Interconnection System Impact Study Report
Request # GI-2014-5

50 MW Solar Photovoltaic Generating Facility
Missile Site 230 kV Substation, Colorado

Public Service Company of Colorado
Transmission Planning
September 27, 2017

Executive Summary

Public Service Company of Colorado (PSCo) received an Interconnection Request (IR) on May 13, 2014 which was assigned GI-2014-5 queue position. GI-2014-5 is a solar photovoltaic generating facility rated at 50 MW gross electrical output that will be located in Arapahoe County Colorado. The point of interconnection (POI) for GI-2014-5 is the 230 kV bus within the Missile Site Substation, which is the point at which power from the wind generating facility is delivered to the PSCo transmission system.

The proposed 50 MW generating facility is expected to consist of approximately 60 SMA inverters rated at 0.853 MVA each. Preliminary information on the generating facility's layout suggests that the inverters will be grouped together into a 34.5 kV collector system, and the 34.5 kV collector system will connect to a 34.5/230 kV 55 MVA main step-up transformer. The generating facility will connect to the POI via an approximately 0.5 mile 230 kV line.

The Commercial Operation Date (COD) originally requested for the generating facility in the IR was October 31, 2018. PSCo completed a System Impact Study Report for GI-2014-5 on December 18, 2014 and a Large Generator Interconnection Agreement (LGIA) was executed on March 6, 2016. The LGIA was subsequently placed into suspension by the customer. In April of 2017 the customer sent PSCo a request to take the LGIA out of suspension and concurrently requested a new COD of December 1, 2018 for the generating facility and a corresponding new back-feed date (for site energization) of June 1, 2018.

As explained in detail below, PSCo determined that an updated System Impact Study would be required for the new COD due to substantial changes in planned generation and transmission facilities in the vicinity of the POI compared to what was originally studied. A new System Impact Study Agreement was executed on June 1, 2017.

In October 2016 PSCo received approval from the Colorado Public Utilities Commission (PUC) to build, own, and operate the Rush Creek Wind Project[1] with 600 MW rated

[1] Proceeding No. 16A-0117E

output whose POI is the 345kV bus within Missile Site Substation. The Rush Creek Wind Project was not included in the initial System Impact Study for GI-2014-5 since its interconnection request (GI-2016-3) was received after the study completion. Since the POIs for both GI-2014-5 and the Rush Creek Wind Project are within the same substation (i.e. Missile Site), their electrical proximity triggered the need for a new (revised) System Impact Study by assuming both generating facilities are in-service and dispatched appropriately.

Figure 1 below is a conceptual one-line diagram of the GI-2014-5 POI and the surrounding transmission system after the Rush Creek Wind Project as well as its network upgrades are in-service.

