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Interconnection Facilities Study Report

Request # GI-2006-1(i)

Cedar Creek Wind Energy, LCC
Facility Study

October 25, 2006

Xcel Energy Services, Inc.
Transmission Planning – Denver, CO

I. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) to specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect 300 MW of new wind generation (Large Generating Facility) at the new PSCo's Keenesburg Switching Station in Weld County, Colorado. The Large Generating Facility will be located near Grover, Colorado and would interconnect at Keenesburg Switching Station via the Customer's 72-mile 230 kV transmission line. Figure 1 shows a simple area diagram. The requested commercial in-service date is November 2007 with a requested back feed date of July 2007. This study indicates that the July 2007 back feed date may be achievable to facilitate the commercial in-service date of November 2007 due to an existing Engineering and Procurement (E&P) Agreement with PSCo.

For interconnecting the Large Generating Facility to the new PSCo Keenesburg Switching Station via the Customer's 72-mile 230 kV transmission, a 3.6-mile section of the existing Ft. St. Vrain to Green Valley transmission line would be converted to triple-circuit configuration to accommodate the Customer's 230 kV transmission to interconnect at Keenesburg Switching Station. This triple circuit will be made up of the Customer's 230 kV line and the existing Ft. St. Vrain to Green Valley 230 kV line. The third circuit is for future needs. The Point of Change of Ownership will be the Interconnection Customer's last dead-end structure on its wind facility transmission line located just outside the Ft. St. Vrain to Green Valley Transmission Line Right of Way. This is shown in figure 2.

The recommended Network Upgrades for Interconnection at Keenesburg Switching Station include three (3) 230 kV circuit breakers, site development and land, associated switches and a control building. The total estimated cost for the facilities required for interconnection is approximately **$8.51 million**[1] including:

- $4.06 million for Customer-funded Transmission Provider's Interconnection Facilities
- $4.45 million for PSCo Network Upgrades for Interconnection

The estimated time required to engineer, permit, and construct the facilities described in above is approximately **23 months**. However, the Customer has taken responsibility for some preliminary tasks associated with the interconnection such as the aforementioned E&P Agreement. Based on these actions, it is anticipated the in-service date of the interconnection can be accelerated.

This wind project was evaluated as a Network Resource, with power directed to PSCo customer loads. During the modeling of the wind project, other PSCo resources in the vicinity of the wind project were used to manage any potential transmission limitations.

[1] Appropriation Estimate considered to have an accuracy of +/-20%.

Therefore, the costs associated with the wind project only consist of those associated with the interconnection of the wind facility.

