

Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)¹. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis

¹ Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Electric Power Transmission and Distribution include information relevant to power transmission between a generation facility and a substation located within an electricity grid, in addition to power distribution from a substation to consumers located in residential, commercial, and industrial areas. Annex A provides a summary of industry sector activities.

This document is organized according to the following sections:

- Section 1.0 — Industry-Specific Impacts and Management
- Section 2.0 — Performance Indicators and Monitoring
- Section 3.0 — References and Additional Sources
- Annex A — General Description of Industry Activities

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with electric power transmission and distribution that occur during the construction and operation phases of a facility, along with recommendations for their management. Additional recommendations for the management of environmental issues during the construction and decommissioning phases of power transmission and distribution systems are provided in the **General EHS Guidelines**. Examples of the impacts addressed in the General EHS Guidelines include:

- Construction site waste generation;
- Soil erosion and sediment control from materials sourcing areas and site preparation activities;
- Fugitive dust and other emissions (e.g. from vehicle traffic, land clearing activities, and materials stockpiles);
- Noise from heavy equipment and truck traffic;
- Potential for hazardous materials and oil spills associated with heavy equipment operation and fueling activities.

1.1 Environmental

Environmental issues during the construction phase of power transmission and distribution projects specific to this industry sector include the following:

- Terrestrial habitat alteration
- Aquatic habitat alteration
- Electric and magnetic fields
- Hazardous materials

Terrestrial Habitat Alteration

The construction and maintenance of transmission line rights-of-way, especially those aligned through forested areas, may result in alteration and disruption to terrestrial habitat, including impacts to avian species and an increased risk of forest fires.

Construction of Right-of-Way²

Right-of-way construction activities may transform habitats, depending on the characteristics of existing vegetation, topographic features, and installed height of the transmission lines. Examples of habitat alteration from these activities includes fragmentation of forested habitat; loss of wildlife habitat, including for nesting; establishment of non-native invasive plant species; and visual and auditory disturbance due to the presence of machinery, construction workers, transmission towers, and associated equipment.³

Recommended measures to prevent and control impacts to terrestrial habitats during construction of the right-of-way include:

- Site transmission and distribution rights-of-way, access roads, lines, towers, and substations to avoid critical habitat through use of existing utility and transport corridors for transmission and distribution, and existing roads and tracks for access roads, whenever possible;⁴
- Installation of transmission lines above existing vegetation to avoid land clearing;

² Also known as a "wayleave" or "easement" in some countries, but referred to as right-of-way for the purposes of these Guidelines.

³ Alteration of terrestrial habitat for construction of transmission and distribution projects may also yield benefits for wildlife such as the creation of protective nesting, rearing, and foraging habitat for certain species; the establishment of travel and foraging corridors for ungulates and other large mammals; and nesting and perching opportunities for large bird species atop transmission towers and associated infrastructures. California Energy Commission (2005).

⁴ Considering potential for electrical interference with telecommunication lines and railway lines due to mutual induction.

- Avoidance of construction activities during the breeding season and other sensitive seasons or times of day;
- Revegetation of disturbed areas with native plant species;
- Removal of invasive plant species during routine vegetation maintenance (see right-of-way maintenance section below);
- Management of construction site activities as described in relevant sections of the **General EHS Guidelines**.

Right-of-Way Maintenance

Regular maintenance of vegetation within the rights-of-way is necessary to avoid disruption to overhead power lines and towers. Unchecked growth of tall trees and accumulation of vegetation within rights-of-way may result in a number of impacts, including power outages through contact of branches and trees with transmission lines and towers; ignition of forest and brush fires; corrosion of steel equipment; blocking of equipment access; and interference with critical grounding equipment.

Regular maintenance of rights-of-way to control vegetation may involve the use of mechanical methods, such as mowing or pruning machinery that may disrupt wildlife and their habitats, in addition to manual hand clearing and herbicide use. Vegetation management should not eradicate all vegetation, but aim to maintain trees and plant growth that may negatively affect infrastructure at a level that is under an economically-damaging threshold. Excessive vegetation maintenance may remove unnecessary amounts of vegetation resulting in the continual replacement of successional species and an increased likelihood of the establishment of invasive species.

Recommended measures to prevent and control impacts from right-of-way vegetation maintenance include:

- Implementation of an integrated vegetation management approach (IVM). The selective removal of tall-growing tree species and the encouragement of low-growing grasses and shrubs is the common approach to vegetation management in transmission line rights-of-way. Alternative vegetation management techniques should be selected based on environmental and site considerations including potential impacts to non-target, endangered and threatened species;⁵
- Removal of invasive plant species, whenever possible, cultivating native plant species;
- Scheduling activities to avoid breeding and nesting seasons for any critically endangered or endangered wildlife species;
- Observing manufacturer machinery and equipment guidelines, procedures with regard to noise, and oil spill prevention and emergency response;
- Avoiding clearing in riparian areas;
- Avoiding use of machinery in the vicinity of watercourses.

An integrated approach to vegetation management may indicate that use of herbicides is the preferred approach to control fast-growing vegetation within transmission and distribution rights-of-way. In this case, the following guidance on herbicide application, storage, and handling should be considered.

If herbicides (in this sector, herbicides are the most common type of pesticide used) application is warranted, they should be managed to avoid their migration into off-site land or water

⁵ Mowing with heavy-duty power equipment may be used to control growth of ground covers and prevent the establishment of trees and shrubs in the right-of-way. Herbicides, in combination with mowing, may control fast-growing weedy species that have a potential to mature to heights over those permitted within the right-of-way. Trimming and pruning may be utilized at the boundaries of rights-of-way to maintain corridor breadth and prevent the encroachment of tree branches. Hand removal or removal of vegetation, while labor intensive, may be used in the vicinity of structures, streams, fences, and other obstructions which make the use of machinery difficult or dangerous.

environments (see Pesticides under the Hazardous Materials section).