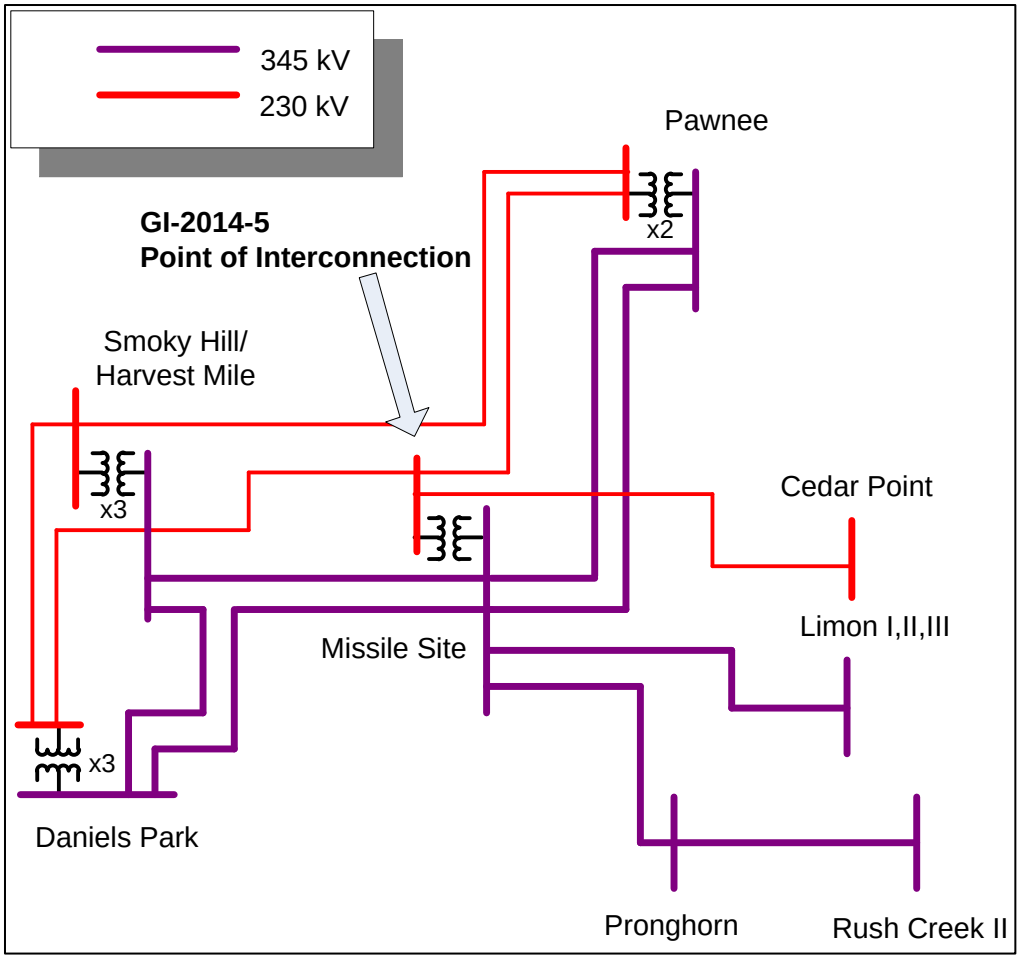


Figure 1: Conceptual one-line of the POI and surrounding Transmission System

As per the IR, GI-2014-5 is studied for both Network Resource Interconnection Service (NRIS)[2] and Energy Resource Interconnection Service (ERIS). The 50 MW electrical

[2] Network Resource Interconnection Service allows Interconnection Customer 's Large Generating Facility to be designated as a Network Resource, up to the Large Generating Facility's full output, on the same basis as existing

output of GI-2014-5 is studied as a stand-alone project. That is, the study did not include any prior-queued IR's existing in PSCo's or any affected party's Generation Interconnection queue except those IR's which are:

a) considered to be PSCo planned resources in recognition of their signed Power Purchase Agreements, or
b) assumed in-service as per the agreed-upon study assumptions with the Interconnection Customer.

Accordingly, this System Impact Study determined the steady state and dynamic system impacts of the injection at the Missile Site 230 kV POI resulting from the proposed 50 MW output of GI-2014-5 in addition to the 600 MW output of the planned Rush Creek wind generation project (GI-2016-3) and the concurrent outputs of the existing Limon and Cedar Point wind generation facilities. Further, this study also identifies the transmission improvements (i.e. Network Upgrades) needed to enable delivery of the proposed 50 MW electrical output of GI-2014-5 to PSCo network loads – that is, for GI-2014-5 to qualify for NRIS.

The System Impact Study consisted of steady state (power flow), short-circuit and transient stability analyses. The power flow analyses were performed using 2021 heavy summer (2021HS) base case. Two power flow models were created from the 2021HS case – a Benchmark Case which models the planned transmission system topology before the proposed GI-2014-5 interconnection (i.e. Before GI-2014-5 case) and a Study Case that includes the 50 MW generation under study (i.e. After GI-2014-5 case). Since the Pawnee – Daniels Park (P-DP) 345 kV project[3] was identified as the Network Upgrade needed to deliver the 600 MW output of the planned Rush Creek wind generation project (GI-2016-3), the P-DP project was included in the Benchmark Case for GI-2014-5. The project was included even though the project in-service date is one year later than the requested in-service date for GI-2014-5. It is apparent from previous studies that GI-2014-5 would not be able to achieve 50 MW NRIS until at a minimum the Pawnee-Daniels Park project is in-service.

Power flow analysis results provided in Table A.1 in the Appendix show that the additional 50 MW injection into Missile Site Substation has no significant differential impact on the transmission system and, therefore, assuming the Pawnee – Daniels Park 345 kV project is in-service, no network upgrades are required. The Pawnee – Daniels Park 345 kV project is planned to be in-service in October of 2019.

The short circuit analysis results based on the 2019 transmission topology did not identify the need for any network upgrades for the proposed GI-2014-5 interconnection.

Network Resources interconnected to Transmission Provider's Transmission System, and to be studied as a Network Resource on the assumption that such a designation will occur. (*section 3.2.2 of Attachment N in Xcel Energy OATT*)

[3] A PSCo planned transmission project for which the Colorado Public Utility Commission (CPUC) has approved a Certificate of Public Convenience and Necessity (CPCN) and has a target in-service date of October 31, 2019. More information at: http://www.transmission.xcelenergy.com/Projects/Colorado

The transient stability analysis was performed using a 2021 heavy summer (2020HS) case and did not identify any unacceptable/degraded stability performance due to the proposed GI-2014-5 interconnection. Both angular stability as well as LVRT (Low Voltage Ride-Through) performance was acceptable for all normally cleared and delayed cleared fault disturbances at the Missile Site 230 kV bus. Therefore, no additional network upgrades are required based on the transient stability analysis.

Based on the power flow, short-circuit and transient stability analysis results, no network upgrades are required for the proposed GI-2014-5 interconnection to achieve 50 MW NRIS provided the Pawnee – Daniels Park 345 kV project is in-service.

