secretary Bird, White Stork, Lesser Flamingo	risk assessment, no collision searches
13	South Africa	Blue Crane Ludwig's Bustard	5-23% of Overberg population killed annually 11-15% of total population killed annually

Figure 15. Summary of known conflict hotspots (numbers in figure and in table) for collision in the African-Eurasian region based on the information collected and made available for this review. Grey colours depict amount of information (made) available on this topic (legend see Appendix 2).

Gaps in the Knowledge

The extent to which information on the issues of bird-power line interactions in the African-Eurasian region was made available for this review is summarised in Appendix 2. When combining those maps with information on the presence of above ground power line networks in the region, it becomes very clear that large gaps in the knowledge exist. In particular, much is still unknown (or at least not readily available) on the magnitude of bird mortality through electrocution and collision and its impact on bird populations in Asia and Africa. ABS Energy Research recently updated its overview of all major electricity networks in the world (ABS, 2011). From this report the overwhelming extent of the national and international power line networks can be understood.

For example, the vast areas of the Russian Federation are crossed by no less than 502,000 kilometres of transmission lines and 2,100,000 kilometres of distribution lines, while Kazakhstan holds a still impressive 68,281 kilometres of transmission lines and almost 460,000 kilometres of distribution lines. In densely populated India, a network consisting of more than 263,000 kilometres of transmission lines and almost 6,500,000 kilometres of distribution lines delivers the energy to its many consumers. Only very small percentages (on average <10%) of these networks have been put underground (ABS, 2011). Although only based on a handful of published studies (no other information was received in spite of a number of efforts to obtain this) on the effects of power lines on birds in these countries, presented in chapters 2 and 3, it is concluded that such widespread power line networks certainly have resulted, and providing no measures are taken, will keep on resulting in huge numbers of bird casualties. Many distribution lines with potentially dangerous poles designs and transmission lines without wire markings cross the many vast open habitats. As far as we know, hardly any effort has been put into studying the impacts of power lines in these regions, let alone develop detailed plans for mitigation.

In Africa, the electricity network comprises less than 2,000,000 kilometres with only 700,000 kilometres in sub-Saharan Africa. The electrification of the continent is, however, quickly expanding. Expecting that much of the new power line design and construction will be similar to those applied in (the few studied) bird conflict hotspots on the continent, the future growth of the electricity network is likely to result in an increasing threat for birds.

Besides the abovementioned gaps in knowledge from regions where both human and financial resources hamper intensive and long-term field programs, it is important to mention that in Europe gaps in the knowledge also exist.

This may sound strange as there is a huge amount of information available on the topic of bird/power line interactions in Europe. However, many of the studies have an anecdotal character, often only describing what has been found under stretches of power line. This is due to poor layout of the study in terms of temporal and spatial effort, lack of control for biases, focus on large conspicuous species, *etc*.

There is good understanding of which vulnerable species are affected, because that has been the focus of most studies, but the demographic impact on the bird populations involved is less well understood. Furthermore, documentation of the significance of the problem for more common species, such as many species of wildfowl, rails, and waders is rarely documented. Finally, few collision mitigation measures have been proven to be successful in minimising nocturnal collisions and further developments in this area are needed. To understand which types of wire markers and pole design and configuration mitigates best for which species, more long term and in depth studies are needed that compare the efficiency of different types of mitigation measures under similar circumstances in a range of habitats involving different species groups.

Because of its sheer extent, it is impossible to study and/or mitigate the impact on birds along the full length of the power line networks in a region, or even nationwide. Therefore, a strategy is needed in which priorities, maybe through developing national zoning maps, are given to potentially problematic sections of power lines using priority lists of key conservation areas and species. It is important that high quality information on the presence of susceptible bird species and their movements is incorporated into this process and that standard protocols and research methods are created that allow the comparison and extrapolation of results. These and other steps to minimise the effects of power lines on birds are included in the recommendations chapter that follows and are described in much more detail in the accompanying 'Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region' (Prinsen *et al*., 2011).

Legislation
Only few international treaties have paid attention to the problem of power lines and bird collisions and electrocution. Although this review is restricted to the African-Eurasian region, it is a global problem involving tens of millions of birds. Therefore, it is important that this issue receives more attention within, for instance, CBD and it might also be important for the Ramsar Convention to highlight it through a separate resolution, given the fact that waterbirds are often victim and power lines often cross open wetland areas.

On the national level, the problem of power lines and bird collision and electrocution is almost entirely dealt with through the provisions within SEA (although in some countries not always a legal obligation) and EIA procedures. In particular, EIA procedures are in place in most countries, providing some guarantee that in general the interests of nature are taken into account. Given the large numbers of bird casualties in relation to power lines, this should have high priority in any EIA procedure and should even be highlighted as a separate obligation.

Many of the potential risks to birds can be avoided in the planning phase of construction of a power line, provided that sound data on bird distribution and movements is available. It is therefore advised that, in the case that bird data are not available, at least a one-year field survey should be part of the EIA procedure.

A number of countries have good experience with voluntary arrangements between government agencies, NGOs and electricity companies aimed at reducing the impact of power lines on bird populations. It is worth having such voluntary arrangements in every country, even if legislation is already in place which forces, for example, the use of high quality and up-to-date bird data in planning procedures and mitigation measures.

8. Recommendations

CMS and AEWA Parties should establish National Working Groups (of a temporary nature) in order to develop Memoranda of Understanding (MoU) between the electricity companies, government agencies and NGO organisations involved in bird conservation and research. Their aim is to work out an agreement on policy and actions to reduce bird mortality (both electrocution and collision) by existing and planned new power lines. Such a Working Group should review the national situation, and discuss priority actions for mitigation measures.

Several countries have already developed such a MoU and they have proven it to be a powerful tool in working together in applying good mitigation measures for existing power lines, better and careful planning of new power lines and research and monitoring of the consequences for certain bird populations. If developed in the correct way, with recognition of each other's responsibilities, it has a high potential to successfully minimise bird losses through electrocution and collision.

It is also recommended that on the government level similar MoUs are being prepared between the various ministries, *e.g.*, with responsibilities on conservation, physical planning and energy. This would also avoid conflicts on the interpretation of existing national and international legislation on energy, physical planning and conservation, if it is not clear from the beginning which legislation or policy (can potentially) overrule the other.

It is recommended that these Working Groups also discuss and agree upon the involvement of the partners responsible for the necessary monitoring and research on the extent of collision and electrocution and to collect data necessary to analyse the effect of mitigation measures. Funding for such monitoring and research should be made available by both the private sector (*e.g.* electricity companies) and the government.

It is very important that already in an early stage of planning, such as SEA and network master plans, the construction and potential routing of power lines is evaluated in relation to the presence of vulnerable habitats and bird populations. The development of national zoning maps showing certain levels of risks for birds, is an important tool in the early stages of planning. Information in this review (summarised in the tables in Appendices 3 and 4) shows that specific groups of bird species are more vulnerable than others; zoning maps can be a helpful tool to identify the areas concerned for such species.

It is strongly recommended that special attention is paid to vulnerable and endangered species as listed under national and international legislations. This should guide the long term planning process in a way that minimises the risks of electrocution and collision for both breeding and migrating birds. This would also reduce the risk on procedures if, for instance, international conservation obligations are not taken into account.

Legislation on SEA and EIA procedures should therefore contain rules on the use of existing bird data (breeding bird atlases, migration atlases, etc.) and/or advanced field surveys on breeding and migratory birds if information is not available or limited. Legislation should also be in place for electricity companies to apply the maximum possible on mitigation measures once a power line is being constructed. The costs of such mitigation measures should be included in the total budget for the construction of the power line from the very beginning.

It is recommended that for planned power lines, thus at the stage of a EIA procedure, such field surveys should at least include one year of ornithological investigations in order to characterise local and regional bird movements, including local commuting flights between breeding, feeding and resting areas as well as seasonal migration. Such investigations should include research on flight movements both during the day, at twilight and at night (species, number of birds, flight height and location of main flight routes). For the latter it is recommended to apply modern research techniques, including the use of bird radar, night vision equipment and/or automatic camera detection systems.

The review shows that limited research and monitoring data are available on the interaction of power-lines and birds in large parts of the African-Eurasian region, but most notably from Asia and Africa. It is worth continuing efforts to collect further information – if at all available; there was hardly any response to the questionnaires – to have a better insight in the magnitude of the problem in these larger regions. Funding should be made available to carry out field surveys in areas were power lines exist with specific attention for vulnerable and endangered bird species, both sedentary and migratory.

When electrocution is (potentially) a risk for birds, which is especially the case with medium voltage distribution lines, the presence and distribution and preferred feeding/hunting areas of large perching birds, such as birds of prey, herons, and storks, need to be mapped in order to provide information as to the locations and types of mitigation needed (*e.g.*, separation width between conductors, length of insulation, *etc*.).

It is recommended to apply, as far as possible, the technical solutions to reduce bird mortality from electricity transmission facilities mentioned in this review report and more extensively in the accompanying guidelines report, published as AEWA/CMS Technical Series No. XX titled 'Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region' (Prinsen *et al*., 2011). To ensure avian safe electricity transmission and distribution facilities, the following measures are recommended as a minimum:

- put existing and new low to high voltage power lines underground in as far as technically and financially feasible, but especially in areas of high relevance to birds;
- develop and support strategic long-term planning of nationwide electricity grid networks, applying appropriate Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) procedures to carefully consider location in the planning process, incorporating all available information on presence of protected areas, key bird areas and susceptible bird species, including important bird flight routes;
- use state-of-the-art technical standards for bird safety for new and retrofitted power lines, including;
  - substitute upright insulators on cross-arms with hanging insulators or put the latest generation of insulating caps on the upright insulators,
  - place the power lines (conductors) below the cross-arms,
  - use insulating chains at least 70 cm in length,
  - insulation of power lines at least on 70 cm of both sides of the cross-arm,
  - insulation of all other energised parts which are closer than 70 cm to a possible perch,
  - installation of bird-friendly perching and/or nesting devices,
  - reduction in the number of collision planes (vertically separated number of conductors) with no ground wire,
  - installation of clearly visible large high contrast (*i.e.* black and white) markers and/or moving and reflecting bird flight diverters in energised conductors and ground wires.

Existing power lines should be examined on their risks for bird electrocution and collision using standardised protocols. Provided financial resources are available, appropriate mitigation measures should be put into place as soon as possible.

Redundant power lines and cables should be removed.
There is clearly a need for a best practice guidance on standard study methods as the information provided so far by countries and present in literature is collected by a wide range of methods, time scales and length of field surveys. This makes it difficult to be more precise on the extent of the problem and analyse the results of mitigation measures in a consistent way. The Scientific Council of CMS and the Technical Committee of AEWA are therefore requested to develop guidelines for research and monitoring. This will provide a better insight into the actual number of birds killed, the species involved, the possible effect of mitigation measures taken, and will produce more rigorous and unbiased data with which to facilitate confident decision making.

UNEP/CMS and UNEP/AEWA Secretariats should monitor the relevant steps that have been planned or adopted by Parties to implement the recommendations put forward above, as well as all information collected to evaluate and monitor bird-power line interactions. It is recommended to establish a Web-based Clearing House. This could provide a central point for the dissemination of successful mitigation measures, training and research information relating to the study and monitoring of bird-power line interactions. The website could provide access on the topic for all relevant stakeholders, including current, comprehensive and easily accessible information and downloadable guidance documents, literature overviews and pointing them to a network of research experts.

UNEP/CMS and UNEP/AEWA Secretariats [Conference of the Parties] should stimulate that the available information and recommendations are made widely available.

Given the global extend of the problem of power lines and birds, causing each year the death of tens of millions of birds, it is recommended that the UNEP/CMS and UNEP/AEWA Secretariats seek the support of the broader conservation community for actions to reduce the problem. Notably CBD should provide guidance to its Parties on the problem.

In order to provide Parties with the most up-to-date information on the best possible mitigation techniques and measures, it is recommended to produce an update on this Review report and Guidelines in about five years time.

9. Bibliography

ABS Energy Research, 2011. Global transmission & distribution report. Ed 9- 2010, United Kingdom, London.

AEWA (Agreement on the Conservation of African-Eurasian Migratory Waterbirds), 2008. International single species action plan for the conservation of the Eurasian Spoonbill *Platalea leucorodia*. AEWA Technical Series No. 35.

Agic, I.J., 2006. Ravens, *Corvus corax* (L. 1758), nesting on high-voltage transmission line pylons in Croatia. Belgrad Journal of Zoology 136: 167-171.

Allan, D.G., 2001. The impact of the inundation of Katse Dam in the Lesotho highlands on the local avifauna, based on a comparison of information collected during a pre-inundation baseline survey (1991) and a post-inundation monitoring study (1996-2000) - LHDA Project 615 - Birds. Durban Natural Science Museum Bird Department Research Reports 13: 1-351.

Alonso, J.A. & Alonso, J.C., 1999. Collisions of birds with overhead transmission lines in Spain. In: Ferrer, M. & Janss, G.F.E. (Eds.). Birds and Power Lines. Quercus, Madrid.

Alonso, J.C., Alonso, J.A. & Muñoz-Pulido, R., 1993. Marking electric power lines for protection of birds (in Spanish). REE, Madrid.

Alonso, J.C., Alonso, J.A. & Muñoz-Pulido, R., 1994. Mitigation of bird collisions with transmission lines through groundwire marking. Biological Conservation 67(2): 129-134.

Alonso, J.C., Palacín, C., Martín, C.A., Muati, N., Arhzaf, Z.L. & Azizi, D., 2005. The Great Bustard *Otis tarda* in Morocco: a re-evaluation of its status based on recent survey results. Ardeola 52: 79-90.

Altemüller, M. & Reich, M., 1997. Influence of high-tension power lines on breeding meadow birds (in German with English summary). Vogel und Umwelt 9 (Sonderheft): 111-127.

Andersen-Harild, P. & Bloch, **D.**, 1973. Birds killed by overhead wires on some locations in Denmark (in Danish with English summary). Dansk Orn. Foren. Tidsskr. 65: 89-97.

Anderson, M.D. & Hohne, P., 2007. African White-backed Vultures nesting on electricity pylons in the Kimberley area, Northern Cape and Free State provinces, South Africa. Vulture News 57: 44.

Andryushchenko, Y.A., Beskaravayny, M.M. & Stadnichenko, I.S., 2002. Demise of Great Bustards and other bird species because of their collision with power lines on the wintering grounds (in Russian with English summary). Branta 5: 97-112.

