



# Interconnection Facilities Study Report Restudy 1

**Request # GI-2006-2**

175 MW wind project

Facility Study

August 11, 2009

PSCo Transmission Planning  
Denver, CO

## 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 a 175 MW wind generation expansion of the existing 400 MW<sup>1</sup> Peetz Logan Wind Facility (GI-2006-1(g)) for total interconnection amount of 575 MW. The Point of Interconnection (POI) will remain at the PSCo Pawnee Station in Morgan County, Colorado. The new wind generation facility would be located near Peetz, Colorado and would interconnect at Pawnee Station via the Customer's 78-mile 230 kV transmission line. The requested commercial in-service date is October 1, 2009 and a requested back feed date of September 1, 2009. This study indicates that the September 2009 back feed date is achievable to facilitate the commercial in-service date (CID) of October 2009.

PSCo will require testing of the full 575 MW of the facility. These tests will include but not limited to power factor capability and voltage control at the POI for various generation output levels (0 to 575 MW) of the Customer's wind generation facility. Appendix A provides a typical testing plan.

The 2006-2 System Impact study restudy 3 was completed on August 6, 2009 for the 175 MW wind project. The wind turbines consisted of 65 Siemens SWT 2.3 MW turbines and 17 GE 1.5 MW turbines.

The recommended Network upgrades for interconnection at Pawnee Station only include minor wiring changes at PSCo's Lookout Center and relay setting changes at Pawnee Station. No other changes to the existing interconnection are required.

The total estimated cost for the facilities required for Interconnection and Delivery is approximately **\$40,000<sup>2</sup>** and includes:

- \$0.04 million for Customer Funded PSCo Interconnection Facilities
- \$0.0 for PSCo Network Upgrades for Interconnection

The estimated time required to engineer, permit and construct the facilities described above is at least 6 months from the date Customer meets all applicable Milestones completed in a timely manner, PSCo anticipates they can meet the back feed date of September 2009 for Delivery of the 175 MW.

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<sup>1</sup> The 400 MW is split 200 MW each between two separate entities each with their own Power Purchase Agreements (PPA's) with Xcel Energy Markets.

<sup>2</sup> Appropriation estimate for the Interconnection only considered to have an accuracy of +/- **20%**. The Network Upgrades For Delivery are Scoping Estimates and considered to have an accuracy of +/- **30%**.

Transmission Studies for the NR evaluation show that the basic PSCo network upgrades for Delivery would consist of:

- The recommended Network upgrades for interconnection at Pawnee Station only include minor wiring changes at PSCo's Lookout Center and relay setting changes at Pawnee Station.
- 200 MVAR of switched capacitors will be added near the Point of Interconnection.

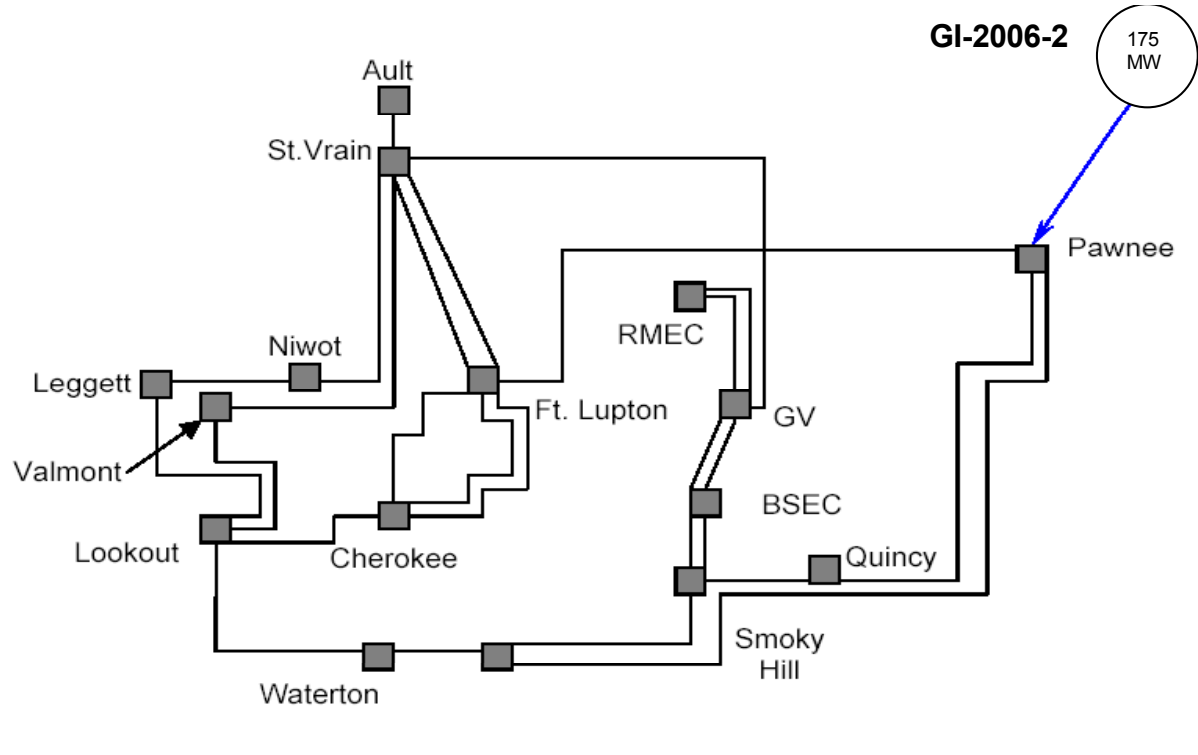
### Customer Voltage and Power Factor Issues

