ENERGY & NATURE WEBINAR

Bird's-eye View

Ornithology for a nature-friendly energy transition

27 June 2024
14:00 – 15:30 CEST

Renewables Grid Initiative | BirdLife International | CMS Energy Task Force | cibio | University of Birmingham | amprion verbindet | Life – Co-funded by the European Union

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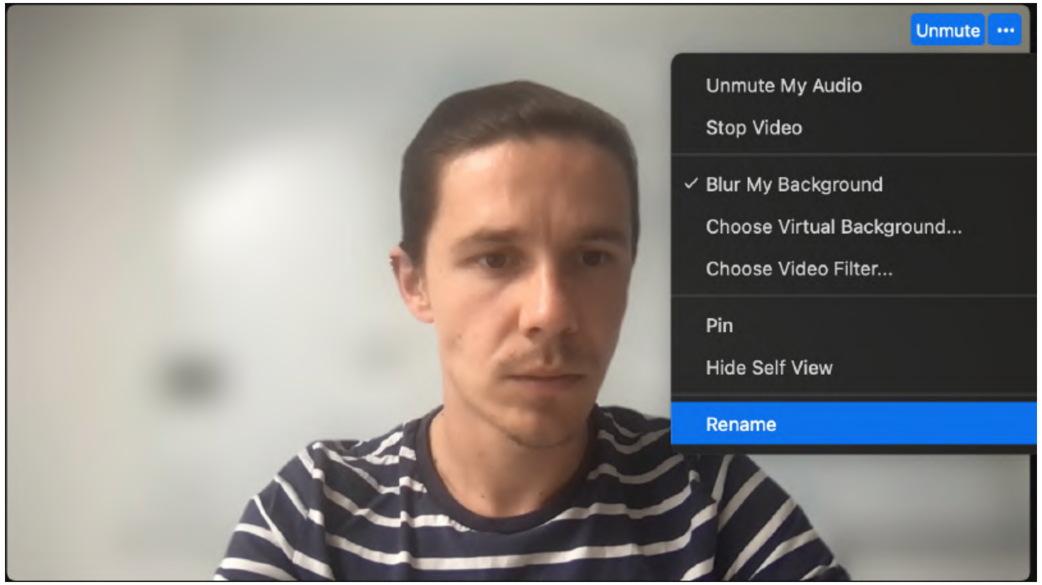

RGI – a unique cooperation between industry and civil society

RGI is a unique collaboration of NGOs and TSOs from across Europe engaging in an 'energy transition ecosystem-of-actors'. We promote fair, transparent, sustainable grid development to enable the growth of renewables to achieve full decarbonisation in line with the Paris Agreement.

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Agenda

14:00 – 14:15	Liam Innis – RGI *Senior Manager – Energy Ecosystems*
14:15 – 14:20	Rhiannon Niven – BirdLife International *Global Climate Change Policy & Energy Task Force Coordinator*
14:20 – 14:35	Graham Martin – University of Birmingham *Emeritus Professor – Aviary Sensory Science*
14:35 – 14:50	Christin Osadnik – Amprion GmbH *Nature Conservation Officer*
14:50 – 15:05	Francisco Moreira - Portuguese Biodiversity Research Centre *Principal Researcher*
	Open discussion

Energy Task Force

Renewables Grid Initiative
BirdLife INTERNATIONAL
CMS ENERGY TASK FORCE
cibio
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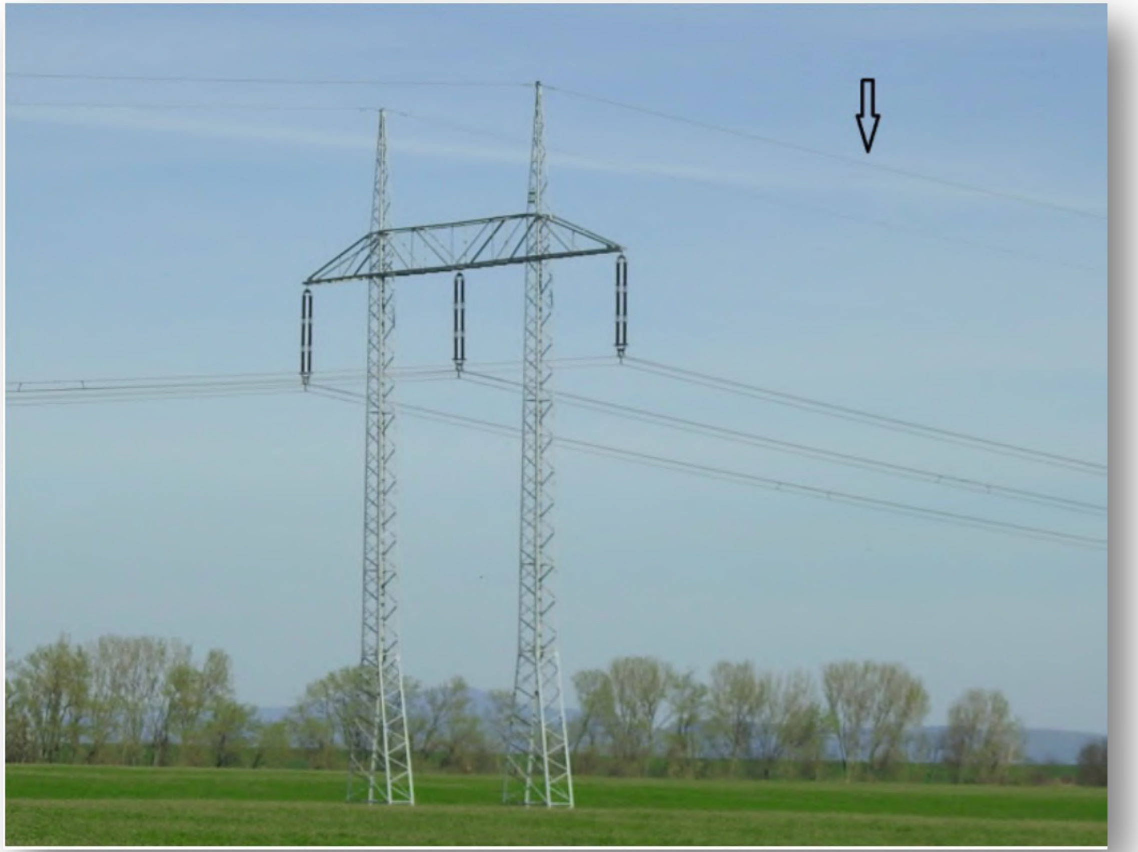
Impacts of power lines on biodiversity

Table 1
Criteria used for classifying the reviewed studies into abiotic impacts of transmission lines (TL) on biodiversity.