Angelov, I., Hashim, I., & Oppel, S., 2011. Persistent electrocution mortality of Egyptian Vultures *Neophron percnopterus* over 28 years in East Africa. Unpublished report.

Anonymus, 1970. Victims of high-tension power lines (in Dutch). De Lepelaar: 8-9.

APLIC (Avian Power Line Interaction Committee), 1994. Mitigating bird collisions with power lines: The state of the art in 1994. Edison Electric Institute, Washington, D.C.

APLIC (Avian Power Line Interaction Committee), 2006. Suggested practices for avian protection on power lines: The state of the art in 2006. Edison Electric Institute, Washington, D.C.

Arroyo, B., Ferreiro, E. & Garza, V., 1998. Understanding the decline of Bonelli's Eagle *Hieraaetus fasciatus* in Central Spain (in Spanish). Pp: 291-304. In: Chancellor, R.D., Meyburg B.-U. & Ferrero, J.J. (Eds.). Holarctic Birds of Prey. ADENEX-WWGBP.

Bagyura, J., Szitta, T., Haraszthy, L., Demeter, I., Sándor, I., Dudás, M., Kállay, G. & Viszló, L., 2004. Population trend of the Saker Falcon *Falco cherrug* in Hungary between 1980 and 2002. Pp: 663-672. In: Chancellor, R.D. & Meyburg, B.-U. (Eds.). Raptors worldwide. World Working Group on Birds of Prey, Berlin & MME-BirdLife Hungary, Budapest.

Bahat, O., 1997. Conservation of threatened raptor populations in Israel. Pp: 177-189. In: Leshem, Y., Froneman, A., Mundy, P. & Shamir, H. (Eds.). Wings over Africa. Proceedings of the International Seminar on Bird Migration and Flight Safety.

Ballasus, H. & Sossinka, R., 1997. The impact of power lines on field selection and grazing intensity of wintering White-fronted- and Bean Geese *Anser albifrons*, *A. fabalis*. Journal of Ornithology 138: 215-228.

Bayle, P., 1999. Preventing birds of prey problems at transmission lines in Western Europe. Journal of Raptor Research 33: 43-48.

Beadnell, C.M., 1937. The toll of animal life exacted by modern civilisation. Proc. Zool. Soc. London, serie A107(II): 173-182.

Bednorz, J., 2000. Ravens *Corvus corax* (L. 1758), nesting on electricity pylons in the Wielkopolska region. Acta zool. cracov. 43: 177-184.

Beer, J.V. & Ogilvie, M.A., 1972. Mortality. Pp 125-142. In: Scott, P. & the Wildfowl Trust (Eds.). The swans. Houghton Mifflin Co., Boston.

Beijersbergen, R.B., 1975. Bird collisions at the Ventjagersplassen (in Dutch). Het Vogeljaar 23: 278-279.

Bergerud, A.T., 1985. The additive effect of hunting mortality on the natural mortality rates of grouse. Pp: 345-366. In: Beasom S.L. & Robertson S.F. (Eds.). Game Harvest Management. Ceasar Kleberg Wildlife Research Institute, Kingsville, Texas.

Bernshausen, F. & Kreuziger, J., 2009. Review of the effectiveness of new developed wire markers based on behaviour observations of overwintering and year round present birds at the Alfsee/Niedersachsen (in German). Planungsgruppe für Natur und Landschaft, Hungen.

Bevanger, K., 1993. Hunting mortality versus wire-strike mortality of Willow Grouse *Lagopus lagopus* in an upland area of Soutern Norway. Norwegian Institute for Nature Research, Trondheim, Norway.

Bevanger, K., 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. Ibis 136(4): 412-425.

Bevanger, K., 1995. Estimates and population consequences of tetraonid mortality caused by collisions with high tension power lines in Norway. Journal of Applied Ecology 32(4): 745-753.

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

Bevanger, K. & Overskaug, K., 1998. Utility structures as a mortality factor for raptors and owls in Norway. Pp: 381-391. In: Chancellor, R.D., Meyburg B.-U. & Ferrero, J.J. (Eds.). Holarctic Birds of Prey, ADENEX-WWGBP.

Bevanger, K. & Brøseth, H., 2001. Bird collisions with power lines - an experiment with ptarmigan (*Lagopus* spp.). Biological Conservation 99(3): 341-346.

Bevanger, K. & Brøseth, H., 2004. Impact of power lines on bird mortality in a subalpine area. Biodiversity and Conservation 27: 67-77.

Bevanger, K., Bartzke, G., Brøseth, H., Ove, J., Gjershaug, F.H., Jacobsen, K.O., Kvaløy, P., May, R., Nygård, T. & Pedersen, H.C., 2009. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2009. – NINA Report 504. Norwegian Institute for Nature Research, Trondheim.

BirdLife Europe, 2011. Meeting Europe's renewable energy targets in harmony with nature (Eds. Scrase, I. & Gove, B.). The RSPB, Sandy, UK.

Biro, G., 2011. Bird protection on high voltage transmission system. Presentation at International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary. Website, see below.

Boldogh, S., 1998. Studies for the effective protection of the White Stork (*Ciconia ciconia*) in Borsod-Abauj-Zemplen county, NE Hungary. Ornis Hungarica 8: 133-136.

Boshoff, A.F., Minnie, J.C., Tambling, C.J. & Michael, M.D., 2011. The impact of power line-related mortality on the Cape Vulture *Gyps coprotheres* in a part of its range, with an emphasis on electrocution. Bird Conservation International 21: Published online.

Brauneis, W., Watzlaw, W. & Horn, L., 2003. The behaviour of birds in the proximity of a selected part of the 110 kV power line between Bernburg and Susigke (Bundesland Sachsen-Anhalt). Flight behaviour, collisions, breeding populations (in German with English summary). Ökol. Vögel 25: 69-115.

Breuer, W., 2007. Stromopfer und Vogelschutz an Energiefreileitungen. Naturschutz und Landschaftsplanung 39: 69-72.

Cheylan, G.A., Ravayrol, A., Cugnasse, J.-M., Billet, J.-M. & Joulot, C., 1996. Dispersal of juvenile Bonelli's Eagles *Hieraaetus fasciatus* ringed in France (in French). Alauda 64: 413-419.

Compañia Sevillana de Electricidad, 1995. Analysis of the impacts of power lines on birds of protected areas: manual for risk assessment and mitigation (in Spanish). Iberdrola & REE.

Costa, J. & Infante, S., 2010. Monitoring and mitigating the impacts of power lines on birds. Unpublished Report, Spain.

Crivelli, A.J., Jerrentrup, H. & Mitchev, T., 1988. Electric power lines: a cause of mortality in *Pelecanus crispus* Bruch, a world endangered species. Col. Waterbirds 11: 301-305.

Del Moral, J.C., 2006. Bonelli's Eagle in Spain. Population in 2005 and census methods (in Spanish). SEO/BirdLife, Madrid.

Dell'Omo, G., Costantini, D., Di Lieto, G. & Casagrande, S., 2005. Birds and power lines (in Italian). Alula 12: 103-114.

Dell'Omo, G., Costantini, D., Lucini, V., Antonucci, G., Nonno, R. & Polichetti, A., 2009. Magnetic fields produced by power lines do not affect growth, serum melatonin, leukocytes and fledging success in wild Kestrels. Comparative Biochemistry and Physiology, Part C 150: 372-376.

Demerdzhiev, D.A., Stoychev, S.A., Petrov, T.H., Angelov, I.D. & Nedyakov, N.P., 2009. Impact of power lines on bird mortality in Southern Bulgaria. Acta Zoologica Bulgarica 61(2): 177-185.

Demerdzhiev, D.A., 2010. Mortality rate in wild birds caused by 20kV power lines. Electrocution in six studied protection sites in the Natura 2000 Network in Bulgaria. Bulgarian Society for the Protection of Birds.

Del Moral, J.C., 2006. Bonelli's Eagle in Spain. Population in 2005 and census methods (in Spanish). SEO/BirdLife, Madrid.

Demeter, I., 2004. Medium-voltage power lines and bird mortality in Hungary. MME BirdLife Hungary, Budapest, Hungary.

Directorate of Culture and Cultural and Natural Heritage (DCCHN), 2010. Implementation of recommendation No. 110/2004 on minimising adverse effects of above ground electricity transmission facilities (power lines) on birds. Report by the governments to the 30th meeting of the Standing Committee of the Bern Convention, Strassbourg. T-PVS/Files (2010) 11. Council of Europe.

Dixon, A., 2009. Saker Falcon breeding population estimates. Part 2. Asia. Falco 33: 4-10.

Dolata, P.T., 2006. The White Stork *Ciconia ciconia* protection in Poland by tradition, customs, law and active efforts. Pp. 477-492. In: Tryjanowski, P., Sparks, T.H. & Jerzak, L. (Eds.). The White Stork in Poland: studies in biology, ecology and conservation. Bogucki Wydawnictwo Naukowe.

Drewitt, A. L. & Langston, R.H.W., 2008. Collision effects of wind-power generators and other obstacles on birds. Annals of the New York Academy of Sciences 1134: 233-266.

Erickson, W.P., Johnson, G.D. & Young Jr, D.P., 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service General Technical Report PSW-GTR-191.

Eskom-EWT Strategic Partnership, 2011. Data from Central Incident Register. Unpublished data.

Faanes, C.A., 1987. Bird behavior and mortality in relation to power lines in prairie habitats. United States Department of the Interior Fish and Wildlife Service, Fish and Wildlife Technical Report 7. Washington, D.C.

Fagundes, A.I., 2009. Monitoring and mitigation of the impacts resulting from the interaction between bird and Powerlines in the Island of Madeira (Portugal) – Final Report (in Portuguese). Unpublished report, SPEA, Lisbon.

Fernández-Garcia, J.M., 1998. Relationship between mortality in electric power lines and avian abundance in a locality of Leon (NW of Spain). Ardeola 45: 63-67

Fernie, K. J. & Reynolds, S.J., 2005. The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: a review. Journal of Toxicology and Environmental Health, Part B 8(2): 127-140.

Ferrer, M., de la Riva, M. & Castroviejo, J., 1991. Electrocution of raptors on power lines in Southwestern Spain. Journal of Field Ornithology 62: 181-190.

Ferrer, M. & Hidalgo, F., 1992. Man-induced sex-biased mortality in the Spanish imperial eagle. Biological Conservation 60: 57-60.

Foster, K.R. & Repacholi, M.H., 2002. Environmental impacts of electromagnetic fields from major electrical technologies. Proceedings of International Seminar Effects of Electromagnetic Fields on The Living Environment. Ismaning, Germany.

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: 83-91.

Gaget, V. & Barbey, F., 1998. Comparison of bird mortality at two THT 400 kV power lines between St André de Corcy and Ste Olive das l'Ain, St Vulbas – Grosne (in French). Unpublished report. CORA Rhône, Lyon.

Gangoso, L. & Palacios, C.J., 2002. Endangered Egyptian Vulture (*Neophron percnopterus*) entangled in a power line ground-wire stabilizer. Journal of Raptor Research 36: 238-239.

Garrido, J.R. & Fernández-Cruz, M., 2003. Effects of power lines on a White Stork *Ciconia ciconia* population in Central Spain. Ardeola 50: 191-200.

Gerdzhikov, G.P. & Demerdzhiev, D.A., 2009. Data on bird mortality in "Sakar" IBA (BG021), caused by hazardous power lines. Ecologia Balkanica 1: 67-77.

Gil, J.A., 2009. Assessment of collision and electrocution risks on power lines in Special Protection Areas, under the scope of the Lammergeir (*Gypaetus barbatus*) recovery plan in Aragón (in Spanish). Pirineos 164: 165-172.

Gil del Pozo, M. & Roig, J., 2003. Interaction between BirdLife and Red Electrica's transmission facilities: experience and solutions. Proceedings of the 4th technical session on power lines and the environment, Madrid.

González, L.M., Margalida, A., Mañosa, S., Sánchez, R., Oria, J., Molina, J.I., Caldera, J., Aranda, A. & Prada, L., 2007. Causes and spatio-temporal variations on non-natural mortality in the vulnerable Spanish Imperial Eagle *Aquila adalberti* during a recovery period. Oryx 41: 495-502.

Goudie, R.I., 2006. Effects of powerlines on birds. Harlequin Enterprises. St. John's, Newfoundland.

Grishchenko, V.N., 2008. Changes in nest site selection of the White Stork in Ukraine. Berkut 16: 52-74.

Gutsmiedl, L. & Troschke, T., 1997. Study of the influence of a 110-kV power line at a Grey Heron colony and resting (migratory) birds (in German with English summary). Vogel und Umwelt 9 (Sonderheft): 191-209.

Guzmán, J. & Castaño, J.P., 1998. Electrocution of raptors on power lines in Sierra Morena Oriental and Campo de Montiel (in Spanish). Ardeola 45: 161-169

Haack, C.T., 1997. Collisions of White-fronted Geese (*Anser albifrons*) with a high tensin power line at Rees (Lower Niederrhein), Nordrhein-Westfalen (in German with English summary). Vogel und Umwelt 9 (Sonderheft): 295-299.

Haas, D., 2010. Bad Engineering affects the Paradise. A short Picture-Story from Ethiopia about „Killer-Poles". Unpublished report distributed by author via email.

Haas, D., 2011. Electrocution of birds. Some further aspects of international high significance. Presentation at International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary. Website, see below.

Haas, D., Nipkow, M., Fiedler, G., Schneider, R., Haas, W. & Schürenberg, B., 2005. Protecting birds from powerlines. Nature and Environment, No. 140. Council of Europe Publishing, Strassbourg.

Haas, D. & Nipkow, M., 2006. Caution: Electrocution! NABU Bundesverband. Bonn, Germany.

Haas, D. & Schürenberg, B., 2008. Bird electrocution; general principles and standards of bird protection at power lines (in German). Proceedings of the Conference 'Stromtod von Vögeln, Grundlagen und Standards zum Vogelschutz an Freileitungen' in Muhr am See, April 2006. Ökologie der Vögel, Band 26, Hamburg.

Harness, R. & Gombobaatar, D.R.S., 2008. Raptor electrocutions in the Mongolia Steppe. WINGING IT 20: 1-6.

