2.4 Energy Transmission Systems

WAC 463-42-155 Proposal – Energy transmission systems. *The applicant shall discuss the criteria utilized as well as describe the routing, the conceptual design, and the construction schedule for all facilities identified in RCW 80.50.020 (6) and (7) which are proposed to be constructed.*

2.4.1 Introduction

Figure 2.4.1-1 Existing Transmission Lines Across Project Site

The Applicant has reviewed and evaluated multiple prospective wind energy sites in various areas of the Pacific Northwest. The main criteria used for selecting a wind power project site include several considerations. The site for the Kittitas Valley wind Power Project was chosen for several reasons including its strong wind resource, compatible land uses and access to suitable transmission lines. There are several sets of large sized high voltage power lines which cross over the Project site including 5 sets of Bonneville Power Administration (BPA) transmission lines and 1 set of Puget Sound Energy (PSE) transmission lines.

The Project will interconnect with the BPA and/or the PSE transmission lines near Bettas Road as indicated on the site layout contained in Exhibit 1. Since interconnection to the grid will not require the construction of any new major transmission feeder lines, several environmental and other impacts have been avoided. The plant electrical system will be designed and constructed in accordance with the guidelines of the National Electric Code (NEC), National Fire Protection Agency (NFPA) and utility requirements. The general schedule for construction of the interconnection facilities and the substation shall be coordinated with the construction of the rest of the Project as outlined in Section 2.12, 'Construction Schedule and Operation Activities'.

2.4.2 Electrical Collection System Overview

Electrical power generated by the wind turbines is transformed and collected through a network of underground and overhead cables which all terminate at the Project substation. It is most likely that only one substation will be constructed for the Project, however, it is possible that two substations be installed allowing access to both the BPA and Puget Sound Energy (PSE) systems. The Project Site Layout in Exhibit 1 shows the general routing paths of the underground and overhead electrical lines as well as the proposed substation locations.

Power from the turbines is fed through a breaker panel at the turbine base inside the tower and is interconnected to a pad-mounted step-up transformer which steps the voltage up to 34.5 kilovolts (kV). The pad transformers are interconnected on the high side to underground cables which connect all of the turbines together electrically. The underground cables are installed in a trench which is typically 3-4 feet deep and generally runs beside the Project's roadways in order to reduce disturbances to additional ground. Also, due to the rocky conditions at the site, a clean fill material such as sand or fine gravel will be used to cover the cable before the native soil and rock are backfilled over top. In areas where solid rock is encountered and deep trenching is not possible, the underground cables will be installed in a shallower trench and covered in a concrete mix in accordance with acceptable electrical code.

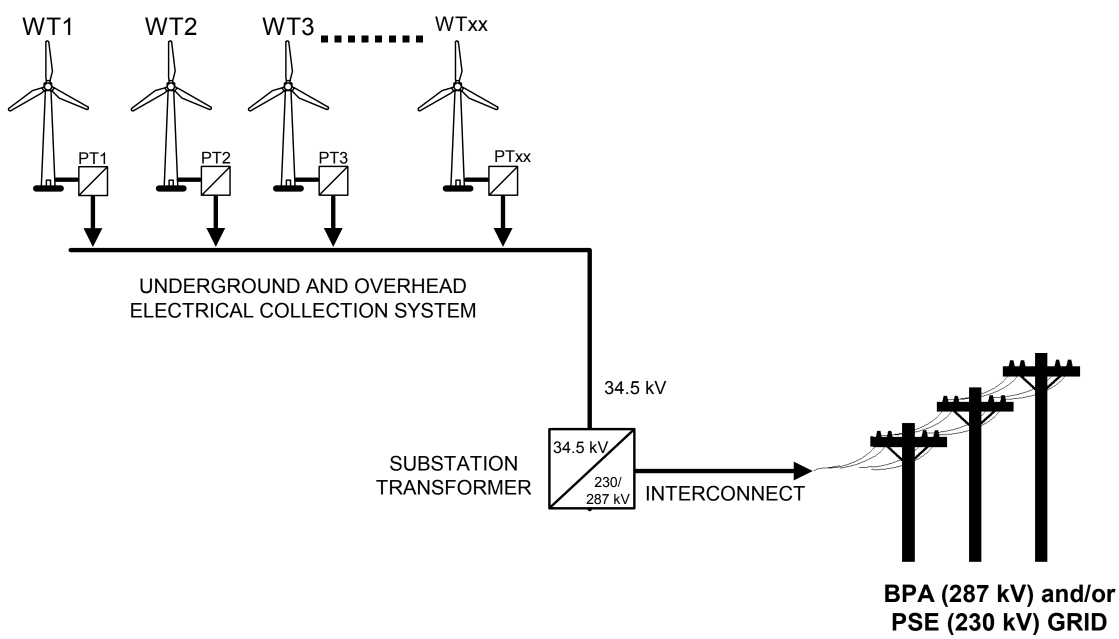
For the short runs of overhead power lines along Bettas Road, a fused, visible, lockable, switched riser pole will be used to run the cables from the underground trench to the overhead conductors. At the substation(s), the electrical power from the entire wind plant is stepped up to transmission level at 230 kV (PSE) or 287 kV (BPA) and delivered to the point(s) of interconnection.