Forest Fires

If underlying growth is left unchecked, or slash from routine maintenance is left to accumulate within right-of-way boundaries, sufficient fuel can accumulate that may promote forest fires.

Recommended measures to prevent and control risk of forest fire include:

- Monitoring right-of-way vegetation according to fire risk;⁶
- Removing blowdown and other high-hazard fuel accumulations;
- Time thinning, slashing, and other maintenance activities to avoid forest fire seasons;
- Disposal of maintenance slash by truck or controlled burning⁷. Controlled burning should adhere to applicable burning regulations, fire suppression equipment requirements, and typically must be monitored by a fire watcher;
- Planting and managing fire resistant species (e.g. hardwoods) within, and adjacent to, rights-of-way;
- Establishing a network of fuel breaks of less flammable materials or cleared land to slow progress of fires and allow fire fighting access.

⁶ As an example, the British Columbia Transmission Corporation (BCTC) maintains a Wildfire Risk Management System (WRMS) that classifies wildfire risk and provides a variety of corresponding mitigation measures. See (Blackwell et al., 2004).

⁷ Controlled burning should only be performed after considering potential impacts to air quality and according to the local air quality management requirements.

Avian and Bat Collisions and Electrocutions

The combination of the height of transmission towers and distribution poles and the electricity carried by transmission and distribution lines can pose potentially fatal risk to birds and bats through collisions and electrocutions.⁸ Avian collisions with power lines can occur in large numbers if located within daily flyways or migration corridors, or if groups are traveling at night or during low light conditions (e.g. dense fog).⁹ In addition, bird and bat collisions with power lines may result in power outages and fires.

Recommended prevention and control measures to minimize avian and bat collisions and electrocutions include¹⁰:

- Aligning transmission corridors to avoid critical habitats (e.g. nesting grounds, heronries, rookeries, bat foraging corridors, and migration corridors);
- Maintaining 1.5 meter (60-inch)¹¹ spacing between energized components and grounded hardware or, where spacing is not feasible, covering energized parts and hardware;
- Retrofitting existing transmission or distribution systems by installing elevated perches, insulating jumper loops, placing obstructive perch deterrents (e.g. insulated "V"s"), changing the location of conductors, and / or using raptor hoods;¹²

⁸ Birds and bats may be electrocuted by power lines in one of three ways: i) Simultaneously touching an energized wire and a neutral wire; ii) Simultaneously touching two live wires; and iii) Simultaneously touching an energized wire and any other piece of equipment on a pole or tower that is bonded to the earth through a ground wire. Raptor Protection Video Group (2000)

⁹ Larger species (e.g. hawks, falcons, owls, vultures, cranes, egrets, and ravens) are at particular risk of simultaneously touching two wires or components while flying due to their long wingspans. Anderson (1991)

¹⁰ Further information is available from Avian Power Line Interaction Committee (2005) and the U.S. Fish and Wildlife Service (2005).

¹¹ Manville (2005)

¹² California Energy Commission (2005)

- Considering the installation of underground transmission and distribution lines in sensitive areas (e.g. critical natural habitats);
- Installing visibility enhancement objects such as marker balls, bird deterrents, or diverters.¹³

Aquatic Habitat Alteration

Power transmission and distribution lines, and associated access roads and facilities, may require construction of corridors crossing aquatic habitats that may disrupt watercourses and wetlands, and require the removal of riparian vegetation. In addition, sediment and erosion from construction activities and storm water runoff may increase turbidity of surface watercourses.

Recommended measures to prevent and control impacts to aquatic habitats include:

- Site power transmission towers and substations to avoid critical aquatic habitat (e.g. watercourses, wetlands, and riparian areas), as well as fish spawning habitat, and critical fish over-wintering habitat;
- Maintaining fish access when road crossings of watercourses are unavoidable by utilizing clearspan bridges, open-bottom culverts, or other approved methods;
- Minimizing clearing and disruption to riparian vegetation;
- Management of construction site activities as described in the relevant sections of the **General EHS Guidelines**.

Marine Habitat Alteration

Transmission across ocean stretches may require use of submarine transmission cables on the ocean floor. Submarine

cables are also occasionally used to transmit high-voltage power across long stretches of water to islands and other locations that are inaccessible by conventional techniques. Cables are installed using a cable-laying vessel and a remotely operated, underwater vehicle. Issues associated with marine habitat alteration include disruption to intertidal vegetation (e.g. eelgrass), coral reefs, and marine life, including marine mammals, and sedimentation resulting in turbidity and reductions in water quality.

Recommended measures to prevent and control impacts to marine habitats include:

- Locating and siting cable routes, and shore access, to avoid critical marine habitats (e.g. breeding grounds and eelgrass) and coral reefs;
- Burying submarine cables when traversing sensitive intertidal habitat;
- Monitoring cable laying path for presence of marine mammals;
- Avoiding laying submarine cable during fish and marine mammals breeding periods, calving periods, and spawning seasons.