Harness, R., Gombobaatar, D.R.S. & Yosef, R., 2008. Mongolian distribution of power lines and raptor electrocutions. Rural Electric Power Conference, Charleston, South Caroline.

Hartman, J.C., Gyimesi, A. & Prinsen, H.A.M., 2010. Are bird flaps effective wire markers in a high-tension power line? – Field study of collision victims and flight movements at a marked 150 kV power line (in Dutch). Report nr. 10-082, Bureau Waardenburg bv, Culemborg.

Heynen, D. & Schmid, H., 2007. Priority regions to remediate medium-tension power lines to protect White Stork and Eagle Owl from electrocution (in German). Schweizerische Vogelwarte, Sempach.

Heijnis, R., 1976. Birds underway. Thousands of birds victim of high-tension power lines (in Dutch).

Heijnis, R., 1980. Bird mortality from collision with conductors for maximum tension (in German with English summary). Őkologie der Vogel 2(Sonderheft): 111-129.

Henderson, I.G., Langston, R.H.W. & Clark, N.A., 1996. The response of Common Terns *Sterna hirundo* to power lines: an assessment of risk in relation to breeding commitment, age and wind speed. Biological Conservation 77(2-3): 185-192.

Hoerschelmann, H. von, Haack, A. & Wohlgemuth, F., 1988. Bird casualties and bird behaviour at a 380-kV-power line (in German with English summary). Őkologie der Vogel 10: 85-103.

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

Horvath, M., Nagy, K., Papp, F., Kovacs, A., Demeter, I., Szugyi, K. & Halmos, G., 2008. The evaluation of the Hungarian medium-voltage electricity network from a bird conservation perspective (in Hungarian). Magyar Madártani és Természetvédelmi Egyesület, Budapest.

Hunting, K., 2002. A roadmap for PIER research on avian power line electrocution in California. California Energy Commission, California.

Infante, S., Neves, J., Ministro, J. & Brandão, R., 2005. Impact of distribution and transmission power lines on birds in Portugal (in Portuguese). Quercus, ICN and SPEA, Castelo Branco. Unpublished report.

Jaklitsch, H., Bierbaumer, M., Wegleitner, S., Edelbacher, K. & Schindler, S., 2011. Monitoring of bird behaviour on a wire-marked 110kV power line in Lower Austria. Poster presented at the International Conference in Budapest: Power lines and bird mortality in Europe. Website, see below.

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

Janss, G.F.E. & Ferrer, M., 1998. Rate of bird collision with power lines: effects of conductor-marking and static wire-marking. Journal of Field Ornithology 69(1): 8-17.

Janss, G.F.E. & Ferrer, M., 1999. Mitigation of raptor electrocution on steel power poles. Wildlife Society Bulletin 27: 263-273.

Janss, G.F.E., Lazo, A. & Ferrer. M., 1999. Use of raptor models to reduce avian collisions with powerlines. Journal of Raptor Research 33: 154-159.

Janss, G.F.E. & Ferrer, M., 2000. Common Crane and Great Bustard collision with power lines: collision rate and risk exposure. Wildlife Society Bulletin 28: 675-680.

Jenkins, A., 2007. Electric Eagle Project. Unpublished report to Eskom.

Jenkins, A.R., Allan, D.G. & Smallie, J.J., 2009. Does electrification of the Lesotho Highlands pose a threat to that country's unique montane raptor fauna? Dubious evidence from surveys of three existing power lines. Gabar 20(2): 1-11.

Jenkins, A.R., Smallie, J.J. & 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): 263-278.

Jenkins, A.R., Shaw, J.M., Smallie, J.J., Gibbons, B., Visagie, R. & Ryan, P.G., In press. Estimating the impacts of power line collisions on Ludwig's Bustards *Neotis ludwigii*. Bird Conservation International.

Kabouche, B., Bayeul, J., Zimmermann, L. & Bayle, P., 2006. Bird mortality in aerial power lines: challenges and prospects in Provence –Alpes-Cote d'Azur (in French). Report DIREN PACA – LPO PACA, Hyères.

Kaiser, N., 1993. Study of Mute Swans *Cygnus olor* of the subjurassiens lakes (in French). Travail de licence, Univ. de Neuchâtel.

Karyakin, I.V., 2008. Lines-killers continue to harvest the mortal crop in Kazakhstan. Raptors Conservation 11: 14-21.

Karyakin, I.V., Kovalenko, A.V. & Novikova, L.M., 2006. The Imperial Eagle in the Volga-Ural Sands: results of researches in 2006. Raptors Conservation 6: 39-47.

Karyakin, I.V. & Novikova, L.M., 2006. The Steppe Eagle and power lines in Western Kazakhstan. Does coexistence have any chance? Raptors Conservation 6: 48-57.

Koops, F.B.J., 1987. Collision victims in the Netherlands and the effects of marking (in Dutch). Vereniging van directeuren van electriciteitsbedrijven in Nederland, Arnhem.

Koops, F.B.J. & Jong, J. de, 1982. Reduction of collision victims by marking of high-tension power lines close to Heerenveen (in Dutch). Elektrotechniek 60(12): 641-646.

Kovacs, A., Demeter, I., Fater, I., Bagyura, J., Nagy, K., Szitta, T., Firmanszky, G. & Horvath, M., 2008. Current efforts to monitor and conserve the Eastern Imperial Eagle *Aquila heliaca* in Hungary. AMBIO: A Journal of the Human Environment 37: 457-459.

Krueger Jr., T.E., 1998. The use of electrical transmission pylons as nesting sites by the Kestrel *Falco tinnunclus* in North-East Italy. Pp: 141-148. In: Chancellor, R.D., Meyburg, B.-U. & Ferrero, J.J. (Eds.). Holarctic Birds of Prey. ADENEX-WWGBP.

Lane, S.J., Alonso, J.C. & Martín, C.A., 2001. Habitat preferences of Great Bustard *Otis tarda* flocks in the arable steppes of central Spain: are potentially suitable areas unoccupied? Journal of Applied Ecology 38(1): 193-203.

Larsen, R.S. & Stensrud, O.H., 1988. Electricity mortality the greatest threat to owl populations in Southeast Norway (in Norwegian). Vår Fuglefauna 11: 29-33.

Lasch, U., Zerbe, S. & Lenk, M., 2010. Electrocution of raptors at power lines in Central Kazakhstan. Waldökologie, Landschaftsforschung und Naturschutz 9: 95-100.

Lehman, R.N., Kennedy, P.L. & Savidge, J.A., 2007. The state of the art in raptor electrocution research: a global review. Biological Conservation 136: 159-174.

Lislevand, T., 2004. Birds and powerlines. Methods to reduce the risk of collisions and electrocution (in Norwegian with English summary). Norsk Ornitologisk Forening (NOF), Trondheim.

Litzbarski, H. & Watzke, H., 2007. Comments on protection of the Great Bustard population in Russia. Pp: 131-138. In: Litzbarski, H. & Watzke, H. (Eds.). Great Bustards in Russia and Ukraine. Bustard Studies 6. Förderverein Großtrappenschutz e.V., Germany.

Lovaszi, P., 1998. Status of the White Stork (*Ciconia ciconia*) in Hungary: results of national censuses between 1941 and 1994. Ornis Hungarica 8: 1-8.

López-López, P., Ferrer, M., Madero, A., Casado, E. & McGrady, M., 2011. Solving man-induced large-scale conservation problems: the Spanish Imperial Eagle and power lines. PLoS ONE 6: e17196.

Mañosa, S., 1997. Strategies to identify dangerous electricity pylons for birds. Biodiversity and Conservation 10: 1997-2012.

Mañosa, S. & Real, J., 2001. Potential negative effects of collisions with transmission lines on a Bonelli's Eagle population. Journal of Raptor Research 35: 247-252.

Manville, A.M., II., 2005. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: state of the art and state of the science-next steps toward mitigation. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. Albany, California, USA.

Margalida, A., Heredia, R., Razin, M. & Hernández, M., 2008. Sources of variation in mortality of the Bearded Vulture *Gypaetus barbatus* in Europe. Bird Conservation International 18. 1-10.

Martínez, J.E., 2003. Impact of power lines on raptor populations in the Sierra Espuña Regional Park (Murcia) (in Spanish). Proceedings of the III International Conference on Prevention Strategies for Fires in Southern Europe, Barcelona.

Marti, C., 1998. Effects of power lines on birds: Documentation (in German with English summary). Schriftenreihe Umwelt Nr. 292. Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Bern.

Matics, R., 2000. Mortality rate of Barn Owl (Tyto alba Scop. 1769) in Hungary based on ringing data. Aquila 105-106: 125-133.

Matsyna, A.I. & Matsyna, E.L., 2011. Protection of birds on the power lines in Russia. Poster presented on International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary. Website, see below.

Matshikiza, M. & van Rooyen, C., 2004. Quantification of bird damage to wooden poles in distribution. Unpublished report to Eskom.

Martin, G.R., 2011. Understanding bird collisions with man-made objects: a sensory ecology approach. Ibis 153: 239-254.

Martin, G. R. & Shaw, J.M., 2010. Bird collisions with power lines: Failing to see the way ahead? Biological Conservation 143: 2965-2702.

Marques, A.T., 2009. Factors influencing Great Bustard and Little Bustard mortality by collision at transmission power lines. Local and regional scale analyses and implications for spatial planning (in Portuguese). MSc. Thesis, Universidade Nova de Lisboa.

Marques, A.T., Rocha, P. & Silva, J.P., 2008. Evaluation of the conflicts between power lines and the Great and Little Bustards in Castro Verde Special Protection Area (in Portuguese). Unpublished Report. ICNB, Lisboa.

Mathiasson, S., 1993. Mute Swans, *Cygnus olor*, killed from collision with electrical wires, a study of two situations in Sweden. Environmental Pollution 80: 239-246.

Meyburg, B., Manowsky, O. & Meyburg, C., 1996. The Osprey in Germany: its adaptation to environments altered by man. Pp: 125-135. In: Bird, D.M., Varlan, D.E. & Negro, J.J. (Eds.). Raptors in Human Landscapes: Adaptations to Built and Cultivated Environments. Academic Press.

Mihelic, T. & Denac, D., 2011. Eagle Owl *Bubo bubo* and White Stork *Ciconia ciconia* electrocution on middle voltage electric poles in Slovenia. Poster presented at International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary. Website, see below.

Mishra, A.K., 2009. Nature Watch; Sarus Crane: On its Way to Extinction. Resonance 14(12): 1206-1209.

Moleón, M., Bautista, J., Garrido, J.R., Martín-Jaramillo, J., Ávila, E. & Madero, A., 2007. The correction of power lines in areas of dispersion of Bonelli's Eagles: potential positive effects on the community of birds of prey. Ardeola 54(2): 319-325.

Moritzi, M., Spaar, R. & Biber, O., 2001. Causes of death of White Storks (*Ciconia ciconia*) ringed in Switzerland (1947-1997). Vogelwarte 41: 44-52.

Murphy, R.K., McPherron, S.M., Wright, G.D. & Serbousek, K.L., 2009. Effectiveness of avian collision averters in preventing migratory bird mortality from powerline strikes in the Central Platte river, Nebraska. University of Nebraska-Kearney, Kearney.

Murillo, 2003. Environmental impact and preventive and corrective measures for power lines and substations. Proceedings of the 4th technical session on power lines and the environment. Red Eléctrica de España, Madrid.

Negro, J.J. & Ferrer, M., 1995. Mitigation measures to reduce electrocution of birds on power lines: a comment on Bevanger's review. Ibis 137: 423-424.

Negro, J.J., Ferrer, M., Sandosa, C. & Regedor, S., 1989. Efficacy of two methods to deter avian electrocutions of distribution power lines (in Spanish). Ardeola 36: 201-206.

Neves, J. & Infante, S., 2008. Monitoring and mitigating distribution and transmission lines' impact on birds (in Portuguese). Unpublished Report, SPEA and Quercus, Castelo Branco, Portugal.

Neves, J., Infante, S., Ministro, J. & Brandão, R., 2005. Impact of transmission lines on birds in Portugal (in Portuguese). Unpublished Report, SPEA and Quercus, Castelo Branco, Portugal.

Newton, I., Wyllie, I. & Asher, A., 1991. Mortality causes in British Barn Owls *Tyto alba*, with a discussion of aldrin-dieldrin poisoning. Ibis 133: 162-169.

Niemi, G.J. & Hanowski, J.A.M., 1984. Effects of a transmission line on bird populations in the Red Lake Peatland, northern Minnesota. The Auk 101(3): 487-498.

Niklaus, G., 1984. Large numbers of birds killed by electric power line. Scopus 8: 42.

Osieck, E. & Miranda, F. de, 1972. Bird mortality at high tension power lines (in Dutch). Unpublished Report. Vogelbescherming Nederland.

Palacios, M.J., 2003. Power lines in Extremadura: conservation action and bird conservation (in Spanish). Proceedings of the National Conference on Power lines and Bird Conservation in Protected Areas, Dirección General de Medio Ambiente, Murcia.

Palacios, M.J. & García-Baquero, M.J., 2003. Power lines in Extremadura: conservation and protection of BirdLife (in Spanish). Proceedings of the 4th technical session on power lines and the environment, Red Eléctrica de España, Madrid.

Piironen, J., 1997. Bird collision risk assessment of transmission grid (110-400 kV) of "IVO Voimansiirto" (in Finnish). University Press, Helsinki.

Ponce, C., Alonso, J.C., Argandona, G., García Fernandez, A. & Carrasco, M., 2010. Carcass removal by scavengers and search accuracy affect bird mortality estimates at power lines. Animal Conservation 13: 603-612.

Podonyi, G., 2011. Service and living space (Bird-friendly solutions on the MV power lines). Presentation at International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary. Website, see below.

Prinsen, H.A.M., Smallie, J.J., Boere, G.C. & Píres, N., 2011. Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region. CMS Technical Series No. XX, AEWA Technical Series No. XX. Bonn, Germany.

Puzovic, S., 2008. Nest occupation and prey grabbing by Saker falcon (*Falco cherrug*) on power lines in the province of Vojvodina (Serbia). Arch. Biol. Sci. Belgrade 60: 271-277.

Raab, R., Spakovszky, P., Julius, E., Schütz, C. & Schulze, C.H., 2010. Effects of power lines on flight behaviour of the West-Pannonian Great Bustard *Otis tarda* population. Bird Conservation International: 1-14.

