DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

HIGH-VOLTAGE TRANSMISSION FACILITIES IN WASHINGTON

Chapter 2 - Transmission, Development Considerations, and Regulations

March 2025

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FIGURES

2.0 CHAPTER 2 – OVERVIEW OF TRANSMISSION FACILITIES, DEVELOPMENT CONSIDERATIONS, AND REGULATIONS

This chapter provides an overview of typical types of transmission facilities and describes both the Action Alternative and No Action Alternative. It also describes activities related to the construction, operation and maintenance, and upgrade or modification of transmission facilities.

As detailed in Chapter 1, this Draft Programmatic Environmental Impact Statement (EIS) is fulfilling the directive of Revised Code of Washington (RCW) 43.21C.405 by evaluating potential future construction and operation of electrical transmission facilities with a nominal voltage of 230 kilovolts (kV) or greater (referred to herein as “transmission facilities”). This Draft Programmatic EIS does not evaluate the potential effects of electricity generation, storage, local distribution, or customer use.

2.1 Overview of Transmission Facilities

The electric systems of transmission facilities are generally divided into two categories for regulatory purposes—high voltage and low voltage. Consistent with the Federal Energy Regulatory Commission (FERC) National Reliability Standards, low-voltage transmission facilities are generally defined as those below 100 kV, while high-voltage transmission facilities typically operate above 200 kV and can sometimes include the 100 to 200 kV range as well (FERC 2023). Typical transmission voltages include 115 kV, 138 kV, 230 kV, 345 kV, 500 kV, and 765 kV (DOE 2023b).

Transmission facilities are broadly used to transfer electricity. As shown in **Figure 2.1-1**, electricity is generally produced at utility-scale power generation facilities. The electricity passes through a substation that increases the voltage level and transports the electricity long distances using high-voltage overhead—or, in some cases—underground transmission facilities. The electricity again passes through a substation to decrease the voltage level to a safer and more usable intensity. Local distribution systems that are made up of low-voltage transmission lines and transformers disseminate the electricity to individual customers, including houses, businesses, and industries (DOE 2023a). High-voltage transmission facilities can also be used to move large electrical loads from one substation to another to meet the National Energy Reliability Corporation (NERC) transmission system planning performance requirements and customer demands (NERC n.d.).

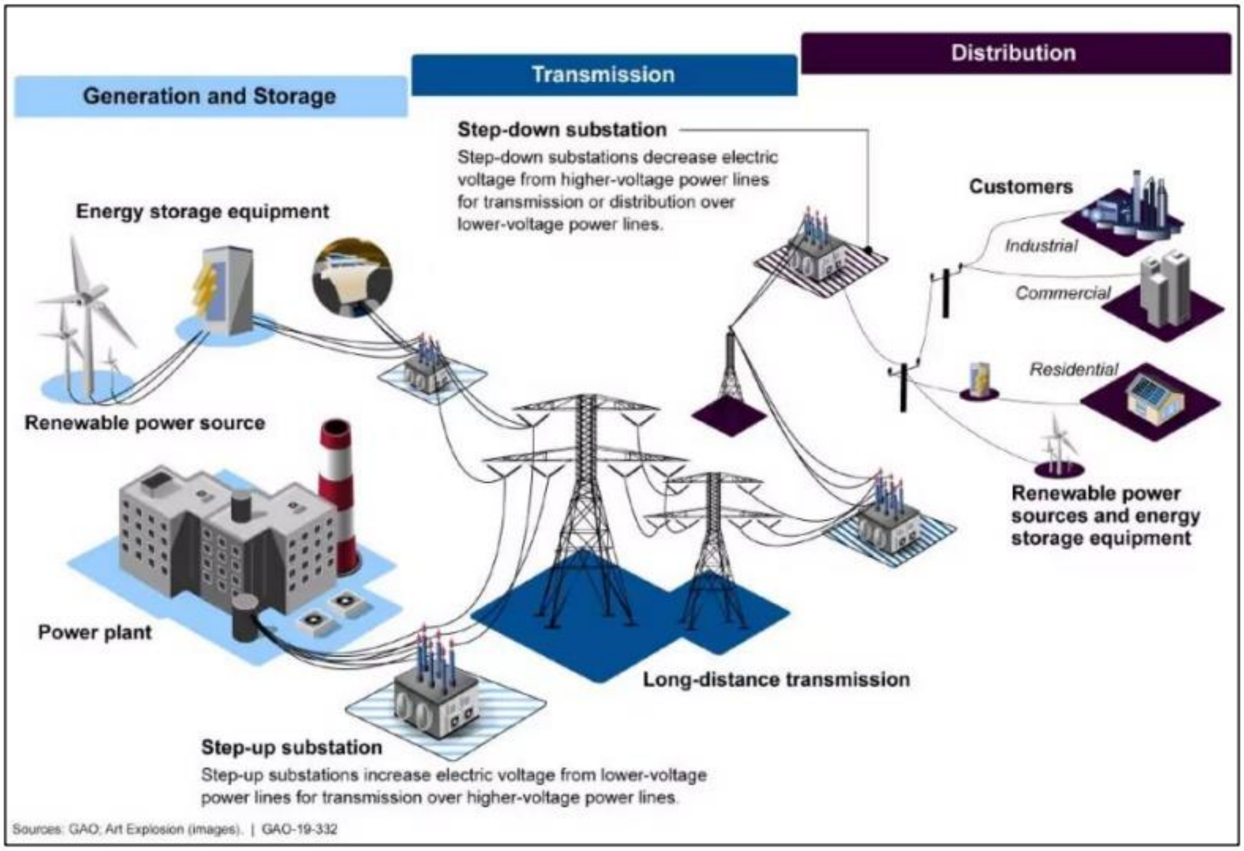

Figure 2.1-1: Transmission Facility Components
Source: GAO 2022

Electrical transmission facilities are essential for maintaining reliable and stable power supply, ensuring that there is minimal loss during transport and that electricity reaches consumers efficiently and safely. The development of transmission facilities also allows for effective incorporation of electricity produced by renewable energy facilities, such as wind and solar. The transmission facilities can facilitate the connection of remote generation sites with high renewable energy production potential but little demand with sites that have high renewable energy demand but little production potential. Increased development of transmission facilities also improves grid resilience by providing redundancy, backups, additional supply, and inter-grid connectivity[1] that can help to compensate for the impacts and struggles associated with outages or disruptions. A more comprehensive transmission grid has the further benefit of reducing electricity prices for consumers since it lowers the cost associated with power delivery (DOE 2023a).

2.1.1 Overhead Transmission

Overhead low- or high-voltage transmission facilities can vary in design, ranging from single wood poles situated along roadways to lattice towers with bundled conductors located in dedicated corridors.

[1] Refers to the linking of multiple electrical grids to allow the exchange of electricity between them. This connection helps balance supply and demand across different regions, enhancing the reliability and stability of the power supply.

