



Interconnection Facilities Study Report GI-2008-33

**300 MW Gas Powered Generation Interconnecting at Pawnee Substation
in Morgan County, Colorado**

**PSCo Transmission Planning
May 16, 2016**

A. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo), designated as GI-2008-33, to specify and estimate the cost of the siting, engineering, equipment procurement and construction needed to physically and electrically connect the GI-2008-33, 300 MW (270 MW net), natural gas-fired generation facility in Morgan, Colorado.

The GI-2008-33 interconnection request will utilize a Point of Interconnection (POI) through a 345 kV termination on the 345 kV bus at the Pawnee Substation. The 300 MW generation facility will utilize a Customer owned, three mile, 345 kV line on the Customers side of the POI to interconnect at the Pawnee Substation. The Customer will be responsible for construction of the transmission line from the generation facility to the POI. For cost estimating purposes it is assumed this line has already been constructed in this study.

The 300 MW generation facility will consist of three (3), GE LMS100 Aero-derivative gas turbine units, rated at 100 MW each. The Customer has indicated that 1/3 of the generation will be delivered to a service area near Pueblo, Colorado, while the remaining 2/3 will be delivered to the Cheyenne area in Wyoming through Western Area Power Administration's (WAPA) transmission network. The Customer requested Commercial Operation Date (COD) of the facility to coincide with the completion of a new 345 kV transmission line between Pawnee and Smoky Hill and the related 345/230 kV substations, which occurred on May 2013.

The GI-2008-33 System Impact Study determined the proposed 300 MW, natural gas-fired, generation facility may interconnect as an Energy Resource after the required system upgrades for delivery are completed. The required system upgrades for delivery include a new Harvest Mile 230/345 kV Substation and subsequent 560 MVA 345/230/13.8 kV transformer which are both components of the Pawnee – Daniels Park 345 kV Transmission Project.