Rayner, J.M.V., 1988. Form and function in avian flight. Pp: 1-66. In: Johnston, R.F. (Ed.). Current Ornithology (5). Plenum, New York.

Real, J., Grande, J.M., Mañosa, S. & Sánchez-Zapata, J.A., 2001. Causes of death in different areas for Bonelli's Eagle *Hieraaetus fasciatus* in Spain. Bird Study 48: 221-228.

Rees, E., 2006. Bewick's swan. T & AD Pyser, London.

Regidor, S., Santos, C., Ferrer, M. & Negro, J.J., 1988. An experiment with modified electric pylons in Doñana National Park (in Spanish). Ecología 2: 251-256.

Reiter, A.S., 2000. Casualties of Great Bustards (*Otis tarda* L) on overhead power lines in the western Weinviertel (Lower Austria). Egretta 43: 37-54.

Rekasi, J. & Jakab, B., 1984. Ecological investigations on the stork population of North-Bacska in the last ten years (in Hungarian). Aquila 91: 101-107.

Renssen, T.A., 1977. Birds under high-tension (in Dutch). Stichting Natuur en Milieu i.s.m. Vogelbescherming Nederland, Zeist.

Robinson, J.A., Colhoun, K., McElwaine, J.G. & Rees, E.C., 2004. Whooper Swan *Cygnus cygnus* (Iceland population) in Britain and Ireland 1960/61 – 1999/2000. Waterbird Review Series, The Wildfowl & Wetlands Trust/Joint Nature Conservation Committee, Slimbridge.

Rollan, À., Real, J., Bosch, R., Tintó, A. & Hernández-Matías, A., 2010. Modelling the risk of collision with power lines in Bonelli's Eagle *Hieraaetus fasciatus* and its conservation implications. Bird Conservation International 20: 279-294.

Rosa, G., Encarnação, V. & Candelária, M., 2005. National Census of White Stork *Ciconia ciconia* (2004) (in Portuguese). SPEA & ICN, Lisboa.

Rose, P. & Baillie, S., 1989. The effects of collisions with overhead lines on British Birds: an analysis of ringing recoveries. British Trust for Ornithology, Thetford, UK.

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

Sampaio, H., 2009. Evaluation of the interaction between birds and power lines in the Azores: Final report (in Portuguese). Unpublished report, SPEA, Lisbon.

Schaub, M. & Pradel, R., 2004. Assessing the relative importance of different sources of mortality from recoveries of marked animals. Ecology 85(4): 930-938.

Schaub, M., Aebischer, A., Gimenez, O., Berger, S. & Arlettaz, R., 2010. Massive immigration balances high anthropogenic mortality in a stable eagle owl population: Lessons for conservation. Biological Conservation 143: 1911-1918.

Schürenberg, B., Schneider, R. & Jerrentrup, H., 2010. Implementation of recommendation No. 110/2004 on minimising adverse effects of above ground electricity transmission facilities (power lines) on birds. Report by the NGOs to the 30th meeting of the Standing Committee of the Bern Convention, Strassbourg. T-PVS/Files (2010) 21. Council of Europe.

Scott, R.E., Roberts, L.J. & Cadbury, C.J., 1972. Bird deaths from power lines at Dungeness. British Birds 65(7): 273-285.

Sergio, F., Marchesi, L., Pedrini, P., Ferrer, M. & Penteriani, V., 2004. Electrocution alters the distribution and density of a top predator, the Eagle owl *Bubo bubo*. Journal of Applied Ecology 41: 836-845.

Shaw, J.M., Jenkins, A.R., Smallie, J.J. & Ryan, P.G., 2010. Modelling power-line collision risk for the Blue Crane *Anthropoides paradiseus* in South Africa. Ibis 152: 590-599

Shaw, J.M., Jenkins, A.R., Ryan, P.G. & Smallie, J.J., 2010. A preliminary survey of avian mortality on power lines in the Overberg, South Africa. Ostrich 81: 109-113.

Shimada, T., 2001. Choice of daily flight routes of Greater White-fronted Geese: effects of power lines. Waterbirds 24(3): 425-429.

Silva, J.P., 2010. Factors affecting the abundance of the Little Bustard *Tetrax tetrax*: implications for conservation. PhD Thesis, Universidade de Lisboa.

Silva, J.P., Santos, M., Queirós, L., Leitão, D., Moreira, F., Pinto, M., Lecoq, M. & Cabral, J.A., 2010. Estimating the influence of overhead transmission power lines and landscape context on the density of Little bustard *Tetrax tetrax* breeding populations. Ecological Modeling 221: 1954-1963.

Smallie, J., Diamond, M. & Jenkins, A., 2009. Lighting up the African continent – what does it mean for our birds? Pp: 38-43. In Harebottle, D.M., Craig, A.J.F.K., Anderson, M.D., Rakotomanana, H. & Muchai, M. (Eds.). Proceedings of the 12th Pan-African Ornithological Congress, 2008, Cape Town. Animal Demography Unit.

Smallie, J. & Strugnell, L., 2011. Use of camera traps to investigate Cape Vulture roosting behaviour on power lines in South Africa. Unpublished report to Eskom.

Smallie, J. & Virani, M., 2010. A preliminary assessment of the potential risks from electrical infrastructure to large birds in Kenya. Scopus 30: 32-39.

Smallie, J., In preparation. A power line risk assessment for selected South African bird species of conservation concern. Currently undergoing final corrections for submission for Master of Science in the field of Environmental Science.

Steenhof, K., Kochert, M.N. & Roppe, J.A., 1993. Nesting raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57: 271-281.

Stjernberg, T., Koivusaari, J., Högmander, J., Ollila, T., Keränen, S., Munsterhjelm, G. & Ekblom, H., 2007: Population size and nesting success of the White-tailed Sea Eagle (*Haliaeetus albicilla*) in Finland, 2005-2006 (in Finnish with English summary). Linnut-vuosikirja 2006: 14-19.

Stoychev, S. & Karafeisov, T., 2003. Power line design and raptor protection in Bulgaria. Sixth world conference on Birds of Prey and Owls, Budapest, Hungary.

Sudmann, S.R., Hüppeler-Borcherding, S. & Klostermann, S., 2000. The behaviour of overwintering, arctic geese in the proximity of marked and unmarked high-tension power lines at the Niederrhein (in German). Naturschutzzentrum im kreis Kleve.

Sultanov, E.G., 1991. Estimation of the damage of bird mortality due to high-tension power lines and communication lines in the Southeastern part of the Republic Azerbaijan (in Russian). Unpublished report, Stavropol.

Sultanov, E.G., Karabanova, N.I., Guseinov, R.A., Kamarli, R.A. & Magerramov, Sch., 1991. On bird mortality due to high-tension power lines during spring migration in the Southeastern part of the Republic Azerbaijan (in Russian). Unpublished report, Stavropol.

Sundar, K.S.G. & Choudhury, B.C., 2005. Mortality of Sarus Cranes (*Grus antigone*) due to electricity wires in Uttar Pradesh, India. Environmental conservation 32(3): 260-269.

Thompson, L.S., 1978. Mitigation through engineering and habitat modification. Pp: 51-92. In Avery, M.L. (Ed.). Impacts of transmission lines on birds in flight. U.S. Fish and Wildl. Serv., Washington, D.C.

Tintó, A. & Real, J., 2003. Application of mitigation measures to reduce Bonelli's Eagle electrocution in Catalonia (in Spanish). In Proceedings of Jornadas Nacionales de Líneas Eléctricas y Conservación de Aves en Espacios Naturales, Murcia.

Tintó, A., Real, J. & Mañosa, S., 2005. A classification method of power lines to prevent forest fires caused by bird electrocution. Proceedings of the III International Conference on Prevention Strategies for Fires in Southern Europe, Barcelona.

Tintó, A., Real, J. & Mañosa, S., 2010. Predicting and correcting electrocution of birds in Mediterranean areas. Journal of Wildlife Management 74: 1852-1862.

Tryjanowski, P., Kosicki, J.Z., Kuzniak, S. & Sparks, T.H., 2009. Long-term changes and breeding success in relation to nesting structures used by the white stork, *Ciconia ciconia*. Annales Zoologici Fennici 46: 34-38.

Tucker, G., Bassi, S., Anderson, J., Chiavari, J., Casper, K. & Fergusson, M., 2008. Provision of evidence of the conservation impacts of energy production. Institute for European Environmental Policy (IEEP), London.

Turcek, F.J., 1960. On the damage by birds to power and communication lines. Bird Study 7: 231-236.

Virani, M. Z., 2006. In Steep Decline. SWARA (Magazine of the East African Wildlife Society) April – June 2006.

Vlas, M.J. de & Butter, M.E., 2003. Collision victims in the Westbroekstermadepolder (in Dutch). Unpublished Report, Rijksuniversiteit Groningen, Haren, The Netherlands.

Watzke, H., 2007. Reproduction and causes of mortaliy in the breeding area of the Great Bustard in the Saratov region of Russia. Pp: 53-64. In: Litzbarski, H. & Watzke, H. (Eds.). Great Bustards in Russia and Ukraine. Bustard Studies 6. Förderverein Großtrappenschutz e.V., Germany.

White, F., 1983. Vegetation map of Africa. UNESCO/AETFAT/UNSO

Winkelman, J.E., Kistenkas, F.H. & Epe, M.J., 2008. Ecological and conservational aspects of wind turbines on land (in Dutch). Alterra-rapport 1780, Alterra, Wageningen.

Yoo, S.H., Lee, K.S. & Park, C.H., 2010. Accident cases and causes of electric line collision of cranes at Cheorwon, Korea. Korean Journal of Ornithology 17(4): 331-343.

Zohmann, M., Nopp-Mayr, U. & Grünschachner-Berger, V., 2010. Impacts of overhead wires and lifts on grouse in Austria (in German). Institut für Wildbiologie und Jagdwirtschaft, Universität für Bodenkultur, Wien.

Zwarts, L.R.G., Bijlsma, R., van der Kamp, J. & Wymenga, E., 2009. Living on the edge: wetlands and birds in a changing Sahel. KNNV Publishing, Zeist, The Netherlands.

Useful Websites:
BirdLife International: www.BirdLife.org

Ramsar Convention on Wetlands: www.ramsar.org

Wetlands International: www.wetlands.org

Wings over wetlands' Critical Site Network Tool: www.wingsoverwetlands.org/csntool

Posters and presentations from International Conference on Power Lines and Bird Mortality in Europe, Budapest, Hungary, April 2011:
www.mme.hu/termeszetvedelem/budapest-conference-13-04-2011/presentations.html

Information on Bird Flappers Bird Flight Diverters:
www.rwerheinruhrnetzservice.com

Information on FireFly Bird Flight Diverters:
www.hammarprodukter.com

Information on mitigation of bird electrocution in Germany:
www.birdsandpowerlines.org

Glossary

(for the descriptions in this glossary we used the glossary in APLIC (2006) and internet sources)

Avian-safe
A power pole configuration designed to minimise avian electrocution risk by providing a separation between energised conductors or phases and grounded hardware larger than the wrist-to-wrist or head-to-foot distance of a bird. If such separation cannot be provided, exposed bare parts are covered to reduce electrocution risk, or perch management is employed.

Bushing (transformer)
An insulator, usually made of porcelain, inserted in the top of a transformer to isolate the electrical leads of the transformer. To prevent dangerous contact by birds, bushing can be covered.

Conductor
The material (usually copper or aluminium), mostly in the form of a wire or cable, suitable for carrying an electric current.

Configuration
The arrangement of parts or equipment, for example, a distribution configuration would include the necessary arrangement of cross-arms, braces, insulators, etc. to support one or more conductors.

Corvid
Birds belonging to the family Corvidae; including crows, ravens, magpies, and jays.

Cross-arm
A horizontal supporting part of a pole or pylon; made of wood, concrete, or steel, manufactured in various lengths, and used to support electrical conductors and equipment for the purpose of distributing electrical energy.

De-energised
Any electrical conducting device disconnected from all sources of electricity.

Distribution line
A circuit of medium voltage wires, energised at voltages from ~1 kV to 60 kV, and used to distribute electricity to residential, industrial and commercial customers.

Earth wire
See ground wire.

Energised
Any electrical conducting device connected to any source of electricity.

Fault
A power disturbance, for example caused by animal electrocution, that interrupts the quality of electrical supply.

Ground wire, grounded parts
A wire (or parts) that makes an electrical connection with the earth and therefore is at ground potential.

High voltage power lines
High voltage power lines (60 kV up to 700 kV) are generally used for transmission networks. Because high voltage power lines mostly have long suspended insulators the electrocution risk for birds is relatively low. On the other hand, collision risk can be high, particularly where phase

conductors and ground wires are arranged at different heights. The ground wire is often relatively thin and presents a particularly high collision risk.

Insulator
Non-conductive material, usually made of porcelain or polymer, in a form designed to support a energised conductor physically and to separate it electrically from another conductor or object.

Jumper wire
An energised conductive wire used to connect various types of electrical equipment. Jumper wires are also used to make electrical conductors on lines continuous when it becomes necessary to change direction of the line (*e.g.*, angle poles, dead-end poles).

Kilovolt or kV
1,000 volts

Low voltage power lines
Power lines are categorised, in part, by the voltage levels to which they are energised. Different authors often use different categorisation. Throughout the report we use the definitions by Haas *et al.* (2005) and APLIC (2006): low voltage or utility lines have a voltage 100 times less than medium voltage lines (*i.e.*, <600 volts). In most countries these are routed underground and therefore offer no risk to bird populations. Where these lines occur above ground, they tend to be relatively well insulated. Low voltage power lines are often thick, darkly coloured and relatively visible, therefore posing a relatively low collision risk.

Medium voltage power lines
These include distribution power lines of utility companies (~1 kV to 60 kV). While in some countries the majority of the distribution power line network is underground, in a global context most networks are above ground. Medium voltage power lines pose the highest electrocution risk for birds when not constructed avian-safe. There is also a risk of collision, but generally less so than for high voltage power lines because the conductors are usually arranged at the same height and, compared to high voltage power lines, low above the ground.

Nest or roosting substrate
The base upon which a nest is built or birds use to rest and sleep, in this context power poles, platforms, boxes and latticework in electricity masts.

Neutral conductor
See ground wire.

Outage
Event that occurs when the energy source is cut off from the supply, see also fault.

Phase
An energised electrical conductor.

