

Tip Sheet

Preventing Electrocution Risks *for Birds on* Distribution Lines

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1. Introduction

Electric power distribution lines are a feature of almost every landscape. Due to growing energy demands, developers are building new power lines more quickly, modernizing existing lines to improve grid reliability, replacing aging infrastructure, and installing technologies that increase efficiency and improve the integration of renewable energies in electricity systems. Globally, distribution grids consist of about 8 million kilometers of medium-voltage lines (10 to 70 kilovolts) and low-voltage lines (less than 10 kilovolts), traversing about 72 million kilometers and reaching households in all corners of the world (IEA 2023; Rystad Energy 2024). The International Energy Agency estimates that to achieve national energy and climate goals, more than 80 million kilometers of grids will need to be added or refurbished by 2040 (IEA 2020). Investments in distribution networks account for nearly two-thirds of global investment in electricity networks (IEA 2020).

Powerline collisions and electrocutions are estimated to kill millions of birds per year (Bernardino et al. 2018; Jenkins, Smallie, and Diamond 2010; Martín Martín et al. 2019), and electrocution from powerlines is a growing global threat to bird species and other wildlife. Most bird electrocutions occur on poles that support medium-voltage distribution lines when perching birds simultaneously contact energized and grounded components or two energized conductors. Compared with higher-voltage transmission lines, the energized and grounded components of medium-voltage are spaced closer together, which increases the likelihood of simultaneous contact and raises electrocution risk. Medium- and large-bodied birds such as raptors, vultures, and waterbirds, along with birds with behavioral tendencies to perch, roost, and occasionally nest on power poles, are particularly at risk. Many large bird species incur significant impacts from electrocution, and certain species of storks, vultures (including condors), eagles, and eagle owls face extinction as a result. Electrocutions can also cause network outages and fire, resulting in financial losses, service disruptions, and legal liabilities (APLIC 2012; Barnes et al. 2022).

2. Scope

This tip sheet discusses the electrocution risk that distribution lines pose to birds. It summarizes basic approaches and measures to reduce bird electrocution risk when designing these lines. It also covers measures to retrofit existing lines. The document targets environmental specialists in international financial institutions and their clients to raise awareness of the issue by presenting key risks and good international industry practice in concise and accessible language. The tip sheet applies to the following sectors: conventional power production and distribution; renewable energy (hydropower, wind, solar, and energy storage projects with above-ground distribution lines or collector lines); oil and gas and mining; railway; and telecommunication.

Although birds are the focus, the recommended measures also apply to large-bodied bats (flying foxes or fruit bats), whose wingspans enable the same simultaneous contact with energized and grounded components as with medium and large-bodied birds. Electrocution risk is also an issue for other wildlife, including primates and other arboreal species. These species are particularly vulnerable when distribution lines run through forested or fragmented forest areas where conductors are used as bridges for wildlife between forest patches. Relatively little research addresses electrocution risk for large-bodied bats and other wildlife (for example, Cunneyworth and Slade [2021]; Rajeshkumar, Raghunathan, and Venkataraman [2013]; Tella et al. [2020]).

Electrocution risk is higher in certain types of landscapes. Landscape-level assessment and planning are recommended to inform route planning and avoid the siting of infrastructure in high-risk areas. A qualified specialist should map these areas and consider landscape features, species occurrence, and zones of high transit and use.¹ However, landscape-level assessment is outside the scope of this document.²

3. Mitigation Hierarchy

The mitigation hierarchy underpins the recommendations in this tip sheet and should guide mitigation planning,³ placing priority on avoiding impacts before considering options to minimize them. Good international industry practice calls for undergrounding, or burying, power distribution lines to eliminate bird electrocution risk. This practice also increases climate resilience, improves community health and safety, and reduces visual impact. Where undergrounding lines is not technically or financially feasible,⁴ powerlines and their associated structures should be designed to avoid electrocution risk to birds (known as bird-safe design). Existing aerial lines should be retrofitted to minimize these risks. Design specifications must also comply with national regulations while applying good international industry practice.

¹ For example, see resources related to the United Nations Development Programme Migratory Soaring Bird Project—the Soaring Bird Sensitivity Mapping Tool (<https://maps.birdlife.org/msbtool/>) and AviStep, the Avian Sensitivity Tool for Energy Planning (<https://avistep.birdlife.org/>), along with broader sources of biodiversity information, including the Integrated Biodiversity Assessment Tool (<https://www.ibat-alliance.org/>).

² A wide range of guidance is available on the topic. See, for example, the International Association for Impact Assessment's 2017 *Key Citation Series for Biodiversity and Ecosystem Services: Biodiversity Number 4: Considering Biodiversity in Spatial and Regional Planning* at https://www.iaia.org/uploads/pdf/Key%20Citations_Biodiversity%2017%20Nov_No%204.pdf.

³ See IFC Performance Standard 1 and its accompanying Guidance Note for an overview of the mitigation hierarchy. The adoption of the mitigation hierarchy to anticipate and avoid (or, where avoidance is not possible, minimize, compensate, or offset for risks and impacts to workers, affected communities, and the environment) is widely regarded as a good international industry practice approach to managing environmental and social risks and impacts. IFC Performance Standard 6 and its accompanying Guidance Note provide more details on the application of the mitigation hierarchy to biodiversity.

⁴ In IFC Performance Standard 1, technical feasibility "is based on whether the proposed measures and actions can be implemented with commercially available skills, equipment, and materials, taking into consideration prevailing local factors such as climate, geography, demography, infrastructure, security, governance, capacity, and operational reliability" (IFC 2012a). Financial feasibility "is based on commercial considerations, including relative magnitude of the incremental cost of adopting such measures and actions compared to the project's investment, operating, and maintenance costs, and on whether this incremental cost could make the project nonviable to the client (IFC 2012a, 5).

4. Understanding the Basics of Bird Electrocution Risks on Distribution Lines

Implementing good international industry practice to reduce bird electrocution risk is complex and requires highly specialized knowledge. This section explains key terminology and concepts relevant to the recommendations and approaches summarized in sections 5 and 6.

Key Terminology and Main Components of a Distribution Pole

The terminology for the basic components of distribution line infrastructure varies across different parts of the world. For consistency and clarity, this document adapts the definitions of the following terms from the international standards of the Avian Powerline Interaction Committee (APLIC) and

the Institute of Electrical and Electronics Engineers (IEEE). Photos 1-3 identify a number of components.