Abiotic impact	Criteria/definition
Barrier effect	TL as a physical barrier for individuals (includes bird collisions); modification of behavior in response to TL presence; roadkill or avoidance on roads used for TL access.
Line as resource	Use of line structures as a resource by species to perching, nesting, roosting and scavenging of electrocuted birds; includes electrocution.
Habitat conversion	Increase in available habitat or in abundance of individuals or colonization by new species.
Fragmentation	When the authors mentioned the term "fragmentation".[a]
Edge effect	When the authors mentioned the term "edge effect".[a]
Electromagnetic field	Responses of organisms to exposure to electromagnetic fields.
Corridor effect	Individual movement along the corridor created by the right of way. We considered movements between habitats or for dispersal.
Habitat loss	Reduction in amount of habitat for an organism.
Fire risk	Fire during the operation phase.
Noise effect	Response of organisms to noise generated by the installation or operation of the transmission lines.

Biasotto, L. D., & Kindel, A. (2018). Power lines and impacts on biodiversity: A systematic review. *Environmental Impact Assessment Review, 71*, 110-119.

The issue: Bird collision with power lines



Bird collision: Risk removal & mitigation

- Collaborative planning to ensure power lines aren't built in high-risk areas
- Placing power lines underground*
- Wire markers/bird flight diverters (BFDs)

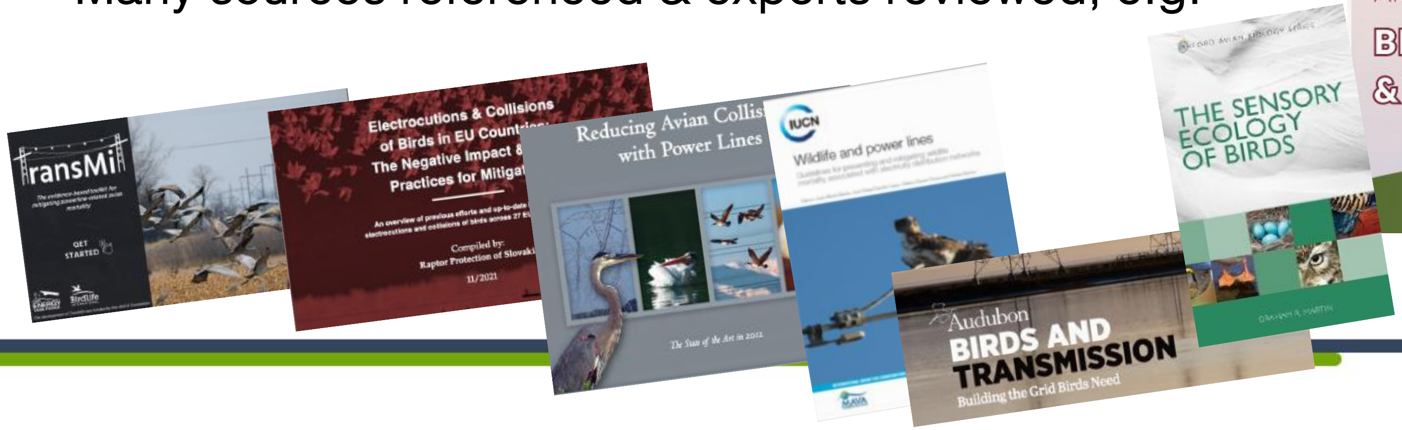


One solution: Bird flight diverters (BFDs)

- Several products on the market
  - Spheres, swinging plates, spiral vibration dampers, strips, large spirals, small spirals, reflective plastic plates, bird flappers, aerial marker spheres, ribbons, tapes, flags, aviation balls, crossed bands, UV illumination
  - Certain models favoured in some countries, not used at all in others
- Technical considerations
  - Cost, longevity, installation method (safety, cost, shut down slot), material requirements, et al.
- Unclarity on which areas should be prioritised for retrofitting
  - Which species most susceptible? Which populations most at risk? No 'one-size-fits-all' marker!
- Unclarity on effectiveness
  - Many studies – varying degrees of scientific rigour, methodologies, not universally comparable (geography, species etc.)
  - Meta studies:
    - 55-94% effectiveness in reducing mortality (Barrientos et al., 2014)
    - 56% average effectiveness (Bernadino et al., 2019)

RGI Research Overview

- Brochure
  - Abridged overview of research & key understandings
  - Effectiveness studies:
    - Only peer-reviewed BACI studies
    - 15 BACI studies in total
    - 3 studies minimum per marker = 4 markers
- Annex report
  - 76 studies in total
  - Deep-dive into global research & methodology
- Many sources referenced & experts reviewed, e.g.