The System Impact Study showed that the Customer does not have any power factor or voltage control for power flows above 300 MW at the POI. For system reliability reasons, this Facilities Study, as per the Customer's request, has determined a solution for this problem. The customer will install 200 MVAR of switched capacitor banks located near the POI. This 200 MVAR has been optimized into four individual 50 MVAR capacitor banks and would be switched on by the Customer's operators as the Customer's generation increases on their line. PSCo System Operations (Lookout Center) may also direct switching of the capacitor banks when system conditions warrant. The cost of these capacitor banks and associated control equipment has not been estimated because these capacitors are part of the Customer's transmission system.

The customer should also be aware that when all their generation is off-line that high voltages of 1.05 pu (242 kV) or greater will occur on their system. This is due to the charging capacitance of their 78-mile 230 kV line and the Customer will be required to compensate for this effect. It is necessary to maintain the voltage at the Pawnee 230-kV bus above 1.02 per unit under system intact conditions. This will require that the customer's capacitors installed near Pawnee on the Pawnee – Peetz Logan 230 kV circuit to be switched on during periods of high wind generation.

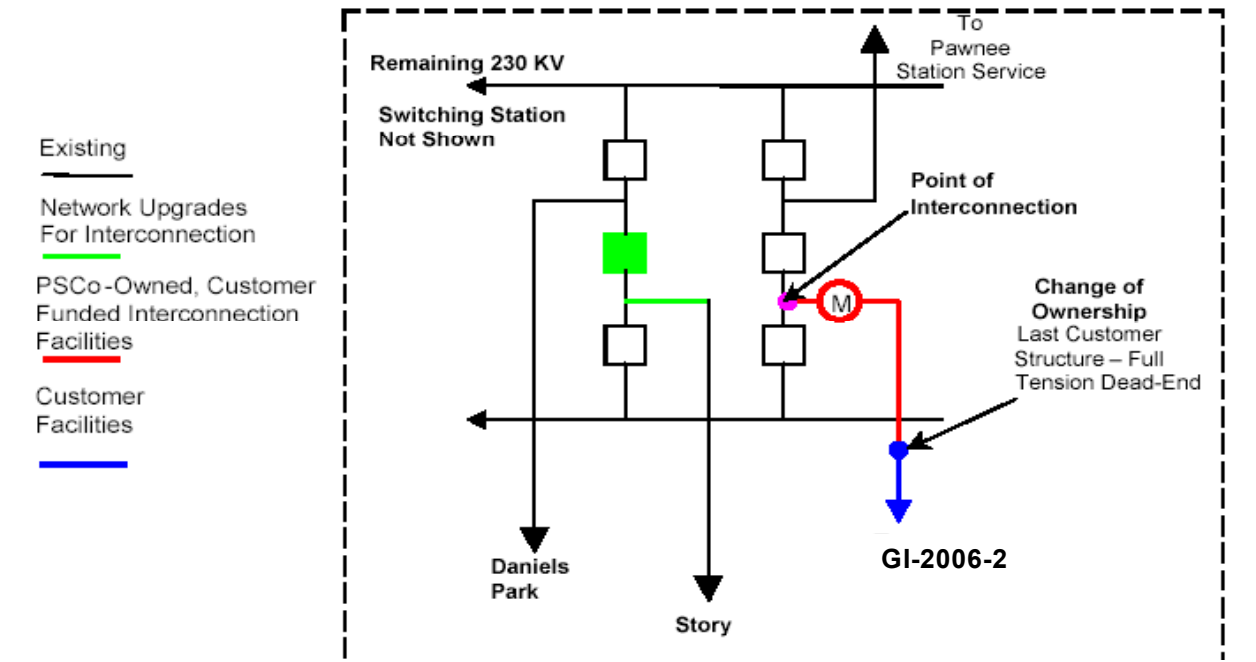
A simple diagram of the regional transmission system is depicted in Figure 1, and a simple one-line diagram of the existing interconnection facilities shown in Figure 2.