Therefore, for GI-2014-5 interconnection:

NRIS (before Pawnee-Daniels Park project is in-service) = 0 MW
NRIS (after Pawnee-Daniels Park project is in-service) = 50 MW
ERIS = 0 to 50 MW on “as-available” basis

As shown in **Tables 1–3**, (see pages 12-13) the cost for the Interconnection Facilities and the Network Upgrades for Delivery is **$1.786 million** and includes:

- $0.997 million for PSCo Transmission Provider Owned; Interconnection Customer Funded Transmission Provider Interconnection Facilities
- $0.789 million for PSCo Transmission Provider Owned; PSCo Transmission Provider Funded Interconnection Network Facilities
- $0.000 million for PSCo Transmission Provider Owned; PSCo Transmission Provider Funded Network Upgrades for Delivery.

It is estimated that this work can be completed in approximately 18 months, following receipt of authorization to proceed.

Based on the 18 months construction time-frame noted above, as well as the planned Pawnee – Daniels Park 345kV project identified as the pre-requisite network upgrade for delivery of GI-2014-5 output, **the proposed December 2018 COD is not viable**. Note that the analyses performed in this System Impact Study inherently assume that COD earlier than June 2019 may not be achievable.

No adverse impacts on the transmission systems of other entities are identified in the System Impact Study. Therefore there are no Affected Systems for GI-2014-5.

Power Flow N-1 Contingency Analysis

The 2021HS base case was updated to dispatch the existing and planned generation within the Pawnee and Missile Site "generation pockets" (i.e. aggregate of generation in the local area) at their respective highest coincident output deemed appropriate for the planning of adequate transmission capacity. This was done in accordance with the generation dispatch assumptions practiced by PSCo Transmission Planning function to study the feasibility and system impact of generator interconnection requests as a Transmission Provider. Accordingly, the existing, planned and proposed generating plants at Pawnee and Missile Site stations were dispatched as noted below.

Pawnee local "generation pocket"

- ✓ Pawnee Fossil Fuel generation = 100% of rated capacity = 536 MW
- ✓ Manchief Gas generation = 90% of rated capacity = 252 MW
- ✓ Peetz Logan Wind generation = 40% of rated capacity = 230 MW

Aggregate Generation Dispatched at Pawnee in all Cases = 1018 MW

Missile Site local "generation pocket"

- ✓ Cedar Point (Missile Site 230kV) = 80% of rated capacity = 200 MW
- ✓ Limon I, II, III (Missile Site 345kV) = 80% of rated capacity = 480 MW
- ✓ Rush Creek (Missile Site 345kV) = 80% of rated capacity = 480 MW
- ✓ GI-2014-5 (Missile Site 230kV) = 100% of rated capacity = 50 MW

Aggregate Generation Dispatched at Missile Site in Benchmark Case = 1160 MW

Aggregate Generation Dispatched at Missile Site in Study Case(s) = 1210 MW

The GI-2014-5 *Benchmark Case* was derived from the 2021HS base case by changing the generation dispatch at Pawnee and Missile Site as noted above. The planned Rush Creek wind generating plant (GI-2016-3) was added at the Missile Site 345kV bus and dispatched at 480 MW rated output. Transmission facilities comprising the Pawnee – Daniels Park project modeled in the 2021HS case were retained in the Benchmark Case since they comprise the network upgrades identified for GI-2016-3. The GI-2014-5 *Study Case* was created by adding the proposed GI-2014-5 generating plant in the Benchmark Case and dispatching it at 50 MW rated output.

PSCo adheres to applicable NERC Reliability Standards & WECC Reliability Criteria for Bulk Electric System (BES) acceptable performance, as well as its internal performance criteria for planning studies. For steady state analysis, the performance criteria are as follows:

P0 - System Intact conditions:
Thermal Loading: <=100% Normal facility rating
Voltage range: 0.95 to 1.05 per unit

P1-P2 – Single Contingencies:
Thermal Loading: <=100% Normal facility rating[4]
Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage

P3-P7– Multiple Contingencies:
Thermal Loading: <=100% Emergency facility rating
Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage

As is evident from the power flow analysis results performed for this study, the additional 50 MW generation injection into Missile Site Substation causes no significant differential impact (greater than 2 percent power flow change) on the transmission system nor exceedance of applicable facility ratings. Therefore, no power flow network upgrade is required for the proposed GI-2014-5 interconnection to achieve 50 MW NRIS.

[4] PSCo allows use of eight-hour facility rating for transformers for which it is available.

Voltage Regulation and Reactive Power Capability

Interconnection Customers are required to interconnect its Large Generating Facility with Public Service of Colorado's (PSCo) Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW.* The guidelines are available at:

http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf.

Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within Northeast Colorado - Region 7 defined in the *RMAVCG*; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.
- Xcel Energy's OATT (Attachment N effective 10/14/2016) requires all non-synchronous Generator Interconnection (GI) Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator as long as the Generating Facility does not have to operate outside its 0.95 lag – 0.95 lead dynamic power factor range capability.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (34.5 kV or 230 kV bus) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/– 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the high side of the generator substation. Further, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure zero reactive power flow under no load conditions (i.e. all or most generators off-line).
- The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).
- The Interconnection Customer has the responsibility to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in NERC Reliability Standard PRC-024-2.

Transient Stability Analysis

The transient stability analysis was performed using a benchmark and study case derived from the WECC 2021 Heavy Summer (2021HS) dynamics case created for use with the General Electric PSLF software program. The benchmark case was updated to match the generation dispatch in the Pawnee and Missile Site area similar to the power flow cases discussed previously. The study case was developed by adding the GI-2016-3 and GI-2014-5 generating facilities and the transmission facilities comprising the Pawnee – Daniels Park project. The model for the generation facility was included from the solar model supplied by the Interconnection Customer.

The transient stability analysis conducted three-phase and single-line-to-ground faults in the immediate study area as well as in northern Colorado. Eight transient stability disturbances were simulated for the benchmark and/or project cases, including the following:

A. NERC/WECC Category P1 (single contingency) Disturbances
(Three-phase, close-in faults at * with normal clearing of 6 cycles)

1. Missile Site* - Daniels Park 230 kV Line
2. Missile Site* - Pawnee 230 kV Line
3. Missile Site* - Smoky Hill 345 kV Line
4. Missile Site* - Pawnee 345 kV Line
5. Daniels Park* - Greenwood 230 kV Line
6. Pawnee* - Story 230 kV Line

B. NERC/WECC Category P4 (multiple contingency) Disturbances
(Single-line-to-ground, close-in faults at * with delayed clearing of 21 cycles)

7. Missile Site* - Daniels Park 230 kV Line
8. Missile Site* - Pawnee 230 kV Line

The results noted in Appendix B demonstrate that no unacceptable/degraded stability performance occurs due to the proposed GI-2014-5 interconnection. Since none of the normally cleared three-phase fault disturbances at Missile Site resulted in tripping of the solar photovoltaic generators proposed for the GI-2014-5 generating facility, it is concluded that angular stability as well as LVRT (Low Voltage Ride-Through) performance of GI-2014-5 is acceptable. Further, loss of a major transmission path from Craig as well as loss of a significant conventional (synchronous) generator at Pawnee did not demonstrate any angular or voltage stability issues on the transmission system. Select stability plots are provided in Appendix C. A complete set of stability plots are available on request.

Short Circuit Analysis

The short circuit study results show that no circuit breakers in the Missile Site Substation (or in PSCo's transmission system in proximity of the POI) will be over-dutied by interconnecting the proposed GI-2014-5 wind generation facility. The base case scenario before GI-2014-5 included preliminary models for all planned transmission system improvements and planned generating plants projected to be in-service through the end of 2019. Therefore, the base scenario includes the Pawnee – Daniels Park 345 kV Project and the Rush Creek wind generation project.

GI-2014-5 Impact on Short Circuit Levels and Breaker Duty Margins at Missile Site 230 kV POI

System Condition	Three-Phase (3-Ph) Fault Level (Amps)	Single-Line-to-Ground (SLG) Fault Level (Amps)	Thevenin System Equivalent Impedance (R + jX) (Ohms)
Before GI-2014-5 Y2019	15,959	13,293	Z1(pos) = 0.565 + j8.302 Z2(neg) = 0.586 + j8.300 Z0(zero) = 2.154 + j13.184
After GI-2014-5 Y2019	16,209	14,392	Z1(pos) = 0.565 + j8.302 Z2(neg) = 0.586 + j8.300 Z0(zero) = 1.285 + j9.966

Costs Estimates and Assumptions

Indicative level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery were developed by Public Service Company of Colorado (PSCo) / Xcel Energy (Xcel) Engineering. The cost estimates are in 2017 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 is $1.786 million.

Figure 2 below represents a project one-line diagram of the proposed interconnection into the Missile Site POI. 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. Cost estimates and system improvements are subject to change upon a more detailed and refined design, which will occur in the facilities study.