RGI Research Overview

Global research on:

1. Bird susceptibility to collision
   incl: morphology, behaviour, collision sensitivity indices

		Bernotat & Dierschke (2021b) Project-specific Mortality Sensitivity Index (pMSI) of breeding, resident & migrant birds for collision with powerlines (relevant for Germany)			D'Amico et al. (2019) Collision Sensitivity Index (n) = priority score		Gauld et al. (2022) Collision Sensitivity Index (n = no. high vulnerability grid cells with powerlines for specie
Order	**Common bird groups**	**Very high**	**High**	**Moderate**	**Spain**	**Portugal**	
Pelecaniformes	Pelicans, ibis and spoonbills		Eurasian spoonbill *(Platalea leucorodia)*		Eurasian spoonbill *(Platalea leucorodia)* (18), Glossy ibis *(Plegadis falcinellus)* (38)	Eurasian spoonbill *(Platalea leucorodia)* (11)	Northern bald ibis *(Geronticus eremita)* (217), Eurasian spoonbill *(Platalea leucorodia)* (5)
	Herons, egrets, bittern	Black-crowned nightheron *(Nycticorax nycticorax)*	Common bittern *(Botaurus stelaris)*, Little bittern *(Ixobrychus minutus)*, Greatwhite egret *(Ardea alba)*, Purple heron *(Ardea purpurea)*	Grey heron *(Area cinerea)* - Greatwhite egret *(Ardea alba)*, Purple heron *(Ardea purpurea)*, Little egret *(Egretta garzetta)*	Eurasian bittern *(Botaurus stelaris)* (8), Black-crowned nightheron *(Nycticorax nycticorax)* (32)	Black-crowned night heron *(Nycticorax nycticorax)* (5), Squacco heron *(Ardeola ralloides)* (4), Purple heron *(Ardea purpurea)* (20) Little bittern *(Ixobrychus minutus)* (47),	N/A
Gruiformes	Rails, gallinules, coots, cranes		Eurasian crane *(Grus grus)*, Corncrake *(Crex crex)*, Spotted crake *(Porzana porzana)*, Little crake *(Porzana parva)*, Ballon's crake (Porzana pusilla)	Hazel grouse *(Tetrastes bonasia)*, Rock partridge *(Alectoris graeca)*, Grey partridge *(Perdix perdix)*, European quail *(Coturnix coturnix)*, Water rail *(Rallus aquaticus)*, Common moorhen *(Gallinula chloropus)*, Eurasian coot *(Fulica atra)* - European quail *(Coturnix coturnix)*, Corncrake *(Crex crex)*, Spotted crake *(Porzana porzana)*, Little crake *(Porzana parva)*	Crested coot *(Fulica cristata)* (7)	Western swamphen *(Porphyrio porphyrio)* (31),	Eurasian crane *(Grus grus)* (362)
Anseriformes	Waterfowl: Ducks, geese, swans, sawbills	Greater scaup duck *(Aythya marila)* - Lesser white-fronted goose *(Anser erythropus)*	Whooper swan *(Cygnus cygnus)*, Eurasian wigeon *(Anas penelope)*, Garganey *(Spatula querquedula syn. Anas querquedula)*, Eurasian teal *(Anas crecca)*, Northern shoveler *(Anas clypeata)*, Eurasian pochard *(Aythya ornari)*, Ferruginous duck *(Aythya nyroca)*, Northern pintail *(Anas acuta)* - Bewick's swan *(Cygnus columbianus)*, Taiga bean goose *(Anser fabalis)*, Pink-footed bean goose *(Anser brachyrhynchus)*, Ferruginous duck *(Aythya nyroca)*, Common eider duck *(Somateria mollissima)*, Eurasian white-winged scoter *(Melanitta fusca)*	Mallard *(Anas platyrhynchos)*, Barnacle goose *(Branta leucopsis)*, Greylag goose *(Anser anser)*, Common shelduck *(Tadorna tadorna)*, Red-breasted merganser *(Mergus serrator)* - Brent goose *(Branta gernicla)* Tundra bean goose *(Anser serrirostris)* Greater white-fronted goose *(Anser albifrons)*, Gadwall *(Mareca strepera)*, Eurasian teal *(Anas crecca)*, Eurasian wigeon *(Anas penelope)*, Northern pintail *(Anas acuta)*, Garganey *(Spatula querquedula syn. Anas querquedula)*, Northern shoveller *(Anas clypeata)*, Eurasian pochard *(Aythya ferina)*, Tufted duck *(Aythya fuligula)*, Greater scaup *(Aythya marila)*, Long-tailed duck *(Clangula hyemalis)*, Common scoter *(Melanitta nigra)*, Common goldeneye *(Bucephala clangula)*, Smew *(Mergellus albellus)*, Goosander *(Mergus merganser)*	Ferruginous duck (Aythya nyroca) (3), Marbled duck (Marmaronetta angustirostris) (6), White-headed duck (Oxyura leucocephala) (11), Red-crested pochard (Netta rufina) (12), Garganey (Spatula querquedula syn. Anas querquedula) (27), Common shelduck *(Tardona tardona)* (34), Tufted duck *(Aythya fuligula)* (37), Mallard *(Anas platyrhynchos)* (43), Common pochard *(Aythya ferina)* (44), Northern pintail (Anas acuta) (45), Northern shoveler (Spatula clypeata) (48),	Common pochard *(Aythya ferina)* (8), Red-crested pochard *(Netta rufina)* (25), Northern shoveler *(Spatula clypeata)* (26), Common shelduck *(Tadorna tadorna)* (38) Gadwall *(Mareca strepera)* (42) Mallard *(Anas platyrhynchos)* (45)	Mallard *(Anas platyrhynchos)* (5), Eurasian wigeon *(Mareca penelope)* (0), White-fronted goose *(Anser albifrons)* (5), Barnacle goose *(Branta leucopsis)* (4), Whooper Swan *(Cygnus cygnus)* (29)
Charadriiformes	Waders/shorebirds: Sandpipers, plovers, snipes, phalaropes	Eurasian curlew *(Numenus arquata)*, Black-tailed godwit *(Limosa limosa)*, Eurasian golden plover *(Pluvialis apricaria)*, Common snipe *(Gallinago gallinago)*, Ruff *(Philomachus pugnax)*, Common redshank *(Tringa totanus)*, Dunlin *(Calidris alpina)*, Common sandpiper *(Actitis hypoleucos)*, Stone curlew *(Burhinus oedicnemus)*, Ringed plover *(Charadrius hiaticula)*, Kentish plover *(Caradrius alexandrines)*, Ruddy turnstone *(Arenaria interpres)* - Eurasian stone curlew *(Burhinus oedicnemus)*, Common redshank *(Tringa totanus)*	Northern lapwing *(Vanellus vanellus)*, Eurasian oystercatcher *(Haematopus ostralegus)*, Wood sandpiper *(Tringa glareola)*, Black-winged stilt *(Himantopus himantopus)*, Pied avocet *(Recurvirostra avosetta)*, Kentish plover *(Caradrius alexandrines)*, Eurasian dotterel *(Eudromias morinellus)*, Eurasian whimbrel *(Numenius phaeopus)*, Eurasian curlew *(Numenus arquata)*, Black-tailed godwit *(Limosa limosa)*, Bar-tailed godwit *(Limosa lapponica)*, Jacksnipe *(Lymnocryptes minimus)*, Great snipe *(Gallinago media)*, Common snipe *(Gallinago gallinago)*, Common redshank *(Tringa totanus)*, Ruff *(Calidris pugnax)*, Broad-billed sandpiper *(Limicola falcinellus)*, Curlew sandpiper *(Calidris ferruginea)*, Purple sandpiper *(Calidris maritima)*, Dunlin *(Calidris alpina)*	Green sandpiper *(Tringa ochropus)*, Little ringed plover *(Charadrius dubius)*, Eurasian woodcock *(Scolopax rusticola)* - Pied avocet *(Recurvirostra avosetta)*, Black-bellied plover *(Pluvialis squatarola)*, Eurasian golden plover *(Pluvialis apricaria)*, Little ringed plover *(Charadrius dubius)*, Common ringed plover *(Charadrius hiaticula)*, Eurasian woodcock *(Scolopax rusticola)*, Spotted redshank *(Tringa erythropus)*, Northern Phalarope *(Phalaropus lobatus)*, Common greenshank *(Tringa nebularia)*, Green sandpiper *(Tringa ochropus)*, Marsh sandpiper *(Tringa stagnatilis)*, Wood sandpiper *(Tringa glareola)*, Ruddy turnstone *(Arenaria interpres)*, Great knot *(Calidris tenuirostris)*, Sanderling *(Calidris alba)*, Little stint *(Calidris minuta)*, Temminck's stint *(Calidris temminckii)*	Kentish plover (Anarhynchus alexandrinus) (31), Common snipe *(Gallinago gallinago)* (21), Stone-curlew (Burhinus oedicnemus) (49)	Redshank *(Tringa totanus)* (9), Common snipe *(Gallinago gallinago)* (13), Pied avocet *(Recurvirostra avosetta)* (37), Common sandpiper *(Actitis hypoleucos)* (41) Eurasian stone-curlew *(Burhinus oedicnemus)* (44)	Eurasian stone curlew *(Burhinus oedicnemus)* (0)
				Black-headed gull *(Chroicocephalus ridibundus)*, European herring gull *(Larus argentatus)*, Yellow-legged gull *(Larus michahellis)*, Caspian gull *(Larus cachinnans)* Whiskered tern *(Chlidonias hybrida)*, White-winged black tern *(Chlidonias leucopterus)* -	Yellow-legged gull (Larus	Whiskered tern *(Chlidonias hybrida)*	

