



## **Interconnection Facilities Study Report GI-2007-6 (Including GI-2007-5)**

250 MW Cedar Creek Wind Energy Expansion Project  
(50 MW Expansion for GI-2007-5 and 200 MW for GI-2007-6)  
In the Vicinity of Grover, Colorado  
**August 18, 2010**

### **I. Executive Summary**

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (Transmission Provider) to evaluate GI-2007-6 (including GI-2007-5) and specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect a 250 MW wind generation expansion (a 50 MW wind generation expansion for GI-2007-5 and a 200 MW wind generation expansion for GI-2007-6) of the existing 300 MW Cedar Creek Wind Energy No. 1 (CCWE1) facility. The Point of Interconnection (POI) will be the Keenesburg 230 kV Switching Station in Weld County, Colorado. The Cedar Creek Wind Energy Expansion facility will connect to the CCWE1-Keenesburg 230 kV transmission line at a transmission tap just south of the CCWE1 facility using a 23-mile 230 kV transmission line (constructed, owned, and operated by the Generation Provider).

The Cedar Creek Wind Energy Expansion Project would include the following wind turbine generators:

- Sixty (60) Nordex N90 wind generator turbines at 2.5 MW each for a total generating capacity of 150 MW
- Sixty-three (63) General Electric 1.5sle wind generator turbines with expanded output (using GE WindBOOST control software) at 1.6 MW each for a total generating capacity of 100.8 MW.

The GI-2007-6 System Impact Study and subsequent re-studies determined that additional facilities are needed to meet the reliability criteria. Below is a list of facilities identified in the System Impact studies for reliability. They represent one potential set of improvements. The Generation Provider is responsible to design the additional facilities.

- Switchable capacitors at three different locations between the POI, the CCWE1 facility, and the proposed wind generation expansion project. A total of approximately 155 MVAR of switched capacitors would be needed to meet the voltage criteria at the POI when the combined Cedar Creek wind farms are operating near the 550 MW maximum generation capability. Of the 155 MVAR of switched capacitors, two 45 MVAR switchable capacitors would need to be connected to the 230 kV system at a capacitor switching station located near the Keenesburg Substation.



- Reactors (approximately 45 MVAR<sup>1</sup>) for the Generation Provider's wind generating plant that are needed whenever the Generation Provider's facilities are off-line or generating at very low levels while the facility is connected to the POI.

The 300 MW generation output from the existing CCWE1 facility, the 50 MW generation output from the proposed GI-2007-5 project, and the 200 MW generation output from the proposed GI-2007-6 project could be delivered to the Transmission Provider's load-serving area with the following network upgrades and dispatch requirement:

- Loop the Ft. St. Vrain-Green Valley 230 kV line (Circuit #5327) into the Keenesburg Substation and install five 230 kV circuit breakers to convert the existing ring bus to a breaker-and-a-half bus configuration.
- Dispatch generation at Ft. St. Vrain within acceptable operating limits.

The study determined that these network upgrades could be completed within sixty-three weeks from the date of Authorization to Proceed with Engineering, as outlined in the Engineering and Procurement (E&P) Agreement executed March 18, 2010. Any delays in obtaining customer security for materials procurement under the E&P, permitting impacts due to Generation Provider capacitor facilities adjacent to the Keenesburg Substation, or delays in the execution of the LGIA that would impact the start of construction will increase the required duration. The duration increase will be based on the ability to schedule outages and construction resources and may not be a day for day increase. The construction schedule is outlined in Part B of the Appendix.

The Generation Provider proposed an in-service date of June 2011. The Transmission Provider will require the testing of the full 550 MW facility (CCWE1 and the Cedar Creek Wind Energy Expansion Project).

The total estimated cost of the recommended system upgrades to interconnect the project is approximately **\$4.89 million** and includes:

- \$0 for the Transmission Provider-Owned, Generation Provider-Funded Interconnection Facilities
- \$0 for the Transmission Provider-Owned, Transmission Provider-Funded Network Upgrades for Interconnection
- \$4.89 million for the Transmission Provider Network Upgrades for Delivery.

A conceptual one-line for the GI-2007-6 facilities along with the GI-2007-5 facilities is shown in Figure 1. A conceptual one-line for the Keenesburg Substation facilities is shown in Figure 2.

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<sup>1</sup> The 45 MVAR of reactors would consist of 35 MVAR of reactors connected at the existing Cedar Creek facility (CCWE1) and 10 MVAR of reactors connected at the Cedar Creek Wind Energy expansion facility.

Figure 1 Conceptual One-Line for GI-2007-5 and GI-2007-6 (250 MW Expansion)