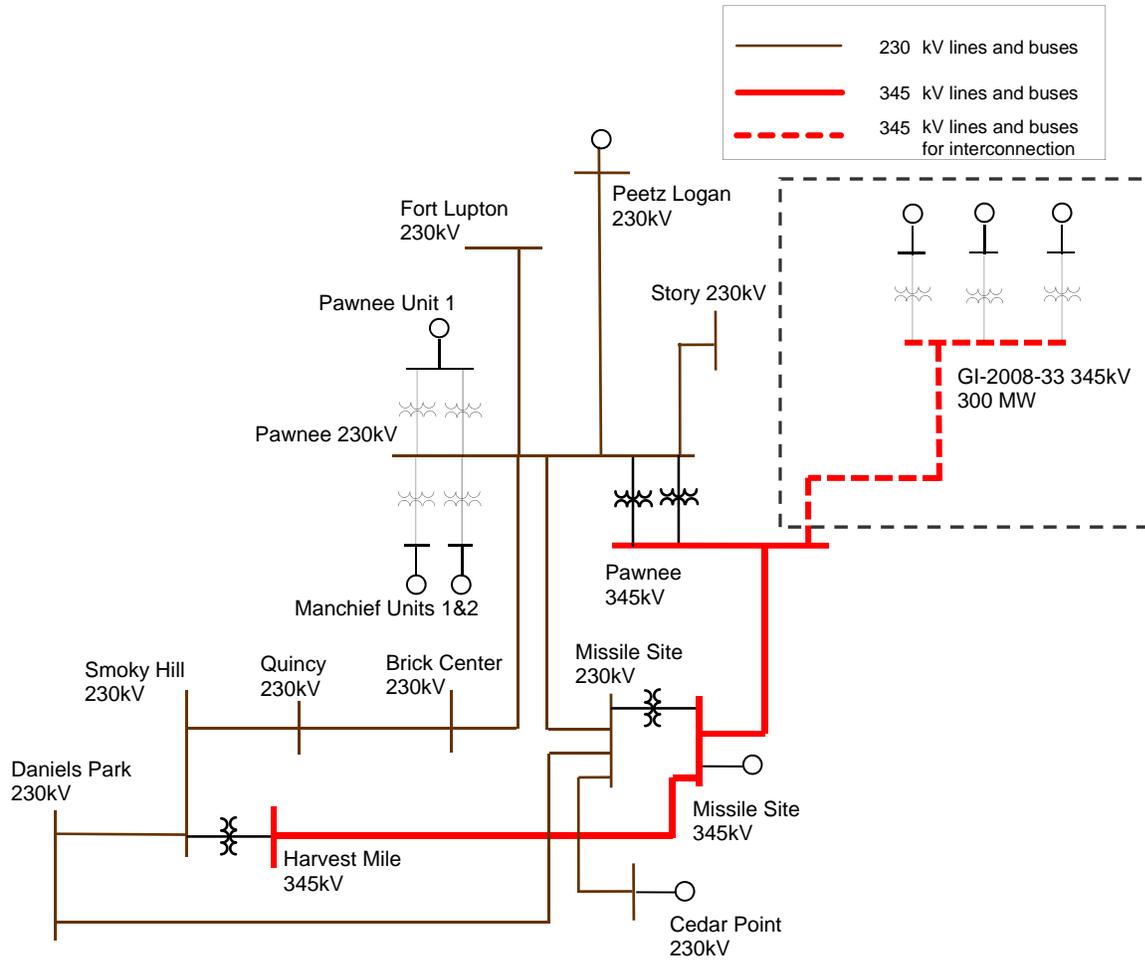


The total estimated cost of the recommended system upgrades to interconnect the project is approximately **\$ 5,730,000** and includes:

- \$1.620 million for PSCo Owned, Customer Funded Interconnection Facilities.
- \$0.000 million for PSCo Owned, PSCo Funded Interconnection Facilities.
- \$4.110 million for PSCo Network Upgrades for Delivery.

A conceptual one-line of the proposed Interconnection is shown in Figure 1 below (NOTE: See Appendix Section C for updated one-line and discussion of metering location shown in that update).

Figure 1: Simple Diagram of the GI-2008-33 Interconnection at Pawnee 345 kV





B. Introduction

On December 17, 2015, Public Service Company of Colorado (PSCo) and a Generation Provider (Customer) signed an Interconnection Facilities Study request (GI-2008-33) to provide cost estimates, a project schedule, and to address the impacts, as identified in the System Impact Study, of interconnecting a 300 MW (270 MW net), natural gas-fired generation facility to the 345 kV bus at PSCo's Pawnee Substation. The Customer's project facility will consist of three (3), GE LMS100 Aero-derivative gas turbine units, rated at 100 MW each. The Customer has indicated that 1/3 of the generation will be delivered to an area near Pueblo, Colorado, while the remaining 2/3 will be delivered to the Cheyenne area in Wyoming through Western Area Power Administration's (WAPA) transmission network. The Customer requested Commercial Operation Date (COD) of the facility was initially requested to coincide with the completion of the new 345 kV transmission line between Pawnee and Smoky Hill and the related 345/230 kV substations, which occurred in May 2013. However, based on results of the System Impact Study, the COD cannot occur until after the installation of the Harvest Mile 230/345kV Substation which is a component of the Pawnee – Daniels Park 345kV Project.

The GI-2008-33 interconnection request will utilize a Point of Interconnection (POI) through a 345 kV termination on the 345 kV bus at the Pawnee Substation. The 300 MW generation facility will utilize a Customer owned, three mile, 345 kV line on the Customers side of the POI to interconnect at the Pawnee Substation. The Customer will be responsible for construction of the transmission line from the generation facility to the POI. For cost estimating purposes it is assumed this line has already been constructed in this study.

On January 23, 2012, an Interim System Impact Study Report was posted on the PSCo OASIS. The study report summarized the results of the power flow analysis only. The study found that a third Smoky Hill 560 MVA 345/230/13.8 kV transformer would be required as a network upgrade in order to interconnect the proposed generation facility.