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



**Figure 2: Interconnection One-Line Diagram**

**Pawnee switch station**



## I. Introduction

PSCo Transmission received a request to conduct a Facilities Study that would evaluate a potential wind powered resource. The Peetz Logan Interconnect Project is requesting a 175 MW expansion. The System Impact Study report was issued and posted on the OASIS web site on April 4, 2007. A System impact Restudy was issued and posted on June 25, 2008 for 200 MW. A system impact restudy (2) for 175 MW was issued on February 25, 2009. A third System Impact study was issued on August 7, 2009

## II. General Interconnection Facilities Description

### 1. Project Purpose & Scope

The purpose of this project is to interconnect an additional 175 MW of wind generation from the Peetz-Logan site into PSCo's existing Pawnee 230 kV Substation. The customer proposes to bring the additional 175 MW into Pawnee over the existing transmission line between Pawnee and customer's substation site. There will be no additional equipment at Pawnee due to the customer's additional generation. See the Figure 3 for the one-line diagram of the interconnection to Pawnee station. Figure 5 shows a general location overview of all facilities. Figure 4 shows a general arrangement of the Pawnee switch station.

### 2. Background

Pawnee substation is a 5 bay breaker and half transmission switching station, which sits adjacent to the Pawnee Generating Station. Presently the Pawnee Generating Station and other nearby generators inject over 1400 MW into the Pawnee Bus.

### 3. Other Considerations

The desired backfeed date for the customer is September of 2009, with a commercial in-service date (CID) of October 2009.

### 4. 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 3.0<sup>3</sup>, last reviewed in December 2006. Xcel Energy requires the interconnection customer to construct the Interconnection Facilities in compliance with this document. This document describes the technical and protection requirements for connecting new generation to the

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<sup>3</sup> Guidelines can be found at [www.xcelenergy.com](http://www.xcelenergy.com).

Xcel Energy operating Company transmission system and also requires that the interconnection Customer be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council, Commission or their successor organizations.

a) Removals and Relocations

None

b) Fault Current

Existing 3 phase and SLG fault currents are 19,675A and 22,524A respectively at the Pawnee 230 kV bus. The anticipated fault current at the Pawnee 230 kV bus after the additional 175 MW is approximately 22,556A respectively.

c) Right of Way

Nothing required

d) High Voltage Electrical Installations

No additional equipment is required at Pawnee substation. Customer plans to use the existing transmission line to interconnect. All (metering) instrument transformers and metering are rated to handle the additional 175 MW.

At Lookout control center minor wiring and programming changes will be installed to reflect the additional wind turbines added to the customers site.

The step-up transformers at the customer facility shall be designed to meet the interconnection guidelines mentioned above. The configuration shall be grounded-wye on the 230 kV primary side, wye on the 34.5 kV secondary side, and delta on the tertiary. The Customer must specify their transformer(s) to meet PSCo's requirements for an effectively grounded system.

e) AC & DC Systems

Existing AC and DC panels are adequate in the Electrical Enclosure Equipment (EEE).

f) Control Building

- All new equipment will fit into existing building.
- g) Grounding

No new grounding is required.

- h) Lightning Protection

No new lightning protection is required.\

- i) Grading & Fencing

No new grading or fencing are required.

- j) Foundations & Structural

No new foundations or steel are required.

- k) Removals & Relocations

No removals or relocations are required.

- l) Control & Protection – Electrical Installations

No new transmission line relaying is required, however the protective relay settings need to be checked, and may need to be adjusted to accommodate the additional 175 MW.

Additional interconnection requirements will need to be satisfied as stated in PSCo's interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW.

Existing RTU at Lookout control center has space to add the additional SCADA points for the additional wind turbines.

- m) Outages

No substation outages will be necessary at Pawnee, however the customer's transmission line may experience periodic outages for their expansion of the wind site.

- n) Project and Operating Concerns

Pawnee 230 kV voltage must remain at 1.02 during intact conditions.



o) Related Substation & Transmission Projects

See Network upgrades for Delivery.

p) Assumptions for Customer's Site

Customer will provide power factor correction equipment to meet voltage tolerances at point of interconnection.

Customer will engineer, procure, and construct all equipment up to the Pawnee 230 kV dead-end structure. This includes transmission line relay equipment at customer's site.

The customer will install 200 MVAR of switched capacitor banks located near the POI. This 200 MVAR has been optimized into four individual 50 MVAR capacitor banks and would be switched on by the Customer's operators as the Customer's generation increases on their line. PSCo System Operations (Lookout Center) may also direct switching of the capacitor banks when system conditions warrant. A one line of this installation is shown in Figure 7.

The customer will need to arrange for station service power through the local utility/service provider, as customer's site may not be in PSCo service territory<sup>4</sup>.

PSCo needs approximately 4-6 weeks to test requirements of 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. A typical testing and commissioning procedure can be found in Appendix A.

Customer will comply with FERC Order 661-A<sup>5</sup> and guidelines for Low Voltage Ride Through (LVRT) capability. PSCo modeled the GE 1.5 SLE turbines with LVRT of 0.0 per unit voltage as provided by the Customer.

Customer will provide reactive support equipment to meet voltage tolerances and power factor at the point of interconnection as required by Xcel Energy and FERC interconnection guidelines.

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

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<sup>4</sup> Currently the customer gets station power via High West Energy REA a Tri-State Generations and Transmission, Inc. (TSGT) member. TSGT has designated Pawnee Station a Network Transmission Delivery Point. Being so makes the Customer an in-direct PSCo Customer subject to PSCo's Interconnection Guidelines for Transmission interconnected Loads Version 1.0 dated 9/30/06. These guidelines can be found at [www.xcelenergy.com](http://www.xcelenergy.com).