Electric and Magnetic Fields

Electric and magnetic fields (EMF) are invisible lines of force emitted by and surrounding any electrical device (e.g. power lines and electrical equipment). Electric fields are produced by voltage and increase in strength as the voltage increases. Electric field strength is measured in volts per meter (V/m). Magnetic fields result from the flow of electric current and increase in strength as the current increases. Magnetic fields are measured in units of gauss (G) or tesla (T), where 1T equals 10,000G. Electric fields are shielded by materials that conduct electricity, and other materials, such as trees and building

¹³ Several studies have found that bird diverters that are installed to increase the visibility of power lines reduce collision rates considerably. Crowder and Rhodes (1999).

materials. Magnetic fields pass through most materials and are difficult to shield. Both electric and magnetic fields decrease rapidly with distance. Power frequency EMF typically has a frequency in the range of 50 – 60 Hertz (Hz), and is considered Extremely Low Frequency (ELF).¹⁴

Although there is public and scientific concern over the potential health effects associated with exposure to EMF (not only high-voltage power lines and substations, but also from everyday household uses of electricity), there is no empirical data demonstrating adverse health effects from exposure to typical EMF levels from power transmissions lines and equipment.¹⁵ However, while the evidence of adverse health risks is weak, it is still sufficient to warrant limited concern.¹⁶

Recommendations applicable to the management of EMF exposures include:

- Evaluating potential exposure to the public against the reference levels developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).^{17,18} Average and peak exposure levels should

remain below the ICNIRP recommendation for General Public Exposure¹⁹;

- Considering siting new facilities so as to avoid or minimize exposure to the public. Installation of transmission lines or other high voltage equipment above or adjacent to residential properties or other locations intended for highly frequent human occupancy, (e.g. schools or offices), should be avoided;
- If EMF levels are confirmed or expected to be above the recommended exposure limits, application of engineering techniques should be considered to reduce the EMF produced by power lines, substations, or transformers. Examples of these techniques include:
 - Shielding with specific metal alloys²⁰
 - Burying transmission lines²¹
 - Increasing height of transmission towers
 - Modifications to size, spacing, and configuration of conductors

Hazardous Materials

Hazardous materials in this sector include insulating oils / gases (e.g. Polychlorinated Biphenyls [PCB] and sulfur hexafluoride [SF₆], and fuels, in addition to chemicals or products for wood preservation for poles and associated wood construction material. The use of herbicides for right-of-way vegetation maintenance is discussed in the above section on 'Right-of-Way Maintenance'.

¹⁴ National Institute of Environmental Health Sciences (2002)

¹⁵ International Commission on Non-Ionizing Radiation Protection (ICNIRP) (2001); International Agency for Research on Cancer (2002); U.S. National Institute of Health (2002); Advisory Group to the Radiation Protection Board of the UK (2001), and U.S. National Institute of Environmental Health Sciences (1999).

¹⁶ U.S. National Institute of Environmental Health Sciences (2002)

¹⁷ ICNIRP is a non-governmental organization formally recognized by the World Health Organization (WHO), which published the "Guidelines for Limiting Exposure to Time-varying Electric, Magnetic, and Electromagnetic Fields" following reviews of all the peer-reviewed scientific literature, including thermal and non-thermal effects. The standards are based on evaluations of biological effects that have been established to have health consequences. The main conclusion from the WHO reviews is that exposures below the limits recommended by the ICNIRP international guidelines do not appear to have any known consequence on health.

¹⁸ An additional source of information is the Institute of Electrical and Electronics Engineers. See IEEE (2005).

¹⁹ The ICNIRP exposure guidelines for General Public Exposure are listed in Section 2.1 of this Guideline.

²⁰ This is effective for reduction of electric field exposure, but not for reduction of magnetic field exposure.

²¹ Ibid.

Insulating Oils and Fuels

Highly-refined, mineral insulating oils are used to cool transformers and provide electrical insulation between live components. They are typically found in the largest quantities at electrical substations and maintenance shops. Sulfur Hexafluoride (SF₆) may also be used as a gas insulator for electrical switching equipment and in cables, tubular transmission lines, and transformers. SF₆ may be used as an alternative to insulating oils. However, the use of SF₆, a greenhouse gas with a significantly higher global warming potential (GWP) than CO₂, should be minimized. In cases the gas is used for applications involving high voltages (>350 KV), equipment with a low leakage- rate (<99 percent) should be used.

Liquid petroleum fuels for vehicles and other equipment may also be used and stored at transmission and distribution projects. Recommendations for prevention and control of hazards associated with spill prevention, emergency response, clean-up, and contaminated soil remediation are addressed in the **General EHS Guidelines**.

Polychlorinated Biphenyls (PCB) were widely used as a dielectric fluid to provide electrical insulation, although their use has been largely discontinued due to potential harmful effects on human health and the environment. Recommendations for the management of PCB include:

- Replacing existing transformers and other electrical equipment containing PCB, and ensuring appropriate storage, decontamination, and disposal of contaminated units;
- Prior to final disposal, retired transformers and equipment containing PCB should be stored on a concrete pad with curbs sufficient to contain the liquid contents of these

containers should they be spilled or leaked. The storage area should also have a roof to prevent precipitation from collecting in the storage area. Disposal should involve facilities capable of safely transporting and disposing of hazardous waste containing PCB;²²

- Surrounding soil exposed to PCB leakage from equipment should be assessed, and appropriate removal and / or remediation measures should be implemented, as addressed in the section on contaminated soil in the **General EHS Guidelines**.

Wood Preservatives

The majority of wooden utility poles are treated with pesticide preservatives to protect against insects, bacteria, and fungi, and to prevent rot. The preservatives most commonly used for power poles are oil-based pesticides such as creosote, pentachlorophenol (PCP), and chromated copper arsenate (CCA). Use of these preservatives is being limited in some countries due to their toxic effects on the environment. While in use, poles may leach preservatives into soils and groundwater, however, levels are highest directly beside poles and decrease to within normal levels at approximately 30 centimeters (cm) distance from the pole.²³ The most significant potential environmental impacts occur at specialized wood treatment facilities if not managed appropriately.

Poles should be pretreated at an appropriate facility to ensure chemical fixation and prevent leaching, and to impede the formation of surface residues at the right-of-way²⁴. Further

²² For a complete discussion on the identification and management of PCB in this industry sector, please see the UNEP publication "PCB Transformers and Capacitors: From Management to Reclassification and Disposal" (2002). Available at: <http://www.chem.unep.ch/pops/pdf/PCBtranscap.pdf>

²³ Zagury et al. (2003)

²⁴ Lebow and Tippie (2001)

information is available in the **EHS Guidelines for Sawmilling and Wood-based Products**.

