



## **Interconnection Feasibility Study Report Request # GI-2013-2**

### **Final Draft Report**

200 MW Wind Generating Facility  
Missile Site 230 kV Station, Colorado

Public Service Company of Colorado  
Transmission Planning  
August 7, 2014

#### **Executive Summary**

Public Service Company of Colorado (PSCo) received an interconnection request on March 5, 2013, for a new 200 MW wind generating facility to be located in Lincoln County, Colorado, which was assigned queue position GI-2013-2. The interconnection request is intended to achieve a 200 MW capacity increase of the existing Cedar Point generating facility. As such, the GI-2013-2 request intends to deliver its output at the existing point of interconnection (POI) – the 230 kV bus within PSCo's Missile Site substation – by using the existing Cedar Point–Missile Site 230kV generation tie-line.

The proposed GI-2013-2 generating facility will consist of 100 Vestas V110 wind turbine generators (WTG). Each WTG is rated 2.0 MW and equipped with a 0.69/34.5 kV transformer. The WTG's will be grouped together by a 34.5 kV collector system that will connect to a 34.5/230kV main step-up transformer which, in turn, will connect to the existing Cedar Point 230kV substation using 10.8 miles of new 230 kV line.

The commercial operation date (COD) requested for the generating facility is June 1, 2015. No back-feed is necessary since the request is an expansion of the existing Cedar Point generating facility. The request is to be studied as both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

The purpose of the Feasibility Study is to determine the network upgrades required, if any, in PSCo's interconnected transmission system for delivery of the 200 MW new generation injected at the Missile Site 230 kV bus to the PSCo network load, that is, for 200 MW NRIS. The Feasibility & System Impact Study was performed using a 2015 heavy summer (2015HS) power flow base case. The study consisted of steady state power flow and short-circuit analyses for the Benchmark case (Before GI-2013-2) and the Study case (After GI-2013-2).

The short circuit results did not identify any adverse system impact due to the proposed generator interconnection. However, the power flow analysis results indicate that the existing 345/230 kV transformation capacity at Smoky Hill is a thermal constraint for the additional 200 MW injection during the single contingency outage of any one of the two Smoky Hill kV auto-transformers. Further, the Clark – Jordan 230 kV (underground) line



is also a thermal constraint during several single contingency outages, the worst overload resulting from the single contingency outage of Smoky Hill – Tollgate – Leetsdale 230 kV line.

Potential mitigations to these two thermal constraints would require transmission reinforcements consisting of the addition of a third 345/230 kV, 560 MVA auto-transformer at Smoky Hill and the replacement of the Clark-Jordan 230 kV underground cable – but neither of these are stand-alone planned projects in PSCo's five-year planning horizon. Alternatively, the proposed Pawnee – Daniels Park 345 kV project<sup>^</sup> submitted by PSCo for approval to the Colorado Public Utility Commission (PUC), is effective in mitigating both thermal constraints.

Therefore, GI-2013-2 interconnection request may not achieve 200 MW NRIS until 2019, which is the earliest estimated in-service date (ISD) of the Pawnee – Daniels Park 345 kV project. Prior to the ISD of Pawnee – Daniels Park 345 kV project, GI-2013-2 may be interconnected as ERIS<sup>\*</sup> to deliver its output using the existing firm or non-firm transmission capacity on an “as available” basis.

Cost estimates for the entire Pawnee – Daniels Park 345 kV project are provided in Table 3 – Network Upgrades for Delivery.

Without any transmission upgrades to mitigate the two thermal constraints – that is, by only utilizing the existing transmission capability in PSCo's transmission system – GI-2013-2 may be interconnected as an NRIS/ERIS at partial output of approx. 100 MW by system readjustment involving the re-dispatch of PSCo generation. For example, both thermal constraints are mitigated by dispatching the Arapahoe #5, #6, #7 generating units at 119 MW rated plant output when GI-2013-2 is at 100 MW output.