On March 21, 2012, a second version of the Interim System Impact Study Report was posted on the PSCo OASIS. This study report included the results of the power flow study, short circuit analysis, cost estimates, and a project schedule. The study report restated the need for a third Smoky Hill 560 MVA 345/230/13.8 kV transformer for network reinforcement; however, it also indicated that the addition of a third 560 MVA 345/230/13.8kV transformer at the Smoky Hill Substation is not feasible. The report continued to state that in order to add additional transformation, a new Harvest Mile 230/345kV Substation would be required. The Harvest Mile 230/345 kV Substation will be an extension of the existing Smoky Hill Substation. It will accommodate the additional transformer and line terminations for present and future needs and will be located approximately one half mile east of the Smoky Hill Substation. In April 2015, the Colorado Public Utilities Commission (CPUC) granted PSCo a Certificate of Public Convenience and Necessity (CPCN) to construct the Pawnee – Daniels Park 345 kV



Transmission Project. The Harvest Mile 230/345kV Substation is a component of that project.

In May of 2015, a Supplemental System Impact Study Report was posted on the PSCo OASIS. This study report included the results of the transient stability analysis. The study report showed that observed generating units were stable (remain in synchronism) and displayed positive damping, and the maximum transient voltage dips and frequency deviations were within criteria. These results indicate that there are no transient stability issues created by the addition of the GI-2008-33 generation facility.

The purpose of Interconnection Facilities Study is to 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 GI-2008-33 large generating facility to PSCo's transmission system at the Pawnee 345 kV Substation.

C. General Interconnection Facilities Description

PSCo's requirements for interconnection can be found in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW – Version 6.0¹, found on the Xcel Energy website. Xcel Energy requires the Interconnection Generation Provider to construct the Interconnection Facilities in compliance with this document. The guidelines describe the technical and protection requirements for connecting new generation to the Xcel Energy Operating Company transmission system and also requires that the Interconnection Generation Provider be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council, Public Utility Commission or their successor organizations.

I. Project Purpose & Scope

Summary

The Customer has proposed a 270 MW gas turbine generating facility to be interconnected at the existing Pawnee 345kV substation yard. The proposed generation step up transformer back feed power date is 12/1/2021.

Attachments:

- System One Line
- General Arrangement

¹ Guidelines can be found at http://www.xcelenergy.com/Colorado/Company/Transmission/Pages/Transmission_Services_Interconnection_Guidelines.aspx



Background

- The second 345kV line between the Pawnee Substation and Missile Site Substation will be terminated and in-service before the commencement of this project.

Notable Items

- The Pawnee 345kV yard will be configured as a four breaker ring bus before this project and will need to be configured as a breaker and a half bus (the planned ultimate design) to accommodate this interconnection.

Future Considerations

The ultimate Pawnee design is unaffected by this project.

Distribution vs. Transmission Asset Ownership and Cost Responsibility

The substation primary function is presently defined as Transmission. This project will not change the primary function of the substation when complete assuming no other changes.

The project cost will be borne solely by Public Service Company of Colorado (PSCo) Transmission. Project costs that affect the whole of the substation are assigned based on the substation's defined primary function (such as grading, fencing, and electrical equipment enclosure) and will be the responsibility of PSCo Transmission since the substation primary function is PSCo Transmission.

Interconnection / Customer Cost Responsibility

Approximately 26.7% of the total project costs will be reimbursable by the customer.

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

The CIP status of this substation was verified with PSCo Real Time Planning and Operations on 4/4/2016.

Facility Ratings and Smart One-Lines

This substation has Bulk Electric System (BES) facilities.

A smart one-line diagram already exists for this substation. The existing smart one-line diagram will be updated to include the changes made by this project.



Facility ratings changes will be managed via the GIST2 system, and will be reviewed and approved per the Procedure for Review and Approval of GIST2-Created Facility Ratings.

III. Right of Way/Permitting

The substation yard will need to be extended and a new fence will be installed to accommodate the line switch. This land is owned by Xcel Energy/PSCo.

IV. Electrical Features

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

Existing equipment is adequately rated and no upgrades will be needed in association with this work.