Renewables Grid Initiative

RGI Research Overview

Global research on:

1. Bird susceptibility to collision
   incl: morphology, behaviour, collision sensitivity indices

2. External factors
   incl. topography, light, weather, powerline features

- **Topography:** The land formations in a given area play an important role in informing the direction and height at which birds fly. Thus, the landscape context in which a power line is constructed can play a role in influencing collision risk. Landforms such as coastlines, river valleys, mountain passes and ridges channel and concentrate flight paths (Bevanger, 1994). For example, shorebirds often gather and fly along coastlines, while mountain chains provide thermals and updraught which benefit the flight of migratory species. Recognising these geographically sensitive zones and considering avoiding in route planning or prioritising mitigation measures in these areas can be pivotal to avoid and reduce collision risk.
- **Habitat:** Besides topography, vegetation also plays a crucial role in bird interactions with power lines. Open areas like swamps and pastures allow birds to fly at lower altitudes, increasing the risk of collisions with power lines. In forested regions, certain birds fly just above the tree canopy, and collisions are more likely when power lines exceed the height of nearby trees. High-risk areas for bird collisions include wetlands, coastlines, and major bird congregation sites (e.g. wetlands) during migration. Additionally, particular consideration should be given to areas such as riverbanks and landfills which are heavily frequented by various bird species.
- **Weather and light conditions:** Adverse weather conditions significantly affect bird flight behaviour and their ability to detect overhead wires, leading to increased collision risks. Fog, rain, snow, and low cloud ceilings force birds to fly at lower altitudes, increasing the likelihood of collisions. Indeed, as reported in Bernadino et al. (2018:5), “most reported incidents of mass bird mortality with anthropogenic structures have occurred during such weather conditions”. Furthermore, wind speed and direction play a role, as strong tail and crosswinds can accelerate bird flight and reduce their control near power lines, while headwinds force birds to fly lower to conserve energy, potentially increasing collision risk. Light conditions are another important factor, especially in high-latitude regions with varying daylight hours. Poor light during winter and early spring has been linked to higher collision risks, especially for nocturnal waterbirds, which may react less effectively to power lines in darkness, increasing the risk of collisions during night-time conditions.