Phase-to-ground
The contact of energised phase conductor to ground potential. A bird can cause a phase-to-ground fault when fleshy parts of its body (or wet feathers of wing or tail) touch an energised phase and ground wire or grounded parts simultaneously.

Phase-to-phase

The contact of two energised phase conductors. Birds can cause a phase-to-phase fault when the fleshy part of their wings or other body parts (including wet feathers of wing or tail) contact two energised phase conductors at the same time.

Pole
A vertical structure, usually made of wood, concrete or steel, manufactured in various heights, and used to support electrical conductors and equipment for the purpose of distributing electrical energy.

Power line
A combination of conductors used to transmit or distribute electrical energy; normally supported by poles or lattice masts.

Problem pole
A pole used by birds for perching, nesting or roosting that has electrocuted birds or has a high electrocution risk.

Retrofitting
The modification of an existing electrical power line structure to make it avian-safe.

Separation
The physical distance between conductors and/or grounded parts from one another.

Structure
A pole or lattice assembly that supports electrical equipment for the transmission or distribution of electricity.

Substation
A transitional point where voltage is increased or decreased in the transmission and distribution system.

Switch (tower or gear)
An electrical device used to sectionalise electrical energy sources.

Transformer
A device used to increase or decrease voltage.

Transmission line
Power lines designed and constructed to support voltages >60 kV.

Volt
The measure of electrical potential.

Voltage
Electromotive force measured in volts.

Wrist or Carpal Joint
Joint in the middle of the leading edge of the wing of a bird.

Species index

Appendix 1 Questionnaire and notes sent to Range States

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)

Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia (CMS Raptor MoU)

Secretariats provided by the United Nations Environment Programme (UNEP)

To the AEWA and CMS Focal Points and the CMS Raptor MoU Contact Points

Date: 27 January 2011
Ref: 11-025-LL/EM/LE

Review of and guidelines for mitigating/avoiding the conflict between migratory birds and electricity power grids in the African-Eurasian region

Dear Madam or Sir,

We are pleased to announce that a consortium has been contracted to carry out a study on the above-mentioned subject matter. In that respect, we would like to ask you, in your capacity as CMS and/or AEWA Focal Point, and/or CMS Raptor MoU Contact Point to cooperate closely with the representatives of the consortium, who will contact you in due course, and provide them with as much information as you can.

As you may know, the issue of the electrocution of birds has been receiving growing attention in recent years. This may pose a critical threat and lead to significant declines in the case of some populations. Many species of migratory birds, especially large species fall victim to transmission lines, conductors or poles of electricity power grids. The electrocution of birds is not just a conservation issue, but can lead to the disruption of power, thereby representing a cause for concern for electricity distribution at regional and national levels.

The entire magnitude of this threat to migratory birds within the African-Eurasian region is still poorly understood. Although guidance on the mitigation/avoidance of electrocution and collision does exist, this is scattered and often limited to a particular region or not easily accessible.

An important first step towards reducing this threat is the assessment of the magnitude of the conflict between birds and electricity power grids in the form of the above-mentioned review and the resulting guidelines, which are being made possible through the support of AEWA's cooperation-partner, RWE Rhein-Ruhr Netzservice GmbH, a daughter company of RWE, one of the largest energy companies in Europe. The company has specialized in fitting preventive "bird-reflectors" to high-voltage power lines using a helicopter as a measure for reducing collisions with large birds.

The consortium contracted to carry out this work by the Secretariats of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Agreement on the Conservation of African-Eurasian Migratory Animals (AEWA), consists of the environmental consultancy, Bureau Waardenburg, based in the Netherlands, the Endangered Wildlife Trust, Wildlife and Energy Interaction Group, South Africa, STRIX Ambiente e Inovação, Portugal and the Boere Conservation Consultancy also based in the Netherlands. The consortium has built up a strong network with international researchers, non-governmental organizations (NGOs) and electricity companies so that it is in an excellent position to be able to tackle all the aspects of this work in the required detail.

UNEP
UNEP / CMS Secretariat • Hermann-Ehlers-Str. 10 • 53113 Bonn • Germany • Tel: (+49) 228 815-2401 • Fax: (+49) 228 815-2449 • E-mail: secretariat@cms.int • *http://www.cms.int*
UNEP / AEWA Secretariat • Hermann-Ehlers-Str. 10 • 53113 Bonn • Germany • Tel: (+49) 228 815-2413 • Fax: (+49) 228 815-2450 • E-mail: aewa@unep.de • *http://www.unep-aewa.org*
UNEP/CMS Office – Abu Dhabi • c/o Environment Agency - Abu Dhabi • P.O. Box 45553 • Abu Dhabi • United Arab Emirates •Tel: (+971) 2 693 45 23 • Fax: (+971) 2 499 72 52 • Email: CmsOffice.ae@cms.int

-2-

The review will present an overall overview of the nature, scale and impact of the collision and electrocution problem for birds, including an overview of the aspects involved and gaps in the knowledge on the extent of bird fatalities. The geographical extent of the review covers the Range States to AEWA and the Raptor MoU. The guidelines will present the state-of-the-art mitigation/avoidance measures and will recommend solutions and appropriate actions, both technical as well as legislative, as well as suggestions for research and potential mitigation measures.

The review will consist of one part in which published aspects of the conflict between birds and the electricity grids are reviewed and summarized in a general way and a second part that presents an overview of the issue at Range State level, focusing on conflict hotspots and species at risk.

The final draft of the review and guidelines will then be reviewed by the AEWA and CMS Secretariats and presented to the 10th Conference of the Parties to CMS (COP10) in November 2011 and the 5th Meeting of the Parties to AEWA (MOP5) in May 2012 for approval, as well as to the first CMS Raptor MoU meeting of signatory states to take place in 2012.

We would like to thank you in advance for your kind cooperation and active support towards this promising project, the results of which will help your government to address the problem of the electrocution of migratory birds in the context of CMS, AEWA and the Raptor MoU.

Yours sincerely,

Elizabeth Maruma Mrema

Executive Secretary
CMS

Bert Lenten

Executive Secretary
AEWA

Laheen El Kabiri

Executive Coordinator
Raptor MoU

Review of and guidelines for mitigating/avoiding the conflict between migratory birds and electricity power grids in the African-Eurasian region

Notes to the questionnaire

With reference to the attached letter from CMS, AEWA and the CMS Raptors MoU, the team of consultants implementing the project on behalf of AEWA and CMS would be very pleased if the CMS, AEWA and the Raptors MoU Parties and Range States as well as national NGOs could provide the necessary basic information to undertake this important work in the best way and to be able to provide the AEWA and CMS Parties and others, with high quality and practical results. Your cooperation is of course needed and much appreciated in providing information based on the attached questionnaire.

The various steps in the process are the following:

- Circulation of the checklist/questionnaire to all Parties, Range States and national NGOs.
- Reviewing incoming information
- Extensive literature review on the topic
- Formulation of overview report and practical guidelines
- Presentation of the results (review, guidelines, etc.) at the CMS COP10, November 2011 in Norway, the AEWA MOP5, May 2012 in France and the 1st Meeting of Signatory States to the CMS Raptor MoU in 2012

The following time schedule is foreseen:

- Start-up of project	- December 2010
- Sending out inquiries	- February 2011
- Collecting all information	- Spring 2011
- Deliver draft reports	- August 2011
- Deliver final reports	- October 2011
- Present review/guidelines at CMS COP10	- November 2011
- Present review/guidelines at AEWA MOP5	- May 2012
- Present review/guidelines at CMS Raptor MoU MSS1	- 2012

We welcome your guidance how the provision of information (see the questionnaire also as a checklist of all relevant data) from your country or organisation could be done in the most efficient way. We therefore would highly appreciate to receive at short notice information on the following:

- Will you be able to provide the requested information?
- or can you provide us with contact information (names, email addresses, telephone, websites) of those who can provide the necessary information; they will than be contacted by staff of the consortium.

Given the time schedule for the project we appreciate to receive the information as requested within six weeks after you have received this letter and its attachment.

This project is being implemented with the kind support of RWE Rhein-Ruhr Netzservice GmbH RWE

CMS AEWA

Review of and guidelines for mitigating/avoiding the conflict between migratory birds and electricity power grids in the African-Eurasian region

Questionnaire for National Focal or Contact Points of Range States of CMS, AEWA and the CMS Raptor MoU as well as relevant national NGOs.

1. Policy

A. **What is the national policy on interactions between birds and the electricity grid?**

(Please state details on policy intentions, decrees, legislation, etc., including objectives, e.g. obligatory preventive mechanisms when constructing new power lines, special prescriptions to Environmental Impact Assessments such as routing away from potential conflict hot-spots, encouraging underground location of cables, restrictions of dangerous types of poles)

2. Solutions undertaken to mitigate/avoid electrocution and collisions and technical standards

A. **Are there incentives for a more 'bird-friendly' electricity transmission and distribution network in your country**?

(Please state details, including measures undertaken to mitigate/avoid electrocution and collisions as well as information on retrofitting initiatives)

B. **What is the status of the technical standards for bird safety in your country**?

(Please state information on technical standards that are being used to decrease bird mortality with power lines, e.g. type of wire markings, type of bird-safe designs to prevent electrocution)

C. **What are the successes and bottlenecks of the measures taken so far?**

3. General information and survey data

A. **What is known of conflicts and positive interactions between birds and the electricity grid in your country**?

(Please state information on known fatalities and regional differences in these, especially related to conflict hot-spots and/or possible conservation-level impact)

B. **What is the status of scientific work and research related to bird safety of the electricity network in your country**?

(If research is or has been carried out, please state effects studied, i.e. electrocution, collisions, mitigation and/or positive effects such as providing breeding substrate)

C. **Who are the key persons/research institutes and stakeholders/companies in your country**?

(If possible, add references and/or contact information of institutes, companies and/or persons who can be contacted for more information on the subject)

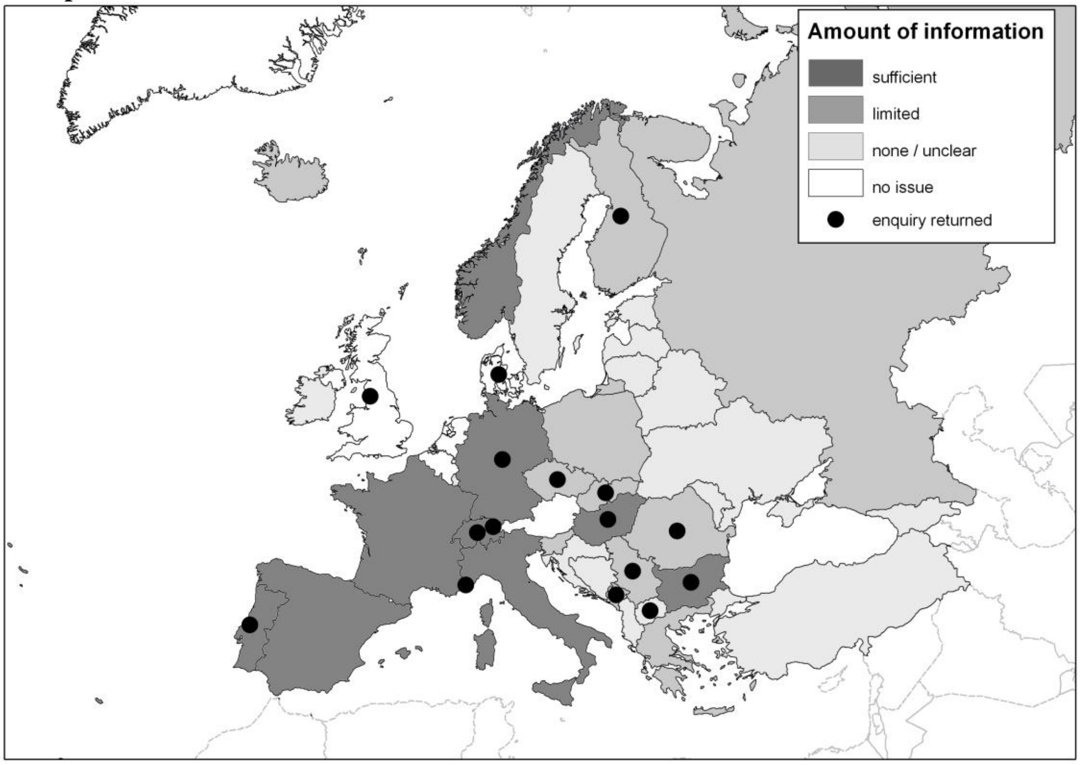
4. Other remarks and/or recommendations

This project is being implemented with the kind support of RWE Rhein-Ruhr Netzservice GmbH RWE

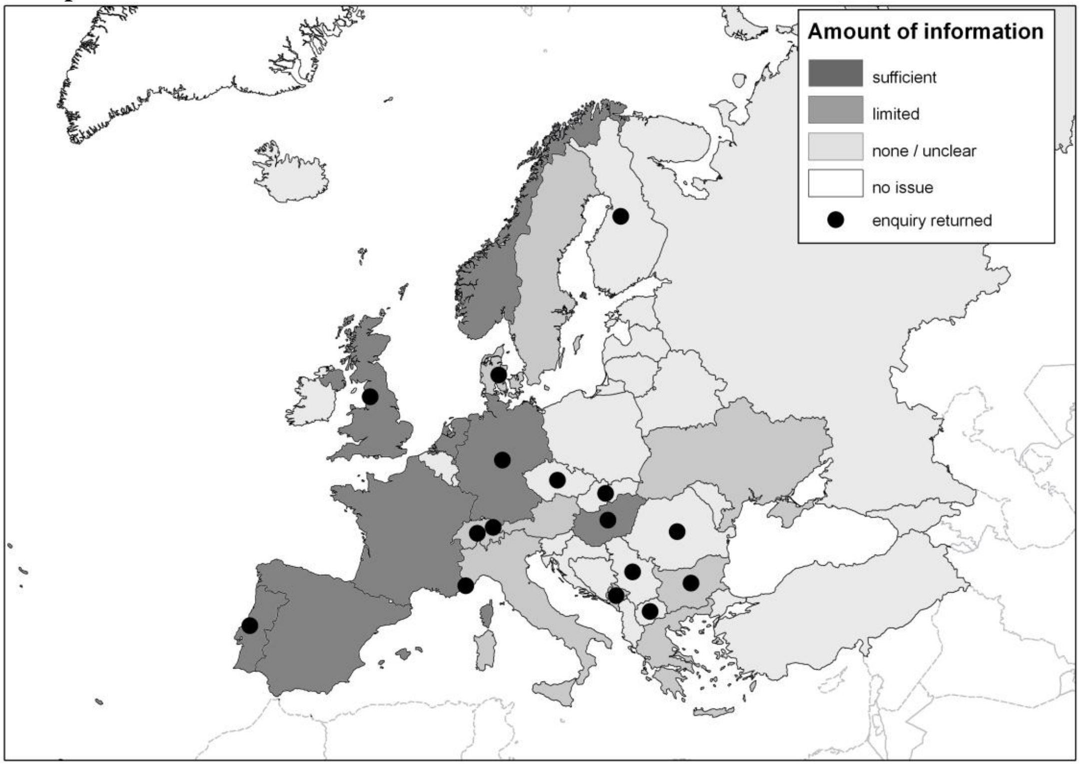
Appendix 2 Range State information from literature & questionnaire

Summary of Range States information on effects of power lines on birds (electrocution and collision) retrieved from literature and provided through the questionnaire.