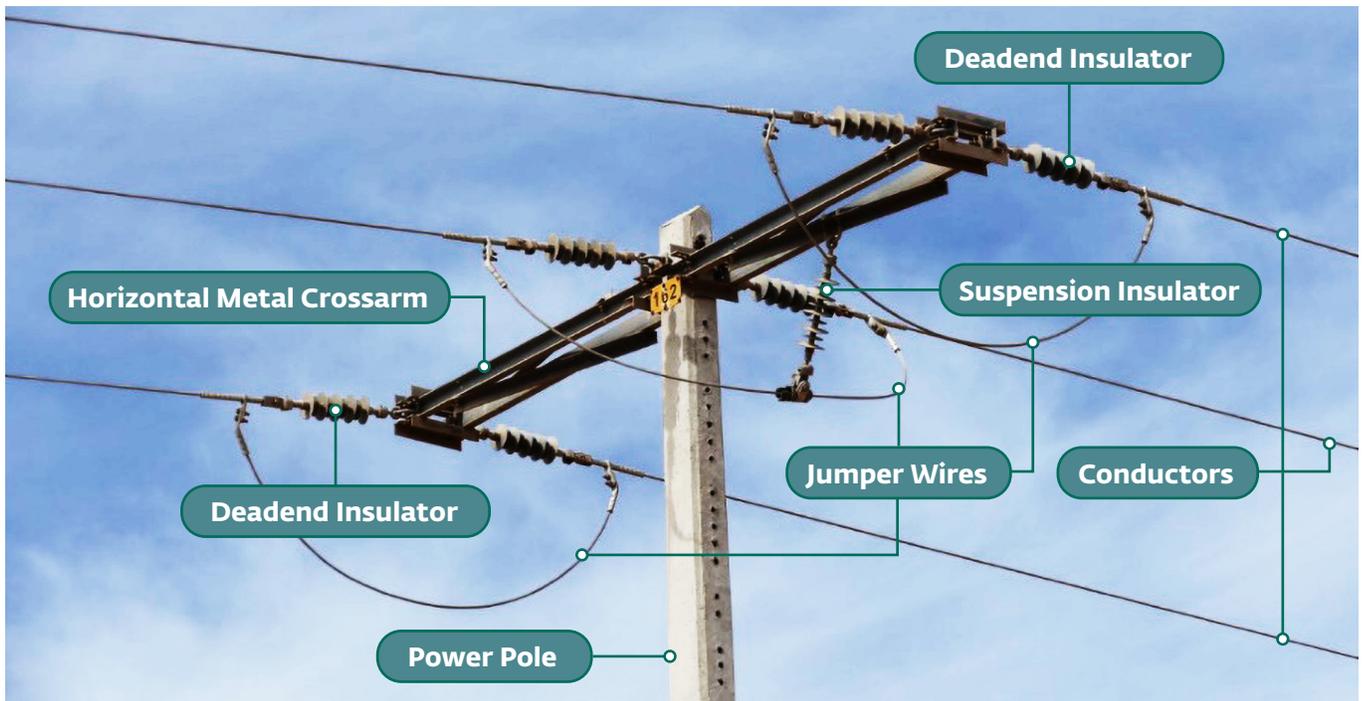
Bushing: An insulator that allows an electrical conductor to pass through a conducting barrier, such as the case of transformers, capacitors, or circuit breakers, without making electrical contact with it.

Conductor: The material—usually copper or aluminum and usually in the form of a wire or cable—suitable for carrying an electric current. Connector: Components used to join or attach conductors.

Crossarm: A horizontal structure attached to utility poles, typically to support electrical conductors and equipment for distributing electrical energy. Crossarms can be made of wood, fiberglass, or steel and manufactured in various lengths to suit insulation design.

Insulation: Materials and methods used to cover exposed or energized parts with durable, environmentally appropriate, nonconducting materials (for example, rubber, plastic) for electrical purposes; also used to reduce bird electrocution risk.

Photo 1. Main Elements of a Power Distribution Pole



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Insulator: Nonconductive material designed to physically support an energized conductor on grounded structures such as poles and to electrically separate it from another conductor or object. Common types include pin, strain and suspension insulators, normally made from porcelain, glass, or polymer.

Jumper wire: A short conductor that establishes a connection between two points of a distribution line.

Power pole or utility pole: Any of a variety of vertical structures used to support electrical conductors and equipment for distributing electrical energy. Poles can be made of wood, fiberglass, concrete, steel, aluminum, or composite material and manufactured in various heights.

Switch: An electrical device used to sectionalize electrical elements such as distribution lines or transformers.

Transformer: Equipment used to decrease or increase (transform) voltages.

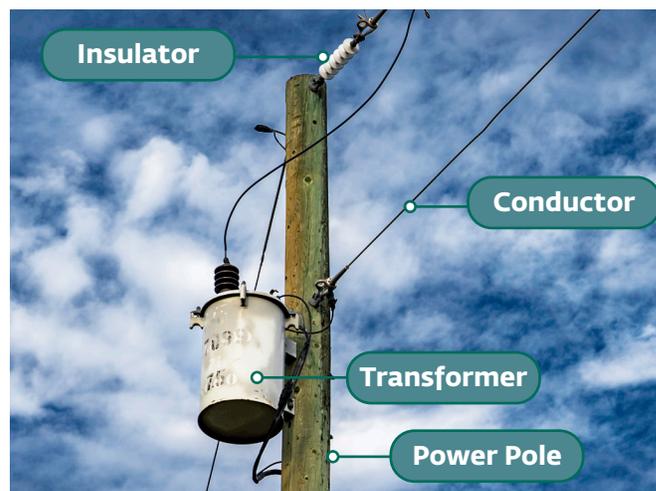
What Causes Bird Electrocution?

Electrocution occurs when a bird's body forms a connection, or bridge, between two energized components at different potentials (different phases) or between an energized and a grounded component. Electrical contact can cause fatalities and serious injuries (such as bone fractures, damage to plumage, and skin injuries) that may later result in the bird's death. Several factors influence electrocution risk: (i) the physical separation between energized (or live) and grounded parts (the electrical design of the pole and mounted components); (ii) the materials used in component design; (iii) the size and behavior of the bird; and (iv) landscape considerations. Electrocution risks vary with the materials used in pole and crossarm design.