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<sup>^</sup> More information at: <http://www.sb100transmission.com/projects/pawnee-daniels-park/index.asp>

<sup>\*</sup> Energy Resource Interconnection Service allows Interconnection Customer to connect the Large Generating Facility to the Transmission System and be eligible to deliver the Large Generating Facility's output using the existing firm or non-firm capacity of the Transmission System on an "as available" basis. Energy Resource Interconnection Service does not in and of itself convey any right to deliver electricity to any specific customer or Point of Delivery.

## **Power Flow N-1 Contingency Analysis**

The 2015HS base case was updated to set the TOT-3 major path flow (north-south) at 896 MW and to dispatch the existing and planned wind generation interconnected at Pawnee and Missile Site stations at their maximum expected coincident output (based on 2012-13 winter operating data). The resulting Benchmark case was then used to create the Study case by adding the GI-2013-2 facility at the Missile Site 230kV bus and dispatching its generation at 200 MW rated output. The wind generation dispatch used at Pawnee and Missile Site stations in the two cases is as follows:

- ✓ Peetz Logan (Pawnee 230kV) = 80% of rated capacity = 460 MW
- ✓ Limon I and Limon II (Missile Site 345kV) = 96% of rated capacity = 384 MW
- ✓ Planned Limon III (Missile Site 345kV) = 96% of rated capacity = 192 MW
- ✓ Cedar Point (Missile Site 230kV) = 96% of rated capacity = 240 MW
- ✓ Proposed GI-2013-2 (Missile Site 230kV) = 100% of rated capacity = 200 MW

Based on the results of 2015HS steady-state power flow analyses (see Table A.1), it is determined that injecting 200 MW at Missile Site 230 kV bus results in significant N-1 thermal overloads on the Smoky Hill 345/230 kV auto-transformers and a small overload on the Clark – Jordan 230 kV (underground) line.

The proposed Pawnee – Daniels Park 345 kV project<sup>^</sup> submitted by PSCo for approval to the Colorado Public Utility Commission (PUC), is effective in mitigating both thermal constraints (see Table A.2). Therefore, GI-2013-2 interconnection request may not achieve 200 MW NRIS until 2019, which is the earliest estimated in-service date (ISD) of the Pawnee – Daniels Park 345 kV project. Prior to the ISD of Pawnee – Daniels Park 345 kV project, GI-2013-2 may be interconnected as ERIS<sup>\*</sup> to deliver its output using the existing firm or non-firm transmission capacity on an “as available” basis.

Without any transmission upgrades to mitigate the two thermal constraints – that is, by only utilizing the existing transmission capability in PSCo’s transmission system – GI-2013-2 may be interconnected as an NRIS/ERIS at partial output of (approx.) 100 MW by system readjustment involving the re-dispatch of PSCo generation. For example, both thermal constraints are mitigated by dispatching the Arapahoe (combined cycle) generating units at its 119 MW rated output when GI-2013-2 is at 100 MW output.

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<sup>^</sup> More information at: <http://www.sb100transmission.com/projects/pawnee-daniels-park/index.asp>

<sup>\*</sup> Energy Resource Interconnection Service allows Interconnection Customer to connect the Large Generating Facility to the Transmission System and be eligible to deliver the Large Generating Facility's output using the existing firm or non-firm capacity of the Transmission System on an "as available" basis. Energy Resource Interconnection Service does not in and of itself convey any right to deliver electricity to any specific customer or Point of Delivery.



## Short Circuit Analysis

The short circuit study results show that no circuit breakers in the Missile Site 230kV switchyard will be over-dutied due to the proposed GI-2013-2 wind generation facility.

**Short Circuit Levels at the Missile Site 230 kV POI Before and After GI-2013-2**

System Condition	Three-Phase (3-Ph) Fault Level (Amps)	Single-Line-to-Ground (SLG) Fault Level (Amps)	3 Ph Fault X/R	SLG Fault X/R
Y2014 Before GI-2013-2	14,309	13,122	12.910	11.458
Y2014 After GI-2013-2	15,095	14,059	12.339	10.713

## Costs Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Public Service Company of Colorado (PSCo) Engineering. The cost estimates are in 2014 dollars with escalation and contingency included and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement, construction 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 Interconnection Facilities is **\$1,565,000** and for the Network Upgrades for Delivery is **\$177,800,000**. Figure 1 below represents a conceptual one-line of the proposed expansion/interconnection at the Missile Site Station 230 kV bus. 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.