Figure 1: PSCo's Regional 230 kV Transmission System One-Line Diagram

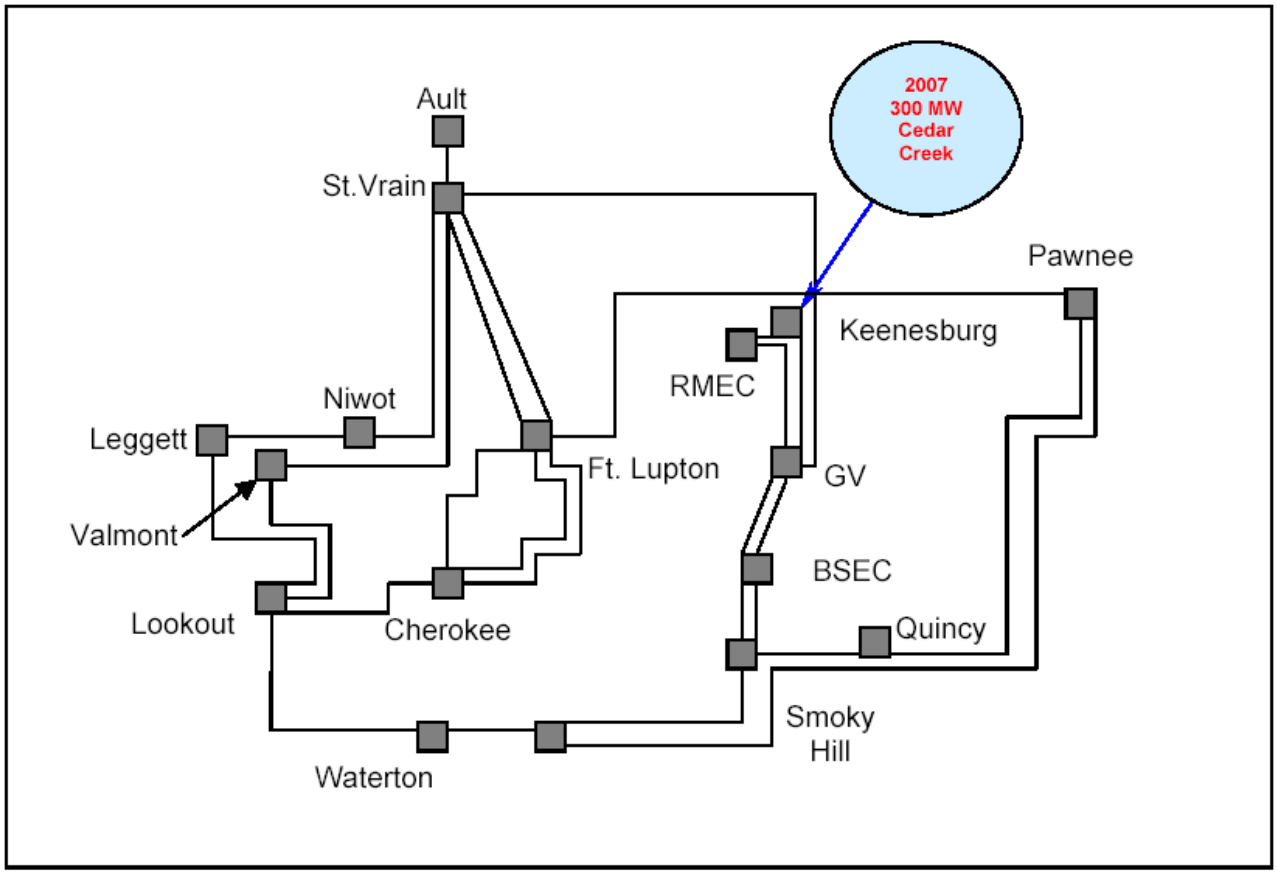
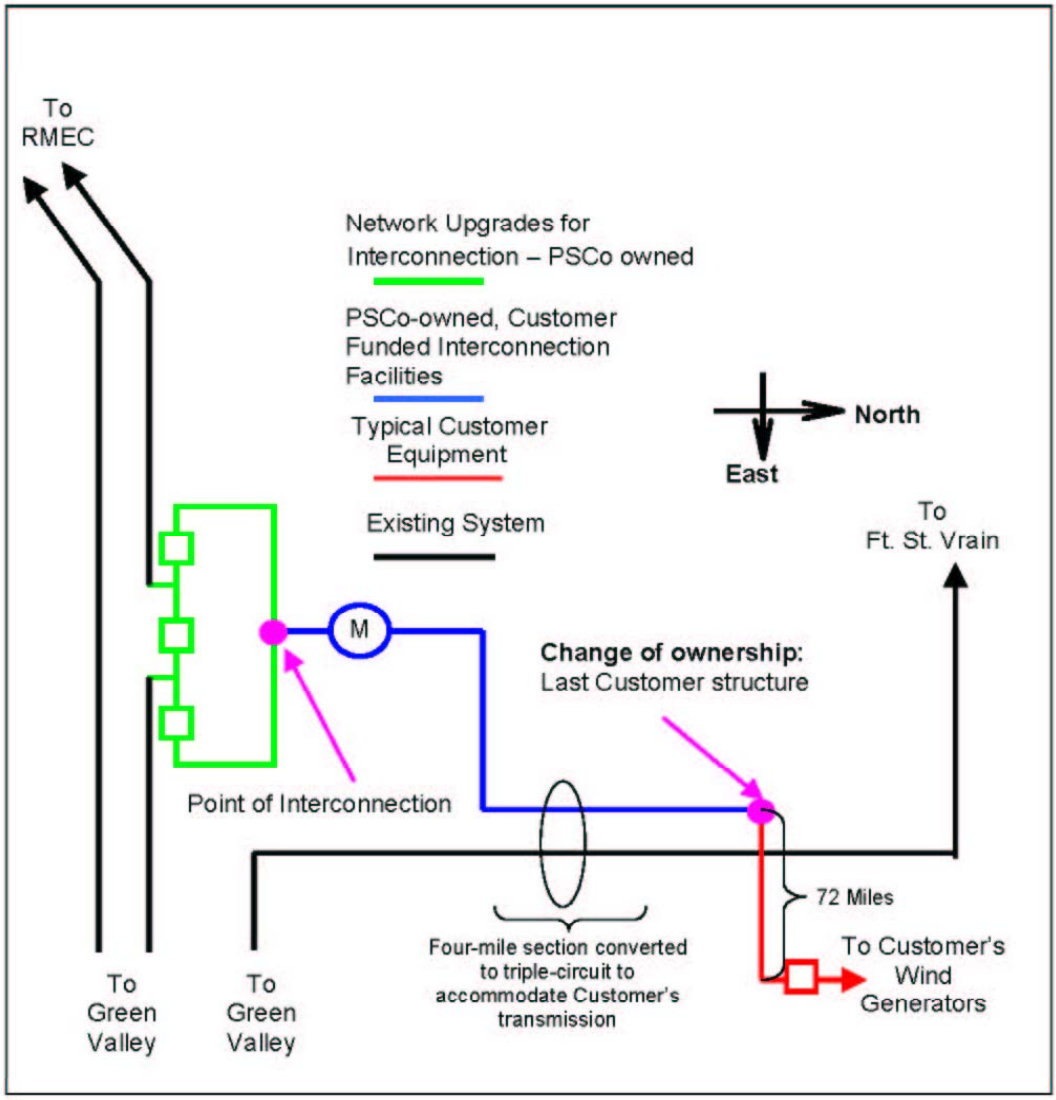