Fiberglass composite and wood are nonconductive, while metal and concrete with internal metal support are conductive and provide a pathway to ground. Wood is a good insulator, especially when dry. Figure A shows the mechanism of electrocution between two energized components that can occur with any material. Figures B–H show the mechanisms of electrocution on steel or concrete poles (Beutel et al. 2019).⁵

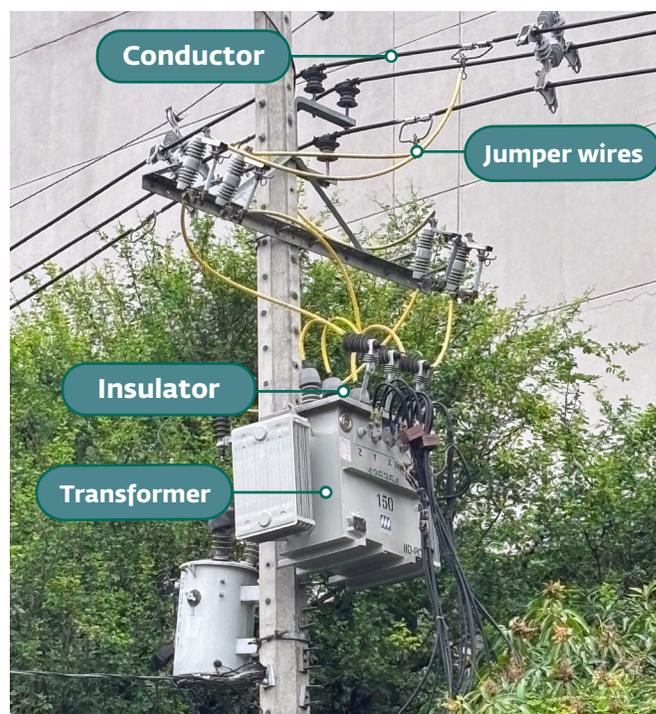
⁵ Electrocution on wooden poles is less common because of the electrical properties of wood, but they could occur depending on factors such as moisture content, age, and treatments applied (see, for example, Beutel et al. [2019]).

Photo 2. Components of a Power Distribution Pole



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Photo 3. Components of a Power Distribution Pole



Source: © Kimberley Joanna Dewhirst / IFC. Further permission required for reuse.

Forming a Connection between Two Energized Components

In figure A, electrocution occurs when a bird makes simultaneous contact with two energized components. In the image, these components are two live conductors. This scenario applies to all types of poles and crossarms. The crossarm design shown is horizontal with upright vertical (or pin) insulators.

Forming a Connection between an Energized Component and a Grounded Component

Electrocution also occurs when a bird touches an energized and a grounded (or earthed) component simultaneously. In figure B, the grounded element is the pole, and electrocution occurs with simultaneous contact with the center energized conductor and the grounded pole. The crossarm design shown is vault or semi-horizontal with suspended insulators.

In figures C-F, the crossarm is the grounded element. In figure C, electrocution occurs with simultaneous contact with an energized conductor and the crossarm. Simultaneous contact with two energized components (the conductors) also poses risk. The crossarms in figures D, E, and F are alternating side-arm designs with pin, suspended, and strain insulators, respectively. As in figure C, electrocution occurs with simultaneous contact with the energized conductors and the crossarms.

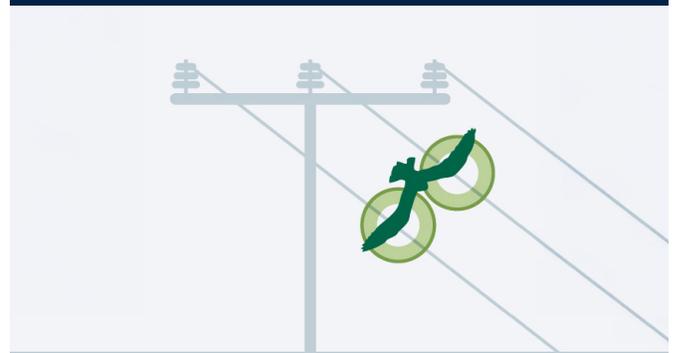
Electrocution occurs less frequently through the formation of an electric arc (figure H) under specific weather conditions. Closely spaced energized components, coupled with high humidity, can increase the likelihood of an electric arc.

Insulator Position and Crossarm Design

Insulator position and crossarm design are key factors in creating a bird-safe distribution line. The arrangement of the insulators that support the conductors determines the placement of the energized components relative to each other and to the grounded components (the geometry of the line) and, by extension, the electrocution risk. For similar reasons, crossarm design also affects electrocution risk. The factors include both the crossarm material (conductive or nonconductive) and its configuration.

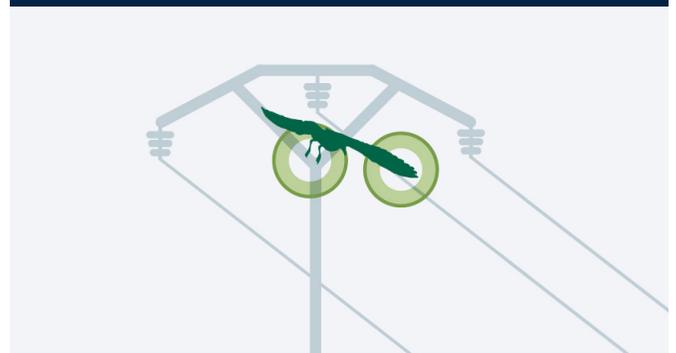
A wide range of insulator types exist, but this guidance focuses on three broad categories: pin, strain, and suspended (see figures H-); section 5 provides guidance on mitigating the risks associated with each type).

Figure A



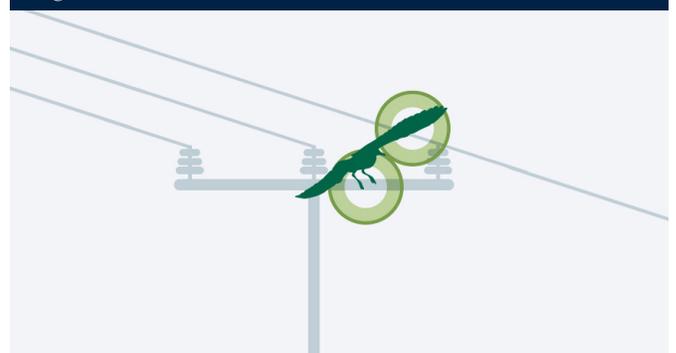
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Figure B