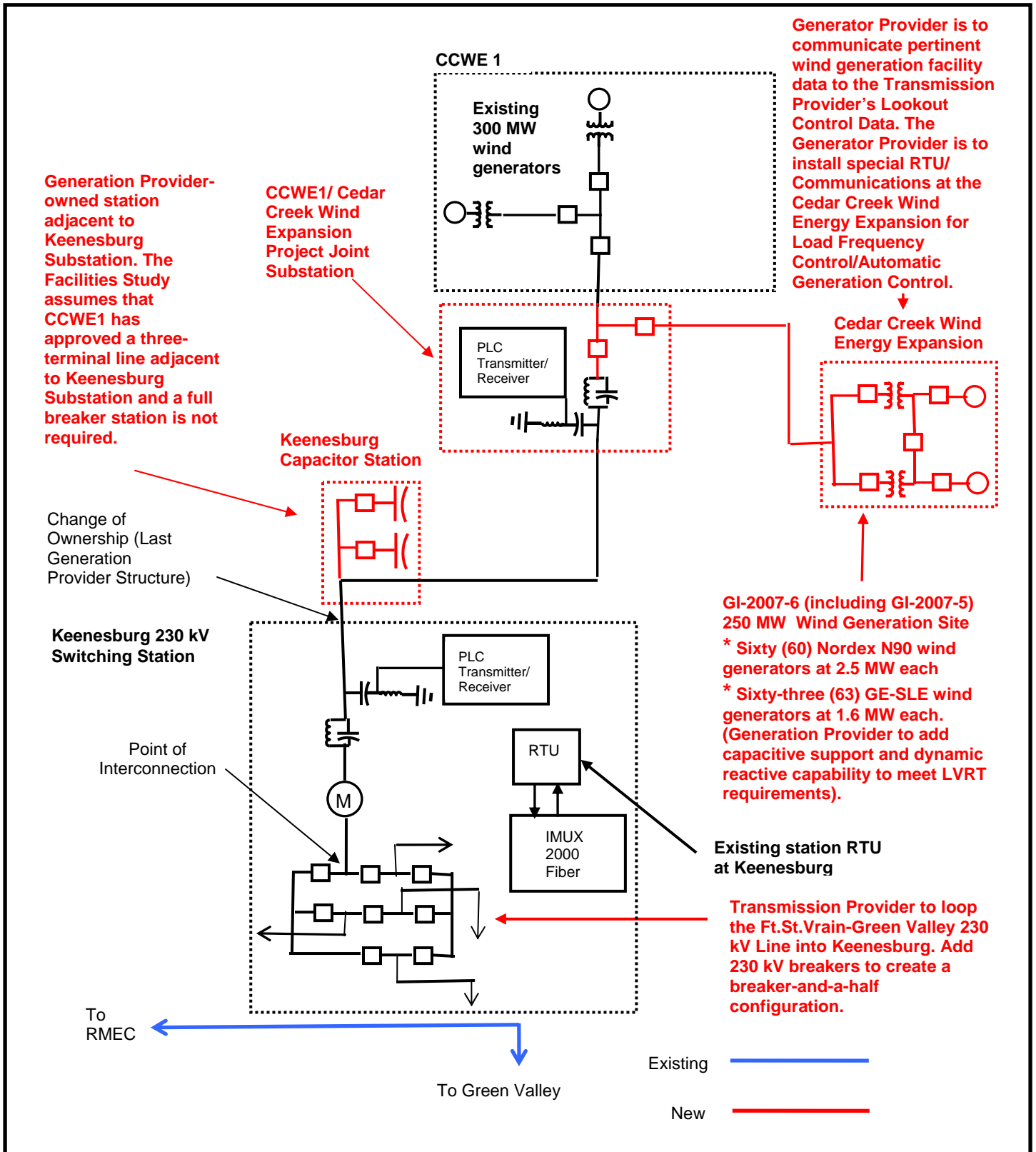
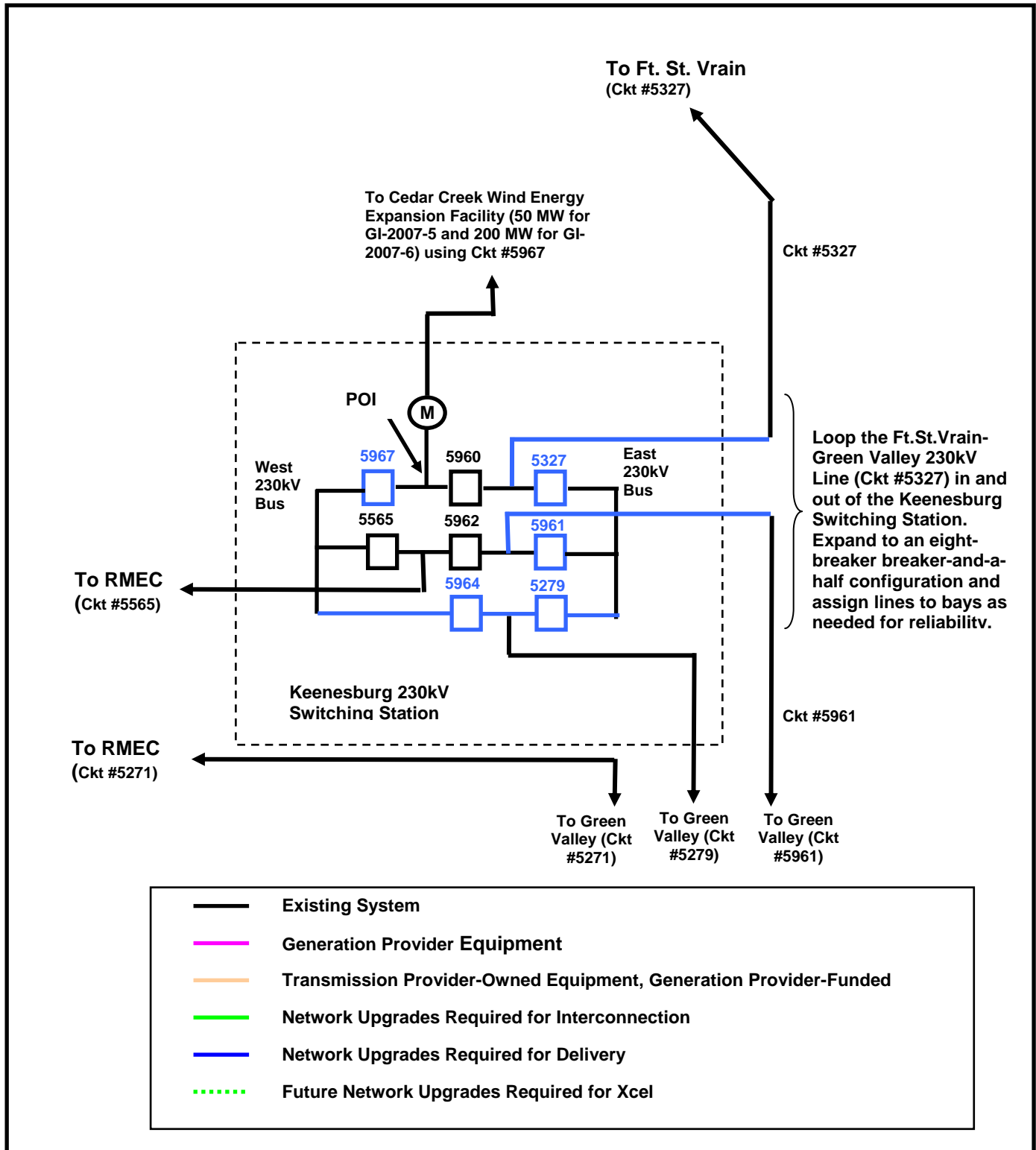