Figure 2: Interconnection at Keenesburg



II. Introduction

On February 10, 2006 Xcel Energy Transmission received a request to conduct a System Impact Study that would evaluate the integration of a "cluster" of potential generation resources. The Cedar Creek Wind Project was one of the resources considered in the "cluster-study". The System Impact Study report was issued and posted on the Rocky Mountain Area OASIS (RMAO) web site on May 25, 2006 and June 21, 2006 at which date the Cedar Creek Wind Project was identified as a project that would proceed with the Large Generator Interconnection Process (LGIP). An Interconnection Facilities Study Agreement was executed with the Customer on June 29, 2006. However, the data provided by the Customer was incomplete and was partially received on August 18, 2006, and remaining details received on September 21, 2006.

III. General Interconnection Facilities Description

1. Project Purpose & Scope

The purpose of this project is to interconnect a wind generation facility of 300.5 MW into a new PSCo Keenesburg 230 kV Switching Station. The Keenesburg Switching Station will be a 3-breaker ring bus that would tap one of the RMEC to Green Valley 230 kV transmission lines. The Customer intends to build a 72-mile 230 kV transmission line from their site to the switching station. The wind generation project will be located in Grover, Colorado. Figure 3 is the preliminary project schedule; figure 4 shows a preliminary one-line diagram of the interconnection to Keenesburg Switching Station, and figure 5 shows a general arrangement layout drawing.

2. Other Considerations

The Customer has taken responsibility for, and completed many of the Siting, Permitting and Land Acquisition tasks and a few of the Transmission Provider's preliminary activities under the Engineering & Procurement Agreement (E&P). The expected project schedule (Figure 3) has been accelerated based on these actions.

To date Customer has on two occasions changed the number and configuration of GE and Mitsubishi Wind Turbines at the Large Generating Facility. Customer has submitted a detailed plans on the number and manufacturer of the wind turbines with the accurate distribution on the customer's collector system.

This Facilities Study with a new blend of GE and Mitsubishi turbines has shown that for three-phase faults on the PSCo system near the Interconnection Point, damped oscillations occur on the **Customer's facilities** showing that dynamic reactive support is needed to meet FERC Order 661-A on Low Voltage Ride Thru (LVRT) requirements[2]. The final size and type of dynamic voltage support will be determined between the Customer and Transmission Provider. Customer is responsible to provide PSCo

[2] LVRT Requirements are located at **www.ferc.gov**.

detailed and accurate models to run dynamic simulations to verify requirements are met.