<sup>5</sup> This can be found at [www.ferc.gov](http://www.ferc.gov).

q) Assumptions for Pawnee

No work is required at Pawnee Substation other than verifying and possibly re-configuring SCADA points for the additional 175 MW.

r) Communications

A new RTU<sup>6</sup> for LF/AGC (Load Frequency Control/Automatic Generator Control) will not be required at the Customer's substation, it is assumed that the existing equipment will provide information to the existing RTU to be installed at the PSCo Control Center. Customer will supply all necessary AC and DC station service and space for the required equipment. Customer will need to supply a communication circuit for the RTU located at the Customer's facility and to the PSCo Control Center.

Typical data required, *subject to change*, will be:

- Breaker Status for all breakers in the Customer's substation.
- MW and MVAR information for all lines coming into or leaving the Customer's substation.
- Voltage values for each phase.
- Weather data such as Wind Speed.

The customer will need to supply two-communication circuits; One from the RTU located at their substation to PSCo Control Center. The second circuit will need to go from the RTU located at their substation to the PSCo Pawnee substation.

Customer will need to supply protective relaying communication circuits going from their substation to the PSCo Pawnee substation.

## **5. 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 (PSCo) 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 (customer) to the transmission provider's transmission system. See FERC 2003-A definitions for further explanation.

## **III. Costs Estimates and Assumptions**

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<sup>6</sup> Xcel Energy's Policy on Load Frequency Control for Wind Powered Generation is currently under review and subject to change.

The estimated total cost for the required upgrades is \$40,000.

The estimated costs shown are (+/-30%) estimates in 2008 dollars and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new PSCo facilities. This estimate did not include the cost for any other Customer owned equipment and associated design and engineering. The following tables list the improvements required to accommodate the interconnection and the delivery of the Project. 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.

Since this project intends to use the interconnection from the 400 MW Wind Facility GI2006-1(g) and GI-2006-2 at Pawnee Station, there will be only minimal costs of \$40,000 associated with the interconnection required for this 175 MW expansion project GI-2006-2. No network upgrades will be required for this project.

**Table 1: Transmission Providers Interconnection Facilities (Customer funded):**

| <b>Element</b>                | <b>Description</b>   | <b>Cost (\$Million)</b> |
|-------------------------------|--|-------------------------|
| <b>PSCo Pawnee Switchyard</b> | Miscellaneous work to interconnect 175 MW expansion project <ul style="list-style-type: none"> <li>• Replaying and testing</li> <li>• SCADA/EMS modifications</li> </ul> | <b>\$0.040</b>          |
| <b>Time Frame</b>             | <b>Months - Substation</b>   | <b>6 months</b>         |
| <b>Total</b>                  | <b>Customer Interconnection Facilities</b>   | <b>\$0.040</b>          |

No Network upgrades are required for GI-2006-2

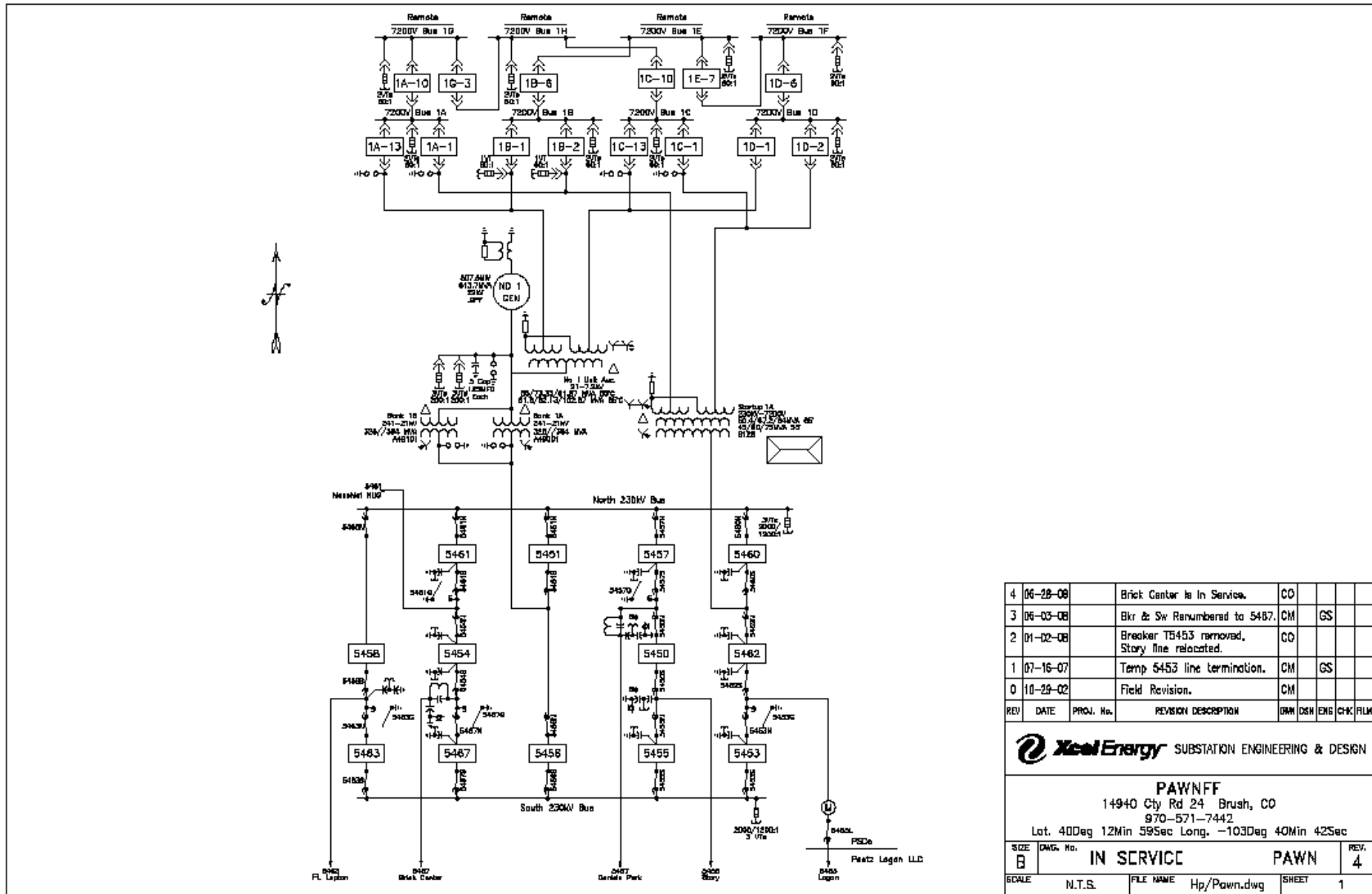
**Table 2: PSCo Transmission Network Upgrades Required for Interconnection:**