Overhead high-voltage transmission towers are designed to keep conductors (transmission lines) separated from their surroundings and from each other. The National Electric Safety Code has specific requirements for different operating voltages; the higher the voltage, the greater the separation distance required between conductors.

A variety of overhead transmission structures are regularly used. These include single wood poles, wood H-frame, engineered wood, lattice steel towers (LSTs), and tubular steel poles (TSPs) (see **Figure 2.1-2**). Single wood poles are typically used for transmission facilities operating at 115 kV where the corridor width is restricted (e.g., within road rights-of-way [ROWs]). Wood H-frames can be used for cross country 115 kV facilities as they allow for greater average span distances. Wood H-frames can also be used for cross country 230 kV facilities where the topography allows. Guy wires are often used with these types of poles when the direction of the line changes or at termination poles. Engineered wood poles, also referred to as glue-laminated poles, can be used for 115 kV and 230 kV facilities when the ROW is restricted.

For 230 kV facilities and above, which are the focus of this Draft Programmatic EIS, both LST and TSP structures are most commonly used. LSTs consist of a steel framework with individual leg members and bracing systems. Bolted connections are used to assemble the lattice structure, ensuring stability and ease of maintenance. TSPs are hollow steel poles fabricated either as one piece or as several pieces fitted together (CPUC 2014a). However, it is assumed that the transmission facilities covered in this Draft Programmatic EIS would require transmission structures that are generally large enough that they arrive at the site in separate pieces and are assembled in sections from the ground up, with cranes or helicopters used to lift sections in place (CPUC 2014b). The choice of design between LST and TSP depends on factors such as voltage requirements and the surrounding environment.

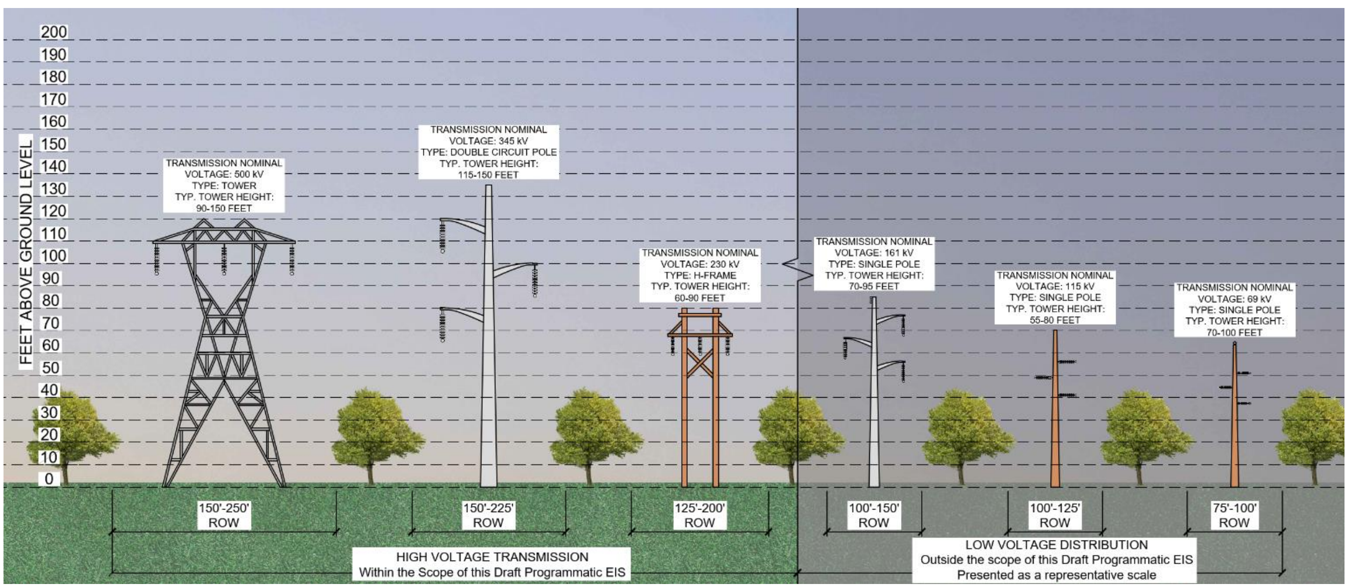

Figure 2.1-2: Overhead Transmission Structure Types

2.1.1.1 Substations and Transformers

The function of a substation is to transform electricity to a higher level of voltage, for efficient transmission over long distances, or a lower level of voltage, for easier and safer local distribution. Substations also provide controlled switching and protection functions. Switching and protection functions are used to balance electricity loads, isolate faults in the system to prevent damage, and support maintenance and repair activities (Prismecs 2024). Substations can vary greatly in size and complexity, depending on the amount of voltage being transferred and the number of connecting transmission lines (CPUC 2014a). Based on need and type of transmission facility, substations can be as small as 500 square feet or cover over 100 acres but are usually around 1 acre in size for local distribution systems and 10 to 20 acres for high voltage transmission facilities[2] (PSCW 2013; CPUC 2014a). **Figure 2.1-3** shows a few examples of substations, reflecting the variety of sizes that may be used.

Figure 2.1-3: Transmission Substations
Source: EFSEC 2024

Transformers are the primary component of substations, and they serve the substations' primary function of stepping up or stepping down the voltage of transmitted power. Given the amount of electricity passing through these transformers, it is vital to ensure that the components remain cool. Smaller transformers are typically self-cooling as their internal components are immersed in oil and are designed to allow the oil to cycle through the system and transfer heat to the external parts of the transformer. Larger transformers may need additional external cooling equipment like pumps to force the cycling of oil or fans to force air across heat exchange surfaces (USDA 2001). Other substation components could include breakers, switches, and capacitor banks. In addition, control equipment typically housed in a building, is required for the operation of the station.

2.1.1.2 Communication Systems

Communication systems help to provide safe and reliable electricity to the end user. The communication system shares real time information, such as the system's status, with power-generating facilities, electrical substations, and utility operation centers (AEP Transmission n.d.). Transmission facilities also have communications for control of the line and substations to detect problems and shut down line sections (CPUC 2014a).