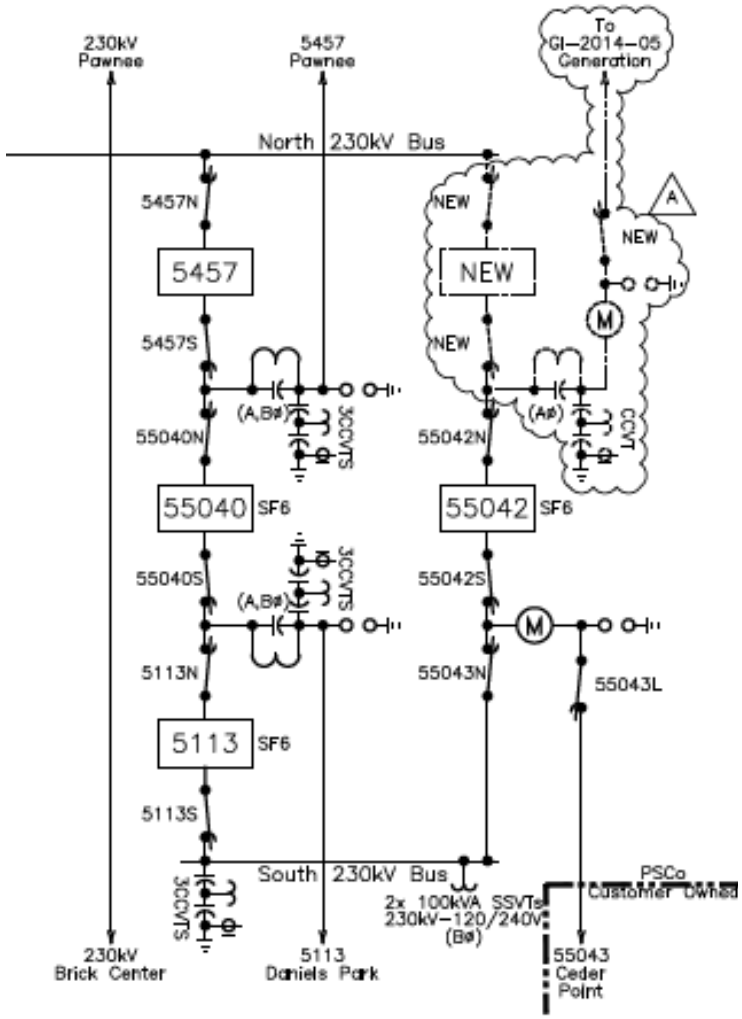


Figure 2: GI-2014-5 Project Oneline diagram at Missile Site 230 kV Substation

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

Element	Description	Cost Est. (Millions)
Missile Site 230kV Transmission Substation	Interconnect Customer to the Missile Site 230kV Transmission Substation (into the 230kV bus). The new equipment includes: • One 230kV gang switch • Three 230kV arresters • One set (of three) 230kV CT/PT metering units • AR15 communications equipment • Associated bus, wiring and equipment • Associated site development, grounding, foundations and structures • Associated transmission line communications, station controls, relaying and testing	**$0.797**
	Transmission line relocation and tap into substation. Structures, conductor, insulators, hardware and labor.	**$0.160**
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction.	**$0.040**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$0.997**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
Missile Site 230kV Transmission Substation	Interconnect Customer to tap at Missile Site 230kV Transmission Substation (into the 230kV bus). The new equipment includes: • One 230kV circuit breaker • Two 230kV gang switches • Associated communications, supervisory and SCADA equipment • Associated line relaying, station controls and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated road and site development, fencing and grounding	**$0.744**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.045**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$0.789**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 3: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	N/A	

Cost Estimate Assumptions

- Scoping level project cost estimates for Interconnection Facilities and Infrastructure Upgrades for Delivery have an assumed +/- 30% accuracy.
- Estimates are in 2017 dollars (appropriate contingency and escalation applied).
- Allowance for Funds Used During Construction (AFUDC) has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Customer 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.
- A CPCN will be required. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection and network delivery facilities (entire Project) is approximately 36 months after authorization to proceed has been obtained.
- 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 LFAGC RTU.
- Customer will string OPGW fiber into substation (Missile Site) as part of the transmission line construction scope.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.

Conclusion

The power flow and transient stability analysis performed for this System Impact Study shows that the additional 50 MW generation injection into Missile Site Substation has no significant impact to the transmission system provided the Pawnee – Daniels Park 345 kV project is in-service.

Therefore, for GI-2014-5 interconnection:

NRIS (before Pawnee-Daniels Park project is in-service) = 0 MW
NRIS (after Pawnee-Daniels Park project is in-service) = 50 MW
ERIS = 0 to 50 MW on “as-available” basis

The estimated total cost for the required upgrades for the interconnection is $1.786 million. Based on the 18 months construction time-frame noted above, as well as the planned Pawnee – Daniels Park 345kV project identified as the pre-requisite network upgrade for delivery of GI-2014-5 output, **the proposed December, 2018 COD is not viable**. Note that the analyses performed in this System Impact Study inherently assume that COD earlier than June, 2019 may not be achievable.