Recommended measures to prevent and control the impacts of wood preservatives at the point of use include:

- Evaluating the cost and benefit of using alternative pole materials (e.g. steel, concrete, and fiberglass);
- Consider use of alternative preservatives (e.g. copper azote);
- Undertake appropriate disposal of used poles. Landfill facilities should be capable of handling wastes that may have chemical leaching properties. Disposal through incineration or through recycling should consider associated air emissions and secondary product residues of preservative chemicals.

Pesticides

Pesticide use should be established as part of an Integrated Pest Management (IPM) strategy and a documented Pest Management Plan (PMP). The following stages should be considered when designing and implementing an IPM strategy, giving preference to alternative pest management strategies, with the use of synthetic chemical pesticides as a last option.

Alternatives to Pesticide Application - The following alternatives to pesticides should be considered:

- Provide those responsible for deciding on pesticides application with training in pest identification, weed identification, and field scouting;
- Use mechanical weed control and / or thermal weeding;
- Support and use beneficial organisms, such as insects, birds, mites, and microbial agents, to perform biological control of pests;

- Protect natural enemies of pests by providing a favorable habitat, such as bushes for nesting sites and other original vegetation that can house pest predators;
- Use animals to graze areas and manage plant coverage;
- Use mechanical controls such as traps, barriers, light, and sound to kill, relocate, or repel pests.

Pesticide Application - If pesticide application is warranted, users should take the following precautions:

- Train personnel to apply pesticides and ensure that personnel have received applicable certifications or equivalent training where such certifications are not required;²⁵
- Review the manufacturer's directions on maximum recommended dosage or treatment, as well as published reports on using the reduced rate of pesticide application without loss of effect, and apply the minimum effective dose;
- Apply pesticides based on criteria (e.g. field observations, weather data, time of treatment, and dosage) and maintain a pesticide logbook to record such information;
- Avoid the use of pesticides that fall under the World Health Organization Recommended Classification of Pesticides by Hazard Classes 1a and 1b;
- Avoid the use of pesticides that fall under the World Health Organization Recommended Classification of Pesticides by Hazard Class II if the project host country lacks restrictions on distribution and use of these chemicals, or if they are likely to be accessible to personnel without proper training,

²⁵ Examples of certification schemes are provided by the US EPA (2006), which classifies pesticides as either "unclassified" or "restricted" and requires workers that apply unclassified pesticides to be trained according to the Worker Protection Standard (40 CFR Part 170) for Agricultural Pesticides. It further requires restricted pesticides to be applied by or in the presence of a certified pesticide applicator.

equipment, and facilities to handle, store, apply, and dispose of these products properly;

- Avoid the use of pesticides listed in Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention;²⁶
- Use only pesticides that are manufactured under license and registered and approved by the appropriate authority and in accordance with the Food and Agriculture Organization's (FAO) International Code of Conduct on the Distribution and Use of Pesticides²⁷;
- Use only pesticides that are labeled in accordance with international standards and norms, such as the FAO Revised Guidelines for Good Labeling Practice for Pesticides²⁸;
- Select application technologies and practices designed to reduce unintentional drift or runoff only as indicated in an IPM program, and under controlled conditions;
- Maintain and calibrate pesticide application equipment in accordance with manufacturer's recommendations;
- Establish untreated buffer zones or strips along water sources, rivers, streams, ponds, lakes, and ditches to help protect water resources.

Pesticide Handling and Storage - Contamination of soils, groundwater, or surface water resources, due to accidental spills during transfer, mixing, and storage of pesticides should be prevented by following the hazardous materials storage and handling recommendations presented in the **General EHS Guidelines**. Additional recommendations include the following:

- Store pesticides in their original packaging, in a dedicated, dry, cool, frost-free, and well aerated location that can be locked and properly identified with signs, with access limited to authorized people²⁹. No human or animal food may be stored in this location. The store room should also be designed with spill containment measures and sited in consideration of potential for contamination of soil and water resources;
- Mixing and transfer of pesticides should be undertaken by trained personnel in ventilated and well lit areas, using containers designed and dedicated for this purpose.
- Containers should not be used for any other purpose (e.g. drinking water). Contaminated containers should be handled as hazardous waste, and should be treated accordingly. Disposal of containers contaminated with pesticides should be done in a manner consistent with FAO guidelines and with manufacturer's directions;³⁰
- Purchase and store no more pesticide than needed and rotate stock using a "first-in, first-out" principle so that pesticides do not become obsolete.³¹ Additionally, the use of obsolete pesticides should be avoided under all circumstances;³² A management plan that includes measures for the containment, storage and ultimate destruction of all obsolete stocks should be prepared in accordance to guidelines by FAO and consistent with country commitments under the Stockholm, Rotterdam and Basel Conventions.
- Collect rinse water from equipment cleaning for reuse (such as for the dilution of identical pesticides to concentrations used for application);

²⁶ The Stockholm Convention on Persistent Organic Pollutants (2001) controls the use of the following POPs-pesticides: Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex, and Toxaphene.

²⁷ FAO (2002)

²⁸ FAO (2000)

²⁹ FAO (2002)

³⁰ See FAO Guidelines for the Disposal of Waste Pesticides and Pesticide Containers.

³¹ See FAO (1996).

³² See the FAO publication on pesticide storage and stock control manual. FAO Pesticide Disposal Series No. 3 (1996).

- Ensure that protective clothing worn during pesticide application is either cleaned or disposed of in an environmentally responsible manner
- Implement groundwater supply wellhead setbacks for pesticide application and storage
- Maintain records of pesticide use and effectiveness.