Fault Current

Location \ Type of Fault	Three Phase (A)	Single-Line-to-Ground (A)
Pawnee 345kV Bus	13,959	14,823

Electrical Removals & Relocations

No removals will be needed for this project.

Electrical Installations (Major Equipment)

Four 345kV, 3000A, 40kA SF6 circuit breakers will be installed. Two circuit breakers are needed for the new interconnection position and two are needed for the conversion from a ring bus to a breaker and a half bus.

Three 345kV metering class CCVTs will be installed. These CCVTs will include an extra winding so voltages can be used for relaying as well as metering.

Three 345kV metering class CTs will be installed.

One 345kV, 3000A motor operated gang switch will be installed. The MOG will be used to isolate the revenue metering equipment.

Two 345kV, 3000A line traps and associated line tuning equipment will be installed. The 345kV PLC scheme operates phase to phase and thus requires two sets of traps and tuners.



Electrical Equipment Enclosure (EEE)

No changes to the EEE will be required. One line panel and four breaker panels will be installed in the EEE for this project.

AC System

The existing AC system consists of two 300kVA station service transformers feeding two main AC panels. A sufficient number of spare breakers are anticipated to be available when this project commences.

DC System

The existing DC system is adequate to accommodate the new relaying and trip/close circuits required for this project.

Grounding

Grounding will be extended to the area of expansion beyond the existing fence.

Lightning Protection

Static lines will be added to dead end structures being installed for lightning protection.

Trenching & Cable

Concrete encased underground duct bank will be installed in the new bay being installed. New control cables will be installed to the new circuit breakers.

V. Civil Features

Grading & Fencing

- New fencing will be installed in the extended portion of the yard.

Storm Water Permit

No storm water permit will be required.

SPCC (Oil Containment)

No oil containment required.

Civil Removals & Relocations

No removals required.



VI. Protection Features

Transmission Line Protection (345kV)

345kV Customer Interconnect Line 7097

- Protection: SEL411L, SEL311C using dual pilot scheme over PLC and Fiber

Transmission Breaker Protection (345kV)

345kV Breakers 7092, 7095, 7096, 7097

- Protection: SEL351S

Transmission Bus Protection (345kV)

345kV North Bus and South Bus

- Protection: GE-B90, SEL487B

VII. Control Features

General

Xcel Energy/PSCo Harmonized Control Standard will be used for this project.

Control Panel Locations

Panel #	Panel Description	Size
TBD	Line 7097 Panel (for interconnection)	28"
TBD	Breaker 7092 Panel	28"
TBD	Breaker 7095 Panel	28"
TBD	Breaker 7096 Panel	28"
TBD	Breaker 7097 Panel	28"
TBD	North Bus Panel	28"
TBD	South Bus Panel	28"

- Panel locations and numbers will be determined when the project commences as another project will be designed and completed before that time.

Removals

- No removals of control equipment will be required.



VIII. Communication Features

RTU

- The existing RTU is a D20.
- Sufficient expansion points exist for the proposed project.

Fiber Optic Cable

- Single mode fiber will be run underground from the splice box at the transmission dead-end to the existing EEE.
- DTT, DCUB and communication will be sent via the fiber optic cable.
- An FDU will be installed inside the EEE.

Removals

No removals of communication equipment will be required.

IX. Project Operating Concerns and Outages

Outages/Temporary Configurations

Brief outages on Auto 2 and Line 7095 Missile Site will be required to open switches that facilitate the installation of new circuit breakers.

X. Material Staging Plan

Major material will be staged at the substation as there is adequate storage space in the yard.

Stock materials will be ordered and staged through the PSCo Sourcing and Material Coordinator.

XI. Related Projects

Customer funded and PSCo Transmission funded work orders will be opened for this project.

XII. Estimate Discussion

The standard contingency factors for estimates are as follows:

- Scoping Est. Contingency Factors: Material: 10%; Labor and Equipment: 10%
- The estimate for this project utilizes the standard contingency levels.