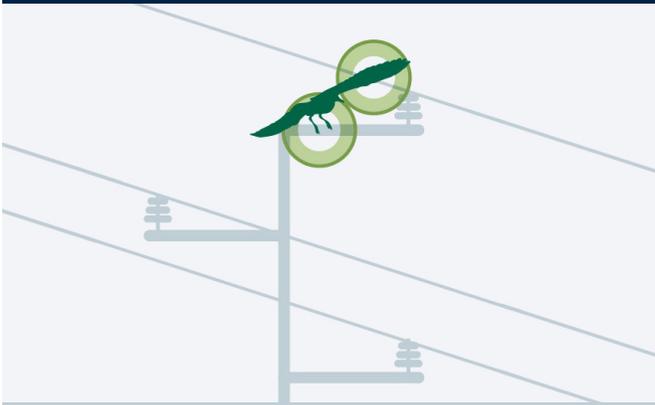
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Figure C



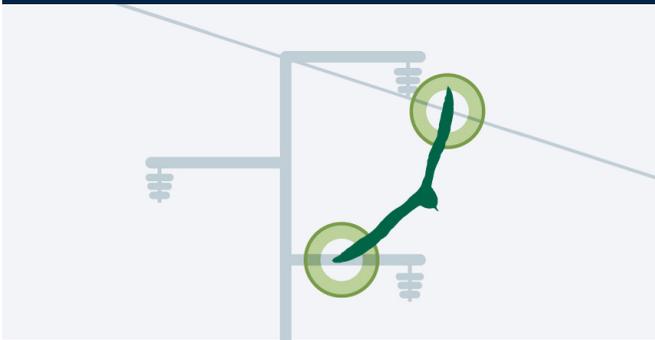
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Figure D



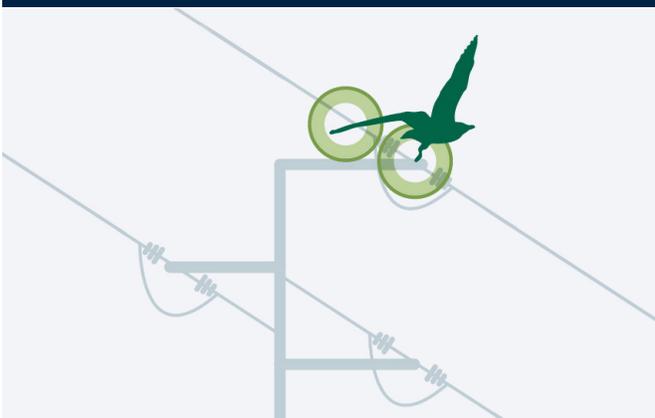
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Figure E



Source: Content in figures has been provided by Martin Martin et al, 2019 and were modified for illustration purposes only

Figure F



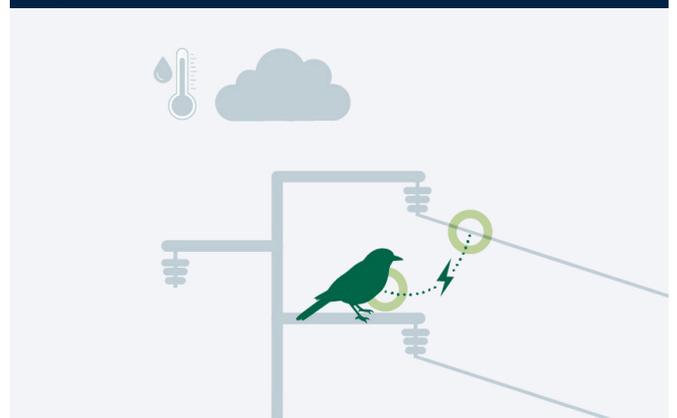
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Pin insulators: Vertical insulators attached to poles in an upright position and mounted on metal pins, holding the conductors above the crossarm, with the conductor fixed on the top of the insulator. Use of upright pin insulators in distribution networks is common in many parts of the world, including emerging markets, for cost and technical reasons. Their upright arrangement increases the likelihood that a bird can make simultaneous contact with energized components or with an energized and grounded component. In the latter scenario, conductors are above the crossarm and accessible to a bird perched on the crossarm. In certain open landscapes with few perching options, crossarm design could compound this risk, such as with a flat-top design with all pin insulators top-mounted (see figure H). This position provides the highest point and could attract birds seeking to perch.

Strain insulators: Insulators often attached in a horizontally mounted position. Placement of the jumpers (in a looping position) relative to the crossarm must be considered when developing a bird-safe design (see figure I).

Suspended insulators: Vertical insulators attached to poles in a suspended (downward) position. They fix the conductors below the crossarm and require a taller power pole than pin insulators (see figure J).

Figure G



Source: Content in figures has been provided by Martin Martin et al, 2019 and were modified for illustration purposes only

Which Types of Birds Are at Risk?

A bird's size and behavior factor into its vulnerability to electrocution. Larger birds, such as large raptors and storks, are at higher risk because they more easily bridge the air gap between energized components or between energized and grounded components. However, even small birds risk electrocution on complicated equipment poles that have transformers, regulators, breakers, and capacitors that support numerous jumpers and that often have additional protective equipment such as surge arresters and fused switches (see section 5, "Reducing Bird Electrocutions through Design," which covers equipment poles). Medium or large species of birds routinely use poles as lookout points, perches, or roosts and thus are at risk the most. Of these species, raptors and corvids are most affected (for example, crows, ravens, and magpies), especially when poles are in places that lack natural perches. Furthermore, electrocutions can increase the risks for these groups—the carcasses of electrocuted birds can attract perching birds of prey or corvids for scavenging, exposing them to greater risk. Gregarious species, such as vultures, are especially at risk because more than one bird could perch on the same pole, increasing the danger of bridging the distance between two energized components or between an energized and a grounded component.