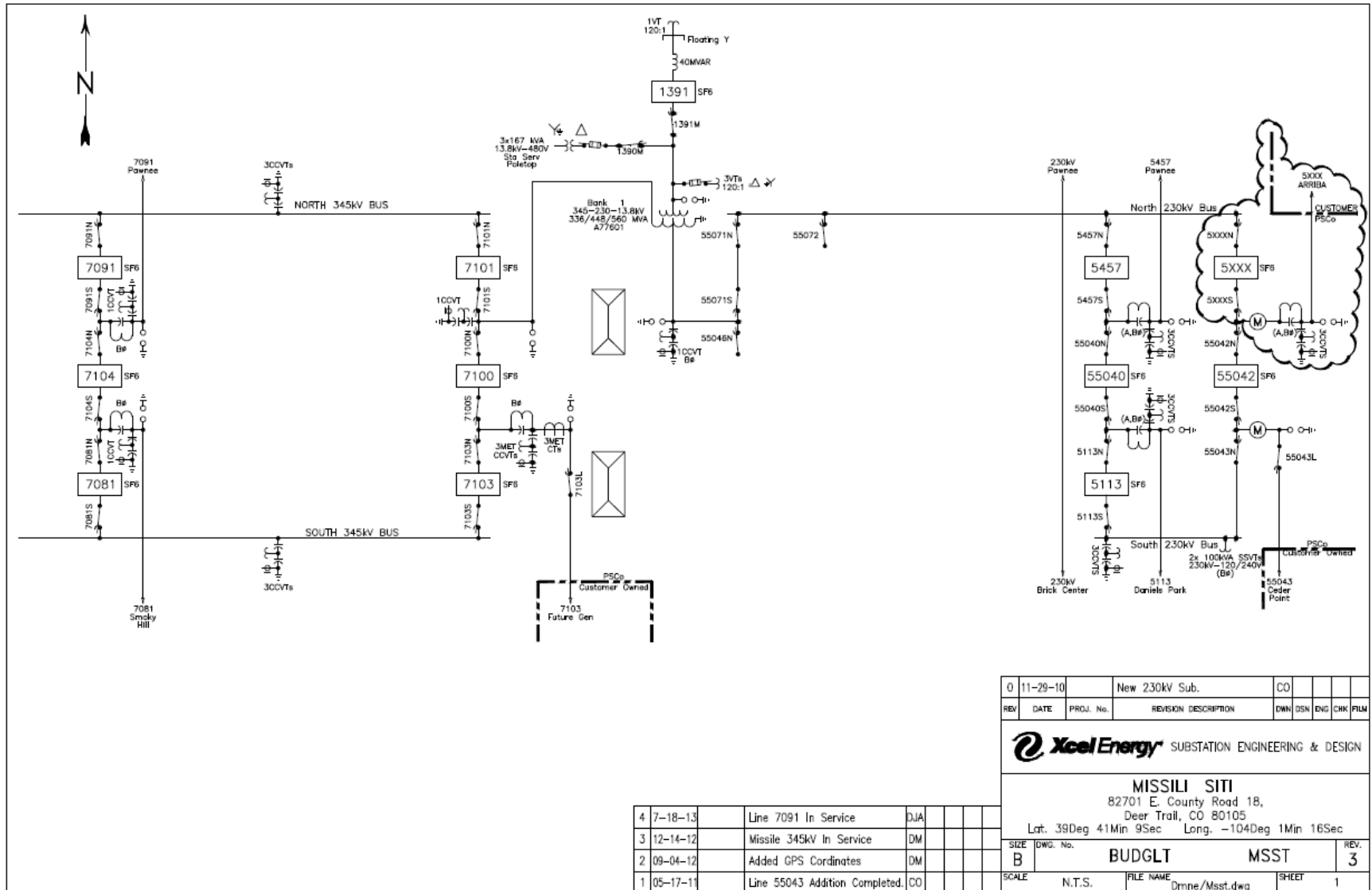


Figure 1 Missile Site Substation Interconnection

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

Element	Description	Cost Est. (Millions)
<b>PSCo's Missile Site 230 kV Transmission Substation</b>	Interconnect Customer to the 230kV bus at the Missile Site Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• One 230kV, 3000 amp gang switch</li> <li>• One 230kV combination CT/PT metering unit</li> <li>• Three 230kV lightning arresters</li> <li>• Primary metering for Load Frequency/Automated Generation Control</li> <li>• Power Quality Metering</li> <li>• Associated electrical equipment, bus, wiring and grounding</li> <li>• Associated foundations and structures</li> <li>• Associated transmission line communications, fiber, relaying and testing</li> </ul>	<b>\$0.760</b>
	Transmission line tap from Customer's last line structure outside of PSCo's yard into new bay position (assumed 300' span, conductor, hardware and labor).	<b>\$0.075</b>
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction.	<b>\$0.010</b>
<b>Customer's 230 kV Substation</b>	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment.	<b>\$0.120</b>
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	<b>\$0.965</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 Months</b>

**Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities**

Element	Description	Cost Estimate (Millions)
<b>PSCo's Missile Site 230kV Transmission Substation</b>	Interconnect Customer to the bus at the Alamosa Terminal Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• One 230kV, 3000 amp circuit breaker</li> <li>• One 230kV, 3000 amp gang switch</li> <li>• Associated station controls, communications, supervisory and SCADA equipment</li> <li>• Associated electrical equipment, bus, wiring and grounding</li> <li>• Associated foundations and structures</li> <li>• Associated equipment and system testing</li> </ul>	<b>\$0.600</b>



	<b>Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities</b>	<b>\$0.600</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 months</b>

**Table 3: PSCo Network Upgrades for Delivery**

<b>Element</b>	<b>Sub Cost (Millions)</b>	<b>Cost Est. (Millions)</b>
<b>Siting and Land Rights Permitting / Acquisition</b>		<b>\$ 6.1</b>
<b>Substation Costs</b>		<b>\$ 52.8</b>
Pawnee Substaton	\$ 5.8	
Smoky Hill Substation	\$ 5.4	
Daniels Park Substation	\$ 6.9	
Harvest Mile Substation	\$27.7	
Missile Site Substaton	\$ 7.0	
<b>Transmission Line Costs</b>		<b>\$118.9</b>
Pawnee – Daniels Park		
<b>Time Frame to site, design, procure and construct</b>		<b>54 months</b>
<b>Total Cost Estimate for PSCo Network Upgrades for Delivery</b>		<b>\$177.8</b>

### **Cost Estimate Assumptions**

- Scoping level project cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2014 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 Solar 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.
- Tri-State and/or Xcel (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 facilities is approximately 18 months after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection facilities construction.
- 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 – Power Flow N-1 Contingency Analysis Results

**Differentially Overloaded Facilities<sup>1</sup> for High Coincidence Wind Generation Dispatch at Pawnee and Missile Site**  
**Pawnee 230kV = 460 MW (80%); Missile Site 345kV = 576 MW (96%); Missile Site 230kV = 235 MW (96%)**  
**200 MW from GI-2013-2 dispatched to Ft St Vrain and RMEC (100 MW each)**

Table A.1 – Without any Network Upgrades

Monitored Facility (Line or Transformer)	Type	Owner	Summer Normal (8-hour) Facility Rating MVA	Branch N-1 Loading Before 200 MW GI		Branch N-1 Loading After 200 MW GI		Differential % Impact	N-1 Contingency Outage
				Flow in MVA	Flow in % of Summer 8-hour Rating	Flow in MVA	Flow in % of Summer 8-hour Rating		
Smoky Hill 230/345 kV # T4	Xfmr	PSCo	560 (644)	617.1	95.7%	679.3	105.3%	9.6%	Smoky Hill 230/345 kV # T5
Smoky Hill 230/345 kV # T5	Xfmr	PSCo	560 (644)	617.1	95.7%	679.3	105.3%	9.6%	Smoky Hill 230/345 kV # T4
Clark – Jordan 230 kV	Line	PSCo	331 (331)	331.1	99.4%	338.3	101.7%	2.3%	Smoky Hill -- Leetsdale 230 kV