XIII. Risk Check List

Risk factors identified at the time the Design Guide Package was prepared are indicated below. Explanations indicate the action taken, if any, in the estimate as a result, such as additional contingencies or multipliers that were applied.

- Survey information is not available. Explain:
- Soil boring results are not available. Explain:
- Unusual soils or environmental conditions exist. Explain:
- Key materials or items need decisions or approvals. Explain:
- Potential permitting delays or unusual requirements exist. Explain:
- There are difficult or seasonal outage requirements. Explain:
- There are conflicting outage requirements. Explain:
- There are risks due to who will construct the project and their availability.
Explain:
- Unusual construction techniques will be required. Explain:
- There are risks associated with plans to reuse existing material. Explain:

- There are potential alternatives still under consideration. Explain:
- Material prices are likely to change or volatile. Explain:
- Material lead times are likely to be longer than estimated. Explain:
- Labor prices are likely to change. Explain:
- There are existing erosion problems. Explain:
- The existing oil containment may not be adequate. Explain:
- The existing lightning protection may not be adequate. Explain:
- The existing bus and equipment ampacity may not be adequate. Explain:

- The existing drawings are incomplete and inaccurate. Explain:

Notes and Comments:



D. Costs Estimates and Assumptions

The cost responsibilities associated with the facilities described in the following estimates shall be handled per current FERC guidelines. The estimated engineering, procurement & construction schedule can be found in Table 1 below.

Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Public Service Company of Colorado (PSCo) / Xcel Energy (Xcel) Engineering. The cost estimates are in 2016 dollars with escalation and contingency factors included. AFUDC is not included. Estimates are developed assuming typical construction costs for previous completed projects. These estimates include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement, construction, testing and commissioning of these new substation and transmission line facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades for is \$5,730,000. Figure 1 above represents a conceptual one-line of the proposed interconnection into the 345 kV bus at the Pawnee Transmission Substation. These estimates do not include costs 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 generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed and refined design.



Table 1: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Pawnee 345kV Transmission Substation	Interconnect Customer to tap at the Pawnee Transmission Substation (into the 345kV bus). The new equipment includes: <ul style="list-style-type: none"> • One 345kV gang switch • Three 345kV arresters • One set (of three) high side metering units • Power Line Carrier System • Station controls • Associated bus, wiring and equipment • Associated site development, grounding, foundations and structures • Associated transmission line communications, relaying and testing 	\$1.500
	Transmission line relocation and tap into substation. Structures, conductor, insulators, hardware and labor.	\$0.100
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction.	\$0.020
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$1.620
Time Frame	Site, design, procure and construct	18 Months



Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Pawnee 345kV Transmission Substation	Interconnect Customer to tap at the Pawnee Transmission Substation (into the 345kV bus). The new equipment includes: Not applicable. See assumptions below.	
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	
Time Frame	Site, design, procure and construct	

Table 3: PSCo Owned; PSCo Funded Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
PSCo's Pawnee 345kV Transmission Substation	Build out the Pawnee 345kV Transmission Substation configuration from a 4-breaker ring bus to a breaker and a half scheme. The new equipment includes: <ul style="list-style-type: none"> • Four 345kV breakers • Seven 345kV gang switches • Three 345kV arresters • Instrument transformers • Station controls • Associated bus, wiring and equipment • Associated site development, grounding, foundations and structures • Associated transmission line communications, relaying and testing 	\$4.110
	Total Cost Estimate for PSCo Network Upgrades for Delivery Facilities	\$4.110
Time Frame	Site, design, procure and construct	18 months

Cost Estimate Assumptions

- Appropriation level project cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2016 dollars (appropriate contingency and escalation included).
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.