| Element                | Description                          | Cost (\$Million) |
|------------------------|--------------------------------------|------------------|
| PSCo Pawnee Substation | No Network Upgrades will be required |                  |

**Assumptions**

- The estimated costs provided are with an accuracy of +/- 30%.
- All applicable overheads are included. AFUDC has not been included.
- There is no contingency added to the estimates.
- Estimates have not been escalated. All estimates are in 2008 dollars.
- Labor is estimated for straight time only – no overtime included.
- No additional metering will be required.
- The Generator 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 work associated with PSCo owned and maintained equipment.
- All required transmission outages necessary to support construction will be obtained as needed that may also require restrictions in Pawnee Area generation.
- This additional wind generation will utilize the existing/planned Peetz Logan Interconnect 230 kV transmission line.

Figure 3: Pawnee one line diagram



| 4   | 06-28-08 |           | Brick Center Is In Service.                 | CO  |     |     |     |
|-----|----------|-----------|---|-----|-----|-----|-----|
| 3   | 06-03-08 |           | Bkr & Sw Renumbered to 5457.                | CM  | GS  |     |     |
| 2   | 01-02-08 |           | Breaker 5453 removed, Story line relocated. | CO  |     |     |     |
| 1   | 07-16-07 |           | Temp 5453 line termination.                 | CM  | GS  |     |     |
| 0   | 10-29-02 |           | Field Revision.                             | CM  |     |     |     |
| REV | DATE     | PROJ. No. | REVISION DESCRIPTION                        | DRW | DSH | ENS | CHK |

**Xcel Energy** SUBSTATION ENGINEERING & DESIGN

**PAWNFF**  
 14940 Cty Rd 24 Brush, CO  
 970-571-7442  
 Lat. 40Deg 12Min 59Sec Long. -103Deg 40Min 42Sec

|          |          |                   |             |          |
|----------|----------|-------------------|-------------|----------|
| SIZE     | DMG. No. | <b>IN SERVICE</b> | <b>PAWN</b> | REV.     |
| <b>B</b> |          |                   |             | <b>4</b> |
| SCALE    | N.T.S.   | FILE NAME         | Hp/Pawn.dwg | SHEET    |
|          |          |                   |             | <b>1</b> |