1.2 Occupational Health and Safety

Most occupational health and safety issues during the construction, operation, maintenance, and decommissioning of electric power distribution projects are common to those of large industrial facilities, and their prevention and control is discussed in the **General EHS Guidelines**. These impacts include, among others, exposure to physical hazards from use of heavy equipment and cranes; trip and fall hazards; exposure to dust and noise; falling objects; work in confined spaces; exposure to hazardous materials; and exposure to electrical hazards from the use of tools and machinery.

Occupational health and safety hazards specific to electric power transmission and distribution projects primarily include:

- Live power lines
- Working at height
- Electric and magnetic fields
- Exposure to chemicals

Live Power Lines

Workers may be exposed to occupational hazards from contact with live power lines during construction, maintenance, and operation activities. Prevention and control measures associated with live power lines include:

- Only allowing trained and certified workers to install, maintain, or repair electrical equipment;

- Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity, to the lines;
- Ensuring that live-wire work is conducted by trained workers with strict adherence to specific safety and insulation standards. Qualified or trained employees working on transmission or distribution systems should be able to achieve the following³³:
 - Distinguish live parts from other parts of the electrical system
 - Determine the voltage of live parts
 - Understand the minimum approach distances outlined for specific live line voltages
 - Ensure proper use of special safety equipment and procedures when working near or on exposed energized parts of an electrical system
- Workers should not approach an exposed energized or conductive part even if properly trained unless:
 - The worker is properly insulated from the energized part with gloves or other approved insulation; or,
 - The energized part is properly insulated from the worker and any other conductive object; or,
 - The worker is properly isolated and insulated from any other conductive object (live-line work).
- Where maintenance and operation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined in a health and safety plan. (Table 2 in Section 2.2 provides recommended minimum safety setbacks for workers);

³³ Further information is available from the Occupational Safety and Health Administration (OSHA). Available at: <http://www.osha.gov/SLTC/powertransmission/standards.html>

- Workers not directly associated with power transmission and distribution activities who are operating around power lines or power substations should adhere to local legislation, standards, and guidelines relating to minimum approach distances for excavations, tools, vehicles, pruning, and other activities;
- Minimum hot stick distances may only be reduced provided that the distance remaining is greater than the distance between the energized part and a grounded surface.

Working at height on poles and structures

Workers may be exposed to occupational hazards when working at elevation during construction, maintenance, and operation activities. Prevention and control measures for working at height include:

- Testing structures for integrity prior to undertaking work;
- Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others;
- Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point;
- Installation of fixtures on tower components to facilitate the use of fall protection systems;
- Provision of an adequate work-positioning device system for workers. Connectors on positioning systems should be

compatible with the tower components to which they are attached;

- Hoisting equipment should be properly rated and maintained and hoist operators properly trained;
- Safety belts should be of not less than 16 millimeters (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibers become evident;
- When operating power tools at height, workers should use a second (backup) safety strap;
- Signs and other obstructions should be removed from poles or structures prior to undertaking work;
- An approved tool bag should be used for raising or lowering tools or materials to workers on structures.

Electric and magnetic fields

Electric and magnetic fields (EMF) are described in Section 1.1 above. Electric utility workers typically have a higher exposure to EMF than the general public due to working in proximity to electric power lines.^{34,35} Occupational EMF exposure should be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

- Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities;

³⁴ A 1994 study estimated the average exposure of electrical workers (including jobs in electric utilities and other industries) in Los Angeles, California to be 9.6 milligauss (mG), compared to 1.7 mG for workers in other fields (S. J. London et al., 1994).

³⁵ Although detailed studies of workplace exposure to EMF in the United States, Canada, France, England, and several Northern European countries have found no conclusive link or correlation between typical occupational EMF exposure and adverse health effects, some studies have identified a possible association between occupational exposure to EMF and cancer, such as brain cancer (U.S. National Institute of Environmental Health Sciences 2002) indicating there is evidence to warrant limited concern.

- Training of workers in the identification of occupational EMF levels and hazards;
- Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers;
- Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the Institute of Electrical and Electronics Engineers (IEEE)³⁶. Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

Exposure to chemicals

Occupational exposures to chemicals in this sector primarily include handling of pesticides (herbicides) used for right-of-way maintenance, and exposure to PCB in transformers and other electrical components.

Pesticides

Occupational health and safety impacts associated with pesticides are similar to those for other hazardous substances, and their prevention and control are discussed in the **General EHS Guidelines**. Potential exposures to pesticides include dermal contact and inhalation during their storage, preparation

³⁶ The ICNIRP exposure guidelines for Occupational Exposure are listed in Section 2.2 of this Guideline.

and application. The effect of such impacts may be increased by climatic conditions such as wind, which may increase the chance of unintended drift, or high temperatures, which may deter the use of personal protective equipment (PPE).

Recommendations specific to the use of pesticides include:

- Train personnel to apply pesticides and ensure that personnel have received the necessary certifications,³⁷ or equivalent training where such certifications are not required;
- Respect post-treatment intervals to avoid operator exposure during reentry to crops with residues of pesticides;
- Ensure hygiene practices are followed (in accordance to FAO and PMP) to avoid exposure of family members to pesticides residues.