Figure 2 Conceptual One-Line for Keenesburg Substation





## II. Introduction

The Transmission Provider received a large generator interconnection request (GI-2007-5) to interconnect 20 Clipper 2.5 MW Liberty Series wind turbines, with a total generation capability of 50 MW, and a commercial operation date of December 31, 2010. The proposed project would be located near the existing 300 MW Cedar Creek Wind Energy No. 1 facility (CCWE1), near Grover, Colorado, and for study purposes represents a 50 MW expansion of the overall wind farm. The GI-2007-5 project would be connected with a new 23-mile 230 kV line to the wind farm end of the existing 78-mile Keenesburg-CCWE1 230 kV transmission line. The existing 230 kV transmission line would deliver the total output from the existing CCWE1 facility and the GI-2007-5 project to the Keenesburg switching station (the POI with the Transmission Provider). The GI-2007-5 System Impact Study report was posted on the RMAO OASIS on December 3, 2008. A second request for an additional 200 MW called GI-2007-6 was subsequently submitted by the Generation Provider. The GI-2007-6 System Impact Study report was posted on the RMAO on June 12, 2009.

The Generation Provider subsequently requested that the Transmission Provider conduct a combined re-study of GI-2007-5 and GI-2007-6 that assumed General Electric and Nordex wind turbines. On April 22, 2010, the GI-2007-5+6 System Impact Re-study was completed. The re-study assumed that the expanded wind generation facility would consist of sixty-eight (68) GE 1.5 MW units and sixty (60) Nordex 2.5 MW units. Subsequently, the Generation Provider contacted the Transmission Provider to announce their intent to use GE's WindBOOST control software to increase the output of the GE 1.5sle turbines 100 kW to 1.6 MW. The use of GE's WindBOOST control software allows the Generation Provider to use fewer GE wind turbine units (sixty-three GE 1.6 MW units instead of sixty-eight GE 1.5 MW units) and the use of this control software necessitated the second re-study. The GI-2007-5+6 System Impact Re-study 2 was completed on June 16, 2010 and determined that there would be no significant system impacts associated with using GE's WindBOOST control software to increase the output of the GE 1.5sle turbines 100 kW to 1.6 MW.

The Cedar Creek Wind Energy Expansion Project will integrate 250 MW of additional wind resources (200 MW from GI-2007-6 and 50 MW from GI-2007-5) at Cedar Creek into the Transmission Provider Balancing Authority. It will increase the total generation capacity at Cedar Creek to 550 MW. The project will require the Transmission Providers's Ft.St.Vrain-Green Valley 230 kV line to be looped into the Keenesburg Substation and include five additional 230 kV circuit breakers at Keenesburg to terminate the lines into a breaker-and-a-half configuration.

The Generation Provider and the Transmission Provider entered into an Interconnection Facilities Study Agreement. The purpose of the Interconnection Facilities Study<sup>2</sup> is the following:

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<sup>2</sup> Information for the Facilities Study is taken from Appendix B of the Standard Large Generator Interconnection Procedures (LGIP) including Standard Large Generator Interconnection Agreement (LGIA)



- Specify and estimate the cost of the equipment, engineering, procurement and construction work needed to implement the conclusions of the Interconnection System Impact Study in accordance with Good Utility Practice to physically and electrically connect the Interconnection Facility to the Transmission System.
- Identify the electrical switching configuration of the connection equipment, including the transformer, switchgear, meters, and other station equipment.
- Identify the nature and estimate the cost of any Transmission Provider's Interconnection Facilities and Network Upgrades necessary to accomplish the interconnection.
- Estimate of the time required to complete the construction and installation of the Transmission Provider's facilities.

### **III. General Interconnection Facilities Description (Design Guides)<sup>3</sup> Introduction**

#### **A. Interconnection and Network Upgrades for Interconnection**

Requirements for interconnection can be found in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW. The Transmission Provider requires the Interconnection Generation Provider to construct the Interconnection Facilities in compliance with this document. This document describes the technical and protection requirements for connecting the new generation to the Transmission Provider operating company transmission system and also includes commissioning, operation, and maintenance guidelines. The Transmission Provider also requires that the Generation Provider be in compliance with all applicable criteria, guidelines, standards, requirements, Western Electricity Coordinating Council (WECC) and Federal Energy Regulatory Commission (FERC) or their successor organizations.

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<sup>3</sup> The "Design Guides" is an abbreviated list of design items contained in this section of the report that were developed by Transmission Provider Substation Engineering and are based on the Transmission Provider's Design Criteria – Physical Design Criteria for Substations.



## 1. Fault Current

A short circuit study was conducted to determine the approximate fault currents (single-line-to-ground and three-phase) expected at the Keenesburg Substation 230 kV bus. Table 1 summarizes the approximate fault currents at the Keenesburg 230 kV bus at the present time. Table 2 reflects the approximate fault currents at the Keenesburg 230 kV bus after the Ft.St.Vrain-Green Valley 230 kV line is looped into the Keenesburg 230 kV bus.

**Table 1: Fault Current Information for the Keenesburg 230 kV Bus – Present System**

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) in ohms	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) in ohms
System Intact	$I_1=17,214.1$ $I_2=I_0=0.0$ $I_A=I_B=I_C=17,214.1$	$Z_1(\text{pos})=0.52452,7.69620$ $Z_2(\text{neg})=0.69782,7.67412$ $Z_0(\text{zero})=1.67082,9.72793$	$I_1=I_2=5,256.0$ $3I_0=15,768.1$ $I_A=15,768.1$ $I_B=I_C=0.0$	$Z_1(\text{pos})=0.52452,7.69620$ $Z_2(\text{neg})=0.69782,7.67412$ $Z_0(\text{zero})=1.67082,9.72793$

**Table 2: Fault Current Information for the Keenesburg 230 kV Bus – Ft.St.Vrain-Green Valley 230 kV Looped Into Keenesburg and Cedar Creek Wind Energy (CCWE1 and Cedar Creek Wind Expansion) Contribution Represented**