2.1.1.3 Obstruction Lighting and Marking

Consistent with the Federal Aviation Administration's (FAA's) guidance, obstructions such as transmission lines may be marked or lighted to warn aircraft operators of their presence during both daytime and nighttime

[2] As defined in this Programmatic EIS, electrical transmission facilities with a nominal voltage of 230 kilovolts or greater.

conditions. Individual projects need to be reviewed to determine whether FAA marking and lighting requirements apply. They may be marked/lighted in any of the following combinations (FAA n.d.):

- **Aviation Red Obstruction Lights:** This option includes flashing aviation red beacons (20 to 40 flashes per minute) and steady-burning lights during nighttime operation. Orange and white paint is used for daytime markings.
- **Medium-Intensity Flashing White Obstruction Lights:** Medium-intensity flashing white obstruction lights may be used during daytime and twilight with automatically selected reduced intensity for nighttime operation. This system is not normally installed on structures less than 200 feet above ground level.
- **High-Intensity White Obstruction Lights:** Flashing high-intensity white lights may be used during daytime with reduced intensity for twilight and nighttime operation. In this type of system, the marking of structures with red obstruction lights and aviation orange and white paint may be omitted.
- **Dual Lighting:** A combination of flashing aviation red beacons and steady-burning aviation red lights for nighttime operation and flashing high-intensity white lights for daytime operation. Aviation orange and white paint may be omitted.
- **Catenary Lighting:** Lighted markers available for increased night conspicuity of high-voltage (69 kV or higher) transmission line catenary wires. Lighted markers provide conspicuity both day and night.
- **Omnidirectional lighting:** This option includes medium-intensity omnidirectional[3] flashing white lighting system that provides conspicuity both day and night on catenary support structures. The unique sequential/ simultaneous flashing light system alerts pilots of the associated catenary wires.
- **High-Intensity Flashing Lights:** High-intensity flashing lights used to identify some supporting structures of overhead transmission lines located across rivers, chasms, gorges, etc. These lights flash in a middle, top, and lower light sequence at approximately 60 flashes per minute. The top light is normally installed near the top of the supporting structure, while the lower light indicates the approximate lower portion of the wire span. The lights are beamed toward the companion structure and identify the area of the wire span. High-intensity flashing white lights are also employed to identify tall structures, such as chimneys and towers, as obstructions to air navigation. The lights provide 360-degree coverage around the structure at 40 flashes per minute and consist of one to seven levels of lights, depending on the height of the structure. Where more than one level is used, the vertical banks flash simultaneously.

Another type of obstruction lighting is the audio-visual warning system (AVWS), which represents a newer technology. Under 47 CFR 87.483, AVWS is a radar-based obstacle avoidance system that activates obstruction lighting and audible warnings to alert pilots of potential collisions with land-based obstructions. This system can be used in transmission facilities instead of, or in combination with, traditional obstruction lighting, which is either continuously on or flashes. The AVWS may help to reduce the impacts associated with new or additional sources of light. Like with other warning systems, AVWS must be approved for use by the FAA.

In addition to lighting, brightly colored balls can be attached to the conductors to make them more visible to low-flying aircraft. Line markers can be attached to the ground wire of transmission lines and some lower voltage

[3] Refers to the capability of receiving or transmitting signals in all directions.

conductors depending on the marker type and local geographic conditions to prevent birds from perching or building nests on the wires (APLIC 2012).

2.1.2 Underground Transmission

Underground high-voltage transmission facilities may also be technically feasible and, depending on project-specific applications and site-specific considerations, may have the following benefits:

- **Improved Reliability and Resilience:** Underground transmission facilities are less vulnerable to external threats, such as high winds, falling branches, and wildfires. This reduces the risk of power outages and enhances the overall reliability and resiliency of the power grid. However, if issues do arise, repairs can take substantially longer than overhead facilities due to repair complexity, limited access, and technical skills required of transmission crews.
- **Lower Maintenance Costs:** While the initial installation costs are higher, underground transmission facilities often have lower long-term maintenance costs because they are less susceptible to damage from weather, vegetation, and other external factors.
- **Safety:** Although not completely excluded from safety risks altogether, underground transmission facilities reduce the risk of accidents and hazards associated with overhead transmission facilities, such as falling structures or wires.

While underground transmission has the benefit of increased resilience to severe weather conditions and reduced risks of power outages, it can cost 5 to 15 times more than overhead transmission facilities to install (EIA 2012; Xcel Energy 2024), require over 14 times as much soil excavation (DOE 2023a), and have approximately half as long of a life expectancy (PRPA 2024).

The installation of underground cables often requires significant excavation and disruption to the land. Excavation work is continuous along the corridor as opposed to specific structure locations required for overhead transmission facilities. Additionally, periodically along the corridor of the underground transmission facility, developers must construct large underground concrete boxes that measure approximately 8 to 10 feet wide by 24 to 30 feet long by 8 to 10 feet high (PSCW 2011; Xcel Energy 2024). These boxes, referred to as vaults, are used by utility crews to splice cables together during construction and during the operation of the transmission facility to perform maintenance and repairs (see **Figure 2.1-4**). Vaults must be placed every 900 to 3,500 feet, depending on the type of cable, topography, and voltage (PSCW 2011). Given the size of the vaults, areas where they must be placed would require substantially more excavation. Higher-voltage underground transmission facilities, such as those addressed in this Draft Programmatic EIS, may also require that vaults be constructed in adjacent pairs to handle redundant sets of cable during maintenance (PSCW 2011). The spacing of the conductors may also vary depending on the voltage to address heat dissipation from the conductors.

Developers typically construct overhead transmission facilities because underground facilities are more expensive and harder to maintain when required. Another typical consideration for developers is how the additional costs would be allocated. Some utility providers have tariffs in place that require the local jurisdiction or customer group requesting the underground transmission facility to pay the difference between the overhead and underground costs (PSE 2014). As of 2009, an estimated 0.5 percent of all transmission lines of at least 200 kV or higher in the United States were underground (EIA 2012). There are instances where 230 kV facilities or above have been placed underground, typically for very short segments or in specific urban areas where overhead transmission facilities are not feasible.

Figure 2.1-4: Underground Vaults
Source: Xcel Energy 2024; Oldcastle Infrastructure n.d.

2.2 Alternatives

2.2.1 Action Alternative

This Draft Programmatic EIS evaluates potential impacts associated with the development of electrical transmission facilities with a nominal voltage of 230 kV or greater in Washington. Electrical transmission facilities are defined in 80.50.020(12) as “electrical power lines and related equipment.” Therefore, the Action Alternative in this Draft Programmatic EIS includes development of new overhead and underground transmission facilities, as well as the upgrade or modification of existing transmission facilities.

2.2.1.1 Overhead Transmission Facilities

This Draft Programmatic EIS evaluates new overhead transmission facilities, which include the following:

- Transmission structures (towers and poles)
- Conductors (wires)
- Ground wires
- Insulators
- Substations, including transformers and ancillary equipment, such as converter stations

After a project-specific environmental review and permitting are complete, it is expected that several years will be needed to construct a transmission facility, with the timeframe varying based on the length of the transmission facility, complexity of construction, and site-specific topography.

2.2.1.2 Underground Transmission Facilities

Although high-voltage transmission facilities are not typically constructed underground, this Draft Programmatic EIS includes underground construction as part of the Action Alternative. Constructing high-voltage transmission facilities underground could be beneficial to protect visual resources, avoid aviation and military operations, or improve electrical reliability in high-risk weather areas. Transmission facilities could also be placed underground to meet the needs of certain site constraints. Due to the extensive construction methods required for this option, it is assumed that, per mile, underground transmission would take longer to construct than overhead facilities.