PCBs

Maintenance shops and other facilities, and activities may involve potential contact with PCB or PCB-contaminated machinery. Recommendations for chemical exposure, including PCB, are addressed in the **General EHS Guidelines**.³⁸

1.3 Community Health and Safety

Community health and safety impacts during the construction and decommissioning of transmission and distribution power lines are common to those of most large industrial facilities, and

³⁷ The US EPA classifies pesticides as either "unclassified" or "restricted." All workers that apply unclassified pesticides must be trained according to the Worker Protection Standard (40 CFR Part 170 and 171) for Agricultural Pesticides. Restricted pesticides must be applied by or in the presence of a certified pesticide applicator. For more information, see <http://www.epa.gov/pesticides/health/worker.htm>

³⁸ Further information on the management of occupational exposure to PCB can be obtained at UNEP publication "PCB Transformers and Capacitors: From Management to Reclassification and Disposal" (2002) available at: <http://www.chem.unep.ch/pops/pdf/PCBtranscap.pdf>

are discussed in the **General EHS Guidelines**. These impacts include, among others, dust, noise, and vibration from construction vehicle transit, and communicable diseases associated with the influx of temporary construction labor. In addition to general health and safety standards outlined in the **General EHS Guidelines**, the operation of live power distribution lines and substations may generate the following industry-specific impacts:

- Electrocutation
- Electromagnetic interference
- Visual amenity
- Noise and Ozone
- Aircraft Navigation Safety

Electrocutation

Hazards most directly related to power transmission and distribution lines and facilities occur as a result of electrocutation from direct contact with high-voltage electricity or from contact with tools, vehicles, ladders, or other devices that are in contact with high-voltage electricity. Recommended techniques to prevent these hazards include:

- Use of signs, barriers (e.g. locks on doors, use of gates, use of steel posts surrounding transmission towers, particularly in urban areas), and education / public outreach to prevent public contact with potentially dangerous equipment;
- Grounding conducting objects (e.g. fences or other metallic structures) installed near power lines, to prevent shock.

Electromagnetic Interference

The corona of overhead transmission line conductors and high-frequency currents of overhead transmission lines may result in

the creation of radio noise. Typically, transmission line rights-of-way and conductor bundles are created to ensure radio reception at the outside limits remains normal. However, periods of rain, sleet or freezing rain sharply increases the streaming corona on conductors and may affect radio reception in residential areas near transmission lines.

Visual Amenity

Power transmission and distribution are necessary to transport energy from power facilities to residential communities, but may be visually intrusive and undesirable to local residents. To mitigate the visual impact of power distribution projects, the following mitigation measures should be implemented:

- Extensive public consultation during the planning of power line and power line right-of-way locations;
- Accurate assessment of changes in property values due to power line proximity;
- Siting power lines, and designing substations, with due consideration to landscape views and important environmental and community features;
- Location of high-voltage transmission and distribution lines in less populated areas, where possible;
- Burying transmission or distribution lines when power must be transported through dense residential or commercial areas.

Noise and Ozone

Noise in the form of buzzing or humming can often be heard around transformers or high voltage power lines producing corona. Ozone, a colorless gas with a pungent odor, may also be produced. Neither the noise nor ozone produced by power

distribution lines or transformers carries any known health risks.³⁹

The acoustic noise produced by transmission lines is greater with high voltage power lines (400-800 kilo volts [kV]) and even greater with ultra-high voltage lines (1000 kV and higher)⁴⁰. Noise from transmission lines reaches its maximum during periods of precipitation, including rain, sleet, snow or hail, or as the result of fog. The sound of rain typically masks the increase in noise produced by the transmission lines, but during other forms of precipitation (e.g. snow and sleet) and fog, the noise from overhead power lines can be troubling to nearby residents.

Measures to mitigate this impact may be addressed during project planning stages to locate rights-of-way away from human receptors, to the extent possible. Use of noise barriers or noise canceling acoustic devices should be considered as necessary.

Aircraft Navigation Safety

Power transmission towers, if located near an airport or known flight paths, can impact aircraft safety directly through collision or indirectly through radar interference. Aircraft collision impacts may be mitigated by:

- Avoiding the siting of transmission lines and towers close to airports and outside of known flight path envelopes;
- Consultation with regulatory air traffic authorities prior to installation;
- Adherence to regional or national air traffic safety regulations;
- Use of buried lines when installation is required in flight sensitive areas.

³⁹ WHO (1998)

⁴⁰ Gerasimov (2003)

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

The power transmission and distribution sector does not typically give rise to significant air emissions or effluents. Where dust or potentially contaminated water runoff exists, site operations should comply with principles and guidelines described in the **General EHS Guidelines** to meet ambient air and surface water guidelines. Table 1 lists exposure limits for general public exposure to electric and magnetic fields published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

Table 1. ICNIRP exposure limits for general public exposure to electric and magnetic fields.		
Frequency	Electric Field (V/m)	Magnetic Field (μT)
50 Hz	5000	100
60 Hz	4150	83
Source: ICNIRP (1998) : "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).		

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored.

Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),⁴¹ the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),⁴² Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),⁴³ Indicative Occupational Exposure Limit Values published by European Union member states,⁴⁴ or other similar sources.

Additional indicators specifically applicable to electric power transmission and distribution activities include the minimum safe working distances for trained employees listed in Table 2 and the ICNIRP exposure limits for occupational exposure to electric and magnetic fields listed in Table 3.

⁴¹ Available at: <http://www.acgih.org/TLV/> and <http://www.acgih.org/store/>

⁴² Available at: <http://www.cdc.gov/niosh/hpg/>

⁴³ Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARD&p_id=9992

⁴⁴ Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

Table 2. Alternating Current - Minimum Working Distances for Trained Employees^a

Voltage Range (phase to phase – Kilovolts)	Minimum Working and Clear Hot Stick Distance (meters)
2.1 to 15	0.6
15.1 to 35	0.71
35.1 to 46	0.76
46.1 to 72.5	0.91
72.6 to 121	1.01
138 to 145	1.06
161 to 169	1.11
230 to 242	1.5
345 to 362	2.13 ^b
500 to 552	3.35 ^b
700 to 765	4.5 ^b

^a OSHA
^b NOTE: From 345-362 kv., 500-552 kv., and 700-765 kv., the minimum working distance and the minimum clear hot stick distance may be reduced provided that such distances are not less than the shortest distance between the energized part and a grounded surface.

Table 3. ICNIRP exposure limits for occupational exposure to electric and magnetic fields.

Frequency	Electric Field (V/m)	Magnetic Field (μT)
50 Hz	10,000	500
60 Hz	8300	415

Source: ICNIRP (1998) : "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)"

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with

published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)⁴⁵.