3. Interconnection & Network Upgrades for Interconnection

Requirements for interconnection can be found in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW – Version 2.0, last revised in January 2004. This document describes the technical and protection requirements for connecting new generation to the Xcel Energy operating company transmission system and also includes commissioning, operation, and maintenance guidelines. Xcel Energy also requires that the Interconnection Customer be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issues by the North American Electric Reliability Council, Western Electricity Coordinating Council, and Federal Energy Regulatory Commission or their successor organizations.

a) Removals and Relocations

The Keenesburg switching station is a new facility. No removals or relocations are required.

b) Fault Current

The worst-case 3-phase short circuit fault current is approximately 17kA at the approximate location of Keenesburg switching station. These values have been modeled with the new generation being installed and assuming little to no contribution from the Large Generating Facility.

c) Electrical Installations

The Keenesburg switching station will be configured as a three-breaker 230kV ring bus sectionalizing RMEC to Green Valley 230 kV transmission line (#5279).

The interconnection guidelines mentioned above require the Customer to install single 230 kV circuit breaker for line protection on the Customer's end of the 72-mile transmission line to isolate PSCo equipment from the generating facility.

The proposed two 3-phase step-up transformers at the customer facility shall be designed to meet the interconnection guidelines mentioned above and IEEE 142. The transformer configuration shall be grounded-wye on the 230kV primary side, grounded-wye on the 34.5kV secondary side, and delta on the tertiary.

d) AC & DC Systems

New AC and DC panels will be supplied in the Electrical Enclosure Equipment (EEE).

e) Control Building (EEE)
A medium sized EEE will be installed, complete with battery, charger, AC and DC panels, lighting, and HVAC system.

f) Grounding
All standard grounding practices in the substation will be observed. All equipment and associated structures will be connected to the ground mat.

g) Lighting Protection
Arresters will be installed on the Keenesburg line to protect the metering equipment. Static masts and static wire will be installed per the design.

4. Civil Features

a) Grading and Fencing
Grading will be created for siting and permitting.

b) Foundation and Structural
All foundations and structures are new. The following is a list of equipment that will be required to accommodate the new 230 kV Switching Station:

- Three (3) dead-end structures
- Three (3) breaker foundations
- Eight (9) 230 kV gang switch foundations
- Three (3) metering instrument foundations
- One (1) EEE foundation

c) Removals and Relocations:
No foundations are required to be removed or relocated.

5. Protection and Control Features

a) Electrical Installations
Three transmission relay panels will be installed in the control building at Keenesburg Switching Station. A new RTU/LCU will be installed and utilized for SCADA. All physical equipment will need to be installed as is shown in the system one-line and general arrangement drawings.

b) Transmission from Keenesburg to RMEC:
Line protection will consist of a SEL 321 (Pkg-P), SEL 311L (Pkg-S) and SEL 501 (for breaker failure) using fiber optic for communication for the primary relay (SEL 311) and secondary (SEL-321) relays. The primary relay will use a DCB scheme through mirrored bits whereas the backup relay will utilize a distance scheme with no communications. There will be only remote/SCADA re-closing on the Keenesburg to RMEC line.

c) Transmission from Keenesburg to Green Valley and Keenesburg to Cedar Creek:

Line protection will consist of a primary relay SEL 321 (Pkg-P), secondary relay SEL 311C (Pkg-S) and SEL 351 (for breaker failure and reclose). For Keenesburg to Green Valley the primary relay will use a DCB scheme through mirrored bits whereas the backup relay will utilize a distance scheme with no communications. For Keenesburg to Cedar Creek the primary relay will use a DCB scheme. The backup relay will utilize a distance scheme with no communications. Both the primary SEL 321 and the secondary SEL 311C relays will initiate the breaker failure relay. Single shot High Speed re-closing will be done for Keenesburg to Green Valley line. At Keenesburg there will be specialized (single line to ground) re-closing implemented for the Keenesburg to Cedar Creek line. Re-closing at the Cedar Creek facility will be the customer's decision. Auto re-closing will be implemented only by the primary relay.

6. Disturbance Monitoring Device

A disturbance-monitoring device is required at Keenesburg Switching Station.

7. Communications

Keenesburg to the Lookout Control Center: Two communication circuits will be required from Keenesburg to the Lookout Control Center, one for the RTU communications (4 wire full duplex dedicated circuit) and one for the control area information from the Jem-Star meter.

At Keenesburg a communication circuit will be installed for voice communications and for with the SEL 2030 and the DFR.

Keenesburg to Cedar Creek: The protective relay circuit will use power line carrier equipment or a communication medium to be supplied by the customer capable of accommodating a high-speed protective relaying circuit. If the customer requires data from the Keenesburg substation they will need to supply: an additional communication line, , specifics on the data needed and be capable of receiving this data via DNP 3.0 at Cedar Creek.