This Draft Programmatic EIS evaluates new underground transmission facilities, which include the following:

- Insulated conductor cables
- Vaults
- Transition structures (risers)

2.2.1.3 Upgrade/Modification of Existing Transmission Facilities

Applicants could also pursue opportunities to modify or upgrade existing transmission facilities. Upgrades or modifications of existing transmission facilities are often considered to improve efficiency and reliability and are required to ensure compliance with updated regulations and standards. Upgrading or modifying an existing transmission facility can include replacing transmission towers, transformers, substations, switchyards, underground cabling, and ancillary equipment.[4] Such actions associated with modification can also include, or result from, reconductoring[5] or upgrading components of a transmission facility to include advanced transmission technologies. Upgrades and modifications do not include routine operation and maintenance activities, such as repairing or replacing components to maintain safe and reliable operation of the transmission facility. Details on routine operation and maintenance activities can be found in Section 2.3.3.

Construction associated with upgrade or modification could require expanding an existing transmission facility ROW. Construction of an upgraded or modified transmission facility would vary greatly depending on the proposed action. However, it is anticipated that actions such as installing advanced transmission technology could take several months, while rerouting or converting transmission facilities could take over a year. More information about the different actions considered as part of upgrading or modifying transmission facilities is provided below.

- **Reconductoring:** It is anticipated that as electric power demand increases, more or larger cables and conductors would be needed to increase the capacity and the interconnectivity of the grid to meet this fluctuation in demand. Historically, installation of new circuits has been the preferred solution to increase transmission capacity, but limited ROW and opposition from local communities can make “reconductoring” a practical alternative. Advances and innovations in materials can be applied to conductors, resulting in higher thermal rating and strength, which can reduce transmission and distribution losses, minimize safety hazards, and increase energy supply to end users (DOE 2015). It is anticipated that reconductoring transmission facilities to take approximately 6 to 18 months to complete (Grid Lab 2024).
- **Advanced Transmission Technologies:** Incorporating advanced technology into existing transmission facilities can help to improve the efficiency and effectiveness of electricity delivery and increase the overall reliability of the system. The technology can be applied to both grid software and grid hardware. Advanced

[4] Ancillary equipment refers to secondary systems and devices that support the main transmission infrastructure.

[5] Reconductoring is the replacement of cable or wire on an electric circuit, typically a high-voltage transmission line, to afford a greater electric-current-carrying capability (DOE 2015).

grid software technology can include solutions such as dynamic line rating[6] that focus on improvements in the control systems and decision-making processes. There are also physical asset and infrastructure solutions, such as power flow controllers and advanced conductors and cables that focus on carrying, converting, or controlling electricity. These different technologies can be implemented independently or in tandem to improve the overall efficiency and effectiveness of the transmission system (DOE 2020). It is anticipated that installing advanced transmission technology could take approximately 3 to 12 months (Grid Lab 2024).

- **Right-Size Replacement:** Right-size replacement[7] intends to provide opportunities to modify in-kind replacement of existing transmission facilities to increase their capabilities. Right-size replacements can extend a system's useful life and reduce the need for new transmission facilities. This type of modification would be similar to constructing a new transmission facility in that it intends to address a long-term transmission need, increases the capacity of the existing transmission facility, and is located in the same general route as and/or expands the existing transmission facility ROWs (18 Code of Federal Regulations Part 35). For example, reconductoring may require the replacement of some or all of the existing transmission facility structures due to design load requirements imparted by the often larger and heavier conductor. It is anticipated that right-size replacement could take approximately 3 to 5 years to complete (Grid Lab 2024).
- **Modifying:** Modifying existing transmission facilities can include constructing additional transmission towers, transformers, substations, switchyards, underground cabling, and ancillary equipment. It is anticipated that modifying an existing transmission facility could take approximately the same amount of time as new construction.
- **Re-Routing:** Rerouting a portion of an existing transmission facility could be required in several scenarios. An existing transmission facility may need to be rerouted to connect a new power source to the transmission system. Rerouting could also be needed if proposed development overlaps or conflicts with the existing transmission facility. It is anticipated that rerouting an existing transmission facility could take approximately the same amount of time as new construction.
- **Converting:** A transmission facility could be converted from an overhead facility to an underground facility. This Draft Programmatic EIS does not evaluate this type of conversion. Converting a transmission facility may be needed in high fire-risk areas, severe weather event areas, or urban areas. It is anticipated that converting an existing transmission facility could take approximately the same amount of time as new construction of an underground transmission facility.

2.2.2 No Action Alternative

Under the No Action Alternative, it is assumed that the appropriate State Environmental Policy Act (SEPA) Lead Agency[8] would continue to review individual project-level applications for transmission facility development under

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[6] A technology used in electric power transmission to optimize the capacity of transmission lines based on real-time conditions rather than static assumptions.

[7] Under FERC Order No. 1920, right-size replacement refers to modifying or upgrading an existing transmission facility to increase its capacity, thereby extending a system's useful life and reducing the need for new transmission facilities.

[8] According to Washington Administration Code 197-11-758, a SEPA Lead Agency is defined as the agency with the main responsibility for complying with the procedural requirements of the Washington State Environmental Policy Act.

existing state and local laws. The No Action Alternative would not use this Draft Programmatic EIS as reference for SEPA compliance, and individual projects would require separate environmental review.

2.3 Phases of Transmission Facility Development

Transmission facility development includes site characterization, environmental reviews and permit approvals, construction, operation and maintenance, and decommissioning[9] (see **Figure 2.3-1**). The phases of transmission facility development analyzed in this Draft Programmatic EIS include construction, operation and maintenance, and upgrade or modification.

The upgrade or modification to an existing transmission facility can occur after construction and during its operation and maintenance phase, but before decommissioning. Upgrades or modifications are often made to improve the efficiency, performance, or address evolving technological and regulatory requirements. The impacts from the upgrade or modification of an existing transmission facility may be similar to those described for construction. However, as described in each element of the environment throughout Chapter 3, there are often opportunities to minimize these adverse impacts. For example, adverse environmental impacts associated with the upgrade or modification of a transmission facility could be minimized by utilizing existing infrastructure and causing less disturbance.

Site Characterization
- System Planning Studies
- General Corridor, Route, and Site Identification
- Desktop Analyses
- Field Surveys
- Site Studies
- Feasibility Studies

Environmental Review and Permit Approvals
- Pre-application Meeting
- Application Submittal
- Environmental Review
- Environmental and Permit Approvals

Construction
- Site Preparation
- Assembly, Testing, and Start-Up
- Post-Construction Reclamation[10]
- Post-Construction Monitoring and Reporting

Operation and Maintenance
- Operation
- Maintenance and Inspection
- Vegetation Management
- Access Road Maintenance

Decommissioning*
- Environmental Studies and Environmental Reviews, if applicable
- Dismantling and Removal
- Recycling
- Revegetation and Site Restoration

* As discussed in Section 2.3.4, decommissioning is not analyzed in this Draft Programmatic EIS.