Figure 4: Pawnee General Arrangement

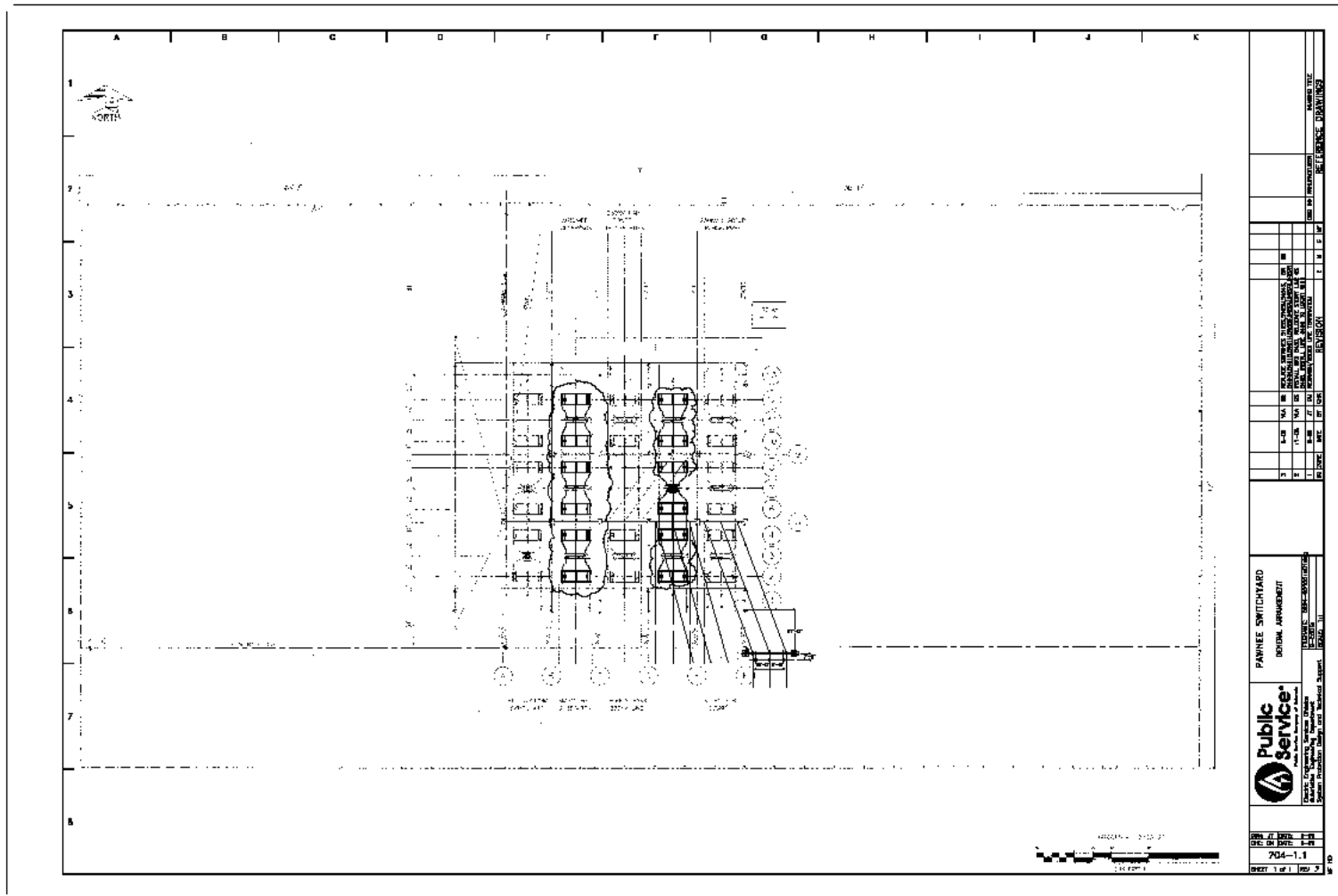
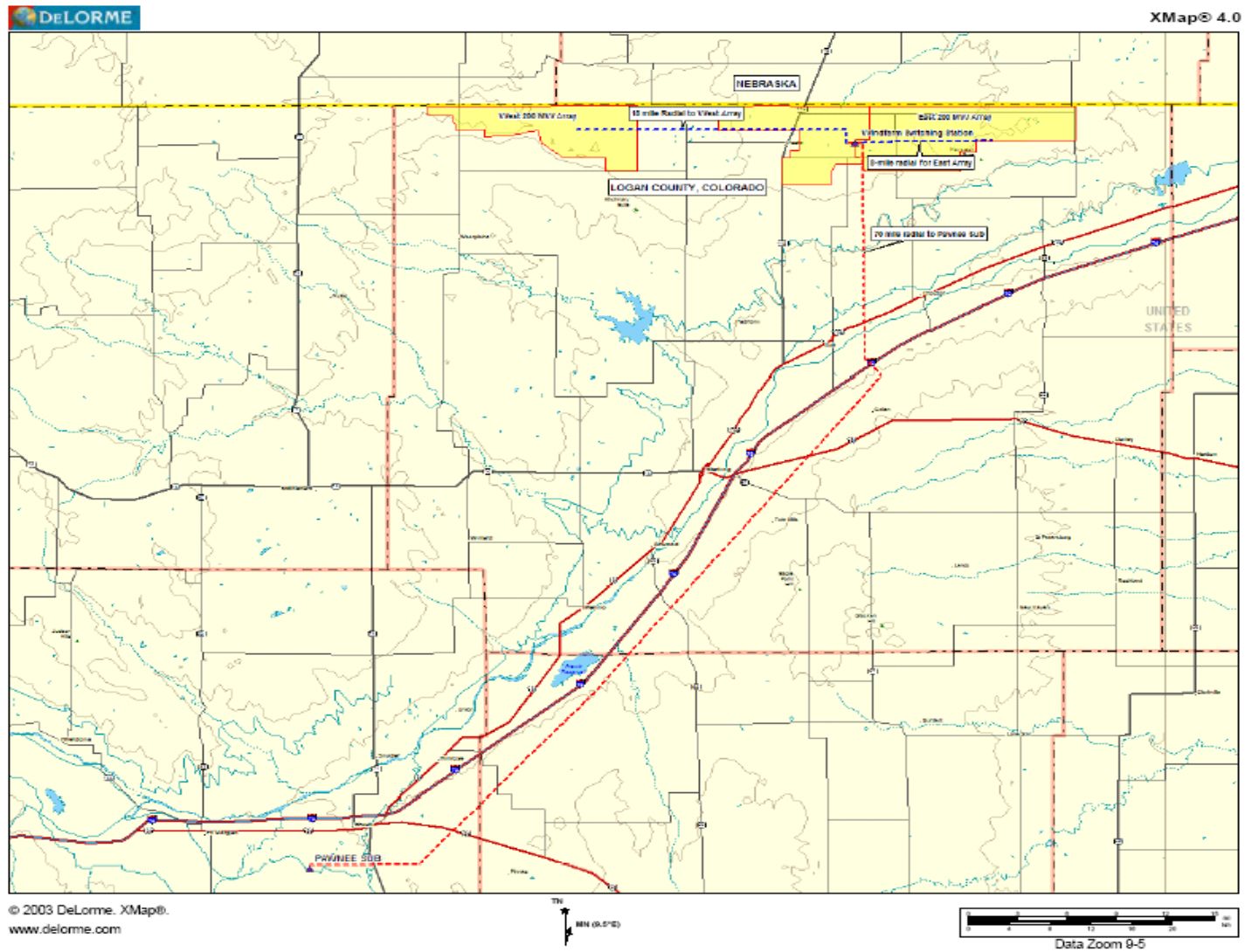