Occupational Health and Safety Monitoring

The working environment should be occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals⁴⁶ as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

⁴⁵ Available at: <http://www.bls.gov/iif/> and <http://www.hse.gov.uk/statistics/index.htm>

⁴⁶ Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

Electric power transmission is the bulk transfer of electricity from one place to another. Typically, power transmission occurs between a power generation facility and a substation located in close proximity to consumers. Power distribution refers to the delivery of electricity from a substation to consumers located in residential, commercial, and industrial areas.

Due to the large amount of power involved, transmission-level voltages are generally considered those above 110 kilo volts (kV). Voltages between 110 kV and 33 kV are typically considered sub-transmission voltages, but are occasionally used for long transmission systems with light loads. Voltages of less than 33 kV are representative of distribution projects.

Electric power transmission and distribution systems are often located in conjunction with highway, road, and other rights-of-way to minimize both costs and disturbance to ecological, socio-economic and cultural resources. Other factors, including land value, view sheds, archaeological resources, geotechnical hazards, accessibility, parks and other important features also contribute to the locating of transmission and distribution line right-of-way alignments.

Project development and construction activities typically include access road construction or upgrade, site preparation and development, removal of select vegetation, if any, and the grading and excavation of soils for the installation of structural foundations and site utilities. These activities are typical of industrial development projects and depend upon a number of factors, including topography, hydrology, and desired site layout, among others. Activities generally associated with the development and construction of power transmission and distribution include land clearing for transmission line rights-of-way, access road construction or upgrade, equipment staging

areas, substation construction and / or upgrade, site preparation, and installation of transmission line components (e.g. transmission towers and substations, access and maintenance roads).

Operational activities may include maintenance of access to the transmission lines, towers and substations (e.g. low-impact trails or new / improved access roads) and vegetation management. Upgrades and maintenance for existing infrastructure are a consideration throughout the life cycle of the project.

Power transmission and distribution facilities are decommissioned when they are obsolete, damaged (e.g. by corrosion) or replaced due to increased power demand. Many power facilities are replaced with new or updated equipment at the same site or right-of-way. Decommissioning activities depend on the proposed subsequent use of the site, environmental sensitivities (e.g. natural grasslands) and the project specifics (e.g. aboveground or underground power lines). Activities may include demolition and removal of the installed infrastructure (e.g. transmission towers, substations, aboveground and underground utilities and road decommissioning) and reclamation of the project site, including ground stabilization and re-vegetation.

The following sections provide a description of the facilities and activities associated with the construction and operation of power transmission and distribution projects. Facilities and activities common to transmission and distribution projects, including right-of-way management and substations, are outlined below as well as facilities unique to transmission and distribution systems, including towers and utility poles. Typical components of a power transmission and distribution project are illustrated in Figure A-1.

Power Transmission Systems

The electric power transmission system is often referred to as a grid. Redundant paths and lines are provided so that power can be routed from any generation facility to any customer area through a variety of routes, based on the economics of the transmission path and the cost of power. The redundant paths and lines also allow power flow to be rerouted during planned maintenance and outages due to weather or accidents.

Power transmission occurs via a system of aboveground power lines and towers located between a power plant and a substation. When crossing a dense residential area is necessary, transmission and distribution systems can also be buried within underground conduits. Though the transmission efficiency is typically lower for underground lines and installation and maintenance are costly, locating the transmission system underground reduces impacts on land values, visual aesthetics, and vegetation loss. Submarine cables placed on the ocean floor by cable-laying boats are also occasionally used to transmit high-voltage power across long stretches of water to islands and other locations that are inaccessible by conventional techniques. Submarine cables are typically self-contained and fluid-filled to provide insulation over long distances.

Regional transmission grids consist of several large transmission systems connected by substations that are designed to transport electricity as efficiently as possible. Transmission networks can cover thousands of kilometers and encompass tens of thousands of towers. Energy is typically transmitted using a three-phase alternating current (AC) that is more efficient than a single phase. Energy is generally produced at low voltage (up to 30 kV) at a generating facility and then stepped up by a power station transformer to a higher voltage in order to reduce resistance and reduce the percentage of energy lost during transmission over a long distance. For long distance

transmission, electricity is usually transmitted at voltages between 110 and 1200 kV. At extremely high voltages, such as those over 2000 kV, corona discharge⁴⁷ energy losses associated with charged conductors can offset benefits of reductions in energy losses from reduced resistance. Over long distances, energy can also be transmitted via High Voltage Direct Current (HVDC). In these instances, smaller losses in energy and lower construction costs offset the need to construct conversion stations at each end of the transmission line to convert the direct current to alternating current for use in distribution systems.

Transmission towers or pylons are utilized to suspend high-voltage overhead power lines. These systems usually transmit three-phase electric power (the common method for transmission of high-voltage lines of over 50 kV) and, therefore, are designed to carry three (or multiples of three) conductors. One or two ground conductors are often added at the top of each tower for lightning protection. Transmission towers can be constructed from steel, concrete, aluminum, wood and reinforced plastic. The wire conductors on high-voltage lines are generally constructed of aluminum, or aluminum reinforced with steel strands. Each transmission tower or support structure must be constructed to support the load imposed on it by the conductors. As a result, foundations for transmission towers can be large and costly, particularly in areas where ground conditions are poor such as in wetlands. Guy wires can be utilized to stabilize transmission towers and resist some of the force of the conductors.

There are three main types of transmission powers or pylons used in a transmission system. Suspension towers support straight stretches of a transmission line. Deviation towers are

⁴⁷ A corona discharge is an electrical discharge resulting from the ionization of the air around the conductor, generally generating power losses and ambient noise.

located at points where a transmission line changes direction. Terminal towers are located at the end of overhead transmission lines where they connect with substations or underground cables.