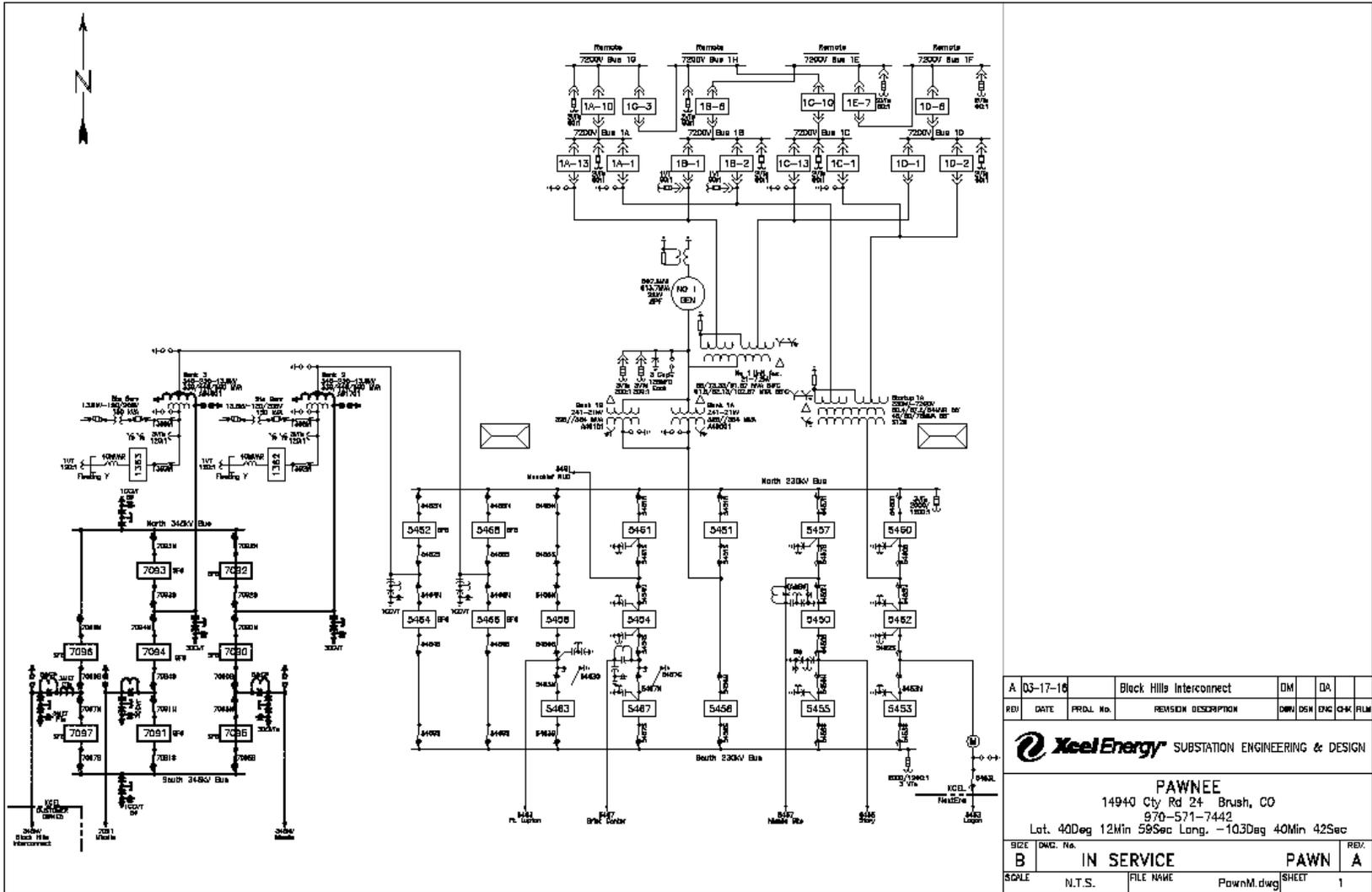


- The Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load (distribution) facilities and metering required for station service are included in these estimates.
- PSCo (or our Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to site, design, procure and construct the interconnection and network delivery facilities is approximately 18 months after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection and network delivery facilities construction.
- It is assumed no additional PSCo funded interconnection facility costs included as all facilities are required and included in the PSCo funded network upgrades for delivery.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LF/AGC RTU.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- No new substation land will need to be acquired.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.