Cedar Creek to Lookout Control Center: Communication circuit using DNP 3.0 Network protocol supplying SCADA points requiring a dedicated ring-down phone circuit. A D-20 RTU at Keenesburg and equipment at Cedar Creek must be capable of sending data and receiving data via DNP 3.0.

Keenesburg to Green Valley and Keenesburg to RMEC: The protective relay circuit will utilize the FOGW (Fiber Optic Ground Wire) that currently exists on this line.

8. Metering

The 230kV revenue metering instruments will be installed at PSCo's Keenesburg Switching Station to measure the MW and MVAR from the Customer's 300 MW Large Generating Facility. PSCo meters will be 4-quadrant, bi-directional meters with recorders. Meters/recorders will be equipped such that they can be accessed remotely through a phone circuit. PSCo will own and operate the metering equipment.

9. Outages

The existing RMEC to Green Valley 230 kV double circuit transmission will be out of service during the foundation installation for the new tap structures, the tap structure installation, and the cutover period for the Keenesburg Switching Station. These outages shall be minimized as much as possible.

10. Project and Operating Concerns

There is one concern with this Wind Project. Customer must provide a model of the dynamic reactive support to meet FERC Order 661-A for LVRT requirements. This is necessary for the Planning Group at PSCo to verify the minimum requirements.

11. Transmission Line Tap Structures and Tap

The existing PSCo RMEC to Green Valley 230 kV transmission would be tapped to provide interconnection to the Keenesburg Project. The following is a list of equipment that will be required:

- Two (2) double-circuit 230 kV dead-end structures with concrete caisson foundations
- Two (2) double-circuit 230 kV dead-end towers with concrete caisson foundations
- One (1) double-circuit 230 kV tangent structure with concrete caisson foundation
- Install approximately 28,000 ft of 636 kcmil ACSR Grosbeak (bundled) conductor
- Install approximately 2,400 ft of 3/8" EHS static wire
- Remove two (2) existing 230 kV tangent structures and 960 ft of 636 kcmil ACSR conductor between new tap structures

The Point of Change of Ownership will be the Interconnection Customer's last dead-end structure on its Large Generating Facility transmission line located outside the Ft. St. Vrain to Green Valley 230/345 kV transmission line ROW. PSCo will install and own the last span of conductor from the Point of Change of Ownership.

From the Point of Change of Ownership to the Keenesburg Switching Station, the scope of work includes:

- Installing two (2) triple circuit (T/C) dead-end structures (double circuit 345 kV with 230 kV under build for Cedar Creek Wind) with concrete caisson foundations.
- Rebuild the existing Ft. St. Vrain to Green Valley 345 kV capable 230 kV operated Transmission Line from single circuit (S/C) tangent structures to T/C tangent poles (D/C 345 kV with 230 kV under build for Cedar Creek Wind) with concrete caisson foundations.
- Install approximately 43 miles of 954 kcmil ACSR Cardinal (bundled) conductor on the west side of the T/C rebuilt (west D/C 345 kV portion).
- Install a new S/C 230 kV transmission into the Keenesburg Switching Station with approximately 11,400 ft of 954 kcmil ACSR Cardinal (bundled) conductor.

12. Assumptions for Cedar Creek Wind Farm Facility

Customer will comply with FERC Order 661-A guidelines for Low Voltage Ride Through[3].

Customer will provide both dynamic and static reactive support equipment to meet voltage requirements and power factor requirements at the point of interconnection.

Customer will engineer, procure, and construct all equipment up to the PSCo's Point of Change of Ownership. This includes transmission line relay/communication equipment at Customer's site.

The Customer will arrange for station service power through the local utility/service provider, as Customer's site is not in PSCo's service territory.

PSCo needs approximately 4-6 weeks to test. Much of the testing can be performed in parallel with the construction schedule.

[3] LVRT Guidelines are locates at **www.ferc.gov**.