The most common type of transmission tower or pylon used for high-voltage power lines is a steel lattice structure. Tubular steel monopoles are also used to support high or medium voltage transmission lines, usually in urban areas. Transmission towers constructed of a steel framework can be used to support lines of all voltages, but they are most often used for voltages over 50 kV. Lattice towers can be assembled on the ground and erected by cable (which uses a large laydown area), erected by crane, or, in inaccessible areas, by helicopter. Transmission towers typically range from approximately 15 to 55 meters (m) in height.⁴⁸

Wooden transmission towers consisting of single poles, H-frames, or shapes resembling A's or V's are also commonly used to support high-voltage transmission lines. Wooden transmission towers are limited by the height of available trees (approximately 30m), and generally carry voltages of between 23 kV and 230 kV, lower than those carried by steel lattice transmission towers⁴⁹. Aluminum towers are often used in remote areas where they can be transported in and installed by helicopter. Towers of reinforced plastic are now available, but high costs currently restrict their use.

For underground transmission lines, the three wires used to transmit the three-phase power must be located in individual pipes or conduits. These pipes are covered in thermal concrete and surrounded in thermal backfill materials. Underground cable conduit systems typically require trenches of at least 1.5m in

depth and width. Due to difficulties in dissipating heat, underground conduits are typically not used for high-voltage transmission lines over 350 kV.⁵⁰

Power Distribution Systems

Prior to consumer use, high-voltage energy is stepped down to a lower voltage aboveground line for use in sub-transmission or distribution systems. Distribution lines typically vary from 2.5 to 25 kV. Finally, the energy is transformed to low voltage at the point of residential or commercial use. This voltage ranges between 100 and 600 volts (V) depending on country and customer requirements. Power distribution poles (or utility or telephone poles) are typically constructed of wood, but steel, concrete, aluminum and fiberglass are also used. Distribution poles are typically spaced no further than 60m apart and are at least 12m in height⁵¹. Wooden distribution poles are limited by the height of available trees (approximately 30m).

Electrical Substations

Electrical substations are stations along the electricity transmission and distribution system that transform voltage from low to high or high to low using transformers. Step-up transformers are used to increase voltage while decreasing current, while step-down transformers are used to decrease voltage while increasing current. Substations typically consist of one or more transformers, as well as switching, control, and protection equipment. Substations can be located in fenced enclosures, underground, or inside buildings.

There are two main types of electrical substations. Transmission substations contain high-voltage switches used to connect together high-voltage transmission lines or to allow specific

⁴⁸ United Kingdom Parliament (2001)

⁴⁹ Great River Energy (2006)

⁵⁰ American Transmission Company (2005)

⁵¹ United States of America Department of Defense (2004)

systems to be isolated for maintenance. Distribution substations are used to transfer power from the transmission system to the distribution system. Typically at least two transmission or sub-transmission lines enter a distribution substation, where their voltage is reduced to a value suitable for local consumption. Distribution substations can also be used to isolate faults in either the transmission or distribution systems. Complicated distribution substations containing high-voltage switching, switching, and backup systems are often located within large urban centers.

Rights-of-Way Management

Both aboveground transmission and distribution projects require rights-of-way to protect the system from windfall, contact with trees and branches, and other potential hazards that may result in damage to the system, power failures, or forest fires. Rights-of-way are also utilized to access, service, and inspect transmission and distribution systems. Underground distribution lines also require rights-of-way where excavation is prohibited or strictly monitored, construction activity is limited, and access to lines can be achieved if necessary. Being larger systems transmitting higher voltages, transmission rights-of-way are typically much larger than those for distribution systems and, consequently, require more extensive management.

Right-of-ways widths⁵² for transmission lines range from 15 to 100m depending on voltage and proximity to other rights-of-way (typical range is between 15 and 30m)⁵³. For overhead distribution power lines up to 35 kV, 12 to 24m corridors (6 to 12m on each side) are recommended⁵⁴. Access roads are often

constructed in conjunction, or within, transmission line rights-of-way to provide access for maintenance and upkeep of the system.

To avoid disruption to overhead power lines and towers, regular maintenance of vegetation within the rights-of-way is required. Unchecked growth of tall trees and accumulation of vegetation within rights-of-way can result in a number of impacts including power outages through contact of branches and trees with transmission lines and towers; ignition of forest and brush fires; corrosion of steel equipment; blocking of equipment access; and interference with critical grounding equipment.

Regular maintenance and clearing of rights-of-way prevents natural forest succession and the establishment and growth of tall trees. Typically, tall trees of approximately 4.5m or more are not permitted within aboveground rights-of-way.⁵⁵ Underground rights-of-way have far fewer vegetation restrictions, though trees with deep tap roots that may interfere with duct banks are usually prohibited from being grown within the right-of-way. Vegetation maintenance of rights-of-way can be accomplished with the following measures.

Mowing with heavy-duty power equipment is used to control growth of ground covers and prevent the establishment of trees and shrubs in the right-of-way. Herbicides, in combination with mowing, control fast-growing weedy species that have a potential to mature to heights over those permitted within the right-of-way. Trimming and pruning is utilized at the boundaries of rights-of-way to maintain corridor breadth and prevent the encroachment of tree branches. Hand removal or removal of vegetation is costly and time-consuming but is often used in the vicinity of structures, streams, fences, and other obstructions making the use of machinery difficult or dangerous.

⁵² For example, Duke Energy prescribes 21-meter minimum rights-of-way for voltages between 44 and 100 kV, 46-meter minimum rights-of-way for voltages of 230 kV, and 61-meter minimum rights-of-way for voltages of 525 kV (Duke Energy, 2006).

⁵³ Santee Cooper (2002)

⁵⁴ United States of America Department of National Defense (2004)

⁵⁵ Georgia Power (2006)

Figure A-1: Electric Power Transmission and Distribution