Figure 5: **General Location Overview**



## 6: Section View of Interconnection at Pawnee

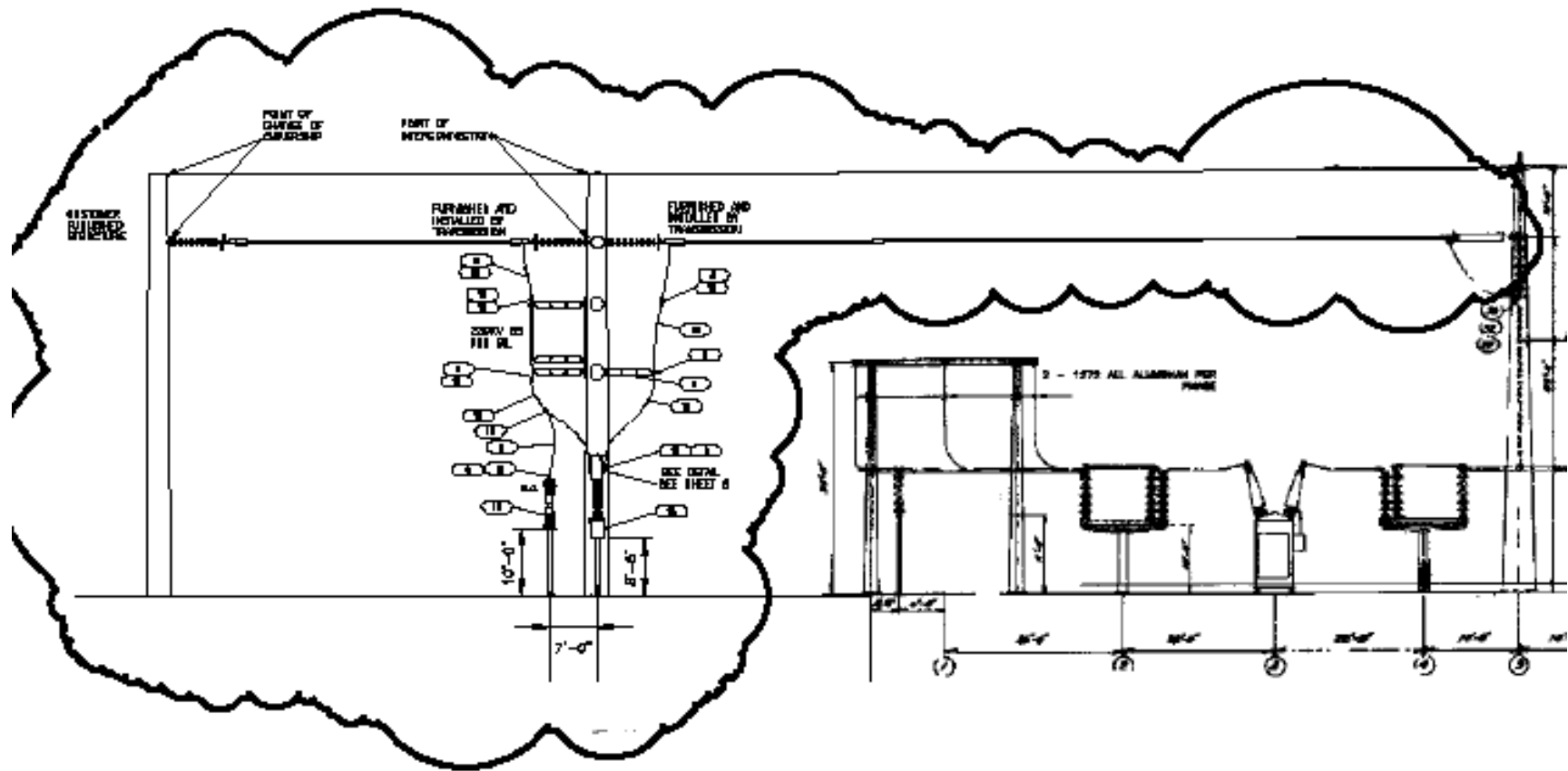
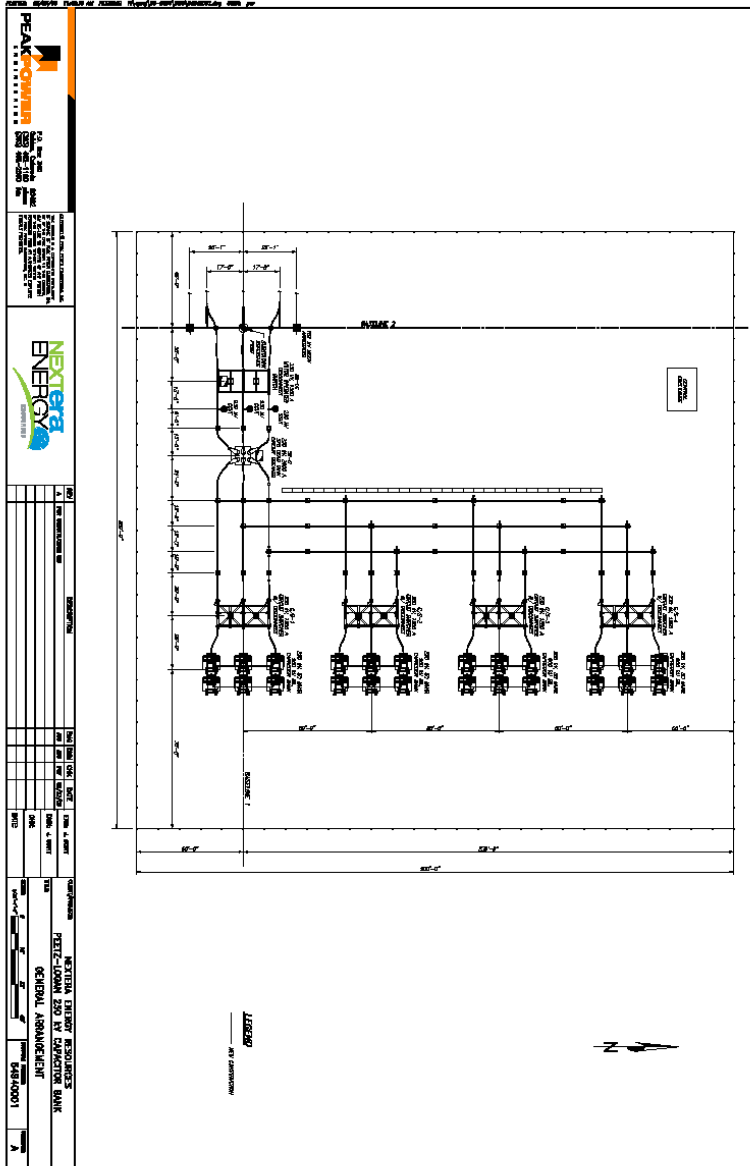




Figure 7: Peetz Logan Line with Shunt Capacitors



**Appendix A**  
**Typical Commercial Testing Document**

**Peetz-Logan Wind Project, PLI Expansion from 400 MW to 575 MW (GI-2006-2)**

**Test Requirements DRAFT-Based on reactive control as the primary operating for maintaining Var neutrality.**

| <b>TEST LINE</b> | <b>Requirement</b>                              | <b>Criteria</b>   | <b>Test</b>   | <b>Pass/Fail</b>  | <b>Conditions</b>  | <b>Other</b>   |
|------------------|---|---|---|---|--|--|
| 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 $\pm 25$ 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.<br><br>4-second telemetered values charted at Lookout Center will be used for evaluation, and provided to FPLE 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 ( $\sim 200$ 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). | Mr. Kerry Franklin will be on standby at Lookout control center waiting for the wind to blow.  |
| 3.               | Reactive Control at zero or less net MW output  | Demonstrate ability to maintain Var compensation at the POI per the SIS.                      | Maintain $\leq 0$ MVar reactive flow at the POI.  | 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.  |

Note: Performance test period begins upon 1) successful commissioning of all turbines and other major electrical equipment to be connected to the Peetz-Logan Interconnect and 2) SCADA in place, with all points available and active, including Lookout to Wind Plant and Wind Plant to FPL Energy Operations.