Appendix A – Power Flow N-1 Contingency Analysis Results

High Coincidence Generation Dispatch at Pawnee & Missile Site:

Pawnee 230kV (100% Coal + 90% Gas + 40% Wind) = 1018 MW;

Missile Site 345kV Wind = 480 MW (80%); Missile Site 230kV Wind = 200 MW (80%)

480 MW output from Rush Creek is dispatched to sink at Blue Spruce, Rocky Mountain Energy Center, & Comanche

50 MW output from GI-2014-5 is dispatched to sink at Comanche

Table A.1 – Differential Impact[5] of GI-2014-5 on Facility Loadings
With Pawnee – Daniels Park 345kV Project In-Service

				Branch N-1 Loading Before 50 MW GI		Branch N-1 Loading After 50 MW GI			
Monitored Facility (Line or Transformer)	Type	Owner	Summer Normal (Continuous) Facility Rating in MVA	Flow in MVA	Flow in % of Summer Normal Rating	Flow in MVA	Flow in % of Summer Normal Rating	Differential Impact of GI-2014-5	N-1 Contingency Outage
Greenwood – Monaco 230 kV	Line	PSCo	404	391	96.1%	394	97.0%	0.9%	Smoky Hill -- Leetsdale 230 kV
Leetsdale – Monaco 230 kV	Line	PSCo	396	354	89.2%	357	90.0%	0.8%	Smoky Hill -- Leetsdale 230 kV

[5] **Due to proposed 50 MW generation increase at Missile Site 230 kV Substation**

Appendix B – Transient Stability Analysis Results

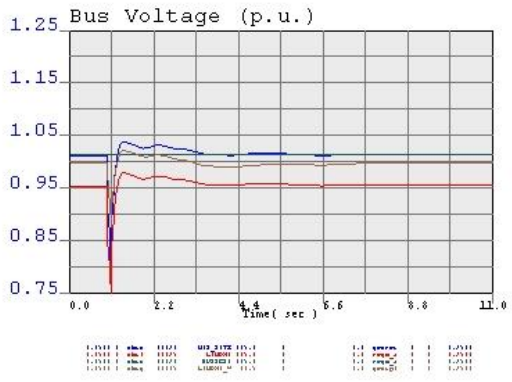
Stability Disturbances							
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Stability Performance	Post-Fault Voltage Recovery	Angular Stability
1	Missile Site 230 kV	3ph	Missile Site – Daniels Park 230 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
2	Missile Site 230 kV	3ph	Missile Site – Pawnee 230 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
3	Missile Site 345 kV	3ph	Missile Site – Smoky Hill 345 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
4	Missile Site 345 kV	3ph	Missile Site – Pawnee 345 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
5	Daniels Park 230 kV	3ph	Daniels Park – Greenwood 345 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
6	Pawnee 230 kV	3ph	Pawnee – Story 230 kV	Primary (6.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
7	Missile Site 230 kV	SLG	Missile Site – Daniels Park 230 kV	Secondary (21.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping
8	Missile Site 230 kV	SLG	Missile Site – Pawnee 230 kV	Secondary (21.0)	Acceptable	Maximum transient voltage dips within WECC criteria	No generator tripped & positive damping

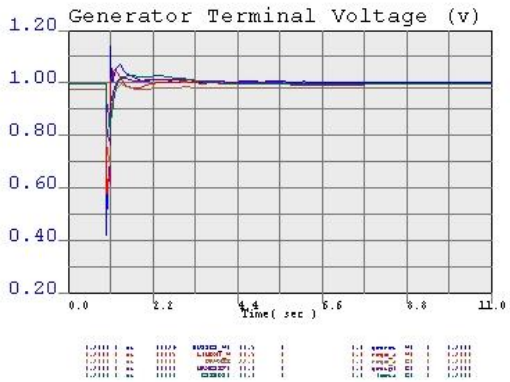
Appendix C – Transient Stability Analysis Plots

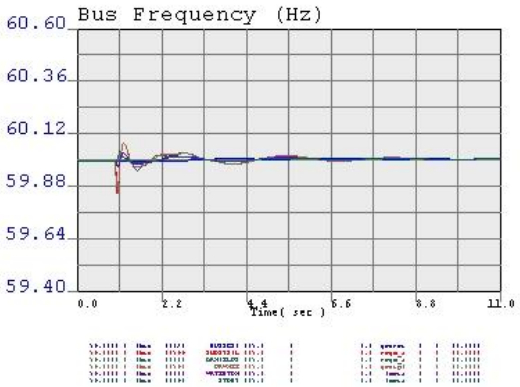
Plots shown below various recordings of bus voltage, bus frequency, generator angle, generator terminal voltage, generator speed, and generator power output for the following outages performed on the study case:

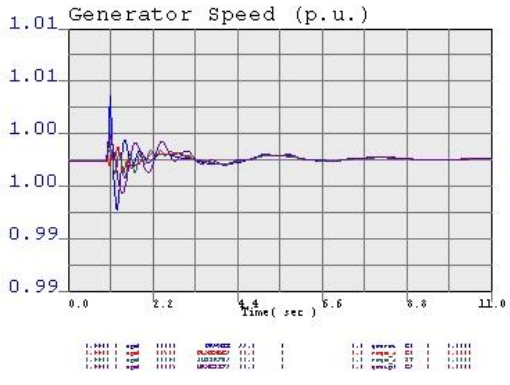
#1 – Missile Site – Daniels Park 230 kV line
#7 – Missile Site – Daniels Park 230 kV line (delayed clearning)
#8 – Missile Site – Pawnee 230 kV line (delayed clearning)