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) in ohms	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) in ohms
System Intact	$I_1=26,101.5$ $I_2=I_0=0.0$ $I_A=I_B=I_C=26,101.5$	$Z_1(\text{pos})=0.34872,5.07551$ $Z_2(\text{neg})=0.43632,5.06407$ $Z_0(\text{zero})=1.67300,8.52040$	$I_1=I_2=7,055.4$ $3I_0=21,166.2$ $I_A=21,166.2$ $I_B=I_C=0.0$	$Z_1(\text{pos})=0.34872,5.07551$ $Z_2(\text{neg})=0.43632,5.06407$ $Z_0(\text{zero})=1.67300,8.52040$

The results found in Table 2 include the proposed Cedar Creek Wind Energy Expansion 250 MW wind farm (50 MW plus 200 MW). The addition of the 250 MW Cedar Creek Wind Energy Expansion is not expected to necessitate the replacement of circuit breakers, switches or other substation equipment due to the increased fault current levels at the Keenesburg Substation. The circuit breakers at Keenesburg have a 3000 amp continuous rating and a 40,000 interrupting rating and the switches have a 3000 amp continuous rating.

## 2. Right of Way

For the purposes of this interconnection facility study estimate, it is assumed that there is adequate land to modify the Keenesburg Substation and loop the Ft.St.Vrain-Green Valley 230 kV line into Keenesburg.



### 3. High Voltage Electrical Installations

The Keenesburg Substation is arranged as a three-breaker ring bus to terminate the Keenesburg-RMEC 230 kV line (Circuit #5565), the Keenesburg-Green Valley 230 kV line (Circuit #5279), and the Keenesburg-CCWE1 230 kV line (Circuit #5967). Looping the Ft.St.Vrain-Green Valley 230 kV line into Keenesburg Substation will require two additional line terminations bringing the total number of terminations at Keenesburg Substation to five. Because of the size and number of the generating units that will transmit power to Keenesburg Substation and the importance of the transmission lines connecting Keenesburg to the Green Valley Substation (a major substation in the Denver Metro area), the Transmission Provider's Substation Engineering group has determined that additional reliability is needed at the Keenesburg Substation; therefore, the Transmission Provider's Substation Engineering group designed the Keenesburg Substation for a breaker-and-a-half configuration to terminate the five transmission lines.

The Transmission Provider will install the following equipment at Keenesburg Station for Network Upgrades<sup>4</sup>:

- Five (5) 230 kV Circuit Breakers
- Eight (8) 230 kV Switches
- Eight (8) 230 kV Coupling-Capacitor Voltage Transformers (CCVT)
- Two (2) dead-end structures for the Keenesburg-Ft.St.Vrain 230 kV line and the Keenesburg-Green Valley 230 kV line
- Two (2) line relay panels
- East and West differential panels
- Electrical bus work
- Steel and foundations
- Minor site work (station wiring, grounding)
- Transmission structures for looping the Ft.St.Vrain-Green Valley 230 kV line (Circuit #5327) into Keenesburg Substation and moving the Green Valley Line (Circuit #5279)

The Generation Provider will use the existing Keenesburg-CCWE1 230 kV transmission line to interconnect to the bulk transmission system. The Generation Provider will be responsible for constructing a capacitor switching station adjacent to or near the Keenesburg Substation to provide voltage support at the POI. This station will have capacitors and circuit breakers arranged so that it taps the 230 kV Cedar Creek line (Circuit #5967). The Transmission Provider has verified that all revenue metering instrument transformers and revenue metering are rated to handle the additional 250 MW Cedar Wind Expansion Project. A tap change on the metering unit will be required and that may necessitate a short outage.

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<sup>4</sup> The network upgrades consists of looping the Ft. St. Vrain- Green Valley 230 kV line (Circuit #5327) into Keenesburg Substation, relocating the Green Valley 230 kV line (Circuit #5279), and modifying the Keenesburg Substation from a ring bus configuration to a breaker-and-a-half arrangement.



The step-up transformers at the Generation Provider's facility shall be designed to meet the interconnection guidelines<sup>5</sup> mentioned previously. The configuration shall be:

- Grounded-wye on the 230 kV primary side
- Delta on the 34.5 kV secondary side

The Generation Provider must specify that their transformers meet the Transmission Provider's requirements for an effectively grounded system.

#### **4. AC and DC Systems**

The Transmission Provider has verified the sufficiency of the existing AC and DC panels in the Electrical Enclosure Equipment (EEE) at Keenesburg.

#### **5. Control Building**

The existing control building at Keenesburg can accommodate the new equipment.

#### **6. Grounding**

New 4/0 ground conductor will be installed at Keenesburg Substation and tied into the existing ground grid to accommodate the network upgrades required for delivery.

#### **7. Lightning Protection**

The existing static wire system will be tied to the new dead-end structures on the incoming transmission lines for additional protection.

#### **8. Grading and Fencing**

No grading work will be required at Keenesburg. No changes to the existing fence will be required.

#### **9. Foundations and Structural**

There will be new drilled pier and slab on grade foundations, and new steel supports, for the circuit breakers, switches, bus supports, CCVT's, dead-end structures and transmission steel poles.

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<sup>5</sup> "Interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW"

<sup>6</sup> DNP is an acronym for "Distributed Network Protocol". It is a protocol for transmitting data between two communications points using serial and IP communications. It optimizes the transmission of data acquisition information and control commands from one computer to another and is intended for SCADA (Supervisory Control and Data Acquisition) applications.



## **10. Removals and Relocations**

Removals and/or relocations will be required for the poles on the existing Ft.St.Vrain-Green Valley 230 kV line (Circuit #5279).

## **11. Control and Protection – Electrical Installations**

The existing transmission line relaying scheme at Keenesburg utilizes an SEL-321 Phase and Ground Distance relay using a Directional Comparison Blocking (DCB) scheme through a Power Line Carrier communication. The back-up relaying uses an SEL-311C relay in a Step Distance scheme and no communications. With a capacitor tapped off of the transmission line in close proximity to the Keenesburg Substation, the transmission line relays will trip for some faults on this tap; therefore, this relay scheme will need to be approved by CCWE1 due to the capacitor banks being tapped off of the transmission line. Additional interconnection requirements will need to be satisfied as stated in the Transmission Provider's Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW.