RGI Research Overview

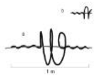
Global research on:

1. Bird susceptibility to collision
   incl: morphology, behaviour, collision sensitivity indices

2. External factors
   incl. topography, light, weather, powerline features

3. Basic principles for effective markers

- **Movement** - Enhancing the visibility of the device can be effectively achieved through motion, particularly by employing a design that allows it to spin around its axis. It is important to ensure that the device has the capability to rotate or flap freely, especially at night, to more effectively draw the attention of birds (NABU, 2013; Liesenjohann et al, 2019; Martin 2022). The factors of contrast and mobility can be combined to give an even higher visibility, if a high-contrast oscillating pattern or checkerboard design is used to combine black and white alternatively within. The movement should be powered by the wind, not by a motor.
- **Able to mounted in regular intervals** - For the installation of bird flight diverters on wires, research and practical insights suggest mounting them at intervals of 5 - 10m, or a maximum of 15-20m (NABU, 2013; BirdLife International, 2022). However, generalising this approach can be challenging. Therefore, the rule of thumb is to place them as closely together on the same wire as engineering constraints permit (Martin, 2022). This recommendation aligns with studies assessing the effectiveness of bird markers at varying interval spacings (Liesenjohann et al., 2019; Silva et al., 2023)
- **Durable over time and under different weather conditions** - Enhancing the longevity of bird markers is vital for maintaining their effectiveness and functionality over extended periods, especially under diverse weather conditions. This not only ensures sustained efficiency in their purpose but also reduces the need for frequent maintenance. Several grid operators have noted that an ideal marker would be able to demonstrate a useable life-span of at least as long in time as that of the infrastructure itself.
- **Economically feasible** – A highly expensive BFD will be a considerable burden for grid operators and thus more difficult to integrated into standard operational budgets. Therefore, an ideal bird marker will be economically feasible in cost per unit and also in terms of the cost of installation and maintenance. Currently available installation methods include ground bucket truck, boat, helicopter, hot stick or drone (NABU & RPS, 2021). An important distinction should be made for marker which can be installed onto energised power lines, or if the power line must be switched off – the latter being more costly and logistically difficult.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
	Name of BFD / instrument	Study title	Year and other citation information	Author	Organisation	Publication source	Abstract	Methodology	Reported effectiveness of marker (Multi-species left and species specific right)		Voltage	Cost	Durability	Placement / mount	Marked wire (e.g. ground wire)	Spacing	Wind resistant	Ice resistant	Weight	Colour	Movability	Luminescence	Dimensions	Species	Sensory perception (frontal or binocular vision)	Flight behaviour	Wing types	Age and Sex	migratory	Resident	Country/region	Landscape Types	Weather
1	Spirals (BFD)	Mitigation of bird collisions with transmission lines through ground wire marking	1994(67)129-134	Alonso et al. *From Lisenjohann page 184*	Museo Nacional de Ciencias Naturales Madrid; Universidad Complutense Madrid	Biological Conservation	A study was conducted to evaluate the effectiveness of groundwire marking in reducing bird mortality through collision at a power transmission line in southwestern Spain. Monthly flight intensity observations and weekly searches for dead birds were carried out at four sectors of the line comprising 28.2 km, during two consecutive winters, 1989-90 and 1990-91, respectively before and after groundwire marking with coloured PVC spirals. Flight intensity and collision frequency decreased respectively by 61% and 60% at marked spans compared to the same spans prior to marking, while there was no significant change in collision frequency at spans left un-marked. After marking, the percentage of birds flying between the cables decreased and that flying above them increased. Our results suggest that many birds avoided flying across the marked spans of the line or climbed while approaching them, and therefore collided less frequently. The percentage decrease in mortality observed in our study falls within the range of results of other groundwire marking or removal studies.	**Before-After, Control-Impact (BACI) Design.** Timeline: The study was carried out during two consecutive winters, December to April 1989-90 and 1990-91, the first before and the second after groundwire marking, which was done during the summer of 1990. Powerline details: These sectors ranged from 4.2 km to 7.4 km in length, and together they covered a total of 28.2 km. The length of line with marked groundwires was 12500 m (29 spans). Carcasss survey: They were searched for dead birds once weekly by one or two observers walking in a zigzag pattern under the line. The search width was about 50 m. The location of each dead bird was marked on a map and all remains were collected and removed from the area to avoid repeated counts during subsequent surveys. The first set of observations and searches was done before the study marked the groundwire with colored PVC spirals. Each sector was surveyed over 70 times in total.	60%	N/A	380 kV	N/A	N/A	N/A	Ground wires (x2)	10 m intervals with a visual effect of 5 m	N/A	N/A	N/A	Red	N/A	N/A	30 cm diameter, 1 m long	Little grebe, Cattle egret, Little egret, Grey heron, White stork, Mallard, Black-winged kite, Red kite, Egyptian vulture, Short-toed eagle, Hen harrier, Montagu's harrier, Common bustard, Bonelli's eagle, Lesser kestrel,	N/A	After marking, the percentage of birds flying between the cables decreased and that flying above them increased.	N/A	N/A	N/A	N/A	Spain	Farmlands and scrublands	N/A