Appendix

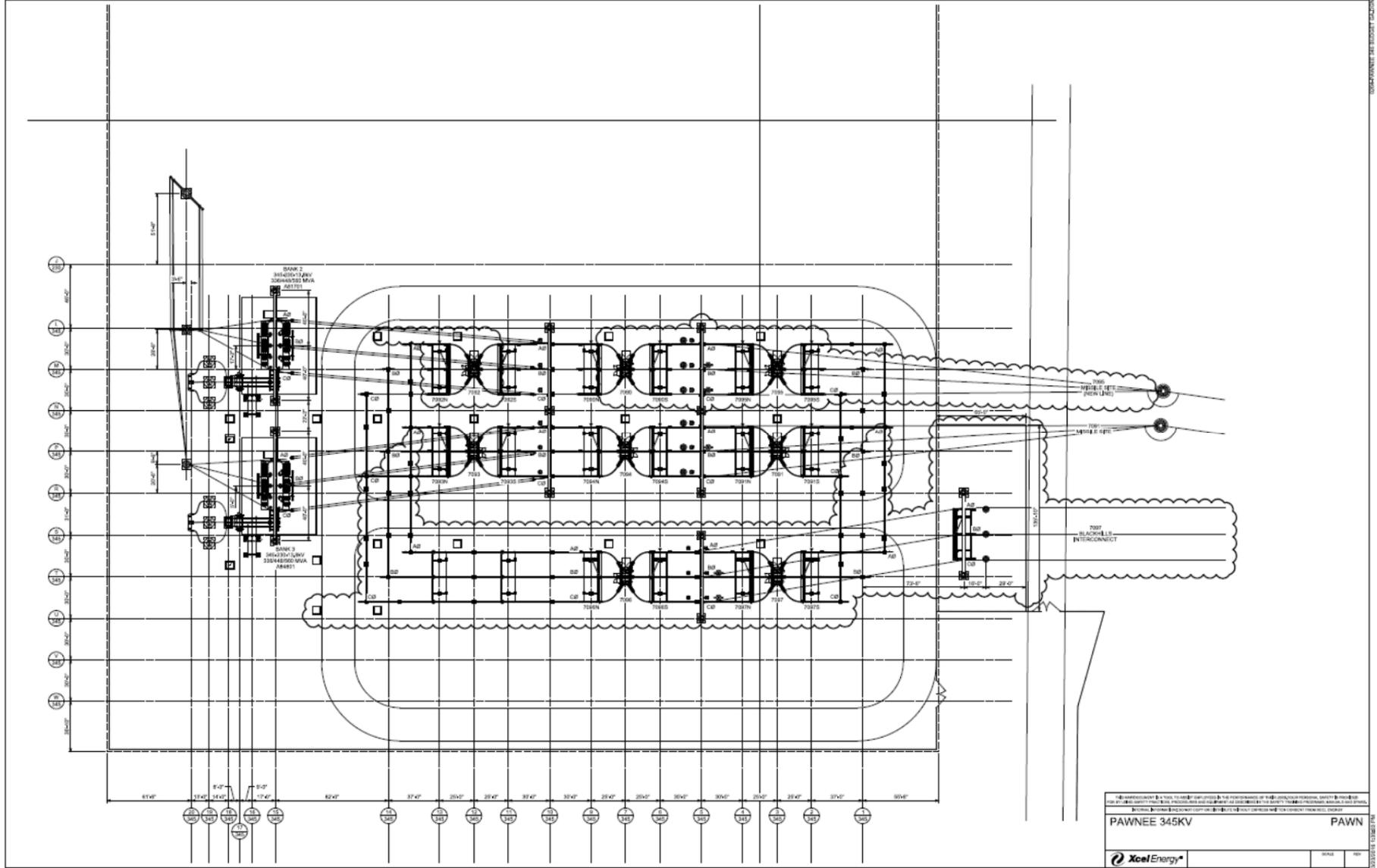


A. Project One-Line of the Pawnee Substation



A 03-17-16		Block Hills Interconnect		DM	DA	
REV	DATE	PROJ. No.	REVISION DESCRIPTION	DMW	DSK	ERIC CHK RLM
SUBSTATION ENGINEERING & DESIGN						
PAWNEE 14940 Cty Rd 24 Brush, CO 970-571-7442 Lat. 40Deg 12Min 58Sec Long. -103Deg 40Min 42Sec						
SIZE	DWG. No.	IN SERVICE			PAWN	REV. A
SCALE	N.T.S.	FILE NAME	PawnM.dwg	SHEET	1	