## **12. Outages**

Looping the Ft.St.Vrain-Green Valley 230 kV line into Keenesburg will require the Ft.St.Vrain-Green Valley 230 kV line to be out-of-service for approximately one week while the cut in is accomplished. The relocation of Circuit #5279 to a new bay position will require a one-day to two-day outage to move the line and complete the testing. Also, Circuit #5967 will require a short outage of one to two days to perform testing and to terminate the line into a breaker-and-a-half configuration. At that time, the metering unit tap will be changed.

## **13. Project and Operating Concerns**

The outage of the Ft.St.Vrain-Green Valley 230 kV line will result in project and operating concerns for the Transmission Provider and the Generation Provider. The generation at CCWE1 may need to be reduced during this outage.

A single point of contact must be provided by the Generation Provider to the Transmission Provider's System Operations to manage the Transmission System reliably for all wind projects at CCWE1 and the Cedar Creek Wind Energy Expansion Project.

## **14. Related Substation and Transmission Projects**

None.



## 15. Assumptions for the Generation Provider's Site

The Generation Provider will provide power factor correction equipment to meet voltage tolerances at the POI as required by Xcel Energy and FERC interconnection guidelines. This also pertains to the station located adjacent to the Keenesburg Substation that will include two 45 MVAR switchable capacitor banks for voltage support at the POI. Station Service at the Cedar Wind expanded station (located approximately twenty-three miles from the existing CCWE1 Substation) is the responsibility of the Generation Provider. It is assumed that the Generation Provider has made arrangements with the local utility/service provider (High West Energy) for a Station Service Point at the new site.

The Transmission Provider needs approximately four to six weeks to test the requirements of the Interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW. Much of the testing can be performed in parallel with the construction schedule.

## 16. Communications

The communications system that connects the Cedar Creek Wind Energy 1 (CCWE1) and Cedar Creek Wind Energy Expansion facilities to the Transmission Provider's SCADA system at Keenesburg Substation is vital for the successful integration of the wind power facilities into the bulk power transmission system. The SCADA system links the Keenesburg Substation with the Transmission Provider's Lookout Control Center (LCC). The existing SCADA System at Keenesburg Substation includes a JEMSTAR high precision revenue meter that transmits the Point of Interconnection (POI) metering information for CCWE1 back to the Lookout Control Center RTU that is connected to the Energy Management System (EMS). With the connection of Cedar Creek Wind Energy Expansion Project, this will represent the total metering data from both generation providers. The Generation Provider for CCWE1 and the Generation Provider for the Cedar Creek Wind Energy Expansion Project will supply protective relaying communication (power line carrier) from their joint substation to the Transmission Provider's Keenesburg Substation. The Generation Provider will supply DNP<sup>6</sup> points and communication circuit between the wind farms and PSCo's Operations Center (Lookout). These points are listed in Table 3 below.



**Table 3. DNP Points from the Generation Provider**

SCADA POINT	PURPOSE	POINT IDENTIFIED	POINT LOCATION
Real power in megawatts (MW)- Interconnection Point	Operations	N/A- (Existing Point)	Keenesburg
Reactive power in megavars (MVAR)- Interconnection Point	Operations	N/A- (Existing Point)	Keenesburg
Line flow (amperes) for each phase- Interconnection Point	Operations	N/A- (Existing Point)	Keenesburg
Phase angles for each phase- Interconnection Point	Operations	N/A- (Existing Point)	Keenesburg
The neutral ampere flow (amperes) for phase unbalance- Interconnection Point	Operations	N/A- (Existing Point)	Keenesburg
Turbine generation (kW)	Forecasting	Power Purchase Agreement	Each turbine
Wind speed (mph)	Forecasting	Power Purchase Agreement	Each turbine
Turbine availability (Number of wind turbines generating, number of turbines available)	Forecasting	Power Purchase Agreement	Each turbine
Wind direction (in degrees relative to true north)	Forecasting	Power Purchase Agreement	Each turbine
Wind speed (mph) at all metered heights	Forecasting	Power Purchase Agreement	Each meteorological tower
Wind direction (degrees relative to true north) at all metered heights	Forecasting	Power Purchase Agreement	Each meteorological tower
Temperature (F)	Forecasting	Power Purchase Agreement	Each meteorological tower
Pressure (mb)	Forecasting	Power Purchase Agreement	Each meteorological tower
Air density (kg/m3)	Forecasting	Power Purchase Agreement	Each meteorological tower
Real power (MW)	Operations	Facilities Study/LGIA	Customer Substation; Cedar Creek II Interconnect to line 5967



Reactive power (MVAR)	Operations	Facilities Study/LGIA	Customer Substation; Cedar Creek II Interconnect to line 5967
Line flow (amperes) for each phase	Operations	Facilities Study/LGIA	Customer Substation; Cedar Creek II Interconnect to line 5967
Volts (kV) for each phase	Operations	Facilities Study/LGIA	Customer Substation; Cedar Creek II Interconnect to line 5967
Breaker status in the Generation Provider's substation.	Operations	Facilities Study/LGIA	Customer Substation; Cedar Creek II Interconnect to line 5967
MW Set Point	Operations/AGC	Facilities Study/LGIA	Cedar Creek II Operations
Park Potential <sup>7</sup>	Operations/AGC	Facilities Study/LGIA	Cedar Creek II Operations
Voltage	Operations/AGC	Facilities Study/LGIA	Cedar Creek II Operations
Remote Local <sup>8</sup>	Operations/AGC	Facilities Study/LGIA	Cedar Creek II Operations

## B. Network Upgrades for Delivery

In general, the network upgrades for delivery shall mean the additions, modifications, and upgrades to the Transmission Provider's transmission system required at or beyond the point at which the interconnection facilities connect to the Transmission Provider's transmission system to accommodate the interconnection of the large generating facility (Generation Provider) to the Transmission Provider's transmission system.