2	Large spirals (swan flight diverters SFD) 	Wire marking results in a small but significant reduction in avian mortality at power lines: a BACI designed study	2012	Barrientos et al *From Liesenjohann page 187*	Museo Nacional de Ciencias Naturales (CSIC), Madrid	PLoS ONE	**Background**: Collision with electric power lines is a conservation problem for many bird species. Although the implementation of flight diverters is rapidly increasing, few well-designed studies supporting the effectiveness of this costly conservation measure have been published. **Methodology/Principal Findings**: We provide information on the largest worldwide marking experiment to date, including carcass searches at 35 (15 experimental, 20 control) power lines totalling 72.5 km, at both transmission (220 kV) and distribution (15 kV–45 kV) lines. We found carcasses of 45 species, 19 of conservation concern. Numbers of carcasses found were corrected to account for carcass losses due to removal by scavengers or being overlooked by researchers, resulting in an estimated collision rate of 8.2 collisions per km per month. We observed a small (9.6%) but significant decrease in the number of casualties after line marking compared to before line marking in experimental lines. This was not observed in control lines. We found no influence of either marker size (large vs. small spirals, sample of distribution lines only) or power line type (transmission vs. distribution, sample of large spirals only) on the collision rate when we analyzed all species together. However, great bustard mortality was slightly lower when lines were marked with large spirals and in transmission lines after marking. **Conclusions**: Our results confirm the overall effectiveness of wire marking as a way to reduce, but not eliminate, bird collisions with power lines. If raw field data are not corrected by carcass losses due to scavengers and missed observations, findings may be biased. The high cost of this conservation measure suggests a need for more studies to improve its application, including wire marking with non-visual devices. Our findings suggest	**BACI** Timeline: Between August 2001 and December 2010, monthly surveys were conducted at 22 different power lines, consisting of 7 transmission lines (220 kV) and 15 distribution lines (15 kV–45 kV), totaling 16.1 km and 27.0 km, respectively. Among these power lines, 15 were surveyed once per month for two complete years, covering one year before and one year after wire marking was implemented. Additionally, 7 lines without wire spirals served as control lines and underwent the same monthly monitoring for two years. Power line details: This research involved a marking experiment and the search for bird carcasses at a total of 35 power lines, which had a combined length of 72.5 km. Fifteen of these lines were our experimental lines, i.e. to which spirals were attached. These were monitored once per month for two complete years (one year before and one year after wire marking). Another 7 lines to which no spirals were attached were used as control lines and were monitored also once per month for two complete years. Because no more non-marked control lines were available, in addition to these 7 control lines we also used as controls the second of 10 two-year and the third of 3 three-year surveys carried out at experimental lines once spirals were attached to them Carcass survey: One month before the beginning of each monitoring year we removed all carcasses under the power line. Each monthly search for bird carcasses was carried out by one observer walking at a slow, regular pace parallel to the wires but making zigzags to reasonably visually cover a 25 m band at each side of the vertical of the central conductor wire. The observer surveyed first one side along the line (e.g. the 25 m band on	9.6%	N/A	220 kV 15-45 kV	310.000 €	N/A	N/A	Phase conductor	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35 cm diameter, 1 m long	Cattle Egret, White Stork, Mallard Anas, Shoveler Duck, Black Kite, Cinereous Vulture, Marsh Harrier, Sparrowhawk, Common Buzzard, Common Kestrel, Red-legged Partridge, Common Quail, Common Moorhen, Little Bustard, Great Bustard, Stone Curlew, Lapwing	N/A	Birds flying in open airspace above vegetation could relax –by means of either behavioural or evolutionary adaptations- the monitoring of this airspace since it is a highly predictable environment, usually clear of hazards (Martin)	N/A	N/A	N/A	N/A	Spain	Farmlands	N/A
3	The Bird-Flight™ Diverter (BFD) - yellow	Mitigating collision of birds against transmission lines in wetland areas in Colombia, by marking the ground wire with bird flight diverters (BFD) -- MITIGACIÓN DE COLISIÓN DE AVES CONTRA	2002	De La Zerda and Roselli, *From Liesenjohann et al. 2019 page 198*	American Bird Conservancy	ResearchGate: Conference: The seventh International Symposium on Environmental Concerns in Rights-of-Way Management	Collision of birds against the ground wire and conductors of high tension lines can be a serious problem in some habitats and for some bird species. Data on collision were gathered in a wetland locality crossed by a 2 circuit 500 kV line in northern Colombia. After 2 years of study, mitigation devices (yellow plastic spirals) were installed on one circuit and observations were carried on after the installation in order to evaluate the effectiveness of the spirals. The bird flight diverters proved to reduce mortality of birds as shown by fewer birds reacting close to the line, fewer birds flying at the height of the conductors and lower collision rates with the marked line.	**BACI** Timeline: The study focused on bird collision data collected in a wetland area where a 2-circuit 500 kV power line crosses. The research spanned 2 years, starting from 1997 to 1999 without bird markers and continuing from 1999 to 2000 with the installation of bird markers. Specifically, yellow spirals were placed on one circuit, and regular monitoring was conducted to observe diurnal and nocturnal flights across the power line. Power line details: Observations were made on the 888-889 and 889-890 spans of the 2nd Circuit (I.S.A. 500 kV Line Chinú-Sabanalarga) and 1019-1020, and 1020-1021 spans of the 1st Circuit that runs parallel to the 2nd Carcass survey: The search for bird carcasses beneath the power line and within a 50-meter radius from the line's center was also part of the study. The number of collisions was calculated by incorporating the results of bias studies, such as search bias, removal bias, habitat bias, and crippling bias, into the total count of bird carcasses.	60% Figure confirmed in Liesenjohann et al., 2019	N/A	500 kV	N/A	N/A	N/A	Ground wires (x2)	10 m intervals with a visual effect of 5 m	N/A	N/A	N/A	Yellow	N/A	N/A	25 cm diameter, 80 cm long	Herons (90% Cattle egret), Ducks, Cormorants, Ibises, rails, American vultures, Doves, Swallows, Great egret, Snowy egret, Little blue heron, Whispering Ibis Black-bellied whistling ducks, Blue-winged	N/A	Birds detect powerlines at greater distances and react on time. The reaction doubled after the instalation of markers. Changed the flight hight at a less dangerous one.	N/A	N/A	N/A	N/A	Columbia	Farmlands, wetlands, and coastal area	N/A