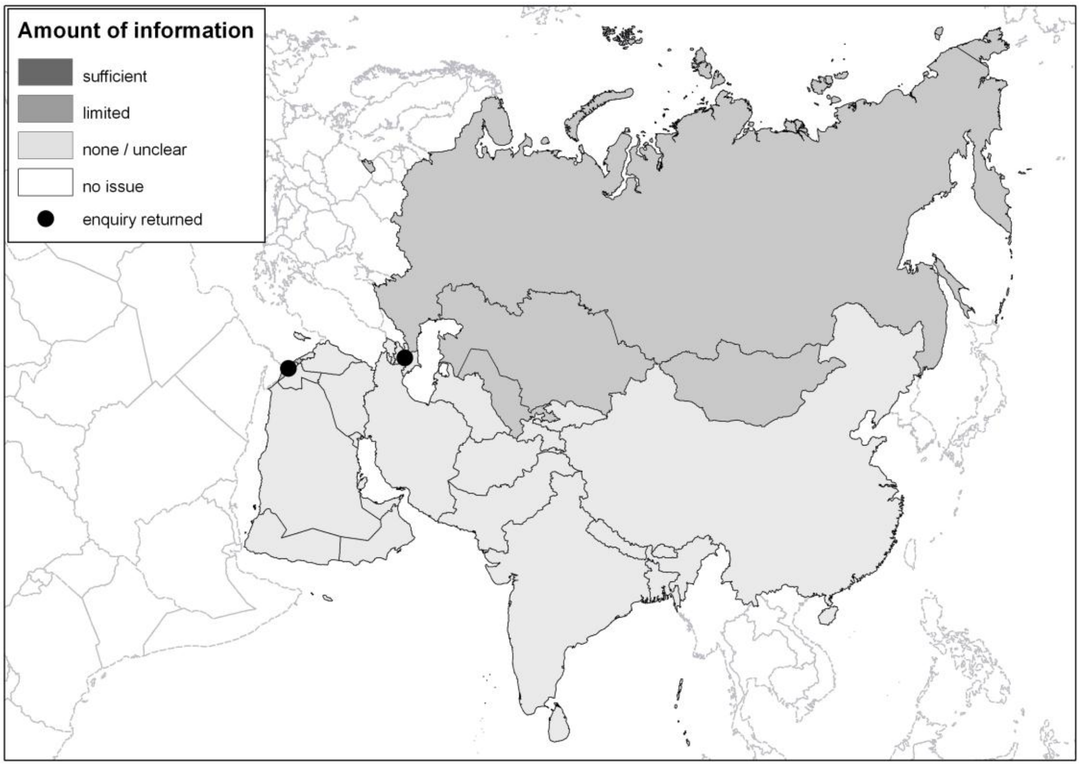
Europe: electrocution



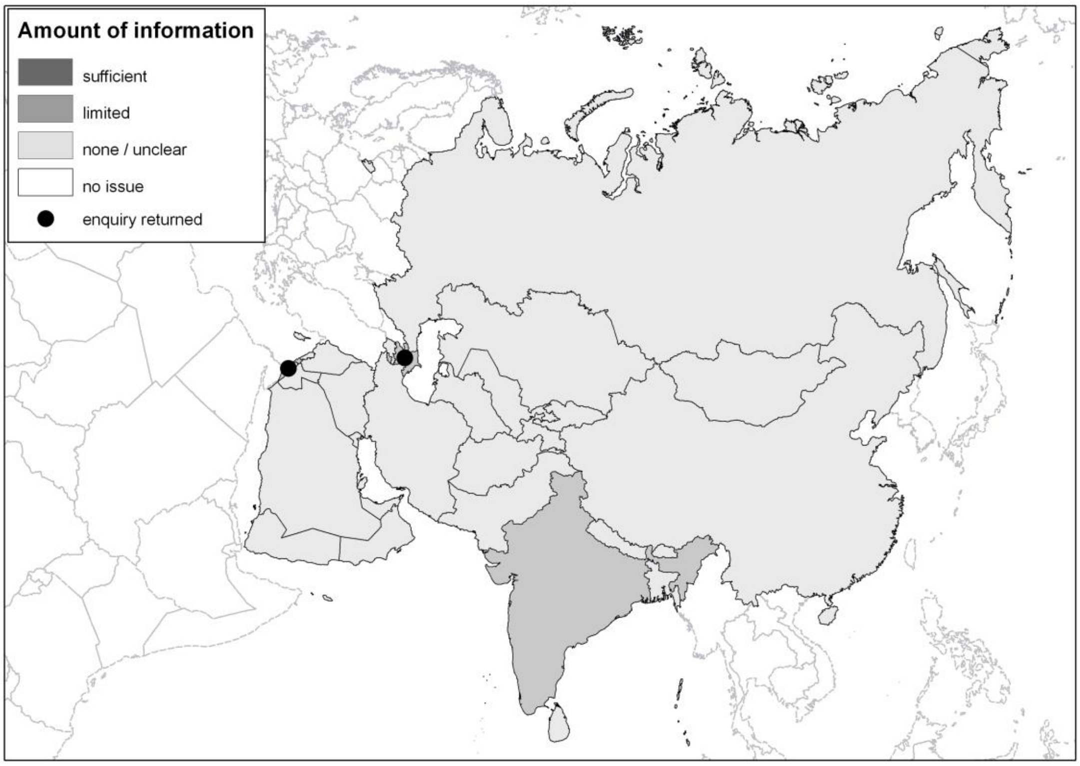
Europe: collision



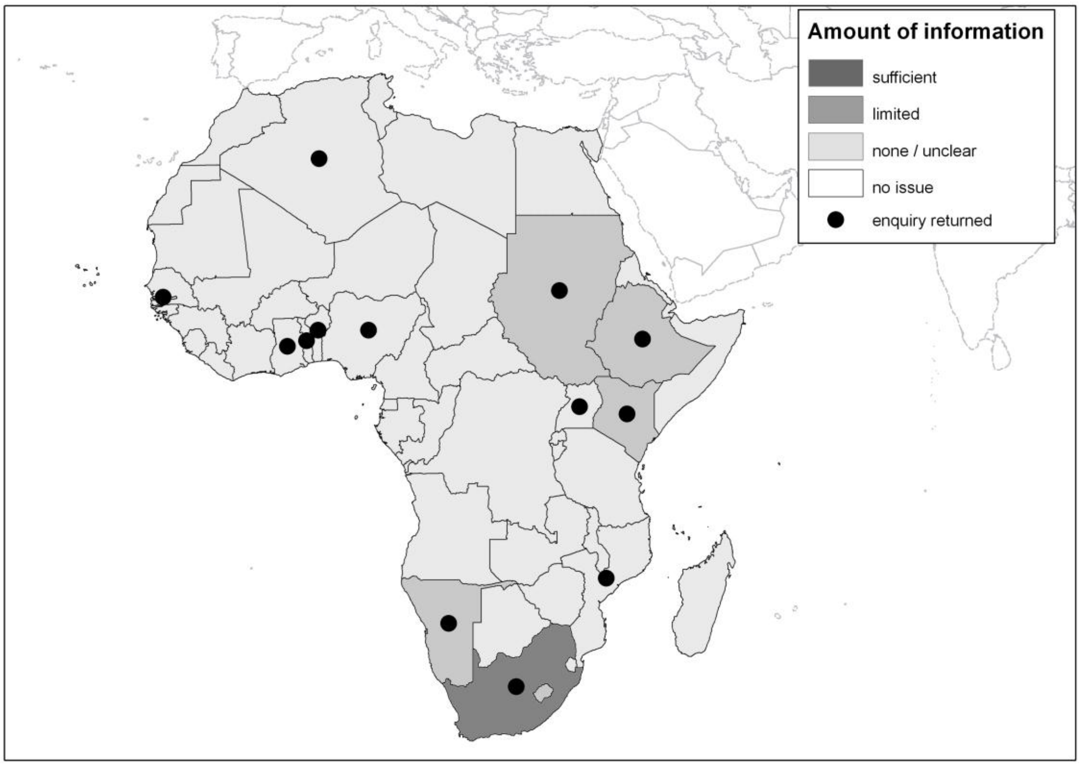
Asia: electrocution



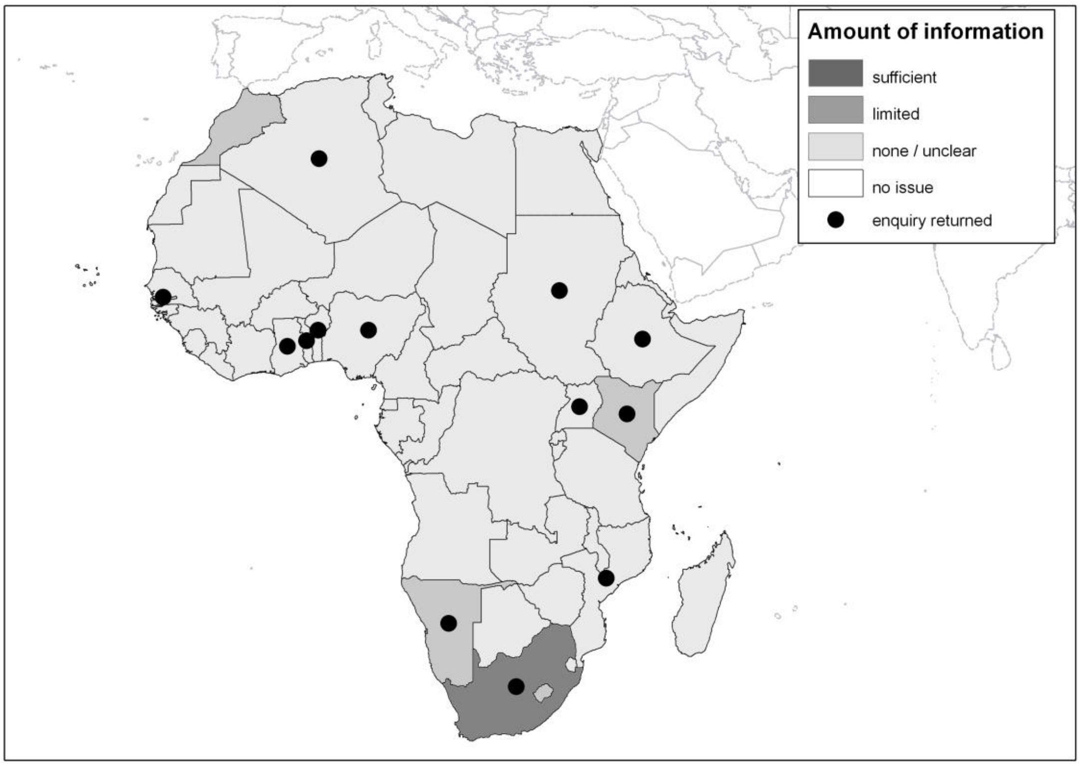
Asia: collision



Africa: electrocution



Africa: collision



Appendix 3 Impact of electrocution and collisions on bird populations

Severity of impacts on bird populations of mortality due to electrocution and collision with power lines for different bird families in Eurasia (table adopted from Haas *et al*., 2003, supplemented with information from this review) and Africa (table based on Smallie (*in prep*), supplemented with information from this review and expert judgement).

0 = no causalities reported or likely.
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 at a larger scale.