### 1. Keenesburg

The network upgrades for delivery at Keenesburg Substation include looping the Ft. St. Vrain-Green Valley 230 kV line (Circuit #5327) into the Keenesburg Substation,

<sup>7</sup> The "Park Potential" represents the expected generation at the revenue meter based on current turbine availability and meteorological conditions. The value is close to the metered generation under normal conditions. During a curtailment, the Park Potential will be greater than the metered generation. The Park Potential reflects the wind farm generation at the point of delivery absent curtailment.

<sup>8</sup> The "Remove Local" DNP point will be supplied by the Generation Provider when it becomes available from the turbine manufacturers.



relocating the Green Valley 230 kV line (Circuit #5279), and modifying the Keenesburg Substation ring bus arrangement to a breaker-and-a-half arrangement that will include five additional 230 kV breakers, eight 230 kV switches, eight 230 kV CCVT's, two deadends, two line relay panels, East and West differential panels (to create an east and west bus so that the existing ring bus configuration can be changed to a breaker-and-a-half configuration), electrical bus work, steel and foundations, and minor site work (station wiring, grounding). The work at Keenesburg Substation includes installing transmission structures for bringing the Ft. St. Vrain-Green Valley line (Circuit #5327) into Keenesburg Substation and moving the Green Valley Line (Circuit #5279).

### **C. Assumptions for Network Upgrades for Delivery**

The timeframe to complete all of the necessary network upgrades for delivery is substantially longer than the Generation Provider's requested Commercial Operation Date (COD). The construction of the network upgrades for delivery will have to be carefully planned. Not all of the work can be performed at the same time due to transmission capacity constraints. Looping the Ft.St.Vrain-Green Valley 230 kV line into Keenesburg will require some short duration transmission outages that could necessitate a reduction in generation in the Keenesburg area while the outage is occurring. The generation affected includes the generation at RMEC and the generation at Ft.St.Vrain. The Transmission Provider will engineer, procure, construct, own and maintain all facilities associated with the network upgrades for delivery.

## **IV. Costs Estimates and Assumptions for the Project**

The following tables list the improvements required to accommodate the interconnection and the delivery of the Project generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

This estimate is for the interconnection of an additional 250 MW of generation at the CCWE1 facility. Network upgrades will require the expansion of the Keenesburg Substation to bring in the Ft. St. Vrain to Green Valley 230 kV line (Circuit #5327). This will require converting the substation from a ring bus to a breaker-and-a-half configuration, with the addition of breaker-and-a half bay, associated foundations, equipment, and relaying. It will also be required to move the existing Green Valley 230 kV line (Circuit #5279) to a new bay position for proper routing and termination of the new Ft. St. Vrain to Green Valley line termination.



**Table 4: Transmission Provider Network Upgrades for Delivery**

Element	Description	Cost Est. Millions
<b>Transmission Provider's Keenesburg 230 kV Substation</b>	Loop the Ft. St. Vrain- Green Valley 230 kV line (Circuit #5327) into Keenesburg Substation., relocate the Green Valley 230 kV line (Circuit #5279), modify the Keenesburg Substation from a ring bus configuration to a breaker-and-a-half arrangement. <ul style="list-style-type: none"> <li>• Five (5) 230 kV Breakers</li> <li>• Eight (8) 230 kV Switches</li> <li>• Eight (8) 230 kV CCVT's</li> <li>• Two (2) Deadends</li> <li>• Two (2) Line relay panels</li> <li>• East &amp; West differential panels</li> <li>• Electrical bus work</li> <li>• Required steel and foundations</li> <li>• Minor site work (station wiring, grounding)</li> </ul>	<b>\$2.95</b>
<b>Transmission Provider's Ft. St. Vrain-Green Valley 230 kV Line</b>	Transmission structures for bringing Ft. St. Vrain-Green Valley line (Circuit #5327) into Keenesburg Substation and moving Green Valley Line (Circuit #5279)	<b>\$1.94</b>
	<b>Total Cost Estimate for the Transmission Provider-Owned, Transmission Provider-Funded Interconnection Facilities</b>	<b>\$4.89</b>
<b>Time Frame</b>		<b>63 Weeks</b>

**Table 5 – Transmission Provider Owned; Generation Provider Funded Interconnection Facilities**

Element	Description	Cost Est. Millions
<b>Facility</b>	<b>None</b>	<b>\$0.00<sup>9</sup></b>
	<b>Total Cost Estimate for the Transmission Provider-Owned, Generation Provider-Funded Interconnection Facilities</b>	<b>\$0.00</b>
<b>Time Frame</b>		<b>0 Months</b>

<sup>9</sup> Depending on the location of the 230kV capacitor bank station (to be installed by the Generation Provider), the Transmission Provider's owned facilities may be impacted. The Generation Provider's tapping and routing of the existing Cedar Creek Circuit #5967 may require modifications to the Transmission Provider existing transmission facilities. As the Customer's location has not been determined, the impact and cost cannot be estimated.



**Table 6: Transmission Provider Owned; Transmission Provider Funded Interconnection Facilities**

Element	Description	Cost
Facility	None	\$0.00
	<b>Total Cost Estimate for the Transmission Provider-Owned, Transmission Provider-Funded Interconnection Facilities</b>	<b>\$0.00</b>
Time Frame		<b>0 Months</b>

**Assumptions**

- The estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimated dollars for substation work includes typical escalations for time frame required for design and construction.
- AFUDC is excluded.
- Labor is estimated for straight time only – no overtime included.
- The Transmission Provider (or it’s Contractor) crews will perform all construction and wiring associated with the Transmission Provider-owned and maintained facilities.
- Estimate assumes no additional land required at the Keenesburg Substation.
- This estimate and schedule is dependent on approval of Network upgrades through the Transmission Provider’s Capital Budget Construction process.
- Lead times for materials were considered for the schedule.
- The Generation Provider transmission line is assumed to be fully compensated per interconnection requirements. Line compensation such as capacitors or line reactors and associated equipment are not included in this estimate and are the responsibility of the Generation Provider.
- The Keenesburg Substation equipment is rated high enough to accommodate the additional 250 MW.
- Relays on the Fort St. Vrain and Green Valley lines will reuse the existing fiber circuits.
- This estimate assumes interconnection facilities and upgrades as outlined in the generation interconnection System Impact Study GI-2007-6 (includes the GI-2007-5 expansion) and re-studies.