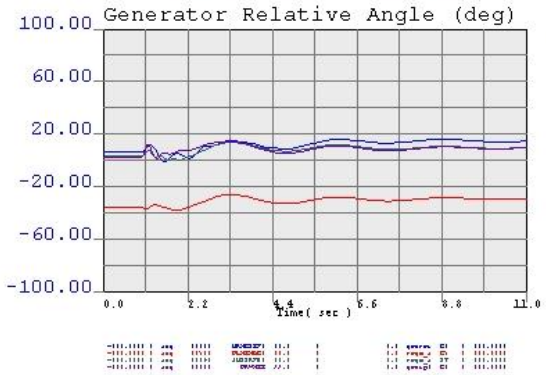
Other plots are available upon request.

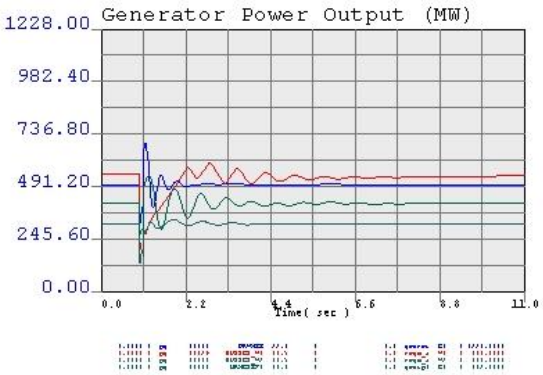












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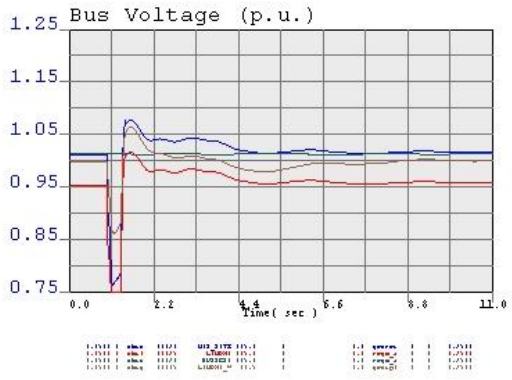
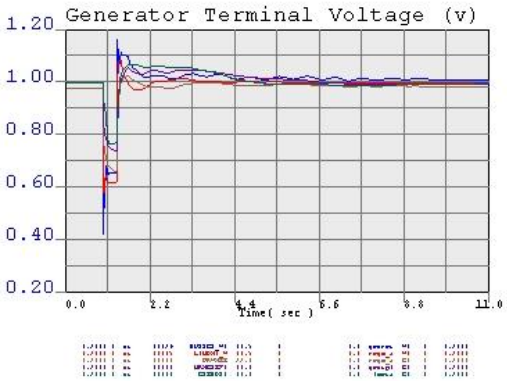
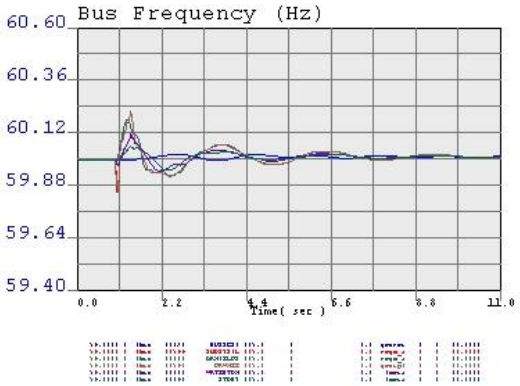
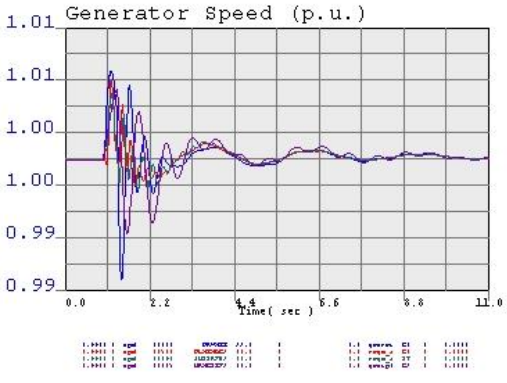
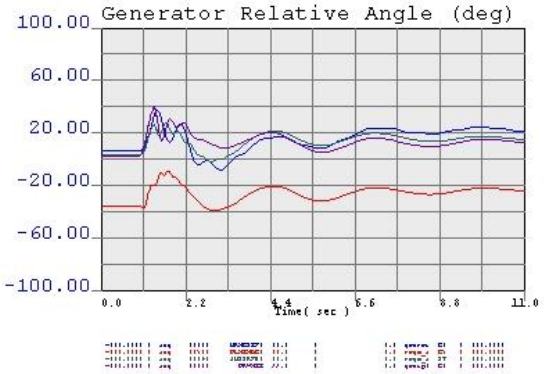
Missile fault, lose Missile Daniels 230kV