The underground collection cables feed to larger feeder lines which run to the main substation(s) as shown schematically in Figure 2.4.2-1

In locations where two or more sets of underground lines converge, pad mounted junction panels will be utilized to tie the lines together into one or more sets of larger feeder conductors.

The Project requires approximately 23 miles of trenched-in underground and 2 miles of overhead 34.5 kV electrical power lines to collect all of the power from the turbines to terminate at the main substation(s).

Figure 2. 4.2-1 Electrical Collection System and Interconnect



2.4.3 <u>Interconnection Facilities and Substation</u>

If connected to BPA's system, the Project will interconnect directly with either the Grand Coulee to Olympia or Columbia to Covington 287 kV lines. If connected to PSE's system, the Project will interconnect directly with PSE's Rocky Reach to White River 230 kV line. There is the possibility that power will be fed to both the PSE and the BPA systems resulting in the requirement for 2 substations since the lines are at two different voltages (230 kV and 287 kV). The locations of the substations are indicated on the Project Site Plan contained in Exhibit 1.

The main functions of the substation and interconnection facilities is to step up the voltage from the collection lines (at 34.5 kV) to the transmission level (230 kV for PSE and 287 kV for BPA), to interconnect to the utility grid and provide to fault protection. The basic elements of the substation and interconnection facilities are a control house, two main transformers, outdoor breakers, relaying equipment, high voltage bus work, steel support structures, and overhead lightning suppression conductors. All of these main elements will be installed on concrete foundations. The substations and interconnection facilities each consist of a graveled footprint area of approximately 2-3, acres a chain link perimeter fence, and an outdoor lighting system. A photograph of a typical substation is shown in Figure 2.4.3-1.

Figure 2.4.3-1 Typical Substation

A typical one-line diagram of a substation and interconnect system which would be used as a preliminary outline for the Project is included in Exhibit 3, 'Project Electrical One-Line Diagram'. Final adjustment to the substation and interconnect are generally made during design review with the utility and their system protection engineers prior to final construction design and execution.

The Project is working with BPA regarding the review, study, and design, and construction of a power transmission interconnect to BPA's 287 kV lines. If connecting to the BPA system, BPA will be responsible for permitting, constructing, owning and operating facilities interconnecting to their system, which are not subject to EFSEC's jurisdiction. The full details of the Project's BPA interconnection will be included in the BPA's Environmental Impact Statement that is to be prepared in a separate document and reviewed by the public and interested agencies under a joint NEPA/SEPA process.

Direct stroke lighting protections will be provided by the use of overhead shield wires and lightning masts connected to the switchyard ground grid. Overhead shield wires will be high strength steel wires arranged to provide shield zones of protection.

2.4.4 Transmission System Impact Studies (SIS)

In November 2001, the Project contracted with BPA to perform a System Impact Study (SIS) to determine the impact of injecting wind power into the BPA grid at the proposed point of interconnection. In addition, the Project has requested that BPA study the impact for transmitting the power from the point of interconnection to the northwest hub. The studies are still being performed by BPA and will determine the scope and approximate costs of upgrading the BPA system to accept the power from the Project. BPA has completed a preliminary intetrconnection feasibility evaluation which has confirmed that an interconnection can made at the proposed point. Once the SIS is complete, a detailed Facilities Impact Study (FIS) will be performed to determine the basic design, construction costs and schedule for installing the BPA interconnection facilities.

The Project will be undergoing a similar SIS and FIS review with Puget Sound Energy in the first quarter of 2003.