4	Double Spiral spiral (Dispositivos BFD espirais duplas) 	Projeto LIFE Estepárias - Conservação da Abetarda, Sisão e Peneireiro-das-torres nas estepes cerealíferas do Baixo Alentejo LIFE07/NAT/P/654	2012	Estanque et al.	LPN - Liga para a Proteção da Natureza/ Project LIFE Estepárias	N/A	To monitor Action C6, around 20.6km of electrical lines were studied over a period of 38 months, distributed across sections corrected with different anti-collision devices. 270 incidents were detected, of which 90% correspond to collisions and 10% to electrocutions. 45 species of birds were identified during the surveys, however, among the birds with a worrying conservation status, the bustard and the bustard were the most affected (n=18 and n=29 respectively). Comparison of different anti-collision devices through an ANOVA resulted in the identification of rotating FBFs as those associated with lower bird mortality in general and bustard and bustard mortality in particular. Comparing mortality before and after signaling the lines allowed us to once again identify the rotating FBF as the only ones that significantly reduce general bird mortality and also that of bustard and bustard.	**BACI Design** Timeline: The total monitoring effort consisted of 1,563 kilometres of prospecting over 38 months, giving an average of approximately 41 kilometres per month. Intial changes in the monitoring scheme to insure adaquate sample size, so in March 2010 and September 2011 the number of pylon sections was increased and the monitoring periods for each section were changed. To determine the variation in bird mortality due to collisions, we compared data relating to 1 annual cycle before the line was signalled, with data relating to 1 annual cycle after the line was signalled, for 5 sections: T2, T3, T9, T15 and T16. Due to the staggered signaling of electrical lines throughout the project period, it was not possible to obtain complete cycles before and/or after signaling for a greater number of sections. Therefore, this analysis was done for the: double spiral BFD, ribbon FBF and rotating FireFly. To see monitoring schedule see Annexx III of the study, page 144. Power line details: The total monitoring effort consisted of 1,563 km of surveys over 38 months, which results in an average of approximately 41 km per month.	14%	N/A	Medium and high voltage	N/A	N/A	N/A	Phase conductor	N/A	N/A	N/A	N/A	Red and White	Fixed	N/A	N/A	Cattle egret, little bustard, corn bunting, common quail, great bustard, european golden plover, spotless starling, red-legged partridge, rock pigeon, white stork, garden warbler, carrion crow, common buzzard	N/A	N/A	N/A	N/A	N/A	N/A	Castro Verde ZPE (Zona de Proteção Especial), Portugal	Scrublands and steppe	N/A
5	Large spirals (swan flight diverters SFD)	Study Evaluating the Effectiveness of Anti-collision Devices (Final Report)	2011	Infante	REN & Quercus	Regulatory Authority for Energy Services	This final report presents the results of work undertaken between August 2009 and July 2011. We present the results of monthly surveys of birds that collided with the lines under study. In this period, removal by scavengers tests were also conducted (RPN), the percentage found by the observers was studied (PEO), and censuses for crossing rates and studies of the impact of Firefly devices on the landscape and soundscape were conducted. This report presents the efficacy results obtained and presents recommendations regarding the use of Firefly's in the marking of MAT Lines, and also presents the findings from REN, SA. regarding the use of these devices in the National Transmission Grid.	**BACI** Timeline: Monitoring of powerlines for the effectivness of different bird markers took place during August 2009 and July 2011. Bird markers were installed between May 31st and June 4th, 2010, and 24 samples were taken monthly to obtain the number of birds killed by collision. The survey was carried out preferably in the last fortnight of each month during the two-year study. See Table 2 page 5 for study controls, and treatment. See table 6 for Before and After treatment mortality rates, page 19. Powerline details: NA Carcass survey: 24 samples were taken monthly to obtain the number of birds killed by collision. Carcass surveys were performed by three observers who travelled on foot under the line and on each side of the line, at 10m from the projection on the ground of the outer conducting cable. Field visits were conducted preferably in the second half of each month.	45.6%	N/A	High voltage	NA	Concerns about longterm durability, especially in areas with ice formation and high winds.	Installed between 24-28th of May, 2010	N/A	N/A	N/A	N/A	N/A	N/A	Rotating	N/A	N/A	White stork, Wood pigeon, Northern lapwing, Cattle egret, Corn bunting, Golden plover, Song thrush, Goshawk, Common crane, Stone curlew, Little bustard, Red kite, Peregrin falcon, Mallard, duck		flight pattern of birds in the sections marked, it was found that marking lines significantly changes the behaviour of birds, inducing them to pass the conductors by going over them, and thus a reduction of				Montadoes da Bacia do Sado, Campos Abertos de 'Evora, Terras de Viana- Alvito, Terras Fortes do Baixo Alentejo (Portugal)	Grasslands	N/A	
6	Swan-FlightTM Diverter (SFD) - white spirals 	Rate of bird collision with power lines: effects of conductor marking and static wire marking.	1998	Janss & Ferrer	The Consejo Superior de Investigaciones Científicas (CSIC)	Journal of Field Ornithology	The number of birds killed (per km) by collision with power lines in west-central Spain did not differ between one transmission line and two distribtuion lines. For all three power lines, we tested the ability of different markers to reduce brid collision by comparing marked spans to unmakred spans along the same power line. A spiral (30 cm X 100 cm) reduced collisions (ground wire marking). Black cross bands (35 cm X 5 cm) were also effective, but not for the vulnerable Great Bustard (Otis tarda) (conductor marking). The third marker, consisting of thing black stipes (70 cm x 0.8 cm), did not reduce mortality (conductor marking). The highest mortality from power-lines collision was recorded for the Great and Little Bustard (Ostis tarda and Otis tetrax).	**BACI Design** Timeline: The study spanned more than four years, divided into two distinct study periods. During the first period (1991-1993), no markers were placed on the powerline spans, and collision casualty surveys were conducted as follows: Seven surveys were conducted at two-month intervals, spanning from February 1992 to February 1993. In the second period, surveys commenced in February 1994 and continued until February 1995, totaling 13 searches. This phase involved three marked spans and four unmarked ones. Power line details: The initial study area covered a 380KV transmission line, double circuit, comprising six duplex conductors forming three cable levels, and featuring two overhead ground wires. This area extended over a span of 4.5 km. Carcass survey: Two individuals searched for bird carcasses beneath the powerlines, covering a width of 70 meters.	81%	N/A	380 kV	N/A	N/A	N/A	Ground wires (x2)	10 m intervals with a visual effect of 5 m	N/A	N/A	N/A	White	N/A	N/A	30 cm diameter, 1 m long	Crane, White storks, Cattle egret, Dabbling ducks, Wood pigeon, Common kestrel, Greater flamingo, Lapwing, Great bustard and Little bustard, Mallard, Common moorhen, Coot, Stone Curlew, Black-winged	N/A	N/A	N/A	N/A	N/A	N/A	Spain	Grasslands, farmlands, and scrublands	**N/A**