Figure 2.3-1: Phases of Transmission Facility Development

2.3.1 Site Characterization

Initially, applicants identify the scale and scope of the proposed transmission facility project. The interconnection points determine the specific location for a new transmission facility or an upgrade or modification to an existing facility. Site characterization typically involves conducting desktop analyses, system planning studies, and, with agreement from the landowner(s), field surveys. Very little modification to the site is attributed to this phase, but impacts could still occur. For example, obtaining soil core samples could have unanticipated impacts on cultural,

[9] The steps taken to safely retire a facility from service. This process ensures that the site can be reused or returned to safe state.

[10] Refers to the process of restoring temporarily impacted land to its original or agreed-upon condition after construction activities are completed.

Tribal, and historical resources or could impact critical habitat. Therefore, for the purposes of the impact analysis completed for this Draft Programmatic EIS, site characterization is included as part of the construction phase.

Siting considerations typically include the transmission ROW width, identification of points of interconnection need, the geography of an area, and access to proposed or existing transmission infrastructure, such as substations. Considerations would also include zoning requirements and identification of critical areas.

The following activities could involve minimal or no site disturbance:

- Mapping and desktop assessment of surface hydrology and floodplains
- Mapping and desktop assessment of habitat, including wetland identification
- Mapping and assessment of water types, including identification of waters that contain fish and water crossings
- Mapping and identification of species (plants and wildlife)
- Completing desktop studies for Tribal, cultural, and historic resources
- Completing desktop slope evaluations and soil stability studies
- Completing desktop assessment of existing land use and ownership
- Completing due diligence assessments for lands with previous industrial uses
- Completing an evaluation of seismic stability and potential storm event runoff
- Completing a baseline air quality assessment, if requested by the SEPA Lead Agency

The following activities could include ground disturbance:

- Digging and Boring: Conducted for subsurface investigations and environmental surveys. These activities could help to understand soil and rock properties, soil conditions, subsurface environmental and/or cultural resources, soil or groundwater contamination, and geotechnical suitability.
- Auguring: Similar to drilling, but often used for shallower depths.
- Trenching: Used to install temporary utilities or to expose existing underground utilities.

2.3.2 Transmission Construction

Once an applicant has obtained all necessary environmental approvals and permits for a transmission facility (see Section 1.6 of Chapter 1, Introduction), the construction process begins. The duration of transmission facility construction can vary based on a variety of factors, including size, scale, type of facility (e.g., wood pole or LST; overhead or underground), whether it is a new transmission facility or an upgraded or modified facility, and site-specific characteristics. However, in general, all transmission facility construction includes the following stages, described in the sections that follow:

- Site Preparation
- Site Construction
- Post-Construction Reclamation

- Post-Construction Monitoring and Reporting

Construction activities, including oversight, administration, compliance, and monitoring, would be managed by the project-level applicant. The workforce is likely to consist of laborers, craftsmen, machine operators, supervisory personnel, and construction management personnel. The number of workers employed during the construction of transmission facilities would vary greatly depending on the size and scale of the proposed project. It is generally anticipated that construction of a transmission facility could require the following general roles and approximate counts:

- **Project Managers and Engineers:** Around 10 to 20 individuals, including civil, electrical, and environmental engineers
- **Construction Workers:** Ranges from 50 to 200 workers and includes linemen, equipment operators, and general laborers

It is assumed that underground transmission facility construction would require more construction workers than overhead transmission facilities. It also anticipated construction activities to occur sequentially, moving along the length of the transmission facility route. For example, a crew would begin preparing a site and once completed, they would move on to the next location while a second crew begins the assembly and start-up of the transmission facility at the first location. With this phased or sequenced approach, all employees would not be in one location at the same time.

2.3.2.1 Site Preparation

Site preparation begins with conducting all necessary preconstruction surveys, such as preconstruction wildlife surveys, for micro-siting and/or mitigation. Once surveys are finalized, the site preparation process can commence. The preparation of overhead and underground transmission facility construction sites could include establishment of applicable temporary erosion and sediment controls, clearing or grubbing of vegetation, tree removal, grading, constructing temporary staging and laydown areas, improving roads, and constructing new roads.

Projects in urban settings often face additional challenges in site preparation, such as limited space, higher traffic disruption, and stricter regulatory requirements. While rural[11] settings may not have these same challenges, they can face logistical challenges, such as difficult terrain and longer distances for material transport. Regardless of whether a setting is urban or rural, projects in environmentally sensitive areas may require special considerations to minimize environmental impact, including more stringent permitting processes and additional mitigation measures.

Construction Access

Construction access roads would likely be required for the movement of trucks, cranes, concrete trucks, bulldozers, and other equipment. Construction access would vary depending on the project scope, location and terrain, and environmental setting. Although existing roads would be used to the greatest extent feasible, roads may need to be improved or new access roads may need to be constructed. Road improvements could include laying rock or gravel where the soil is unstable, removing any overgrown vegetation, and widening the road and adjacent disturbance areas for safety clearances. New roads would require clearing, grading, and installing gravel or other suitable material. In areas with steep slopes or grades, drain drips or water bars could be required for

[11] Rural encompasses all population, housing, and territory not included within an urban area.

adequate drainage and to minimize soil erosion. In such areas, it is often required that terraces be created to ensure level work areas at the structure locations. In wetland or unstable soil areas, matting could be installed to allow heavy construction equipment access while minimizing impacts on soils, vegetation, and habitat. Furthermore, temporary bridges across waterways could be installed for access. Before constructing new roads, special consideration is given to the anticipated restoration required after construction is completed, including revegetation, rock cover, and other drainage and erosion control features (PacifiCorp 2021).

Access roads could also serve as the primary means of movement for maintenance crews through operation and maintenance. These roads could be used to access transmission lines, substations, and ancillary facilities for inspection, maintenance, and/or emergency repairs over the life of any project (PacifiCorp 2021).

Clearing and Grading

Clearing of existing shrubs, vegetation, asphalt, obstructions, and trees could be required for transmission facility ROWs, new and improved access roads, and staging and laydown areas, as well as future operational conditions. Site grading would entail establishing applicable temporary erosion and sediment control features, removing excess soils or soils that are unsuitable for construction from the site, and replacing them with load-bearing granular materials and aggregates to facilitate construction. The extent of site grading would depend on the proposed transmission facility and environmental setting. Construction in areas with steep slopes or unstable soils would require more earthmoving equipment to achieve appropriate elevations for site construction. Site grading activities could require the use of excavators, scrapers, dozers, paddle wheel scrapers, haul vehicles, and graders.

Staging and Laydown Areas

Staging areas are used to temporarily store materials, construction equipment, or vehicles and to assemble transmission facility components. The size and total number of staging areas vary depending on the size, scale, and type of transmission facility being proposed. In urban areas, parking lots or already developed areas can be used, while remote areas may require additional clearing and grading.