B. Project General Arrangement at Pawnee Substation



DRAWING NUMBER: 20120001-0001



C. Generic Testing Procedures

TESTING PROCEDURES

*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 PS*

Requirement	Specific Req.	Test	Pass	Conditions	
Power Factor verification at Point of Interconnection (POI)	Prove power factor limits at various levels	Maximum leading and lagging reactive power capability at the POI	Variability recorded and noted	Full lag and lead PF (±.95 or better) with all available turbines on line at 25%, 50%, and higher levels conditional upon wind availability and system conditions.	
	Full compensation for line capacitance at no load	Offset VAR output of connecting line	Mvar <=±10, report reactive shunts in use, or other source(s) of reactive compensation	0 MW output, all turbines off, 2+ hours, not curtailed to achieve zero.	
Voltage Setpoint at POI	Raise/lower setpoint	Series selected at time of test, e.g., "raise 1.0 kV"	Right direction, e.g., raise not lower, as requested, subject to p.f. limits and reactive equipment capability	>60 MW	
		Increment setpoint by predetermined value (minimum of two steps above and below base voltage)			
		Return Voltage back to previous setpoints and base voltage			
Hold voltage setpoint	Setpoint selected at time of test, e.g., 1.01 p.u.	Voltage held within +/- 1% as plant is capable, variability recorded and noted	>60 MW at start of test period (may drop below during test), 6+ hours duration		
Communication	Responsiveness	Series of reasonable requests, e.g., "switch to voltage control mode", "report # turbines online", "report status of shunt caps & reactors, curtail to XX MW.	Professional, prompt (within one minute) response, accurate and complete. 100% compliance for one week.	0-120, dependent on wind availability.	
		Physical link	Documented dedicated circuit, Lookout-wind op center	Documentation submitted prior to operational testing.	no operational requirement
		Site visit to observe wind operations center (most likely RTP or Op engineer or manager)	Written summary of how control center works, and first-hand validation. Visit may be waived or delayed at PSCo discretion.	no operational requirement	
	Provide EMS/SCADA points from plant to Lookout	Verified receipt of points via EMS including MW/MVAR output at POI, turbine statuses, and other relevant data from farm	no operational requirement		



D. Project Schedule

GI-2008-33 Facilities Study Report 270 MW Gas Generation Interconnection @ Pawnee 345kV Substation											
ID	Task Name	Duration	Day 1	1Q	2Q	3Q	4Q	5Q	6Q	ISD	
1	GI-2008-33 Facilities Study Report 270 MW Gas Interconnection	78w	◆	[Blue bar spanning from Day 1 to end of 6Q]							
2	Authorization to Proceed: Execution of Interconnection Agreement	0w	◆								
3	Sighting & Land Rights and Permitting	6w	◆	[Blue bar for 6 weeks]							
4	Substation Design/Transmission Line Design & Engineering	40w	◆	[Blue bar spanning from Day 1 to end of 3Q]							
5	Substation/Transmission Line Material Procurement	36w			◆	[Blue bar spanning from start of 2Q to end of 5Q]					
6	Substation/Transmission line Construction	36w				◆	[Blue bar spanning from start of 3Q to end of 6Q]				
7	Relay, Protection & Control Equipment Testing	10w						◆	[Blue bar for 10 weeks]		
8	Final Commissioning	4w							◆	[Blue bar for 4 weeks]	
9	Project Completion / Backfeed	0w								◆	
10											



E. Customer Questions and Comments

Question / Comments: