EXHIBIT AA
ELECTRIC TRANSMISSION LINE

Table of Contents

List of Tables

List of Figures

Attachments

Introduction

This Exhibit provides information about the Facility pursuant to OAR 345-021-0010(1)(aa)(A) through (B) and presents supporting information to meet Specific Standards for Transmission Lines pursuant to 345-024-0090.

AA.1 Electric and Magnetic Fields

OAR 345-021-0010(1)(aa)(A) *Information about the expected electric and magnetic fields, including:*

AA.1.1 Distance from Generator lead line Centerline to Edge of Right-of-Way

(i) The distance in feet from the proposed center line of each proposed transmission line to the edge of the right-of-way;

RESPONSE

AA.1.1.1 230-kV Overhead Generator Lead Lines

A new 230-kV generator lead line will connect the Facility from the nearest (northerly) Facility collector substation to the Diamond Butte or Cedar Spring substation. This segment is referred to as Reach 1 of the 230-kV generator lead line and will consist of a single circuit on monopole or H-frame towers with double-bundle conductor. The final design of the generator lead line and collector systems has not been completed at this time. For the purposes of this Exhibit, the H-frame tower configuration was modeled since it results in higher electric and magnetic field (EMF) strengths. In addition, for analysis purposes, this Exhibit assumes that Reach 1 of the line (from the interconnection substation to the northernmost Facility substation) will consist of double bundle 1,272 kcmil conductors and that Reach 2 (between Facility substations) will consist of single conductor 795 kcmil conductors. The generator lead line will be supported on monopole or H-frame towers. For the purposes of this Exhibit, the H-frame tower configuration was modeled since it results in higher EMF strengths.

The 230-kV generator lead line will be located for the most part on private land pursuant to leases or easements with landowners. Some sections may be located within existing public right-of-way, with the appropriate authorizations received from the respective right-of-way manager (e.g., Gilliam County or ODOT). No new private or public right-of-way will be established, or existing right-of-way widened for any of the above described facilities. The 230-kV generator lead line disturbance corridor will be approximately 150 ft wide. The generator lead lines will be located approximately in the center of this corridor; therefore, the centerline of the generator lead lines will be about 75 ft from the edge of the disturbance corridor.

AA.1.1.2 34.5-kV Collector Lines and Cables

The power collection system portion of the Facility's electrical system consists of the collector cable system that will be installed along and between the turbine strings and include the following: Overhead collector lines (34.5-kV) with two circuits on vertical poles; overhead collector lines (34.5-kV) with one circuit on vertical poles; and underground collector lines (34.5-kV) with up to three parallel circuits.

Similar to the 230-kV generator lead line, collector lines will be located for the most part on private land pursuant to leases or easements with landowners. Some sections may be located within existing public right-of-way, with the appropriate authorizations received from the respective right-of-way manager (e.g. Gilliam County or ODOT). No new private or public right-of-way will be established, or existing right-of-way widened for any of the above described facilities. The disturbance corridor for the 34.5-kV overhead collector lines will be approximately 75 ft wide. The collector lines will be located approximately in the center of this corridor; therefore, the centerline of the overhead collector lines will be about 37.5 ft from the edge of the disturbance corridor. The ground disturbance for the 34.5-kV underground collector cables will be 25 ft wide, or less, depending on the number of collector circuits at a specific location. The collector cables will be buried at least 3 ft below the surface and located approximately in the center of the disturbance corridor; therefore, the centerline of the underground collector lines will be about 12.5 ft from the edge of the disturbance corridor. In some locations the disturbance corridor associated with the underground collector lines may overlap with other temporary or permanent ground disturbance areas, for example access roads or turbine pad areas.

AA.1.2 Types of Occupied Structures within 200 Ft of Centerline of Proposed Generator lead Lines

(ii) The type of each occupied structure, including but not limited to residences, commercial establishments, industrial facilities, schools, daycare centers and hospitals, within 200 feet on each side of the proposed center line of each proposed transmission line;

(iii) The approximate distance in feet from the proposed center line to each structure identified in (A);

RESPONSE

AA.1.2.1 230-kV Overhead Generator lead Lines

There are two occupied buildings within 200 ft of the centerline of the proposed overhead generator lead line routes. There are adjacent residences located on participating landowner's property on Weedman Farms (Tax Lot 01N21E02100). The buildings are approximately 100 ft from the centerline of Reach 2 of the generator lead line, where the electric field will be about 0.24 kV per m or less, depending upon the final generator lead line configuration. This electric field estimate is much less than the 9 kV per m standard set forth in OAR 345-024-0090(1).

AA.1.2.2 34.5-kV Collector Lines and Cables

The existence of any occupied buildings, or any structures meant for regular occupation, within 200 ft on either side of the centerline of the proposed collector line and cable routes has not been finalized and therefore is not provided at this time. This information will be based on micrositing and will be provided to EFSC prior to construction. However, since the electric fields produced by the collector lines are very low, the existence of an occupied building within 200 feet of the line, or even adjacent to the edge of the right-of-way, is not significant. The estimated electric field at the edge of the overhead collector line is less than one percent of the 9 kV per m standard set forth in OAR 345-024-0090(1).

AA.1.3 Graphs of EMF Levels

(iv) At representative locations along each proposed transmission line, a graph of the predicted electric and magnetic fields levels from the proposed center line to 200 feet on each side of the proposed center line;

RESPONSE

AA.1.3.1 Overview of EMFs Produced by Power Lines

All power lines, electrical wiring, and electrical equipment produce EMF. The earth also generates magnetic and electric fields. The EMF produced by the alternating current (AC) electrical power in North America alternates through 60 cycles per second, or 60 hertz (Hz). Electric fields are produced by voltage and increase in strength as the voltage increases. The electric field strength is measured in units of volts per m (V/m). Magnetic fields result from the flow of current through wires or electrical devices and increase in strength as the current increases. Magnetic fields are measured in units of gauss (G) or tesla (T).

Electric Fields

Electric fields around transmission lines are produced by electrical charges, measured as voltage, on the energized conductor. Electric field strength is directly proportional to the line's voltage (i.e., increased voltage produces a stronger electric field). Electric field strength declines as the distance from the conductor increases. Electric fields are shielded or weakened by materials that conduct electricity (even materials that conduct poorly, including trees, buildings, and human skin).

Magnetic Fields

Magnetic fields around transmission lines are produced by the electrical load, or the amount of current flow, through the conductors measured in terms of amperage. Like the electric field, the magnetic field alternates at a frequency of 60 Hz. The magnetic field strength is directly proportional to the amperage (i.e., increased power flow results in increased amperage which produces a stronger magnetic field). Like the electric field, the magnetic field strength declines as the distance from the conductor increases. However, magnetic fields pass through most materials and are therefore more difficult to shield. Both electric fields and magnetic fields decrease rapidly as the distance from the source increases. The strength of the magnetic field depends on the current in the conductor, the geometry of the construction, the degree of cancellation from other conductors, and the distance from the conductors or cables.

AA.1.3.2 EMF Characteristics for 230-kV Overhead Generator lead Lines

Refer to Figure AA1 for a representation of the typical proposed H-frame overhead structure configuration of the 230-kV single-circuit generator lead line. The structure is typical for both reaches of the 230-kV generator lead line from the interconnection substation to the northernmost Facility substation (Reach 1) and between Facility substations (Reach 2). Both reaches will include two shield wires, one each near the tops of the two vertical poles. For purposes of the analysis completed for this Exhibit, the conductor type for Reach 1 will consist of double bundle 1,272 kcmil; Reach 2 will be single conductor 795 kcmil.

Refer to Figure AA2 through Figure AA5 and Table AA1 below for the predicted EMFs at 1 m aboveground due to the generator lead lines during maximum load conditions. The indicated EMFs are representative of the locations of maximum anticipated fields, which occur at approximately the mid-span between pole structures where clearances aboveground are near the minimum.

Table AA1: Calculated EMFs for the 230-kV Generator Lead Line

	Left edge of D/C* (-75')	Maximum on D/C	Right edge of D/C (+75')
Reach 1			
Electric Field (kV/m)	0.68	3.48	0.68
Magnetic Field (Gauss)	0.045	0.261	0.045
Reach 2			
Electric Field (kV/m)	0.50	2.58	0.50
Magnetic Field (Gauss)	0.016	0.094	0.016

*D/C = disturbance corridor

AA.1.3.3 EMF Characteristics for 34.5-kV Overhead Collector Lines

Refer to Figure AA6 for a representation of the typical proposed overhead structure configuration of the 34.5-kV double-circuit collector line. The conductor size will be 1,590 kcmil.

Refer to Figure AA7, Figure AA8, and Table AA2 below for the predicted EMFs at 1 m aboveground due to the double-circuit overhead collector line during maximum load conditions. The indicated EMFs are representative of the locations of maximum anticipated fields, which occur at approximately the mid-span between pole structures where clearances aboveground are near the minimum.

Table AA2: Calculated EMFs for the 34.5-kV Double-Circuit Overhead Collector

	Left edge of D/C (-37.5')	Maximum on D/C	Right edge of D/C (+37.5')
Electric Field (kV/m)	0.015	0.187	0.017
Magnetic Field (Gauss)	0.032	0.092	0.030

Refer to Figure AA9 for a representation of the typical proposed overhead structure configuration of the 34.5-kV single-circuit collector line. The conductor size will be 1,590 kcmil.

Refer to Figure AA10, Figure AA11, and Table AA3 below for the predicted EMFs at 1 m aboveground due to the single-circuit overhead collector line during maximum load conditions. The indicated EMFs are representative of the locations of maximum anticipated fields, which occur at approximately the mid-span between pole structures where clearances aboveground are near the minimum.

Table AA3: Calculated EMFs for the 34.5-kV Single-Circuit Overhead Collector

	Left edge of R/W (-37.5')	Maximum on R/W	Right edge of R/W (+37.5')
Electric Field (kV/m)	0.07	0.295	0.07
Magnetic Field (Gauss)	0.018	0.066	0.021

AA.1.3.4 EMF Characteristics for 34.5-kV Underground Collector Cables

Refer to Figure AA12 for a representation of the typical 34.5-kV underground cable configuration. For purposes of the analysis prepared for this Exhibit, the conductor size will be 1,000 kcmil. Up to three parallel circuits may be installed, at 12.5-foot spacing from centerline to centerline.

Refer to Figure AA13 and Figure AA14 for the predicted magnetic fields under maximum electrical load at 1 m aboveground due to a single circuit and three parallel circuits, respectively. Electric field data is not given. Due to the insulated and shielded underground cables, the electric fields at ground level are very low and not measurable.

AA.1.3.5 Measures Proposed to Reduce Electric or Magnetic Field Levels

(v) Any measures the applicant proposes to reduce electric or magnetic field levels;

RESPONSE

There are several reasonable and customary measures that the Applicant can incorporate to reduce electric or magnetic field exposure to the public. Because some characteristics of the Facility will unavoidably produce EMF, the planning and design of the Facility will incorporate the following prudent avoidance and mitigation measures:

- *Locate facilities remotely from the public*—because both EMF strengths fall off greatly with distance, designing EMF-producing facilities so they are not located in close proximity to residences and continuously occupied buildings reduces the public's exposure to EMF. Generally, the disturbance corridor width or code-prescribed safety clearance provides adequate spacing for reducing EMF exposure.
- *Locate facilities on private land*—For the most part facilities will be located on private land where the public does not have access, except for limited use of public right-of-way as previously noted. In addition, the Applicant will construct aboveground lines at least 200 feet from any residence. The Applicant will provide landowners a map of underground and overhead transmission lines on their property and will advise landowners of possible health risks.
- *System design*—Designing and maintaining all generator lead lines so that alternating current electric fields do not exceed 9 kV per m at 1 m above the ground surface in areas accessible to the public.
- *Current balance*—magnetic fields can be reduced by maintaining equal current in each of the three phases of the generator lead line. By their very nature, the wind turbines produce balanced current from phase to phase. Any single-phase station

service power that is drawn from the substation will be small in relation to the total power in the generator lead line and will not significantly affect current balance.

- *Multiple circuits*—two circuits will be carried on each 34.5-kV overhead collector circuit pole. A cancellation effect that will reduce the electric field from that which would be experienced with a single circuit can be achieved by appropriate arrangement of the phases. EMF will be reduced by transposing conductors to improve the cancellation of fields. For the monopole double-circuit 34.5-kV overhead lines, conductors will be arranged with A, B, and C phases from top to bottom on one side of the pole, and with C, B, and A phases from top to bottom on the other side of the pole.

AA.1.3.6 Assumptions and Methods Used in EMF Analyses

(vi) The assumptions and methods used in the electric and magnetic field analysis, including the current in amperes on each proposed transmission line; and

RESPONSE

The EMF values were calculated using the Corona and Field Effects Program Version 3 developed by the BPA, U.S. Department of Energy. This program and similar programs have been used for many years with results verified by actual measurements. Field strength values are calculated at 1 m aboveground.

The assumptions and variables affecting the calculations and field strength estimate for the 230-kV generator lead line are listed below:

- *Electric current*—the magnetic field is proportional to the amperage (current or load) in the conductor, which in turn is proportional to the power being transmitted from the Facility. For the purpose of estimating the maximum anticipated magnetic field strength, the calculations were made assuming maximum net generation by the Facility, resulting in a current of 1,325 amps per phase in Reach 1 and 475 amps per phase in Reach 2.
- *Voltage*—the electric field is proportional to the voltage of the line, which is nominally 230,000 volts.
- *Conductor spacing*—the proposed structure configuration of both reaches of the generator lead line is shown in Figure AA1. The conductor spacing will be 18 ft from phase to phase for both reaches.
- *Ground clearance*—the maximum EMFs at ground level will occur at mid-span between generator lead line poles where the conductors are closest to the ground. For the purpose of this Exhibit, the minimum clearance between the ground and the conductor was assumed to be about 30 ft. Final design and construction of the line will result in actual clearances greater than the above under all weather and loading conditions.
- *Conductor size*—the assumed conductor in Reach 1 is 1,272 kcmil ACSR 'Bittern,' two conductors per phase, with 12-inch spacing between paired conductors. The assumed conductor in Reach 2 is 795 kcmil ACSR 'Drake,' one conductor per phase.

- *Shield wire*—the presence of a shield wire slightly affects the electromagnetic field strength. Two OPGW shield wires of 0.75-inch-diameter will be used on both reaches of the 230-kV generator lead line.

The assumptions and variables affecting the calculations and field strength estimate for the 34.5-kV overhead collector lines are listed below:

- *Electric current*—the magnetic field is proportional to the amperage (current or load) in the conductor, which in turn is proportional to the power being transmitted from the turbines connected to the circuit. For the purpose of estimating the maximum anticipated magnetic field strength, the calculations were made assuming the circuits are limited to 900 amps per phase.
- *Voltage*—the electric field is proportional to the voltage of the line, which is nominally 34,500 volts.
- *Conductor spacing*—the proposed configurations of the overhead collector lines is shown in Figure AA6 and Figure AA9. On the double-circuit line, vertical spacing between phases in a common circuit is 7 ft, and the minimum horizontal spacing between circuits is about 5 ft. On the single-circuit line, vertical spacing between phases is about 3.5 ft and each phase is horizontally offset from the adjacent phase by 5 to 6 ft.
- *Ground clearance*—the maximum EMFs at ground level will occur at mid-span between generator lead line poles where the conductors are closest to the ground. For the purpose of this Exhibit, the minimum clearance between the ground and the lowest conductor was assumed to be about 25 ft. Final design and construction of the line will result in actual clearances greater than the above under all weather and loading conditions.
- *Conductor size*—the assumed conductor is 1,590 kcmil ACSR 'Falcon,' one conductor per phase.
- *Shield wire*—a single, 0.75-inch-diameter OPGW shield wire will be used at the top of the pole.