Helicopter Landing Zones

Helicopters can be used for a variety of construction activities where traditional ground equipment may not be allowed or is limited, such as in remote or sensitive areas. For example, helicopters can be used for the following activities (NWPPA n.d.):

- Conducting micro-siting surveys[12]
- Conducting alternative geotechnical analyses
- Transporting personnel, equipment, and/or materials
- Setting structures
- Stringing wires
- Post-construction monitoring or surveys

[12] Micro-siting surveys refer to the process of identifying the exact placement of a transmission facility structure.

As part of the site preparation phase, helicopter landing zones or pads may be needed for re-fueling and loading. The number and size of landing pads would depend on the helicopter model being used, length of the proposed transmission facility, and number of restricted construction sites. Helicopter landing pads would be constructed as close to the proposed construction site as practicable. The landing zone locations would also be prioritized in areas that require minimal site preparation and that are free of obstructions, such as open spaces, fields, or parking lots.

2.3.2.2 Site Construction (Assembly, Testing, and Start-Up)

The following sections describe the site construction process and activities associated with the assembly, testing, and start-up of overhead and underground transmission facilities.

Overhead Transmission

Overhead transmission line construction is typically completed in the following stages, but various construction activities may overlap, with multiple construction crews operating simultaneously:

- Installing structure foundations
- Assembling and erecting support structures
- Stringing conductors, ground wires, and fiber-optic lines

Foundations

Except for wood pole construction, most overhead transmission facilities have some form of concrete foundation. The size of the foundation typically depends on the type of structure and the terrain. Construction begins with the auguring of holes for structure footings. LSTs typically require four footings, each 3 to 4 feet wide and 15 to 30 feet deep. TSPs require one hole that is typically 8 to 12 feet wide and 40 to 60 feet deep. After the footing holes are excavated, they are reinforced with steel and then filled with concrete. It is anticipated that the foundations for both LSTs and TSPs would have a slight projection above the ground. Once the concrete has cured, crews can begin construction of the structure itself (CPUC 2014b).

Structure Installation

For wood pole construction, including engineered wood, once the insulators are attached to the wood poles, they are typically installed directly into the ground without a separate concrete foundation. Depending on the soil type, wood poles may require the use of casings. The structure installation process involves digging a hole, placing a pole in the hole, and then backfilling the hole with soils or other materials. The depth of the hole and the type of backfill material are carefully chosen to ensure stability and support for the pole. Guy wires are added at termination or turning wood structures and may be used to enhance stability of the system.

Steel overhead transmission facility structures are generally built from the ground up. Sections of LST structures are assembled near the installation site and lifted into place. Crews then bolt the sections together. TSPs can be assembled entirely near the site and erected in one piece or assembled in sections, depending on the terrain and available space. Structures can be lifted and set in place by a crane or helicopter, depending on accessibility for ground-based construction equipment (CPUC 2014b).

Structures and foundations would be designed to the requirements of the following applicable publications:

- American Society of Civil Engineers (ASCE) Standard 10, Design of Latticed Steel Transmission Structures
- ASCE Standard 48, Design of Steel Transmission Pole Structures

- ASCE Manual of Practice 113, Substation Structure Design Guide
- American Institute of Steel Construction 360 Specification for Structural Steel Buildings
- American Concrete Institute 318 Building Code Requirements for Structural Concrete and Commentary

Conductors, Ground Wires, and Fiber-Optic Lines

Construction of overhead transmission facilities includes the wire-stringing operation, during which conductors and ground wires are strung between structures. This operation can also include the installation of sheaves, vibration dampeners, weights, suspension, identification markers, and dead-end hardware assemblies for the entire length of the route (CPUC 2014b).

Conductors are the "wires" that are connected to the structures that relay the electric current. Conductors used in transmission lines are usually constructed from aluminum placed over a steel core for reinforcement. Conductors are generally not insulated, with air serving as the insulating material (Xcel Energy 2024). For voltages up to 200 kV, a single conductor per phase can be used, which includes a total of three wires. For voltages over 200 kV, bundled conductors are used to increase the capacity of the line and reduce power loss. Bundled conductors consist of two or more conductor cables per phase connected by non-conducting spaces (CPUC 2014a). Each alternating current circuit has three phases (e.g., lines), whereas each direct current circuit has two phases.

A lightweight sock line, or pilot line, is strung by bucket trucks, heavy equipment, and sometimes helicopters. The pilot line is threaded through wire rollers attached to the insulator of each structure. The pilot line is then attached to a conductor pulling cable, which is connected to a tensioning machine on a truck. The conductors are pulled from one structure to the next by a puller machine (CPUC 2014b). The puller and tensioner work together during the pulling operation to ensure that the conductor maintains the proper ground clearance at all times. Wire set-up sites or pulling stations, where the associated pulling machinery and equipment are staged, are located at intervals along the span (CPUC 2014b).

After a section of conductor is pulled through a series of structures, a tensioner is used to apply the proper tension. Applying proper tension is crucial as conductors can expand and contract with temperature changes, ensuring they will not sag too low when temperatures are high (CPUC 2014b). Guard poles or guard structures may be installed at transportation crossings, flood control areas, utility crossings, parks, and other sensitive locations to protect these underlying areas during wire-stringing operations. The guard structures intercept the wire in the event that it drops below a conventional stringing height, preventing damage to structures. These guard structures are temporary and are removed after conductor installation is complete (CPUC 2014a). At crossings of interstate and state highways, closures may be required during stringing operations to ensure public safety.

Once the conductors are pulled through the structures and have adequate tension, they are permanently connected (i.e., "clipped in") to the insulator, which is attached to the structure. Insulators are made from non-conductive material and are used to prevent the unintended flow of electricity between conductors and supporting structures (CPUC 2014a). Insulators have historically been made of porcelain or toughened glass, which requires routine maintenance to avoid dust build-up leading to insulator flashover and noise. Newer insulators are made of polymer or silicon, which are lightweight and shatter-resistant (CPUC 2014a).

Ground wires are unpowered protective wires that are strung along the tops of towers to protect the system from lightning strikes. Ground wires sometimes include a fiber optic communication line to provide reliable control of the lines and substations (CPUC 2014a). Finally, vibration dampeners, weights, and spacers between the conductors of a bundled phase are installed (CPUC 2014b).

Fiber optic lines, or communication systems, help to provide safe and reliable electricity to the end user. The communication system shares real time information, such as the system's status, with power-generating facilities, electrical substations, and utility operation centers (AEP Transmission n.d.). A primary communication wire is typically installed as part of the transmission facility, and a secondary communication path can also be installed for redundancy. Communication systems can be installed both above and below ground. The communication line can be attached to transmission structures or installed in separate locations, such as nearby streets. The ground wire sometimes incorporates a fiber optic communications line (CPUC 2014a).