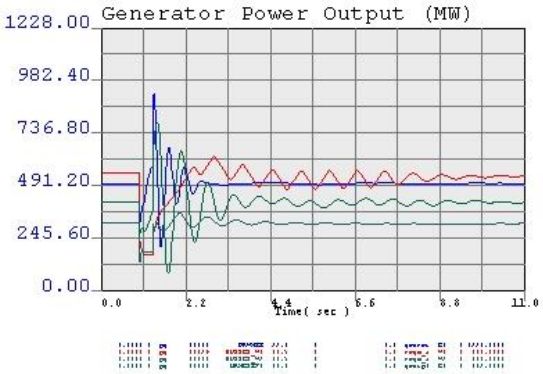




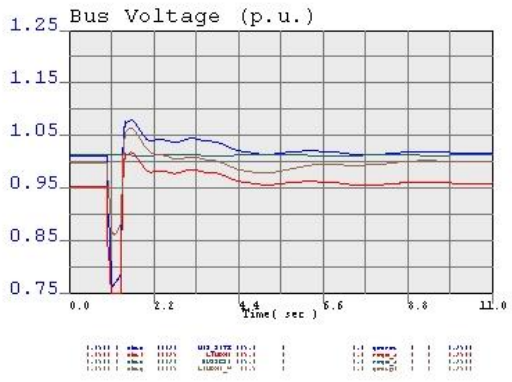


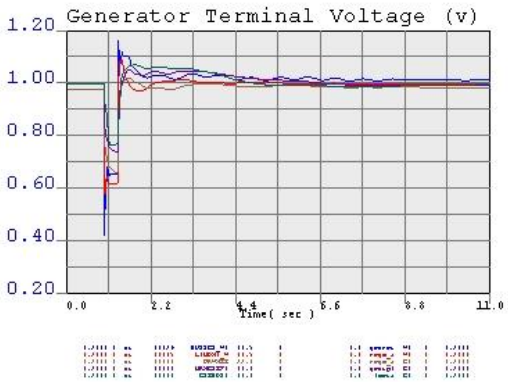


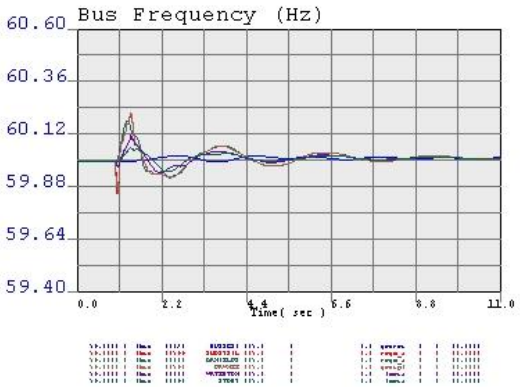


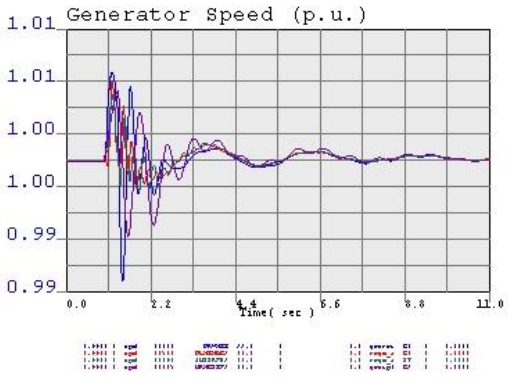


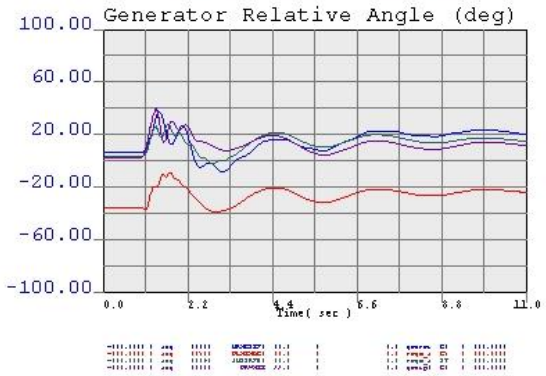
7
Missile fault, lose Missile Daniels 230kV

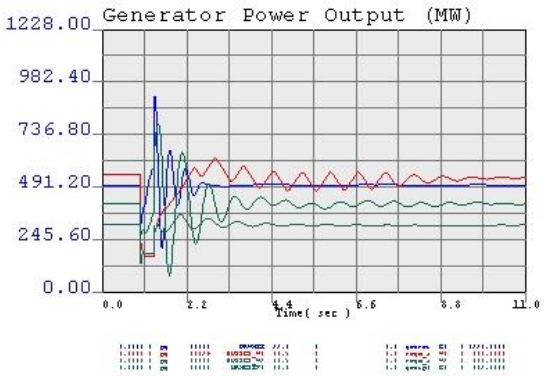












8
Missile fault, lose Missile-Pawnee 230kV