The 34.5-kV underground collector circuits do not produce an electric field at ground level because the electric field is contained within the conducting shield layers of the cable. The insulation and shielding of the cables do not contain the magnetic field; therefore, there is a measurable magnetic field at the surface of the ground above the cables. See Figure AA12 for the configuration of the underground collector cables.

The assumptions and variables affecting the calculations and field strength estimate for the 34.5-kV underground collector circuits are listed below:

- *Electric current*—the maximum loading was assumed to be 300 amps per phase.
- *Conductor size*—the assumed conductor is 1,000 kcmil, one conductor per phase.
- *Cable location*—the cables are assumed to be buried a minimum of 36 inches, with the three phases arranged in a trefoil arrangement.

- *Parallel circuits*—the existence of parallel circuits affects the strength of the magnetic field. Results are given for a single circuit, and for 3 circuits with 12 ft of separation between circuits.

AA.1.3.7 Monitoring Program

(vii) The applicant's proposed monitoring program, if any, for actual electric and magnetic field levels; and

RESPONSE

The Applicant does not propose to monitor actual EMF levels at this time.

AA.2 Radio and TV Interference

OAR 345-021-0010(1)(aa)(B) *An evaluation of alternate methods and costs of reducing radio interference likely to be caused by the transmission line in the primary reception area near interstate, U.S., and state highways;*

RESPONSE

See Figure AA15 and Figure AA16 for representations of the anticipated radio frequency interference (RFI) levels in db microvolts/m relative to the centerline of the 230-kV generator lead lines in Reaches 1 and 2, respectively. RFI levels for the 34.5-kV overhead and underground collector circuits are not shown because the RFI emissions from those lines are negligible.

RFI effects due to the high-voltage generator lead lines drop rapidly with distance from the line, being inversely proportional to the square of the distance from the line. RFI effects are negligible at distances of more than a couple hundred ft from the line.

The Applicant proposes to minimize the effects of radio frequency interference through the use of modern hardware and construction practices to minimize corona discharge, the source of RFI. The Applicant will also avoid using 345-kV and 500-kV voltage levels where corona discharge effects are much more noticeable.

AA.3 Proposed Site Certificate Conditions

Similar to the conditions proposed by previously-approved wind energy facilities in the vicinity of the Facility, the Applicant proposes the following conditions:

Condition 101
The certificate holder shall install the 34.5-kV collector system underground to the extent practical. The certificate holder shall install underground lines at a minimum depth of 3 feet. Based on geotechnical conditions or other engineering considerations, the certificate holder may install segments of the collector system aboveground where underground installation is not feasible; however, the total length of aboveground segments must not exceed 30 percent (approximately 45.5 miles) of the collector system.

Condition 102
The certificate holder shall take reasonable steps to reduce or manage human exposure to electromagnetic fields, including but not limited to:

- *Constructing all aboveground generator lead lines at least 200 feet from any residence or other occupied structure, measured from the centerline of the generator lead line.*
- *Providing to landowners a map of underground and overhead generator lead lines on their property and advising landowners of possible health risks from electric and magnetic fields.*
- *Designing and maintaining all generator lead lines so that alternating current electric fields do not exceed 9 kV per meter at 1 meter above the ground surface in areas accessible to the public.*
- *Designing and maintaining all generator lead lines so that induced voltages during operation are as low as reasonably achievable.*

Condition 103
In advance of, and during, preparation of detailed design drawings and specifications for 230-kV and 34.5-kV generator lead lines, the certificate holder shall consult with the Utility Safety and Reliability Section of the Oregon Public Utility Commission to ensure that the designs and specifications are consistent with applicable codes and standards..

AA.4 Conclusion

Based on the above information, the Applicant has satisfied the requirement of OAR 345-021-0010(1)(aa), and has demonstrated that the standard contained in OAR 345-024-0090(1) has been satisfied.

Figures

ATTACHMENTS