7	The Bird-Flight™ Diverter (BFD) - white	Reduction of wire casualties through marking of high-voltage power lines in the Heerenveen area	1982 Het Vogeljaar, 30(6), 308–316.	Koops and De jong *APLIC 2012 study page 92*	The Bird Year Foundation	Information from Reducing Avian Collisions with Power Lines Collision victims of hightension lines in the Netherlands and effects of marking. KEMA Report 01282-MOB 86-3048.	Many human activities pose risks to birds. This also applies to high-voltage lines, because the wires cause wire casualties. These are birds that injure themselves or fly to death against the wires. The number of wire casualties caused by a high-voltage line depends on the number of birds that pass the wires during spring and autumn migration or during local movements such as feeding and sleeping migration. Marking the wires appears to have a positive influence on the number of victims. At the beginning of 1973, two parallel high-voltage lines were built west of Heerenveen above a bird-rich meadow area. Since the lines were completed, members of the Association of Frisian Bird Protection Guards (BFVW) have regularly searched for wire victims under both lines. More than 800 victims were found in two years (De Jong 1976).	**Before-After, Control-Impact (BACI) Design** Timeline: the study consists of two parts. First, the counting of wire casualties during the period when no markings were in place in the high-voltage lines. This part of the study was conducted from April 1973 through October 1977. Second, to examine the effect of the markings that had been applied and to determine which form of marking yielded the best results. This part of the research was carried out from November 1977 to December 1978. Powerline details: The study was conducted under the parallel 110 kV line Oudehaske-Wolvega and 220 kV-lijn Oudehaske-Ens. The survey section lies between pylons 10 and 30, a distance of 5875 m. The distance between the pylons of both lines is about 55 m. The 110 kV line has 31 m high pylons with three single phase wires (current-carrying wires) and three ground wires on each side. One ground wire runs through the tops of the masts and two ground wires run through the ends of the upper crossarms. The 220 kV line has 43 m high pylons with three phase bundles on either side, each of which in turn consists of three wires.	69.5%	N/A	220kV 110kV	N/A	N/A	N/A	Ground wires (x2)	15 m intervals between two ground wires	N/A	N/A	N/A	White and blue	N/A	N/A	30 cm diameter	Mallard, Moorhen Coot, Oystercatcher, Lapwing, Ruffed Godwit, Whimbrel, Black-headed gull, Common gull, Wood pigeon, Homing pigeon, Starling, other species	N/A	N/A	N/A	N/A	N/A	N/A	Netherlands	Grasslands, farmlands, river and coastal areas	N/A
8	Helical bird diverter - black and white (SFD) 	A large-scale experiment demonstrates that line marking reduces power line collision mortality for large terrestrial birds, but not bustards, in the Karoo, South	2021	Shaw et al.	FitzPatrick Institute of African Ornithology, DST-NRF Centre of Excellence, University of Cape Town, Rondebosch, South Africa	Ornithological Applications	Line markers are widely used to mitigate bird collisions with power lines, but few studies have robustly tested their efficacy. Power line collisions are an escalating problem for several threatened bird species endemic to southern Africa, so it is critical to know whether or not marking works to adequately manage this problem. Over 8 yr, a large-scale experiment was set up on 72 of 117 km of monitored transmission power lines in the eastern Karoo, South Africa, to assess whether line markers reduce bird collision mortality, particularly for Blue Cranes (Grus paradisea) and Ludwig's Bustards (Neotis ludwigii). We tested the 2 marking devices commonly used in South Africa: bird flappers and static bird flight diverters. Using a before-after-control-impact design, we show that line marking reduced collision rates for Blue Cranes by 92% (95% confidence interval (CI): 77–97%) and all large birds by 51% (95% CI: 23–68%), but had no effect on bustards. Both marker types appeared similarly effective. Given that monitoring at this site also confirmed high levels of mortality of a range of species of conservation concern, we recommend that marking be widely installed on new power lines. However, other options need to be explored urgently to reduce collision mortality of bustards. Five bustard species were in the	**BACI** Timeline: The experiment spanned from 2008 to 2016 (8 years) with a BACI marking monitoring approach within a replicated block design. This design compared spans on the same transmission lines, with buffer spans in between treatments. The monitoring involved several phases: Quarterly carcass surveys occurred from July 2009 to January 2011. A clearing survey was conducted in May 2011. Subsequent 6-weekly surveys of marked lines continued until October 2012. Powerline details: The large-scale experiment covered 72 out of 117 km of monitored transmission power lines in the eastern Karoo, South Africa. It aimed to evaluate whether line markers could reduce bird collision mortality, specifically targeting Blue Cranes (Grus paradisea) and Ludwig's Bustards (Neotis ludwigii).The experiment included four survey lines: Line 1 and Line 2 each spanned 27 km, while Line 3 was 32 km, and Line 4 covered	51%	92% collision reduction for Blue cranes	400 kV	Given the high cost of retrospective marking of high-risk areas, and our current inability to reliably predict collision hotspots (Shaw et al. 2010, 2018), we	The line markers were highly durable, with only one out of 2,696 devices failing (a detached flapper) by the end of the 5.4-	Marking devices were manually installed from a helicopter during two sessions between April 11-15 and May 4-7, 2011.	Ground wires (x2)	10 m intervals with a visual effect of 5 m	N/A	N/A	N/A	Yellow and black	N/A	N/A	N/A	Blue cranes, Ludwig's Bustards focus all bustards, and all large birds (cranes, bustards, storks, eagles, Secretarybirds, geese, ducks, herons,	N/A	This group of birds is classed as "poor fliers" (i.e. they have large bodies with high wing loadings :the ratio of body weight to wing area), so they must fly fast to remain airborne,	N/A	N/A	N/A	N/A	South Africa	Grasslands, and farmlands	In this arid environment, rainfall can be highly localized, affecting bird movements and therefore presence (e.g., Ludwig's Bustards; Shaw et al. 2016), but

What next?

- Launch in September, in the run up to our Wingspan Conference
  - 15-17 October, in Brussels

- Findings?
  - More research is necessary
    - Should be done according to BACI methodology
    - More species, broad geographical scope
  - More systematic monitoring on existing grid projects is key
    - Collaborative!
  - More technological innovation is desirable
  - Funding!

Thank you!

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Renewables Grid Initiative