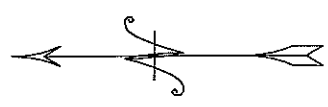
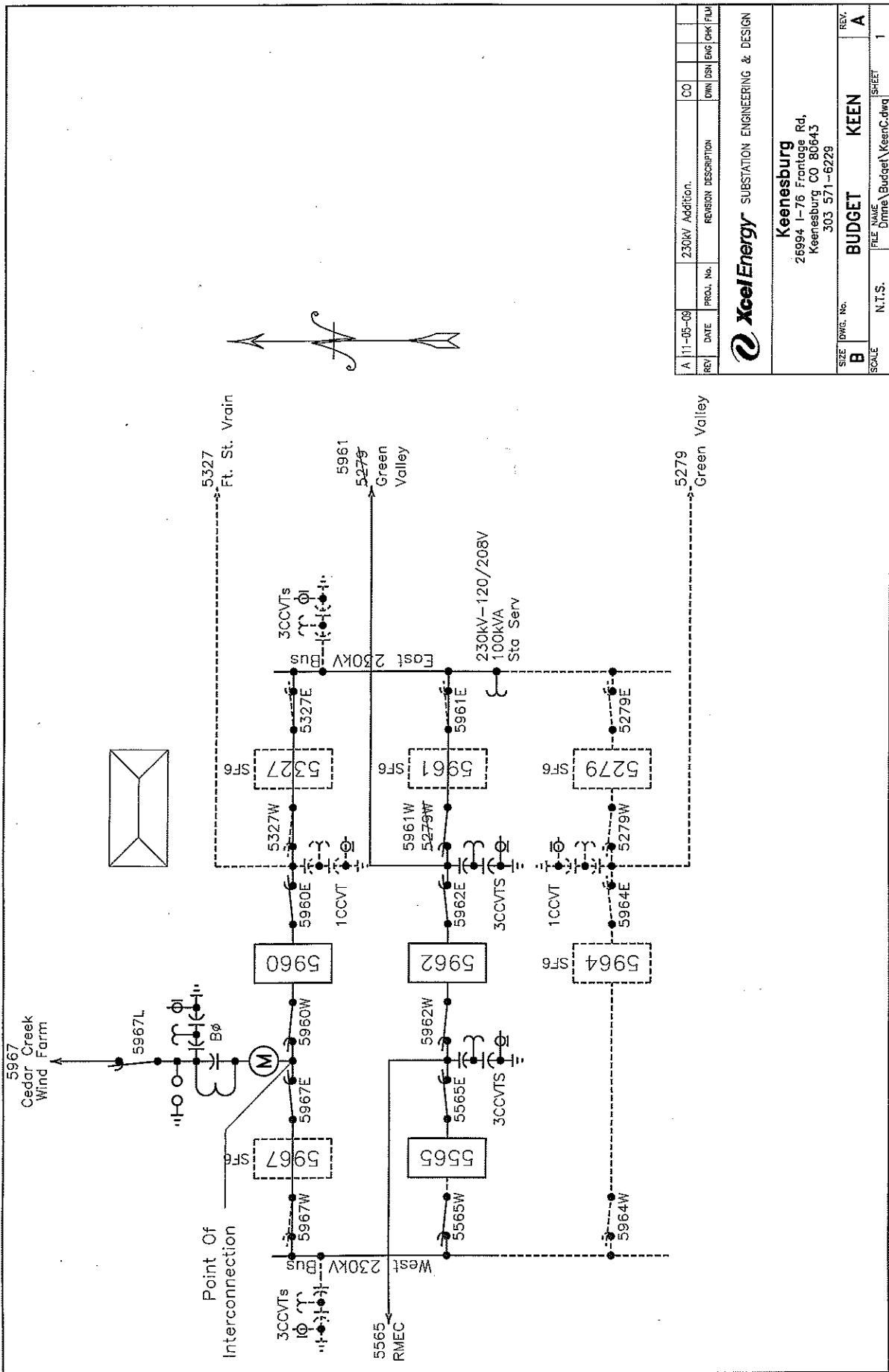
**V. Appendix Items**

The Appendix has three sections – Section A that includes the “Project One-Line”, Section B that includes the “Project Schedule”, and Section C that includes sample results from a “Sample Testing Procedure”. The “Sample Testing Procedure” has been supplied to the Generation Provider to make the Generation Provider aware of acceptance tests that would be required for commissioning.