2.4.5 Stand-By Power Consumption

The Project will consume a small amount of power during periods of low wind. On an annual basis, the Project will consume less than 1% of what it generates to support auxiliary systems at the wind turbines such as hydraulic systems, pumps, heaters, fans, controller electronics, lighting, etc. Unlike traditional power plants, the Project does not consume a large amount of power for start-up. Each wind turbine comes on line at random depending upon the local wind speed at each turbine location and power consumption is generally that used for the auxiliary systems at each turbine. As with any power plant, the transformers and auxiliary systems at the substation also consume some power to stay energized and is also generally less than 1% of total plant output over the course of a year.

2.4.6 Step-Up Transformers

2.4.6.1 Pad Mount Transformers

Each of the wind turbines will have a generator step-up transformer mounted on a concrete pad at the tower base. The transformers are typically a mineral oil-filled, liquid-cooled-type, loop-feed, dead front configuration with bay-o-net type fusing, a current limiting fuse and a load break under-oil switch to allow each turbine to be isolated. Each transformer will be sized to carry its respective load without exceeding a 55 °C temperature rise. The step-up transformer impedance will be optimized based on the facility power output requirements, and feeder circuit breaker interrupting ratings and internal fuses. Protection to the transformer and turbine generator is provided by a switchable breaker at the turbine bus cabinet electrical panel inside the turbine tower.

2.4.6.2 Substation Transformers

The Substation is designed to work with either one or two 2 main transformers. The step-up transformer impedances will be optimized based on the facility power output requirements and the protection requirements set-forth by the utility to match the circuit breaker interrupting ratings. The transformers will be liquid-type with cooling fins and fans. Each transformer will be sized to carry its respective load without exceeding a 55 °C temperature rise. Each transformer will be pad-mounted with an oil containment basin consisting of crushed stone for the mineral oil stored in the transformer. The quantity of mineral oil in each transformer is included in Section 2.9, Spill Prevention and Control.

2.4.7 Capacitor Banks and Power Factor Control

Capacitor banks will be installed at each wind turbine in a bus cabinet inside the base of each tower as well as in a central bank at the substation. The capacitor banks at the substation will be sized and configured depending on the utility's requirements and needs for switching and control. Generally, a remote terminal unit (RTU) is installed which allows the utility to switch banks on or off depending the requirements at their systems operations center. The Project anticipates approximately 50 MVArs of capacitors will be installed at the substation to provide power factor control. Capacitor banks have been included in the one-line diagram in Exhibit 3.

2.4.8 Protective Relaying

The substation control house generally houses all of the protective relaying devices. Protective relays are used for switchyard control, indication, metering, recording, instrumentation and annunciation. The relays provide protection of both the utility's and the wind plant's electrical systems by automatically detecting and acting to isolate faulted, or overloaded, equipment and lines. This protection will help to minimize equipment damage and limit the extent of associated system outages in the event of electrical faults, lightning strikes, etc.

2.4.9 Lighting

The substation will be equipped with night-time and motion sensor lighting systems to provide personnel with illumination for operation under normal conditions, for egress under emergency conditions. Emergency lighting with back-up power is also designed into the substations to allow personnel to perform manual operations during an outage of normal power sources. See Section 5.1.4, 'Aesthetics Light and Glare', for additional details.

2 4.10 Substation Grounding System

The electrical system is susceptible to ground faults, lighting and switching surges that may result in high voltage which can constitute a hazard to site personnel and electrical equipment, including protective relaying equipment. The substation will be designed and constructed to have a robust grounding grid which will divert stray surges and faults. Generally, the substation grounding grid consists of heavy gauge bare copper conductor buried in a grid fashion and Cadd welded to a series of multiple underground grounding rods.

2.4.11 Supervisory Control and Data Acquisition (SCADA) System

Each turbine has its own controller in the tower base and operates independently. Overall wind plant control is achieved through a central Supervisory Control and Data Acquisition (SCADA) System as shown schematically in Figure 2.4.11-1. Each turbine is connected to the SCADA system through communications lines between all of the turbines. The central SCADA computer will be installed either at the substation control house or in the O&M building. The SCADA system allows for remote control and monitoring of individual turbine and the wind plant as a whole from both the central host computer or from a remote personal computer (PC.) In the event of faults, the SCADA system will send messages to a fax, pager or cell phone to alert operations staff.

2.4.12 Energy Transmission System Construction Schedule

The general schedule for construction of the electrical collection system, interconnection facilities and the main substation shall be coordinated with the construction of the rest of the Project as outlined in Section 2.12, 'Construction Schedule and Operation Activities'.

Figure 2.4.11-1 Electrical and Communication Collection System