Bird families in **Eurasia** identified as vulnerable to electrocution and collison internationally	Causalities due to electrocution	Causalities due to collision
Loons (*Gaviidae*) and Grebes (*Podicipedidae*)	0	II
Shearwaters, Petrels (*Procellariidae*)	0	II
Boobies, Gannets (*Sulidae*)	0	I
Pelicans (*Pelicanidae*)	I	II-III
Cormorants (*Phalacrocoracidae*)	I	I
Herons, Bitterns (*Ardeidae*)	I	II
Storks (*Ciconidae*)	III	II
Ibisses (*Threskiornithidae*)	I	II
Flamingos (*Phoenicopteridae*)	0	II
Ducks, Geese, Swans, Mergansers (*Anatidae*)	0	II
Raptors (*Accipitriformes and Falconiformes*)	II-III	I-II
Partridges, Quails, Grouse (*Galliformes*)	0	II-III
Rails, Gallinules, Coots (*Rallidae*)	0	II
Cranes (*Gruidae*)	0	III
Bustards (*Otidae*)	0	III
Shorebirds / Waders (*Charadriidae + Scolopacidae*)	I	II-III
Skuas (*Sterkorariidae*) and Gulls (*Laridae*)	I	II
Terns (*Sternidae*)	0-I	I-II
Auks (*Alcidae*)	0	I
Sandgrouse (*Pteroclididae*)	0	II
Pigeons, Doves (*Columbidae*)	I-II	II
Cuckoos (*Cuculidae*)	0	I-II
Owls (*Strigiformes*)	II-III	II
Nightjars (*Caprimulgidae*) and Swifts (*Apodidae*)	0	I-II
Hoopoes (*Upudidae*) and Kingfishers (*Alcedinidae*)	I	I-II
Bee-eaters (*Meropidae*)	0-I	I-II
Rollers (*Coraciidae*)	I-II	I-II
Woodpeckers (*Picidae*)	I	I-II
Ravens, Crows, Jays (*Corvidae*)	II	I-II
Medium-sized and small songbirds (*Passeriformes*)	I	I-II

Bird families in **Africa** identified as vulnerable to electrocution and collison internationally	Vulnerable to electrocution	Vulnerable to collision	Likely location of interaction across sub-Saharan Africa
Podicipedidae – Grebes	0	I	Throughout, near water
Pelecanidae – Pelicans	I	II	Throughout, near water
Phalacrocoracidae – Cormorants	I	II	Throughout, near water
Ardeidae – Herons, egrets, bitterns	II	II	Throughout, near water
Ciconidae – Storks	II	III	Throughout, near water
Threskiornithidae - Ibises, spoonbills	II	II	Throughout, near water
Phoenicopteridae - Flamingos	0	III	Throughout, near water. Particularly Rift Valley
Anatidae & Dendrocygnidae – Wildfowl, ducks, swans, geese, teal, shovellers, pochards	I	II	Throughout, near water
Accipitridae - Vultures, Eagles, Hawks	III	II	Throughout
Sagitariidae – Secretary Bird	I	II	Savannah regions throughout
Falconidae – Falcons	I	II	Throughout
Phasianidae & Numididae - Gamebirds, Quails, Pheasants	I	II	Throughout
Rallidae – Rails	0	I	Throughout
Gruidae – Cranes	I	III	Wetland and grassland areas, particularly East and Southern Africa
Otididae – Bustards	0	III	Open savannah and grassland regions. E and S Africa.
Charadriidae – Plovers	0	I	Throughout, near water
Recurvirostridae - Waders - Stilts, Avocets	0	I	Throughout, near water
Scolopacidae - Sandpipers	I	0	Throughout, near water
Laridae - Gulls, Terns	I	I	Throughout, near water
Pteroclidae - Sandgrouse	0	I	Arid regions
Columbidae – Pigeons	I	I	Throughout
Tytonidae & Strigidae – Owls	II	I	Throughout
Picidae - Woodpeckers	0	I	Forest, woodland and savannah areas. Particularly East, Central and parts of Southern Africa
Apodidae – Swifts	0	I	Throughout
Bucerotidae - Typical hornbills	I	I	Forest, woodland and savannah areas. Particularly East, Central and parts of Southern Africa
Bucorvidae - Ground-hornbills	I	I	Savannah and grassland areas. Particulalry parts of East and Southern Africa
Alaudidae – Larks	0	I	Throughout
Hirundinidae - Swallows	0	I	Throughout
Muscicapidae – Thrushes	I	0	Throughout
Lanidae – Shrikes	0	I	Throughout
Corvidae – Crows	I	I	Throughout
Sturnidae – Starlings	I	I	Throughout
Passeridae – Sparrows	0	I	Throughout
Passerines in general	I	0	Throughout

Appendix 4 Impact on species of AEWA/CMS/CMS Raptor MoU

Severity of impacts on bird species of mortality due to electrocution and collision with power lines for different migratory bird species in the African-Eurasian region for which impacts have been found in this review.

CMS Appendix I = Migratory species that have been categorized as being in danger of extinction throughout all or a significant proportion of their range.

CMS Appendix II = Migratory species that have an unfavourable conservation status or would benefit significantly from international co-operation organised by tailored agreements

Level of impact per species based on knowledge of families (appendix 3)

0 = no causalities reported or likely.

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 at a larger scale.

Species		CMS Appendix I	CMS Appendix II	AEWA Annex 2	MoU Birds of Prey	Casualties due to electrocution	Casualties due to collision
Pelecanus onocrotalus	White Pelican	X	X	X		I	II - III
Pelecanus crispus	Dalmatian Pelican	X	X	X		I	II - III
Phalacrocorax carbo	Great Cormorant			X		I	II
Bubulcus ibis	Cattle Egret			X		II	II
Ardea cinerea	Grey Heron			X		II	II
Ardea purpurea	Purple Heron		X	X		II	II
Ciconia ciconia	White Stork		X	X		III	III
Ciconia nigra	Black Stork		X	X		III	III
Leptoptilos crumeniferus	Marabou Stork			X		III	III
Platalea leucorodia	Eurasian Spoonbill		X	X		II	II
Phoenicopterus roseus	Greater Flamingo		X	X		0	III
Phoenicopterus minor	Lesser Flamingo		X	X		0	III
Cygnus olor	Mute Swan		X	X		I	II
Cygnus cygnus	Whooper Swan		X	X		I	II
Cygnus colombianus	Bewick's Swan		X	X		I	II
Anser fabalis	Bean Goose		X	X		I	II
Anser brachyrynchus	Pink-footed Goose		X	X		I	II
Anser albifrons	Greater White-fronted Goose		X	X		I	II
Anser anser	Greylag Goose		X	X		I	II
Branta bernicla	Brent Goose		X	X		I	II
Branta leucopsis	Barnacle Goose		X	X		I	II
Alopochen aegyptiacus	Egyptian Goose		X	X		I	II
Anas querquedula	Garganey		X	X		I	II
Anas clypeata	Northern Shoveler		X	X		I	II
Anas penelope	Eurasian Wigeon		X	X		I	II
Anas platyrhynchos	Mallard		X	X		I	II
Pandion haliaetus	Osprey		X		X	III	II
Aegypius monachus	Eurasian Black Vulture		X		X	III	II
Torgos tracheliotos	Lappet-faced Vulture		X			III	II
Trigonoceps occipitalis	White-headed Vulture		X			III	II
Gyps fulvus	Griffon Vulture		X		X	III	II
Gyps rueppellii	Rüppell's Vulture		X			III	II
Gyps africanus	White-backed Vulture		X			III	II
Gyps coprotheres	Cape Vulture		X			III	II
Neophron percnopterus	Egyptian Vulture	X	X		X	III	II
Gypaetus barbatus	Bearded Vulture		X			III	II
Buteo buteo	Common Buzzard		X		X	III	II
Buteo rufinus	Long-legged Buzzard		X		X	III	II
Buteo hemilasius	Upland Buzzard		X		X	III	II
Buteo rufofuscus	Jackal Buzzard		X			III	II
Buteo augur	Augur Buzzard		X			III	II
Polemaetus bellicosus	Martial Eagle		X			III	II
Aquila fasciata	Bonelli's Eagle		X			III	II
Aquila pennata	Booted Eagle		X		X	III	II
Aquila chrysaetos	Golden Eagle		X			III	II
Aquila heliaca	Imperial Eagle	X	X		X	III	II
Aquila adalberti	Spanish Imperial Eagle	X	X			III	II

Species		CMS Appendix I	CMS Appendix II	AEWA Annex 2	MoU Birds of Prey	Casualties due to electrocution	Casualties due to collision
Aquila nipalensis	Steppe Eagle		X		X	III	II
Aquila rapax	Tawny Eagle		X		X	III	II
Aquila clanga	Greater Spotted Eagle	X	X		X	III	II
Aquila verrauxxii	Verreaux's Eagle		X			III	II
Circus pygargus	Montagu's Harrier		X		X	III	II
Circus cyaneus	Hen Harrier		X		X	III	II
Circus aeruginosus	Marsh Harrier		X		X	III	II
Milvus milvus	Red Kite		X		X	III	II
Milvus migrans	Black Kite		X		X	III	II
Accipiter gentilis	Northern Goshawk		X		X	III	II
Accipiter nisus	Eurasian Sparrowhawk		X		X	III	II
Circaetus gallicus	Short-toed Eagle		X		X	III	II
Haliaeetus vocifer	African Fish Eagle		X			III	II
Haliaeetus albicilla	White-tailed Eagle	X	X		X	III	II
Falco tinnunculus	Common Kestrel		X		X	II - III	II
Falco rupicoloides	Greater Kestrel		X			II - III	II
Falco naumanni	Lesser Kestrel	X	X		X	II - III	II
Falco vespertinus	Red-footed Falcon		X		X	II - III	II
Falco columbarius	Merlin		X		X	II - III	II
Falco subbuteo	Hobby		X		X	II - III	II
Falco biarmicus	Lanner Falcon		X		X	II - III	II
Falco cherrug	Saker Falcon		X		X	II - III	II
Falco rusticolus	Gyrfalcon		X		X	II - III	II
Falco peregrinus	Peregrine Falcon		X		X	II - III	II
Coturnix coturnix	Quail		X			I	II - III
Rallus aquaticus	Water Rail			X		0	II
Crex crex	Conrcrake		X	X		0	II
Gallinula chloropus	Common Moorhen			X		0	II
Fulica atra	Common Coot		X	X		0	II
Balearica regulorum	Grey Crowned Crane			X		I	III
Grus grus	Common Crane		X	X		I	III
Grus canadensis	Sandhill Crane		X			I	III
Grus antigone	Sarus Crane		X			I	III
Grus vipio	White-naped Crane	X	X			I	III
Grus japonensis	Red-crowned Crane	X	X			I	III
Anthropoides paradisea	Blue Crane		X	X		I	III
Otis tarda	Great Bustard	X	X			0	III
Haematopus ostralegus	Oystercatcher			X		I	II - III
Vanellus vanellus	Lapwing		X	X		I	II - III
Pluvialis apricaria	Golden plover		X	X		I	II - III
Numenius phaeopus	Whimbrel		X	X		I	II - III
Numenius arquata	Eurasian Curlew		X	X		I	II - III
Limosa limosa	Black-tailed Godwit		X	X		I	II - III
Scolopus rusticola	Eurasian Woodcock			X		0	II - III
Gallinago gallinago	Common Snipe		X	X		I	II - III
Phalaropus fulicarius	Grey Phalarope		X	X		I	II - III
Tringa totanus	Common Redshank		X	X		I	II - III
Philomachus pugnax	Ruff		X	X		I	II - III
Larus marinus	Great Black-backed Gull			X		I	II
Larus argentatus	Herring Gull			X		I	II
Larus ridibundus	Black-headed Gull			X		I	II
Chlidonias niger	Black Tern		X	X		I	I - II
Sterna hirundo	Common Tern		X	X		I	I - II
Streptopelia turtur	Turtle Dove		X			I - II	II
Strix uralensis	Ural Owl				X	II - III	II
Asio otus	Long-eared Owl				X	II - III	II
Coracias garrulus	European Roller		X			I - II	I - II

Appendix 5 Range State information supplied through questionnaire

Brief summary of Range States information on general and/or specific legislation and/or volunteer arrangements between stakeholders, in relation to power lines and bird electrocution and collision as provided through the questionnaire by a number of countries and information received from NGOs and/or researchers.
For the following countries this information was taken from the Bern Convention questionnaire (Document: T-PVS/files (2010/11), on the same problems: Bosnia and Herzegovina; Croatia; Estonia; France and Italy.

Algeria: there is no legislation in place and it seems that also EIA procedures are not being applied to the construction of power lines. Some positive remarks about larger bird species breeding on pylons; in some regions special nesting platforms for storks have been constructed on top of the pylons to avoid electrocution and problems with outage caused by electrocution of birds.

Austria: no specific legislation but EIA procedures are in place on high voltage power lines. A high percentage of medium voltage lines are already underground. There are governmental working groups on this issue as well as with the largest electricity network provider. Marking on wires has taken place for specific areas such as Natura 2000 sites and especially those areas important for the Great Bustard. Approval procedures for power lines may include the application of mitigating measures. Specific problem on collision not with power lines: grouse collisions with cables of ski lifts and fences.

Azerbaijan: no national policy or legislation. Some monitoring on bird victims by Ornithological Institute of the Academy of Sciences. Electricity companies seems to just destroy nests on poles if these are noted.

Benin: general environmental legislation on existing and new power lines exist, which force preventive mechanisms to be applied. It is not clear if this just means application of EIA procedures, or specific mechanisms aimed at decreasing bird mortality. To date there has been no monitoring or research of the problem.

Bosnia and Herzegovina: the Nature protection legislation contains provisions that makes it an obligation to prepare mitigation measures on power line constructions to reduce bird mortality. This is done in close consultation with the Ministry of Energy, Mining and Industry and its guidelines for the construction of power lines.

Bulgaria: no special legislation; but building of power lines can be banned or restricted close to *e.g.* Natura 2000 sites. There are EIA procedures that could lead to decision to bring power lines underground if planned close to very sensitive areas. Electricity companies take, on a volunteer basis, measures to reduce bird mortality on power lines although it is estimated that just 5% of the power lines are bird friendly. There have been publications on the extend of the problem of electrocution and collision but only the last 10 years. There is a LIFE project on this issue in relation to Imperial Eagles, Lesser Kestrel and European Black Vulture and some ongoing monitoring by NGOs, such as BirdLife Bulgaria. There is also a project at the Bourgas wetlands (LIFE project with BSPB/BirdLife Bulgaria).

Canada: (Canada is not a Party to AEWA/CMS but frequently present as an observer and returned the questionnaire) no special national policy or legislation on the federal level if it comes to power lines and migratory birds; on the federal level they are subject to EIA procedures if crossing provincial borders. Sometimes provincial EIA procedures (some migratory birds are protected on the provincial level) are in place as well for power lines and electricity companies have to apply them. Mitigation measures are being used by electricity companies, but there is no further information available to Environment Canada.

Croatia: The Nature Conservation Act has specific provisions requiring mitigation measures for power line constructions. Also the National Strategy and Action Plan on Biodiversity addresses this issue as well. Planning and construction of power lines is subject to detailed EIA procedures.

Czech Republic: recent (2009) legislation exists indicating that all power lines must have mitigation measures by 2024. New power lines must have mitigation measures from the very beginning following the Nature Conservation and Landscape Act of 1992. A best practice guide book on mitigation is in preparation but no rules as yet on what technical equipment and solutions should be used. Monitoring and some research have just been started and testing mitigation measures has only started in 2010.

Denmark: A decision has been taken on a major project to underground all power lines starting with the lower voltage ones and later, pending technical solutions, also higher voltage power lines. This decision is directly related to the strong increase of the number of wind turbines and therefore a much denser power line network. Besides this long term and costly plan, EIAs must always been carried out and the outcome can influence places and transects for power lines or partially placing them underground *e.g.* when crossing wetlands, larger streams, valleys etc. is unavoidable. Protected areas will, as much as possible, be avoided.

Estonia: no specific legislation on birds and power lines but there are EIA procedures that have to take the issue into account. There are strong efforts to bring power lines underground.

Ethiopia: no special legislation for power lines and there is only recently there good EIA legislation in place, which should guarantee a balanced decision making on the construction of *e.g.* power lines and possible negative effects. This is applied to new constructions. The implication of EIA procedures is done in close consultation with the Ethiopian Wildlife Conservation Authority.
The old power lines are still a problem in relation to electrocution and collision and no mitigation measures seem to be planned. The power lines in the Rift Valley are the main problem given its importance for migratory birds.