IV. Costs Estimates and Assumptions:

A. Interconnection

The following are the estimated costs for the Customer Funded Interconnection Facilities and the PSCo Network Upgrades required for interconnecting the Customer's proposed 300.5 MW wind generation at a new PSCo 230 kV Keenesburg Switching Station. The Transmission Provider's Interconnection Facilities (Customer Funded) includes the rebuild of existing PSCo transmission to accommodate the customer's new transmission. Table 1 describes the costs assumed for work to be performed by PSCo, and funded by the Customer and for the dedicated "sole-use" interconnection facilities installed between the 230 kV Point of Interconnection located at Keenesburg Switching Station, and the Customer Wind Farm Facility. The estimated total cost for the PSCo Interconnection Facilities and Network Upgrades to provide an Interconnection for the Customer requested generation are:

- **$4.06 million for Transmission Provider's Interconnection Facilities at Keenesburg Switching Station (Customer funded).**
- **$4.45 million for PSCo Network Upgrades for Interconnection at Keenesburg Switching Station (PSCo funded).**

The estimated costs shown above are "appropriation estimates" with an accuracy of ± 20%. These estimates are in 2006 dollars, do not include escalation, and are based upon typical construction costs for previously performed similar construction. These estimates do not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering for the Customer's facilities.

Table 1: PSCo Transmission Provider's Interconnection Facilities (Customer funded)

Element	Description	Cost ($Million)
New PSCo Customer Tap Switchyard	Interconnect 230 kV line from Large Generating Facility to a new 230 kV PSCo switchyard. The new equipment required includes: • 230 kV bidirectional revenue metering • Required steel supporting structures • One (1) JEM-Star 230 kV metering unit • Associated metering, control, and relaying equipment	**$0.42**

Element	Description	Cost ($Million)
Transmission Rebuild	Rebuild approximately 3.6 miles of the existing Ft. St. Vrain 230kV single circuit Transmission Line. The line will be rebuilt to an ultimate triple circuit transmission line. This new facility will initially include the Ft. St. Vrain to Green Valley 230kV Transmission Line, and a 230kV transmission line which will be owned and operated by PSCo but serve as a radial feed from the Large Generating Facility. The third circuit will be used for future PSCo considerations.	**$3.37**
New Transmission Construction	Construct approximately 0.5 miles of new single circuit 230kV transmission line from the rebuilt Ft. St. Vrain Transmission Line to the Point of Interconnection.	**$0.27**
Time Frame	**Substation & Transmission**	**6 months**
Total	**Transmission Provider's Interconnection Facilities**	**$4.06**

Table 2 describes the estimated costs of PSCo Transmission Network Upgrades associated with the Cedar Creek Project Interconnection.

Table 2: PSCo Transmission Network Upgrades Required for Interconnection

Element	Description	Cost ($Million)
New PSCo Keenesburg Switching Station	Construct Keenesburg 230 kV switching station to interconnect the Large Generating Facility. The new equipment required includes: • Three (3) 230 kV 3000 amp 40 kA circuit breakers • One (1) SCADA RTU/Load Control Unit • Site development and land • Control building	**$3.07**
	Transmission Line tap structures and tap	**$0.92**
	Siting & Land Rights	**$0.36**
Green Valley & RMEC Substation	Replace relaying at remote ends	**$0.10**
Total Cost	**Estimated Costs for Network Upgrades for Interconnection**	**$4.45**
Time Frame	**Substation**	**23 months**

B. Major Assumptions related to Table 1,Table 2, and Figure 3

- The estimated costs provided are “Appropriation Estimates” with an accuracy of ± 20%.
- All applicable overheads are included. AFUDC has been included with the PSCo Network Upgrades and removed from the Customer Interconnection Facilities.
- There is no contingency added to the estimates.
- Estimates have not been escalated. All estimates are in 2006 dollars.
- Large Generating Facility is not in PSCo’s retail service territory. Therefore no costs for retail load metering are included in these estimates.
- PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
- A Certificate of Public Convenience and Necessity (CPCN) will not be required from Colorado Public Utility Commission (CPUC) for the PSCo network upgrades for interconnection.
- The estimated time for design, procurement and construction for the PSCo network upgrades required for the interconnection is at least 23 months after the Interconnection Agreement has been signed.
- All required transmission outages necessary to support construction will be obtained as needed.
- Land necessary for the new 230kV switchyard will be available within close proximity to the transmission line to be sectionalized.

V. Engineering, Procurement & Construction Schedule

The following schedule identifies milestones needed to complete the interconnection of the proposed 300.5 MW wind farm facility.