Table A.2 – After Addition of Smoky Hill (Harvest Mile) – Daniels Park 345 kV Line  
(comprising the Pawnee – Daniels Park SB-100 Project)

Monitored Facility (Line or Transformer)	Type	Owner	Summer Normal (8-hour) Facility Rating MVA	Branch N-1 Loading After 200 MW GI		% Mitigation	N-1 Contingency Outage
				Flow in MVA	Flow in % of Summer 8-hour Rating		
Smoky Hill 230/345 kV # T4	Xfmr	PSCo	560 (644)	466.1	72.1%	-37.5%	Smoky Hill 230/345 kV # T5
Smoky Hill 230/345 kV # T5	Xfmr	PSCo	560 (644)	466.1	72.1%	-37.5%	Smoky Hill 230/345 kV # T4
Clark – Jordan 230 kV	Line	PSCo	331 (331)	278.7	83.7%	-18.0%	Smoky Hill -- Leetsdale 230 kV

<sup>1</sup> Due to proposed 200 MW generation increase at Missile Site 230 kV Station

## Appendix B – Generation Dispatch in PSCo Control Area (70) in Benchmark and Study Power Flow Cases

ARAP4	0.0
ARAP5&6	0.0
ARAP7	0.0
ALMSACT1	0.0
ALMSACT2	0.0
CABCRKA	0.0
CABCRKB	0.0
CHEROK3	150.0
CHEROK4	383.0
COMAN_1	360.0
COMAN_2	365.0
COMAN_3	804.0
FRUITA	0.0
FTLUP1-2	0.0
FTNVL1&2	0.0
FTNVL3&4	0.0
FTNVL5&6	0.0
MANCHEF1	0.0
MANCHEF2	0.0
PAWNEE	536.0
PLNENDG1	48.0
PLNENDG3	50.4
PLNENDG4	50.4
PLNENDG2	48.0
RMEC1	147.0
RMEC2	147.0
RMEC3	292.0
SPNDLE1	0.0
SPNDLE2	0.0
SPRUCE1	0.0
SPRUCE2	0.0
ST.VRAIN (Slack Gen)	308.8
ST.VR_2	127.0
ST.VR_3	132.0
ST.VR_4	132.0
ST.VR_5	150.0
ST.VR_6	0.0
VALMONT	0.0
VALMONT6	0.0
VALMNT7	0.0
VALMNT8	0.0
LAMAR_DC	0.0

BAC_MSA GEN1	90.0
BAC_MSA GEN2	90.0
BAC_MSA GEN3	100.0
BAC_MSA GEN4	100.0
BAC_MSA GEN5	90.0
BRTNNUG1	0.0
BRTNNUG2	0.0
QF_TC-T4	66.0
QF_TC-T3	84.0
QF_TI-T1	66.0
QF_TI-T2	51.0
QF_BCP2T	66.0
QF_B4-4T	0.0
QF_B4D4T	0.0
QF_CPP1T	0.0
QF_CPP3T	0.0
RAWHIDE	300.0
RAWHIDEA	0.0
RAWHIDEB	47.0
RAWHIDEC	47.0
RAWHIDED	0.0
RAWHIDEF	126.5

**Wind Generation**

PEETZ LOGAN	460.0
CEDAR CREEK I	270.0
CEDAR CREEK II	225.0
LIMON-I	196.0
LIMON-II	196.0
LIMON-III	196.0
CEDAR POINT	240.0
COGREEN-TWINBUTTE	50.0
SPRNGCAN	48.0
RDGCREST	24.0
PONNEQUI	0.0

**Solar PV Generation**

GSANDHL_PV (Mosca)	10.9
IBEDROL_PV (SLV)	20.4
COGENTIX_PV (BlancaPk)	20.4

**Study Case Dispatch Changes**

GI-2013-2	200.0
RMEC3	192.0
ST.VR_5	50.0