## Appendix



**A. Project One-Line**

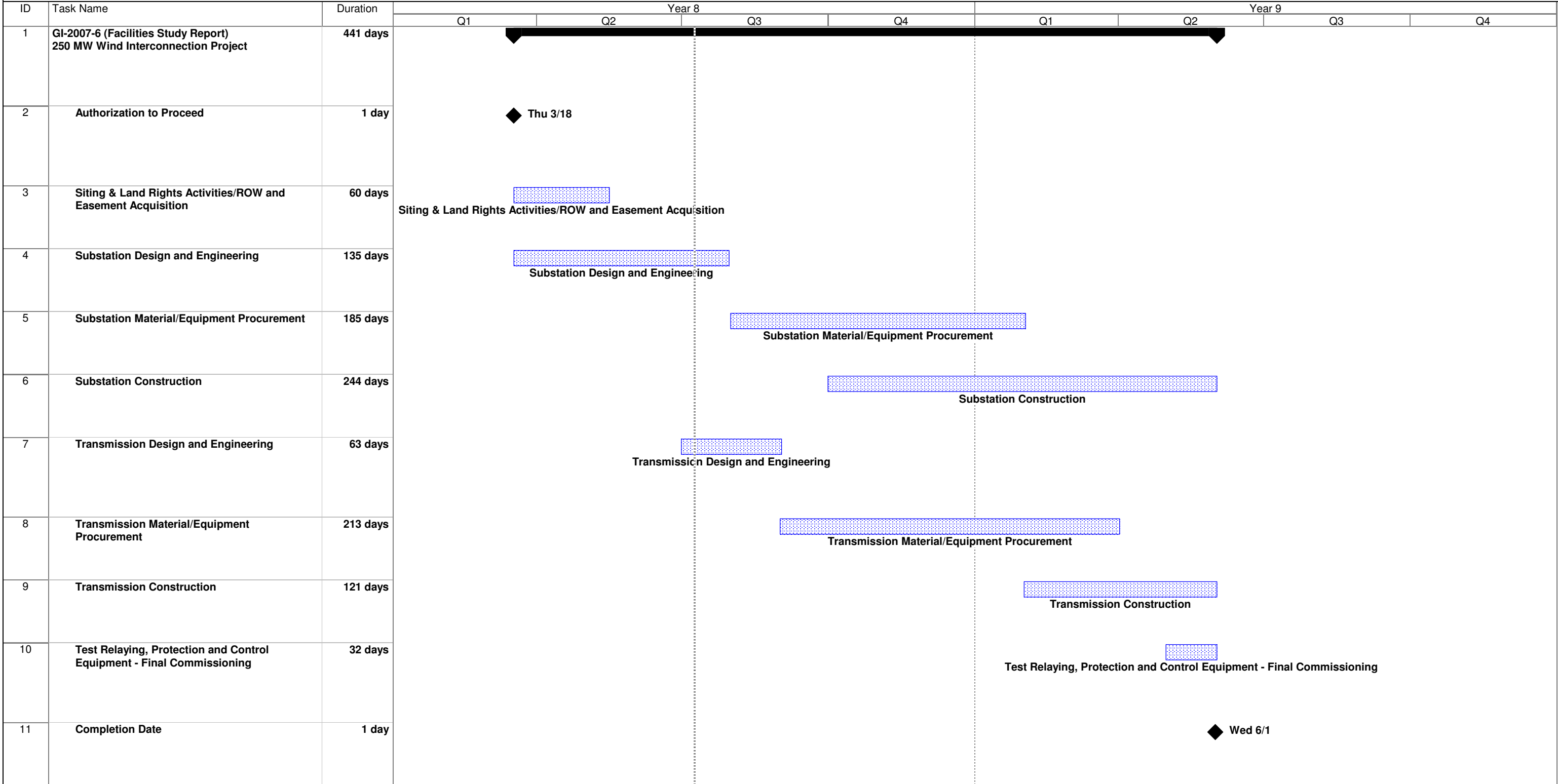


REV	DATE	PROJ. No.	REVISION DESCRIPTION	CO	ENGR	CHK	FLD
A	11-05-09		230KV Addition.				
<b>Xcel Energy</b> SUBSTATION ENGINEERING & DESIGN							
<b>Keenesburg</b> 26994 I-76 Frontage Rd. Keenesburg CO 80643 303 571-6229							
SIZE	DWG. No.	BUDGET	KEEN	REV.			
B				A			
SCALE	N.T.S.	FILE NAME	Dimme\Budget\KeenC.dwg	SHEET	1		



## **B. Project Schedule**

# GI-2007-6 (Facilities Study Report) 250 MW Wind Interconnection Project



Project: Schedule 7-9-10.mpp  
Date: Fri 7/9/10

Task		Milestone		Rolled Up Task		Rolled Up Progress		External Tasks		Group By Summary	
Progress		Summary		Rolled Up Milestone		Split		Project Summary			



## C. Sample Testing Procedure



## SAMPLE TESTING PROCEDURE

**NOTE\*\*** Performance test period begins upon 1) successful commissioning of all turbines and other major electrical equipment to be connected to the Point of Interconnection, 2) SCADA in place, with all points available and active, and 3) Notification to the Transmission Provider by owner of readiness to start. Test Period ends upon successful completion of all tests. Additionally, test requirements are subject to change based on changes to the Facilities and System Impact Studies.

Line	Requirement	Criteria	Test	Pass/Fail	Conditions	Other
1.	Reactive Control over generating range	Demonstrate ability to maintain VAR neutrality at the POI per the System Impact Study (SIS).	Maintain 0 MVAR reactive flow at the POI within a deadband of $\pm$ __ MVAR and a system voltage within $\pm$ 5% of nominal at the POI.	Allowed bandwidth not exceeded, except in the case of performing the capacitor test below	Two ramp-ups and ramp-downs between zero and >85% output	Demonstrates normal plant operation over the full range using reactive power control.  Four-second telemetered values charted at Lookout Center will be used for evaluation, and provided to Interconnection Customer for review.
2.	Acceptable operation of all installed equipment	Demonstrate proper operation of capacitors installed at the POI.	All generator-operated capacitors installed near the POI (~__ MVAR) online, either automatically to maintain MVAR bandwidth, or due to manual change to MVAR/voltage setpoint to deliver reactive power to Transmission System.	All capacitors online for at least five minutes.	>85% output, at a time approved by System Operator (Lookout).	Interconnection Customer's representative, Mr. Kerry Franklin, will be on standby at Lookout Control Center waiting for wind conditions suitable for testing.
3.	Reactive Control at zero or less net MW output	Demonstrate ability to maintain VAR compensation at the POI per the SIS.	Maintain $\leq$ __ MVAR reactive flow into the Transmission Provider system.	Plant always net inductive when appearing as a net load (MW delivered to plant).	All generators off-line	Demonstrates automatic operation of shunt reactors adequate to offset transmission line charging.
4.	Communication	Series of reasonable requests, i.e. "Report # turbines online", "Curtail to XX MW."	Respond professionally and promptly to reasonable requests.	Professional, prompt (within one minute) response, accurate and complete. 99.9% compliance for one week.	0-__ MW, full range at least once during test period	Requests may come in via phone call or via EMS
		Dedicated phone circuit	Have a tested phone line to Lookout Center from Wind Op. Center	Documentation and testing prior to operational testing	No operational requirement	
		Provide EMS/SCADA points from plant to Lookout	Have points verified to and from the Transmission Provider SCADA	Provide points via EMS, including MW/MVAR output at POI	No operational requirement	Other points may be requested