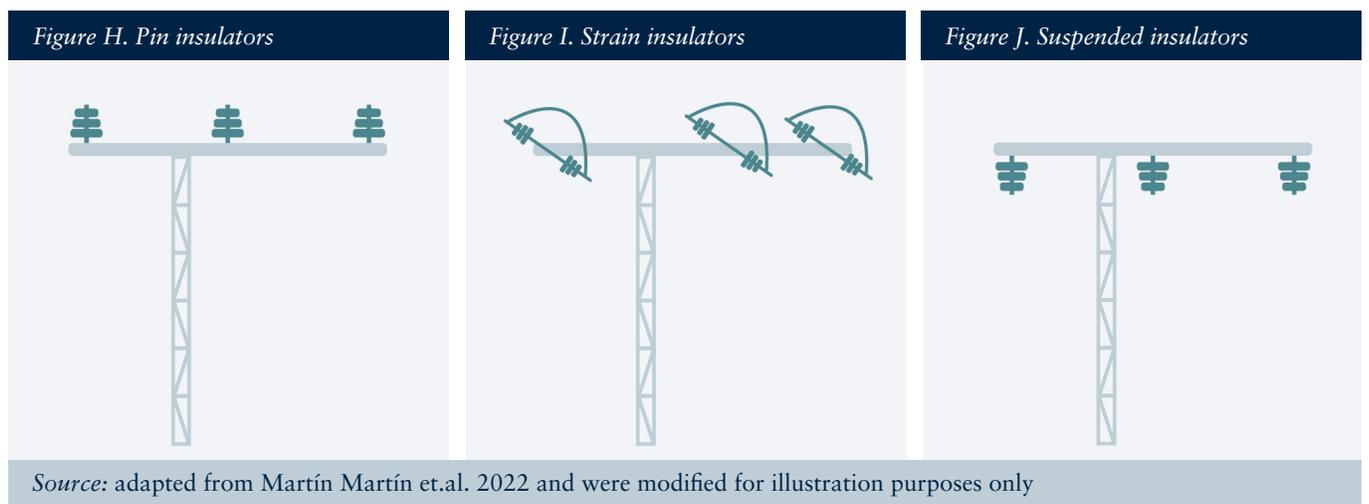
High-Risk Landscapes

Electrocution risk on power lines is higher in certain landscape types or where specific environmental conditions occur. In open landscapes with few natural perches (such as deserts, steppes, grasslands, marshes, and certain agricultural landscapes), birds will use artificial perches to perch and nest. Another high-risk landscape is a migratory bottleneck, where soaring birds gather and often perch while waiting for favorable weather conditions before continuing their journey (Martín Martín et al. 2019). Other high-risk areas include stopover sites within migratory flyways; and prey concentration areas, wetlands, landfills, and open-air dumps that attract certain raptors and storks. In these conditions, the risk of making contact with distribution lines and their associated structures is increased.

Unintended Consequences of Modernizing

Changes associated with modernizing existing lines can increase the electrocution risk, such as replacing wooden poles with steel poles or concrete with reinforcing steel bars. To minimize risks, the design and retrofitting measures presented in sections 5 and 6 should be followed as appropriate.

Figures H - J: Types of insulators. H: Pin insulators, I: Strain insulators with three jumpers below the crossarm, J: Suspended insulators



Source: adapted from Martín Martín et.al. 2022 and were modified for illustration purposes only

5. Reducing Bird Electrocutions through Design

Buried power distribution lines eliminate electrocution risk and are the safest for birds and other wildlife. The safety of aerial lines depends largely on safe distancing, which refers to the spacing between energized components and between energized and grounded components. Implementing safe distancing measures is a permanent solution that reduces electrocution risk effectively because it does not rely on long-term maintenance and is not vulnerable to errors in product selection and installation (as with insulation). Safe distancing should be used in all contexts of electrocution risks to birds and other wildlife, as determined by the project's environmental risk and impact assessment.

Once safe distancing measures have been implemented, or where design parameters defined in national regulations restrict their use, insulation is also an important element for bird-safe distribution lines. As defined in section 4, insulation is the covering of exposed, energized parts with durable and environmentally appropriate material to reduce the electrocution risk to birds.⁶ How insulators are arranged or positioned on power poles is also an important factor.

This section addresses insulator position, safe distancing and insulation, along with other topics essential to reducing bird electrocution risk through design.

Insulator Position

The following design recommendations can reduce electrocution risk associated with insulators.

- **Pin insulators:** Upright pin insulators present the highest electrocution risk and endanger birds, especially when positioned on steel or concrete crossarms. Their use is discouraged unless an overriding safety issue for people exists or a hybrid configuration is proposed.⁷ Where use is unavoidable, incorporating safe distancing measures is essential (see next section). After

applying safe distancing measures, insulation could reduce the electrocution risk to birds even more. However, see notes in "Insulation to Address Risk in New Construction" section below on the importance of maintaining insulation.

- **Strain insulators:** Strain insulators pose particular risk to birds if jumpers are arranged in a looping position over the top of the crossarm. Spacing also requires careful consideration. The length of strain insulators should exceed the wingspan of the largest perching bird in the landscape to prevent perching birds from bridging exposed conductors with their wings. Jumper wires should not loop over the top of the crossarm but should instead be fixed below the conductors and insulators. However, several situations could make this design impracticable: (i) some utility work practices require the center jumper to loop over the top of the crossarm; (ii) double-deadend configurations could require the center jumper to be routed over the top because of clearance constraints; and (iii) jumper routing must conform to utility-specific work practices that may require routing above the crossarm to maintain a safe workspace for line workers. In these cases, the jumper should be fully insulated (or sheathed) and in double-deadend configurations, it should be supported on an insulator.⁸
- **Suspended insulators:** Vertical insulators attached in a suspended position are generally safer than pin insulators because birds perch on the top of the crossarm, and their raised wings during takeoff or landing are unlikely to touch the conductors under the bird's perched position. Special large-diameter discs can also be used with these insulators (including both suspended and strain or transformer bushings).

Safe Distancing

Regardless of insulator position, there must be sufficient separation between the energized components and any grounded element, including any potential perching site under the jumper wires. These distances should be determined *based on the largest, regularly occurring species in the region that would be susceptible to electrocution*. For example, 150 centimeters of horizontal separation and

⁶ Distribution lines also endanger certain mammals. In forested areas where tree-dwelling mammals are present, sheathed wires should at minimum be used to reduce electrocution risk (see footnote 8 for a description of sheath).

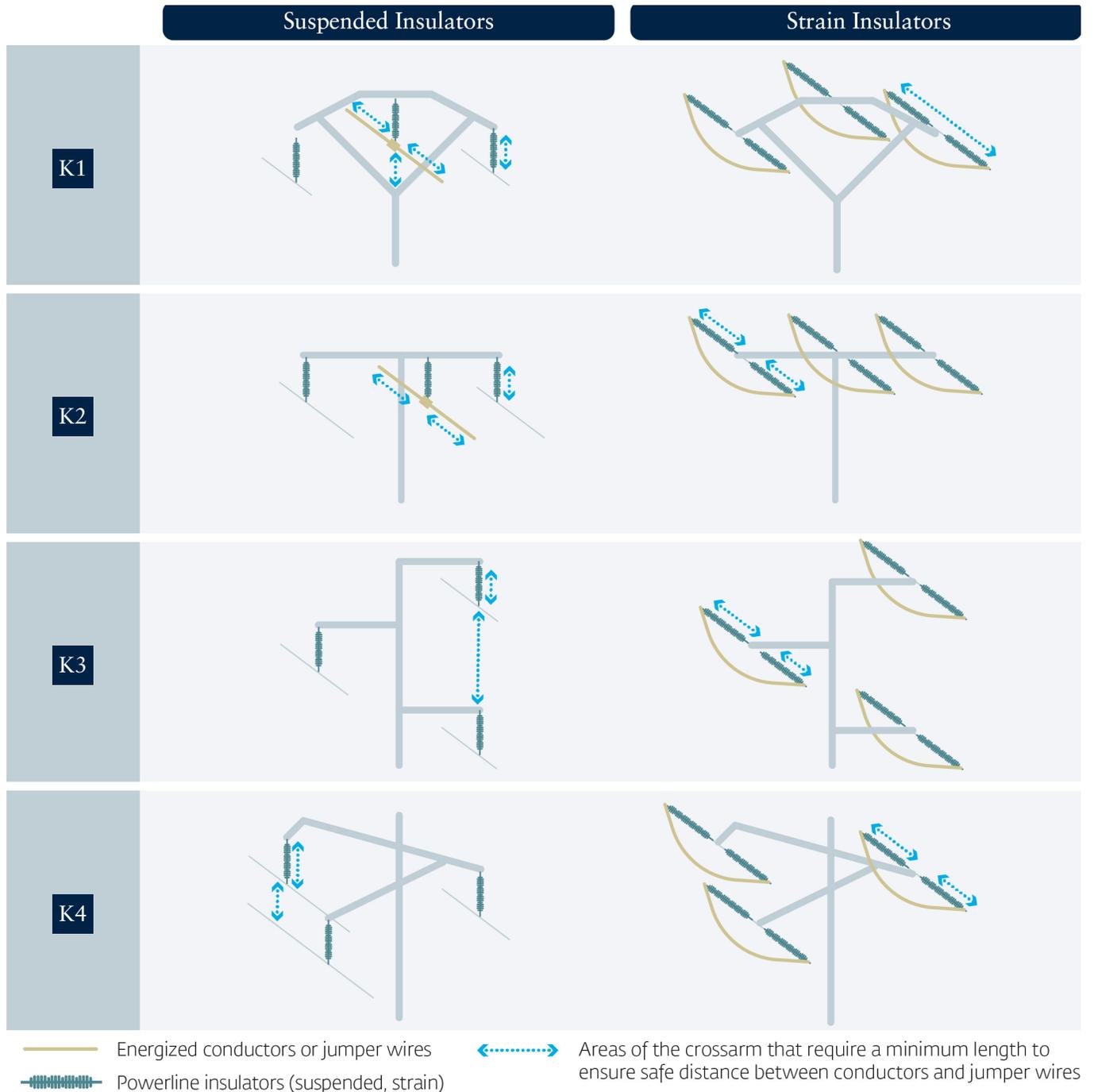
⁷ A hybrid configuration example is a pin insulator for the center conductor with the two suspended insulators for the outer conductors. This design provides adequate distance between the conductors.

⁸ A sheathed jumper is a conductor enclosed in a sheath, typically a thicker, durable outer covering that provides mechanical protection in addition to electrical insulation.

100 centimeters of vertical separation between energized components and between energized and grounded components may be sufficient (APLIC 2006). However, published cases show

that the horizontal and vertical separation needs to increase to account for the wingspans and body sizes of larger bird species such as storks, cranes, or vultures, especially considering their conservation status and the surrounding

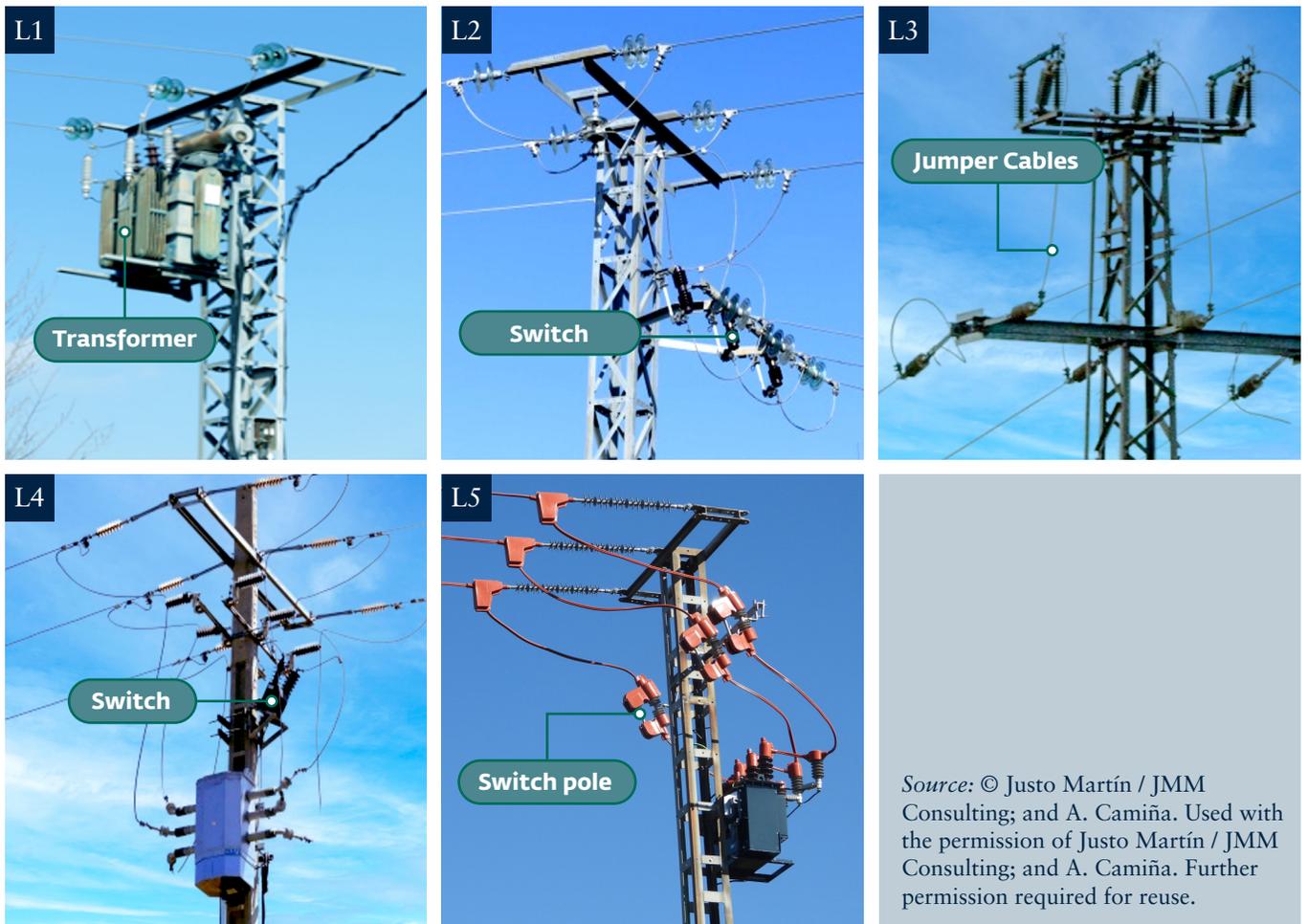
Figure K



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Note: Configurations show crossarms, conductors, insulators, and jumper wires, with blue indicating where safe distancing between these components must be considered. Precise spacing distances depend on the species present. For strain insulators, insulating the jumper wires or using sheathed wires is recommended.

Figure L



Note: Photos are of high-risk equipment poles: L1 transformer pole, L2 derivation or tap pole, L3 and L4: switch poles.

landscape (Göcsei et al. 2014; Martín Martín et al. 2019; Martín Martín et al. 2022).

Basing the safe distance on wingspan, the toe-to-wingtip distance, and the tip of the bill to the tip of the tail distance is recommended.⁹

Figures K1–K4 show examples of safe distancing between energized components using suspended and strain insulators. The color-coding is as follows: (i) gold presents the energized conductors or jumper wires; (ii) teal shows the power line insulators (suspended and strain only), crossarm

and pole; and (iii) blue indicates areas where safe distancing needs to be assessed to establish a bird safe design.

Insulation to Address Risk in New Construction

In certain circumstances, using insulation in new construction safeguards birds effectively. For example, conductors can be fully insulated or grouped to form a single aerially bundled conductor with insulation covering the span wires. Insulating conductors reduces electrocution risk significantly, but the increased costs of such approaches

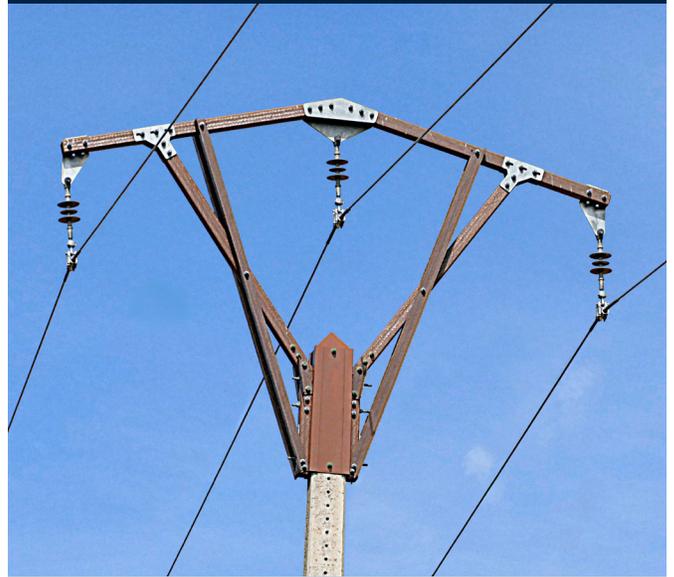
⁹ Wingspan is measured by the wrist-to-wrist distance. The Avian Powerline Interaction Committee defines the wrist as “the joint toward the middle of the leading edge of a bird’s wing; the skin covering the wrist is the outermost fleshy part on the wing” (see “Electrocutions” on the Avian Powerline Interaction Committee website at <https://www.aplic.org/electrocutions> for more information). The Cornell Lab of Ornithology defines tail as “a set of stiff feathers at the rear of the bird arranged in symmetrical pairs on either side of the midline.” It defines bill as “a bony structure extending above and below a bird’s mouth that is covered with a keratin-layer and has evolved into an astonishing variety of shapes and sizes depending on the species’ feeding and courtship habits.” See the Cornell Lab’s All About Bird Anatomy interactive learning tool at <https://academy.allaboutbirds.org/features/birdanatomy/>.

Photo 4



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Photo 5



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must be assessed. Where overriding cost or technical constraints prevent safe distancing or the lower-risk pole configurations discussed, the insulation measures covered in section 6 could be alternatives for reducing bird electrocution risk. Depending on the type of materials used, insulation can require regular, long-term maintenance to remain effective, which might not be realistic in an emerging market context. Decisions on this topic should be made on a case-by-case basis. If insulation is used, the costs of adequate maintenance programs should be included in project operational budgets and lender requirements.

Some companies offer insulated crossarms made from polymeric materials reinforced with fiberglass. Their dielectric properties prevent current transfer through the structural element, ensuring that a bird touching both an energized conductor and the crossarm does not create a conductive path. Safe distancing from other components (such as conductors) is still necessary. See Photos 4 and 5 that show examples of insulated crossarms.

Equipment Support Structures

Vertical structures mounted with electrical equipment typically pose higher electrocution risk (see examples in figures L1 - L5), and fatalities from bird electrocution may concentrate at these structures (Harness and Wilson 2001). The increased number of energized components alone raises risk, but the reduced spatial separation between components compounds those risks. Thus, insulating the various components is the most effective way to reduce electrocution risk (see section 6 on retrofitting for more information). As a general principle for spatial separation, devices such as disconnectors or lightning arresters should be installed on a lower auxiliary arm rather than on the main crossarm. Conductive elements associated with equipment structures should not be placed above the crossarm.

6. Retrofitting Hazardous Lines

When bird-safe design options have not been implemented on an existing operational network, electrocution risk can be reduced through retrofitting. The guidance in this section also applies to where safe distancing may not be feasible, as described above in the “Equipment Support Structures” section.