The following schedule identifies project milestones for three separate phases of work needed to complete the proposed interconnection: Siting, Permitting & Land Acquisition, Substation Design & Construction and Transmission Line Design & Construction. The total estimated duration to complete all of the required activities and tasks is 23 months after the Large Generator Interconnection Agreement (LGIA) has been executed.

The Customer has taken responsibility for, and completed the majority of the Siting, Permitting and Land Acquisition tasks required. The Customer has also entered into an E&P Agreement with the Transmission Provider and funded the preliminary activities and tasks required to advance the project prior to execution of the LGIA. The following schedule illustrates the full 23 month duration estimated for this project, however, based on the Customer's actions as discussed above, this project is now in approximately month 14 of the following 23 month schedule.

Figure 3: Engineering, Procurement & Construction Schedule

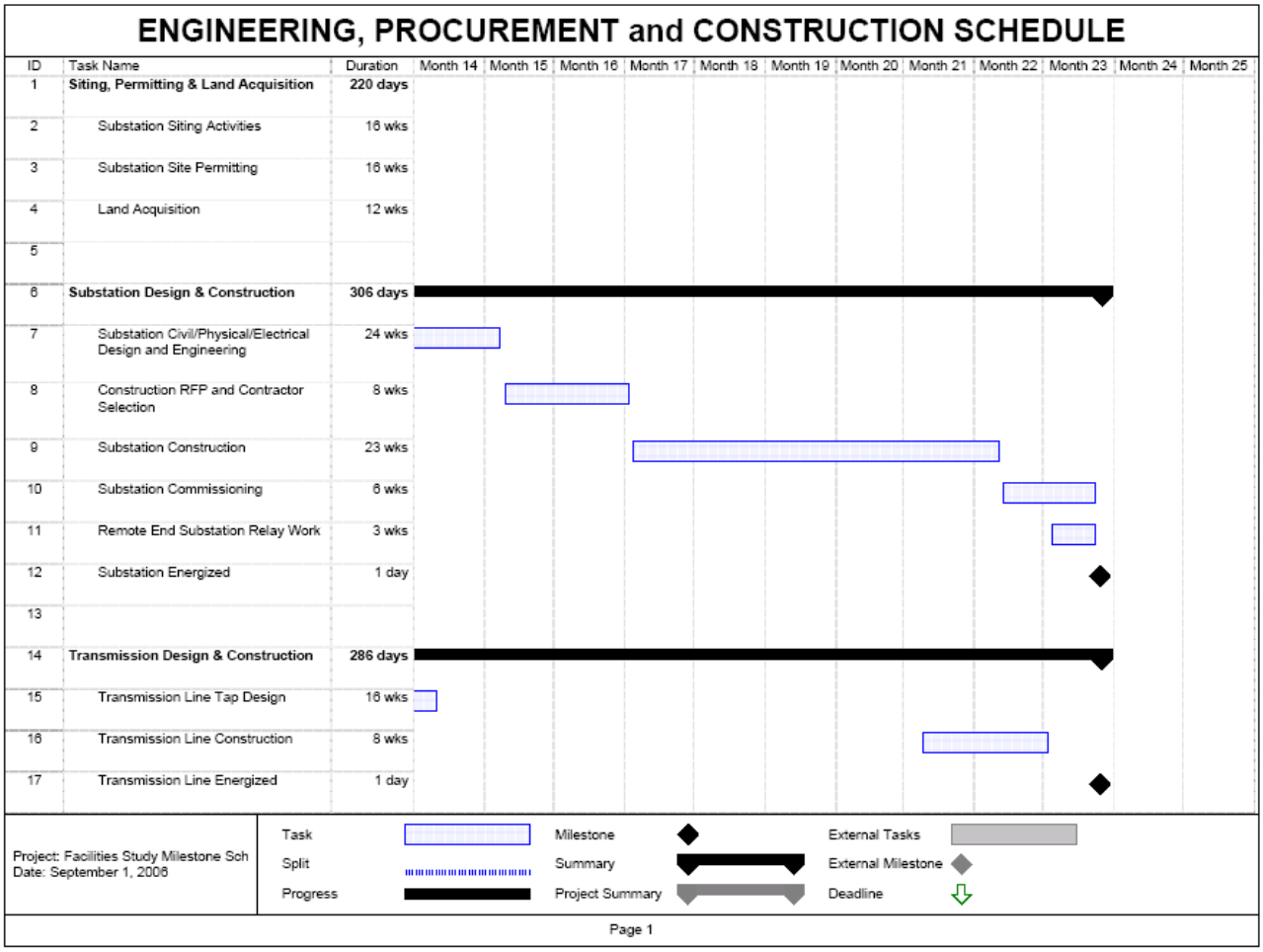


Figure 4: Keenesburg Substation: One-Line Diagram

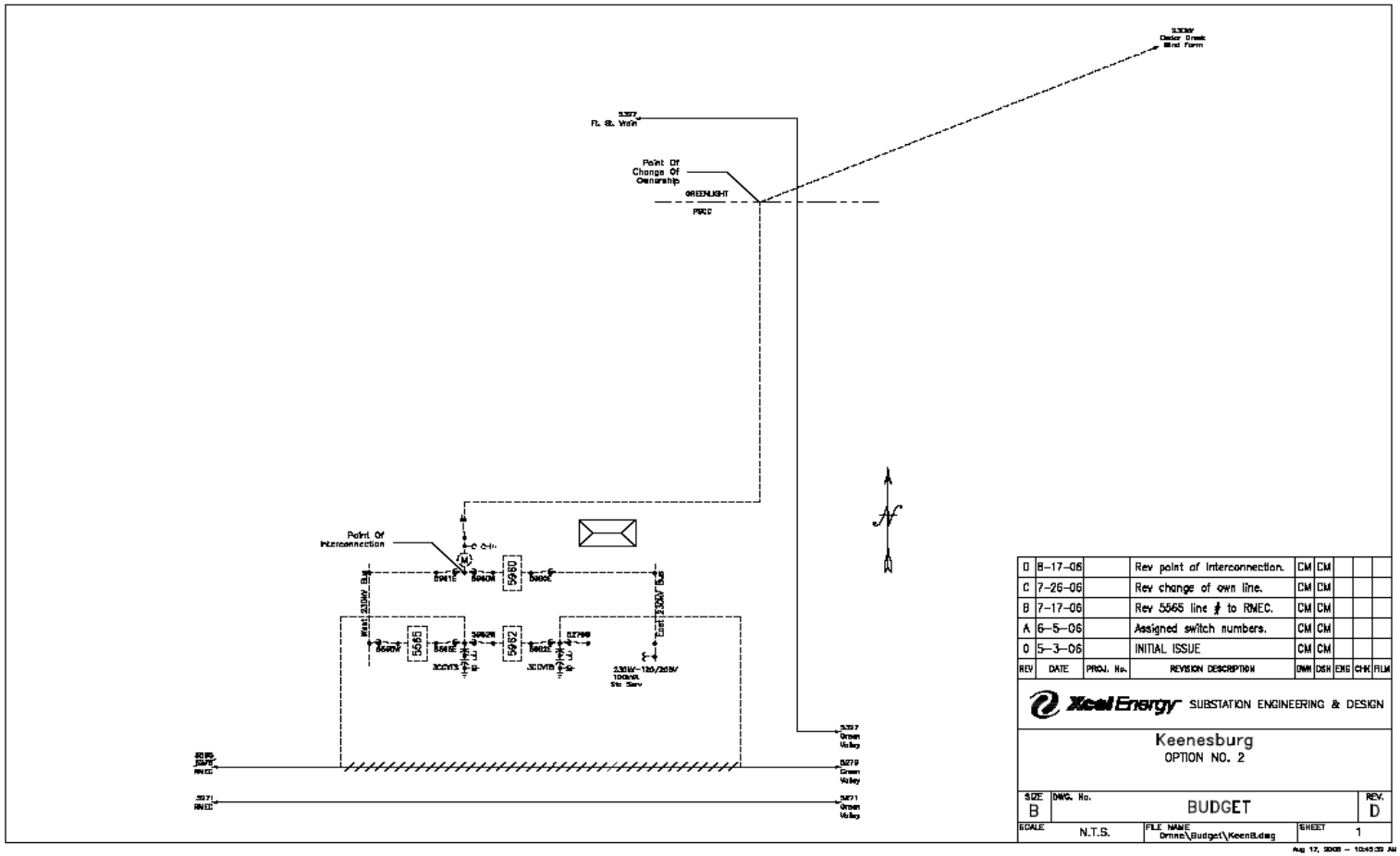


Figure 5: Keenesburg Substation: Proposed General Arrangement Drawing