Substations and Transformers

Construction of a substation begins with site preparation, including clearing of vegetation, site grading, and installation of site drainage, ground grid, and concrete foundations (including spill prevention, control, and countermeasures for the transformer[s]). A non-conductive gravel pad is placed over the substation yard, and a security fence is installed surrounding the site for safety and security (PSCW 2013). In some instances, a communication tower may be required.

Underground Transmission

In this Draft Programmatic EIS, underground transmission facilities can include the following construction methods:

- Open trenching
- Trenchless crossings (including horizontal direction drilling [HDD], jack and bore, or tunneling)
- Underwater

Underground transmission facilities must be buried, which requires substantially more earthwork than overhead transmission facilities. There are two primary methods used for installing underground transmission lines: open trenching and trenchless crossings. Both are evaluated in this Draft Programmatic EIS as described below.

Open Trenching

The most common technique of underground transmission construction is open trenching. Open trenching is the most straightforward method and can be performed with basic construction skills and equipment. Open trenching involves the use of heavy machinery to dig an open trench at a depth typically of 6 to 8 feet but can be greater (PSCW 2011). This method allows precise control of the trench depth, making it suitable for projects with specific depth requirements. Traditional trenching equipment is generally less expensive to purchase and maintain in comparison to trenchless crossings that require drilling or tunneling. In the event of utility repairs or maintenance, traditional trenching offers relatively direct access to the utilities compared to trenchless. However, open trenching results in surface disruption, which can be problematic in urban or environmentally sensitive areas. Additionally, restoration of the surface after trenching can be time-consuming and costly.

Trenchless Crossings

The second method is trenchless crossings, used when open trenching is not practical due to the presence of structures or sensitive surface resources, shallow bedrock or groundwater levels, or because the soils will not bear the weight of heavy equipment (Hair 2015). Trenchless crossing techniques evaluated in this Draft Programmatic EIS include HDD, jack and bore, and tunneling.

Horizontal Directional Drilling

The HDD technique uses a surface-launched drilling rig to dig an underground tunnel with minimal surface disruption (Hair 2015). The process begins with crews digging sending and receiving pits. A drilling rig is used to cut a small pilot hole throughout the length of the route. Once it reaches the receiving end, it is pulled back through the pilot hole, creating a large tunnel while pulling the transmission line through. HDD is suitable for soft to hard clays and wet soils and involves drilling rather than extensive excavation (City of Portland n.d.). This method also provides flexibility in the drilling path, allowing the operator to maneuver around obstacles and along curves. HDD is anticipated to result in minimal impacts on natural habitats, is more suitable for environmentally sensitive areas, and can reduce post-construction site restoration costs (Hair 2015).

Jack and Bore

Jack and bore is another trenchless construction technique that uses a hydraulic auguring machine to create an underground tunnel. The jack and bore process requires moderate excavation at the entry and exit points for the jack and bore machine to be positioned. Typical boring pits are around 14 by 35 feet and deep enough to accommodate the boring equipment (PSCW 2011). A casing, which includes the transmission wires, is then jacked horizontally through the ground while a rotating auger simultaneously removes the soil. This technique is generally limited in maneuverability and steering; therefore, it is often used for short, straight segments (FDOT 2010).

Tunneling

Tunneling is generally used in urban areas where open trenching would not be a viable option and is typically located at depths greater than with HDD or jack and bore. In most cases, a tunnel boring machine (TBM) is used and can encompass the installation of tunnels by microtunneling, pipejacking, or conventional tunneling. The main difference between microtunneling/pipejacking and conventional tunneling is the method of lining the tunnel. Pre-formed pipes are used as the structural lining in pipejacking/microtunneling and in conventional tunneling, the lining is typically formed of precast concrete segments that are interlocked to line the tunnel bore as the TBM advances (National Grid 2023).

Construction would include forming work areas and entry and exit areas for the TBM to be used. The first phase of tunneling is to construct the launch and reception shafts. Following construction of the shafts, a base slab and tunnel headwall structure would be cast at the bottom of each shaft and a thrust wall installed within the launch shaft to allow the TBM to advance. The TBM would be lowered into the launch shaft and tunneling commenced between the launch and reception shafts. Once the tunnel is constructed and the transmission conductors have been installed, the shafts would either be capped using prefabricated beams/slabs then backfilled, or a tunnel head house constructed. The requirement for a tunnel headhouse would be determined depending on whether the required cable ratings could be achieved without mechanical ventilation within the tunnel (National Grid 2023).

Underwater

Underwater crossings of transmission lines along rivers or lakes involve laying cables directly on the waterbed. Before laying the cables, a detailed survey of the river or lakebed is conducted to identify the best route and avoid obstacles. Specialized barges or vessels are used to lay the cables on the waterbed. The cables are typically weighted or buried slightly to ensure they remain in place (Riverkeeper 2024). Measures are taken to minimize environmental impacts, such as avoiding sensitive habitats and ensuring proper sediment management. This method avoids the need for extensive excavation and surface disruption, making it suitable for some environmentally sensitive areas. Since the cables are underwater, they have no visual impact on the landscape.

Accessing and repairing underwater cables can be more challenging and costly than land-based cables. Examples of this construction method proposed in other transmission facility projects include:

- **Transbay Cable Project:** Approximately 53 miles of high-voltage direct-current cable connecting two substations to enhance the reliability of San Francisco's electric grid (Babcock & Brown 2007).
- **Lake Champlain:** Nearly 97 miles of transmission cable proposed along the bottom of Lake Champlain (Adirondack Explorer 2024).
- **Hudson River:** Nearly 89 miles of transmission cable along the bottom of the Hudson River (Riverkeeper 2024).

Supporting Infrastructure for Underground Transmission Facilities

Additional infrastructure for underground transmission facilities would likely include underground vaults, transition structures, and lightning arrestors.

Underground Vaults

Once the trench or tunnel is prepared and the vaults are constructed, the underground cable can be placed. These cables consist of several components but can be described generally as a bundle of copper or aluminum conductor wires through which electricity passes, surrounded by an insulation layer composed of gas, fluid, polyethylene, or other non-conductive materials. Both the wire bundle and the insulation layer are then encased in an outer jacket that protects the wire from water infiltration and external damage (PSCW 2011).

Transition Structures

When underground transmission facilities need to connect to overhead lines, a transition structure or station is needed. For underground lines less than 345 kV, a 60- to 100-foot-tall transition structure similar in composition and construction to an overhead transmission support structure is installed. Transition structures are designed to keep conductors separated. The insulated overhead conductor is linked through a solid insulator device to the underground conductor. This insulator device keeps moisture out of the cables and ensures that the overhead line is appropriately distanced from the supporting structure (PSCW 2011).

For underground lines of 345 kV or greater, a transition station is needed. Depending on the length of the underground transmission facility, intermediate transition stations might be necessary. Transition stations are similar in composition to a small substation and typically cover 1 to 2 acres. These stations require grading, access roads, and stormwater management facilities (PSCW 2011).