Retrofitting offers a variety of options for insulating energized and grounded components, and many companies market and design such products. Insulation options include insulator caps, conductor covers, jumper wire covers, bushing covers, and other protective covers that prevent a bird from making the simultaneous contacts described in section 4. Retrofitting options include insulating crossarm components (for example, insulator caps, conductor covers, and jumper wire covers), insulating the pole tops with a cap where poles are conductive, and installing covers on pin insulators and covers on grounded crossarms (see examples in Photos 4 and 5; Dixon et al. 2019). Retrofitting jumper wires below the crossarm can reduce ground clearance or interfere with other pole-mounted infrastructure (such as guy wires and telecom lines), so safe distancing must be verified in these situations. The ultimate objective is to insulate all energized points.

Installing insulated overhead distribution cables as part of new circuits or circuit upgrades to manage illegal electricity connections and minimize damage from vegetation can also reduce bird electrocution risks.

However, retrofitting has drawbacks, including higher costs compared with a safe design, the need to de-energize lines to install these measures and the related potential network reliability issues, and health and safety risks during installation.

Qualified engineers should select the retrofitting materials, and qualified technicians should install and maintain the components. As part of a long-term routine maintenance program, these materials and devices should be monitored regularly and replaced when necessary to maintain effectiveness. Monitoring frequency depends on climatic conditions, the type of material used, and the stress that seasonal conditions place on the components.

Photos 4, 5, and 6 depict center-top pin insulators with a cross configuration. Unless retrofitted with insulation, these types of poles are dangerous both for large and medium-sized birds.

Another retrofitting method replaces the old crossarm with a new insulated one while keeping the existing pole, as described in the section above “Insulation to Address Risk in New Construction.”

Where to Retrofit

The areas to retrofit should be determined through a risk assessment that identifies line spans and vertical support structures where electrocution could occur, placing priority on the highest-risk areas. The assessment must take place during the time of year when electrocution risk is greatest, consider spatial patterns of bird electrocution, and include data on species-specific risk (Biasotto et al. 2022). Qualified specialists must conduct such studies. Alternatively, if the grid operator collects data on when, where, and how often birds disrupt service, those data can be used to prioritize retrofitting (kettel et al. 2022).

Selecting the Right Material

When insulation is used, the insulating material must be durable (for example, resistant to cold, wind, heat, and ultraviolet light) and suited to the local climate. Insulation materials should comply with international standards, such as those of the International Electrotechnical Committee or IEEE.¹⁰ They should be made of environmentally resistant substances such as silicone or ultraviolet-resistant hard polymer resin, with a product life comparable to the component they protect. Rubber should be avoided because it may begin to disintegrate in environments with excessive heat.

Redirection Measures

Certain bird species use powerlines for perching and roosting. Perch deterrents and perch guards create barriers that prevent birds from contacting energized components and ground components. Global research

on the effectiveness of measures to discourage perching and roosting is limited. Highly effective perch deterrents often require more expensive equipment and incur higher installation costs than insulation measures. To be effective,

¹⁰ Although IEEE and International Electrotechnical Committee are broadly aligned, IEEE is targeted largely to the US market.

Photo 6



Source: © Andrew Dixon. Used with the permission of Andrew Dixon. Further permission required for reuse.

Note: An electrocuted Saker falcon on the grounded pole top (Mongolia).

Photo 7



Source: © Raptor Conservation Fund. Used with the permission of Raptor Conservation Fund. Further permission required for reuse.

Note: A retrofitted pole with both the pole-top and crossarm insulated and showing a live Saker Falcon.

perch deterrents must be sized for the target species and installed correctly without compromising electrical clearances. Perch deterrents with excessively sharp edges should be avoided because they can fatally injure birds. Research on the use and design of elevated perches is largely limited to Canada, Europe, and the United States. Qualified specialists should assess the suitability of these measures in all other markets. In all cases, safe design measures and insulation should be fully optimized before implementing redirection options.

Nest Management

Birds also use powerlines for nesting. Nest management measures include stick deflectors, nest removal, and installing artificial nest platforms (Dwyer et al. 2013). Nest management can reduce local breeding populations if artificial or alternate breeding substrates are not available locally. As with redirection measures, research on the use and design of nest platforms outside Europe and North America is limited. Again, qualified specialists should assess the suitability of these measures in all other markets. In all cases, safe design measures and insulation should be fully optimized before implementing these mitigation measures.

Photo 8



Source: © Justo Martín / JMM Consulting. Used with the permission of Justo Martín / JMM Consulting. Further permission required for reuse.

Note: A retrofitted pole with the three conductors and covers for the upright pin insulated (Spain).

7. Conclusions

Electrocution on distribution power lines is a major threat to many bird species and a conservation issue of global importance. Many electrocution-related bird injuries and deaths can be avoided through bird-safe design and retrofitting. The implementation of this tip sheet can help achieve this outcome, which includes the measures summarized below.

- Avoid siting distribution lines in high-risk areas. A qualified specialist should map these areas and consider landscape features, species occurrence, and zones of high transit and use.
- Use underground power distribution lines, which are the safest for birds.
- Maintain safe distancing between energized components and grounded elements. Safe distancing is a permanent solution that does not require maintenance. Although this guidance sets minimum distances as a general benchmark, spacing must ultimately match the largest regularly occurring and at-risk species in the region.
- Use suspension insulators and avoid using upright pin insulators wherever possible. Insulator position and type are key risk factors for bird electrocution. If upright pin insulators cannot be avoided on certain poles, ensure adequate insulation and distancing of energized or grounded components.
- Use insulated overhead distribution cables for new circuits and circuit upgrades. These cables, already used to manage illegal electricity connections and damage from vegetation, are also effective against bird electrocution.
- Loop jumper wires beneath the crossarm when using strain insulators. If wires must loop above the crossarm, they should be insulated.
- Use fully insulated crossarms together with appropriate safe distancing to achieve a bird-safe electricity grid.
- Consider the design of pole-mounted equipment carefully. The concentration of conductive elements on poles increases electrocution risk to birds. Insulate components on the arm and optimize safe distancing, when feasible.
- Identify high-risk segments and poles when retrofitting hazardous lines. Expert advice should guide prioritization of these areas for appropriate mitigation measures.
- Plan for regular, long-term maintenance of insulation, performed by technicians with specialized training. The implementing entity should assess the performance and resourcing of maintenance programs and ensure that maintenance costs are factored adequately into the operational budget.
- Use high-quality insulation materials. Durability varies with product specifications and climate conditions. Qualified engineers should select insulation products and materials that meet International Electrotechnical Committee or IEEE standards (or equivalent), and qualified technicians should install and maintain them.
- Apply redirection and nest management measures with caution. These measure can increase risk or be ineffective and thus incur financial costs without achieving the desired outcome. Implement them only after applying safe distancing and insulation.

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