European Union: there are the general obligations for the protection of biodiversity, including birds, under the Birds Directive and Habitat Directive, which are rather strict if it comes to creating problems for certain species and habitats, especially if Natura 2000 sites are involved. This also applies to the construction of power lines. Special obligations for power lines are present in the EIA/Directive and procedures from 1985 which states:
EIA Directive 85/337/EEC – Annex I (projects that shall be made subject to an assessment): 20. construction of overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15 km. Annex II (projects which need for assessment shall be made by MS): 3b. Transmission of electrical energy by overhead cables (projects not included in Annex I).
Similar obligations are laid down in SEA procedures:

2001 – SEA Directive 2001/42/EC – Article 3 – environmental assessment shall be carried out for all plans and programmes which are prepared for energy and which set the framework for future development consent of projects listed in Annexes I and II of Directive 85/337/EEC, or which have been determined to require an assessment pursuant to Article 6 or 7 of Directive 92/43/EEC, in view of the likely effect on sites.

For a correct implementation of these Directives, the Birds Directive and Habitat Directive guidance documents are also available to clarify certain definitions and issues (such as alternative solutions, overriding public interest etc.) and to what extend a possible intervention by the EU would be possible.

EU Member States have the possibility to apply for LIFE funding to protect important habitats and species. This is also possible in relation to the construction of power lines or to improve existing power lines in order to reduce their impact on habitat and species. A few member States have received LIFE grants in relation to power lines (*e.g* mitigate dangerous pylons) and endangered bird species. For example: Hungary (Great Bustard and Imperial Eagle), Spain/Aragon region (a number of endangered birds of prey as well as both Little and Great Bustards).

Finland: the problem is not recognised in national legislation or environmental policy on the national level and no national standards or mitigation guidelines are available. The electricity suppliers have their own guidelines on bird mitigation measures (*e.g*. plastic ball markers and a short transect has been placed underground). Mitigation by the companies focuses on outage prevention and aircraft safety and there are some bird related recommendations. No good studies before a power line construction takes place. Some research shows the effect on a number of species based on ringing results.

France: there is no specific national legislation but there is an intensive cooperation between all stakeholders, including the French Bird Conservation Society (LPO) on the issue of power lines and bird mortality. This works quite well and is often further organised at the regional level. Together plans are being made for mitigation measures per region or for specific (vulnerable and/or endangered) species under the EU Bird Directive and international conventions like Bonn and Bern.

Germany: SEA and EIA procedures are in place and power lines/bird interactions are part of the assessment. Appropriate national legislation on mitigation is in place together with guidelines on the technical aspects to be applied. Germany has a long tradition in addressing the problems of power lines and bird electrocution in particular. The Working Group on ‘Birds and power lines’ of German NGO NABU has, for over 30 years, been active on this issue and assists in many ways to reduce the problem: monitoring, research, developing mitigation measures and appropriate legislation on the national level. The Working Group achieved much in their discussion and active cooperation with the government and electricity companies. The umbrella organisation (VDE) of the electricity companies issued in August 2011 new guidelines for mitigation of power lines, also as a way to reduce the number of outages. These new guidelines are obligatory for all companies (based on Federal legislation from 2002) and are to be applied countrywide. New constructions should have mitigation measures from the beginning, existing ones should be made more bird safe before the end of 2012.

Ghana: no concrete policy or legislation on birds and power lines. However within the EIA procedures for infrastructures, serios attention is paid to important issues such as avoiding dangerous poles, routing away from ‘hotspots’ for bird conservation, etc. There are also no technical standards set for mitigation measures and there is no monitoring of the problem.

The Gambia: no specific legislation or policy other than general EIA procedures as *e.g*. laid down in the National Environment Act of 1994 (NEMA). But so far the issue of bird collision and electrocution has been considered to a limited extent when power lines were constructed, mainly if it came to routing away from potential problem areas. At some place cables have been placed underground. NEMA requires that attention is being paid to the obligations as laid down in international conventions. No research or monitoring.

Hungary: although there is no specific legislation other than EIA procedures in place, considerable efforts have taken place to make electricity companies aware of the issue. This has led to the so called: ‘Accessible Sky Agreement’ signed by the distribution companies, and IGO and NGO stakeholders. This informal arrangement has worked quite well to reduce the problems and make power line constructions, old and new ones, more bird friendly. Electricity companies also contribute financially to research and conservation measures and have to present measures to avoid negative impacts of power lines. BirdLife Hungary is closely involved in monitoring the problem and research projects.

EU/LIFE program is supporting mitigation measures to better protect *e.g.* Saker Falcon and Red-footed Falcon. Avoiding negative impacts is a general obligation for all projects under the EIA procedures.

Israel: no formal legislation or obligations to insulate pylons or taking other preventive or mitigation measures. But on a voluntary basis much is done by the distribution company (IEC), which has taken many measures to *e.g.* insulate pylons and certainly near IBAs, rubbish dumps and nature reserves. There is a consultation process between the IEC and the Israeli Nature and National Parks Authority (INPA) on transects for new lines and how to insulate pylons and avoid potential conflict areas. Data on casualties are collected in a systematic way along power lines and through the public but there is no real research done but plans are prepared for 2012 focusing on problems with pelicans and White Storks. There are no general applicable technical standards

Italy: no specific legislation available but the Ministry of Environment, Land and Sea has published guidelines for mitigation measures. EIA procedures are in place if it comes to construction and routing.

Kenya: EIA procedures are a legal requirement for the construction of electricity infrastructure and to analyse its environmental and conservation impact. However, the legislation does not provide for an obligation to mitigate the construction and make them avian-safe. Conservation NGO's have been involved in rapid impact assessment of parts of power lines. There have been discussions with the main electricity company to mitigate existing lines and poles. So far, high costs have been an obstacle to realise this. The electricity company seems to be willing to make certain types of pylons avian-safe, including newly constructed power lines. There are, however, no formal arrangements between the electricity company and conservation organisations to develop a joint policy to reduce the problem of bird electrocution/collision. Research or monitoring is not carried out in spite of efforts by conservation organisations to have projects funded.

Latvia: (Bern Convention has no relevant information)

Monaco: no above ground power lines and therefore no legislation on the issue of power lines and bird electrocution or collision.

Montenegro: the Nature Conservation Act of 2009 has specific arrangements that construction of electricity poles etc. should be in such a way that birds cannot be electrocuted and to avoid collision. (this does not apply to railway lines).
It also contains obligations to monitor bird populations, specially protected species, in accordance also with international conventions to which Montenegro is a Party.
There is also a rather strict EIA procedure when new power lines are planned and constructed; this takes bird conservation aspects into account and requires monitoring of bird populations etc.

Mozambique: there is no specific policy related to the interactions between birds and the electricity grid, but national environmental legislation (EIA procedures) applies. So far, no specific mitigation measures have been undertaken and there is no relevant information on the conflict between birds and the electricity grid.

Namibia: EIA procedures are compulsory for every new power line but there is no official policy on birds and power lines. There is an alliance between the electricity company and the Namibia Nature Foundation to look at mitigation measures and technicians are trained to apply them; guidance is available online. This also to reduce the large number of power outages related to bird electrocutions and which represent an economic problem. New power lines must be constructed in a bird friendly way.

Nigeria: there is currently no legislation on power lines and bird protection. There is the general national policy on the protection of wildlife that could play a role. There is no research or monitoring ongoing within Nigeria on the problem of power lines and birds.

Portugal: much is done to prevent collision and electrocution, including extensive monitoring and research; results are published and information widely available. This all in close cooperation between the different electricity companies, conservation authorities and NGOs. Legislation on new infrastructures, including power lines, requires the authorisation by the conservation authorities and thus provide guarantee that possible bird problems are taken into account. Conservation authorities also developed guidelines on planning and mitigation measures and technical standards. EIA procedures are in place as well and could help to prevent problems. Conservation authorities are a member of the national EIA commission and can prevent the building of power lines in or near areas with a high risk of collision such as IBAs and nature reserves. Electricity companies already apply a number of technical mitigation measures on existing and new power lines. A financial supporting system exists to improve the environmental performance of electricity companies implementing voluntary measures to reduce their impacts on nature.

Republic of Korea: there is little known about the implementation of EIA procedures and there is probably not an obligation to apply EIA procedures when power lines are planned or constructed. There are, as far as is known, no legal regulations concerning the application of mitigation measures, *e.g.* for pylons, to prevent bird collisions or electrocution and no technical handbooks providing information how to construct bird safe pylons, etc. No regulated communication exists between electricity companies and the conservation society. Some local and regional authorities have taken measures on their own to burry power lines or to remove them from areas with endangered species such as wintering areas for cranes, including the Hooded Crane.

Romania: there is no legislation and no national policy regarding the problem. Also the application of EIA procedures is not mentioned in the questionnaire. That will change with the EU directives in place. There is a strong pressure from NGOs towards legislation on this issue and towards the electricity companies. The available information on mitigation etc. seems to be seen as ‘forgotten knowledge’ in Romania by the existing electricity companies. Some monitoring is taken place and there is a strong wish for an agreement between all parties to reduce the impact of power lines on birds and force the electricity companies to apply mitigation measures.

Russian Federation: there is basic legislation on the need to prepare EIAs for all type of economic activities, which includes power line infrastructure. There is also general fauna protection legislation, which includes the prevention of killing of fauna (not only birds) from for instance telecommunication infrastructures and electricity infrastructure, *e.g.* power-lines, and from man-made constructions in general. For telecommunication infrastructure and power lines more specific regulations are in place (Gov. Reg. RF of 13 Aug.1996. no 997), which requires that power line constructions includes bird safety and mitigation measures (poles and insulators are mentioned in this respect; fences around ground based constructions, etc.). These rules also advise that in places with intense bird migration/ movements, power lines preferably should be placed underground. In relation to the numerous regulations, a number of technical handbooks and guidelines are available to assist electricity and construction companies with applying bird safe equipment and how to prevent electrocution and/or collision. These probably need to be updated. Although not formally organised there are some contacts between the electricity companies and bird conservation organisations, mainly on the regional level.

Serbia: there are EIA procedures in place that take the conservation legislation and its obligations as a serious aspect of the final assessments. It is said that special attention is devoted to bird migration routes and that power lines cannot be built within such routes. Besides that there is a whole series of legislation in which the problem of power lines and birds are taken into account. This ensures mitigation and other protective measures are undertaken on the regional and local level. Limited research is carried out on bird safety and power lines. In 2005, the Serbian electricity company EPS accepted to modify existing power line poles and to design new poles, especially those that are used for medium and low voltage power lines.

Slovakia: there is legislation available (Nature and Landscape Protection Act) that forces constructors to take measures to prevent the killing of birds; that includes power lines. Besides the legislation there is a close cooperation between the electricity companies and the conservation authorities to discuss and agree preventive measures in an early stage, including placing power lines underground. Various EU/LIFE projects, but also many smaller projects on the national and regional level, addresses the problems of birds and power lines (also across borders) in relation to rare and endangered species like some birds of prey and Great Bustard. State Nature Conservancy does regular surveys of casualties. This shows that there are still problems with the older power lines.

South Africa: no specific policy on birds and power lines. But the EIA procedure requires a study of avifauna with suggested mitigation measures in general terms if the birds may be affected. This is particularly the case if it concerns threatened species that are protected by the Threatened or Protected Species List, under the Biodiversity Act. Whilst this protection does not actually specify power lines, it makes it illegal to wilfully harm, disturb, destroy hunt etc. certain species, their nests or eggs. A partnership between the main electricity supplier and the Endangered WildLife Trust is aiming at reducing the risks for birds and to apply appropriate mitigation measures also to reduce the outage problem.

Spain: There is a specific regulation on power lines construction and mitigation of new lines (the legal obligations are in accordance with the EU Directives, Bern and Bonn conventions) in sensitive areas (protected areas, important bird areas and/or areas with threatened species. This laid down in the Nature and Landscape Protection Act. There is legislation that requires the authorisation by governmental authorities on construction or changes of new and existing infrastructures, including power lines. Conservation authorities can enforce mitigation measures if the magnitude of the problem requires that.

Sudan: there is no specific national wildlife policy but there are EIA procedures in place that involve the governmental conservation organisation. There are bird protection areas and their interests play a role in the EIA procedures. No monitoring of the problem but there is a small ongoing study on the collision problem with Egyptian Vulture

Switzerland: construction of higher voltage lines are subject to strict EIA procedures and they may include compensatory measures for habitats and species, in particularly if it concerns protected areas and species of red data lists, this also concerns the route. There are Guidelines on Electricity Grids and Landscape Protection and the Swiss Landscape Concept stipulates that “transmission lines may not affect avifauna”. The legislation on power lines specifically requires that the constructions of the pylons/poles are bird safe and the protection of birds is fully considered when planning new power lines. Underground cables is probably the future given a verdict of the Swiss Federal Supreme Court. Older types of power lines may still cause a problem and will be replaced by ones that are much safer for birds. There are guidelines published to assist with applying technical measures to reduce the problem of power lines and birds. On the national level a survey on high-risk areas has been undertaken with special attention to larger bird species like White Stork and Eurasian Eagle Owl. Eliminating electrocution for Eurasian Eagle Owl would result in a population increase as shown in a regional study.

Togo: there is environment/conservation legislation but of a general nature and with an EIA character. It applies to species and natural habitats conservation as well as for instance human health. No specific legislation on power lines and birds. No research or monitoring is undertaken.

Uganda: no specific policy on birds and power lines. There is general legislation for the protection of birds. EIA procedures are laid down in legislation and have to take the conservation legislation into account, including possible damage to birds. Uganda follows the Equator Principles (EPs). There are measures taken to prevent collision and electrocution but they are not put into mandatory legislation.

United Kingdom: legal obligations in place are in line with the EU Directives (see EU legislation). Collision and electrocution are not seen as a major problem because a range of measures are in place to avoid them, including replacing unprotected wires by insulated ones, markers etc. These measures are part of the National Policy Statements in relation to planning applications (that includes not only power lines). For instance, dangerous types of pylons are not used and mitigation measures are in place for existing power lines. Underground placing is considered an option. Guidelines for surveys and monitoring are being developed *e.g.* in Scotland and there has been research done on the extent of electrocution and collision.