Lightning Arrestors

Lightning arrestors are installed where the underground cable connects to the overhead lines to protect it from lightning strikes. Lightning arrestors are critical to the longevity of underground cables since the insulating material cannot be repaired if large voltage changes damage the cables (PSCW 2011).

2.3.2.3 Post-Construction Restoration

Backfilling of Trenches, Holes, and Tunnels

After the overhead support structures or cables and vaults have been installed, all trenches, holes, and/or tunnels are backfilled with the soils previously excavated from the site. In some instances, other backfill material is used in trenches around the cables to ensure sufficient heat transfer to the surrounding soils and groundwater (PSCW 2011).

Site Restoration and Revegetation

Reclamation and maintenance requirements for overhead and underground transmission ROW can vary depending on the specific regulations and guidelines set by different authorities. Although more extensive, typically site restoration for underground transmission facilities is similar to overhead transmission facilities. Once construction activities are completed and all excavated areas are backfilled, all roadways, landscaped areas, and undeveloped areas are restored to their pre-construction or agreed-upon conditions and topography (PSCW 2011). Infrastructure such as driveways, curbs, and private utilities impacted by transmission facility development would be restored to their pre-construction conditions.

Transmission facility development would also be required to vegetate disturbed areas to stabilize the soil and prevent erosion. This often involves an integrated vegetation management approach in which native species that are compatible with the local ecosystem are planted. This Draft Programmatic EIS outlines revegetation requirements, such as approving seed mixes by the SEPA Lead Agency in coordination with other stakeholders. Furthermore, tall trees would not be planted within the ROW of overhead transmission facilities to avoid interference with overhead lines, and deep-rooted shrubs or trees would not be planted within the ROW of underground transmission facilities to prevent interference with underground lines.

2.3.3 Transmission Operation and Maintenance

Activities for the operations phase would vary based on type of facility, scale, and site characteristics. Facilities are not expected to have staff on site daily, but maintenance crews are anticipated to be regularly deployed. Unlike other components associated with transmission facilities, substations may be staffed on a routine or daily basis during operations and typically have a permanent access road connecting the site to the nearest public road (PSCW 2013). This is particularly necessary and important should large equipment need replacing.

2.3.3.1 Post-Construction Monitoring and Reporting

Once initial post-construction restoration is completed, ongoing monitoring and reporting associated with mitigation measures identified in this Draft Programmatic EIS would be implemented. These efforts could include, but are not limited to, the following:

- Monitoring earth resources throughout operation and maintenance to avoid and/or minimize impacts related to soil compaction, soil erosion, and/or accretion13.
- Implementing a vegetation management plan to reduce direct and indirect impacts to sensitive vegetation.
- Implementing an invasive species management plan to reduce the spread of invasive species on the right-of-way, adjacent construction sites, and access roads.
- Implementing a revegetation plan to restore areas impacted by project construction. The revegetation plan would include a monitoring plan to determine the success of the restoration areas through operation and maintenance.
- Implementing a wildlife mitigation and monitoring plan, including avian protection and monitoring, throughout operation and maintenance to minimize impacts on the surrounding habitat and wildlife species.

[13] Refers to the process of growth or increase, typically by the gradual accumulation of additional layers of matter.

- Archaeological monitoring during maintenance activities to avoid and/or minimize impacts on cultural resources

Routine Inspections

Routine inspection and maintenance are vital to the longevity and efficiency of transmission facility operation. Recurring inspections would occur throughout the life of a transmission facility project and are required by federal regulations FAC-003-4 and FAC-501-WECC-4. Activities associated with routine inspections would vary depending on the type of transmission facility, scale, and location. Generally, routine inspections for transmission facilities would include an examination of the different components of the facility such as poles, anchors, hardware, fixtures, and conductors. Conductors and fixtures could be tested for corrosion, breaks, broken insulators, and correct tension. Substation structures would be inspected on a recurring basis for corrosion, equipment misalignment, operational parameters, or foundation problems.

Maintenance and Repairs

Maintenance of transmission facilities could include repairing old, degraded, obsolete, or inoperable components, conductors, or structures. Maintenance could also include replacing a component, conductor, or structure with a direct, "like-for-like" component to support ongoing facility operation. It is anticipated that required maintenance and repairs would be addressed as soon as warranted or within a 12-month period.

Right-of-Way Maintenance

ROW conditions would be examined during the routine inspections. The transmission facility ROW is likely to require ongoing maintenance to ensure adequate access to the structures. Access roads may require regrading or repairs to water bars or culverts due to flooding or inadequate drainage. Vegetation and debris along access roads and ROWs would be addressed and maintained as well.

Vegetation Maintenance

As discussed in Section 2.3.2.3, overhead transmission facility ROWs would be free of tall trees, while underground transmission facility ROWs would be free of any deep-rooted shrubs or trees. Vegetation within transmission facility ROWs and adjacent areas must be inspected and maintained on a regular basis to meet requirements set forth by NERC (FAC-003-4).

Vegetation maintenance would be required on a recurring basis to manage the growth of trees or vegetation within or encroaching upon transmission facility ROW. This can include mowing, trimming, tree removal, and the use of herbicides. Other new remote sensing technologies, such as Light Detection and Ranging (LiDAR) can be used for more effective vegetation management (DOE 2023b). In addition to routine vegetation management activities, there may be emergency situations where tree hazards require immediate response.

In some instances, helicopters can be used in remote areas to conduct scheduled vegetation maintenance. The use of helicopters can reduce ground disturbance, as well as the time needed to complete the required maintenance activities (BPA 2021). As discussed in Section 3.1, helicopters would be restricted from flying above sensitive wildlife habitats during noise-sensitive periods and would not conduct field landings or fly below 50 feet above ground level.

2.3.4 Transmission Decommissioning

Transmission facilities are decommissioned following the end of their useful lives, which generally range from 40 to 100 years. Underground transmission lines typically have a life expectancy closer to 40 years, while overhead transmission lines can approach 100 years (PRPA 2024). If a transmission facility is no longer needed at the end of its useful life, the applicant would be required to prepare a decommissioning plan and appropriate environmental analyses as identified by the SEPA Lead Agency when decommissioning is proposed (see general condition Gen-8 in Section 3.1). Furthermore, permitting agency(ies) may require financial security as part of a decommissioning plan.

When decommissioning is required, the decommissioning plan would provide a detailed outline of the following procedures:

- Complete decommissioning-phase environmental studies, as determined by the SEPA Lead Agency (at the time of project application or when decommissioning is proposed). These environmental studies could include socioeconomic studies and environmental assessments to better determine applicable mitigation measures.
- Remove project components, including conductors, insulators, hardware, structures, and foundations.
- Recycle, when appropriate, or disposal of project materials.
- Restore and revegetate all disturbed areas.

Since it is not possible to know whether a transmission facility would remain in operation or require decommissioning so far into the future, the environmental impacts associated with decommissioning a transmission facility are not analyzed in this Draft Programmatic EIS.

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