Interconnection Facilities Study Report
GI-2014-4

60 MW Wind Generation Facility Expansion Interconnecting at Spring Canyon in Logan County, Colorado

PSCo Transmission Planning
July 10, 2014

A. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo), designated as GI-2014-4, to specify and estimate the cost of the siting, engineering, equipment procurement and construction needed to interconnect a 60 MW wind generation expansion to the existing 60 MW Spring Canyon Energy wind generation facility in Logan, Colorado. The GI-2014-4 interconnection request is a continuation of the interconnection request identified as GI-2012-3, and was required to clarify that the new large generation facility will be an expansion of the existing 60 MW wind facility and will utilize the same Point of Interconnection (POI) as the existing 60 MW wind facility through the 230 kV termination on the 230 kV bus at the Spring Canyon Substation. The Generation Provider (Customer) has agreed that the results of the Feasibility Study and System Impact Study under GI-2012-3 designation are sufficient for the Interconnection Request GI-2014-4.

The 60 MW wind generation expansion will utilize the Customer's 230 kV line on the Customers side of the POI to interconnect at the POI at Spring Canyon. The Customer will be responsible for construction of the short 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. It has been determined that the Customer requested Commercial Operation Date (COD) of December 31, 2014 is feasible (NOTE: See Appendix Section C).

The GI-2014-4 System Impact Study determined the proposed 60 MW wind generation facility expansion may interconnect as an Energy Resource after the required system upgrades for delivery are completed. The required system upgrades for delivery include adjustments to PSCo's existing bi-directional revenue meter and communications equipment.

Power flow studies have indicated the Sidney 230/115 kV transformer is overloaded by 115.5% when the North Yuma – Spring Canyon 230 kV line is taken out of service and the Alvin – Wauneta 115 kV line is overloaded by 110% when the North Yuma – Wray 230 kV line is taken out of service. The Customer has contacted both PSCo and Tri-State Generation and Transmission (TSGT) to determine an acceptable mitigation of Sidney 230/115 kV transformer overload by curtailing generation output from the wind generation expansion facility, and the Customer has contacted Western Area Power Administration (Western) to determine their schedule for a replacement or uprate of the transmission line.

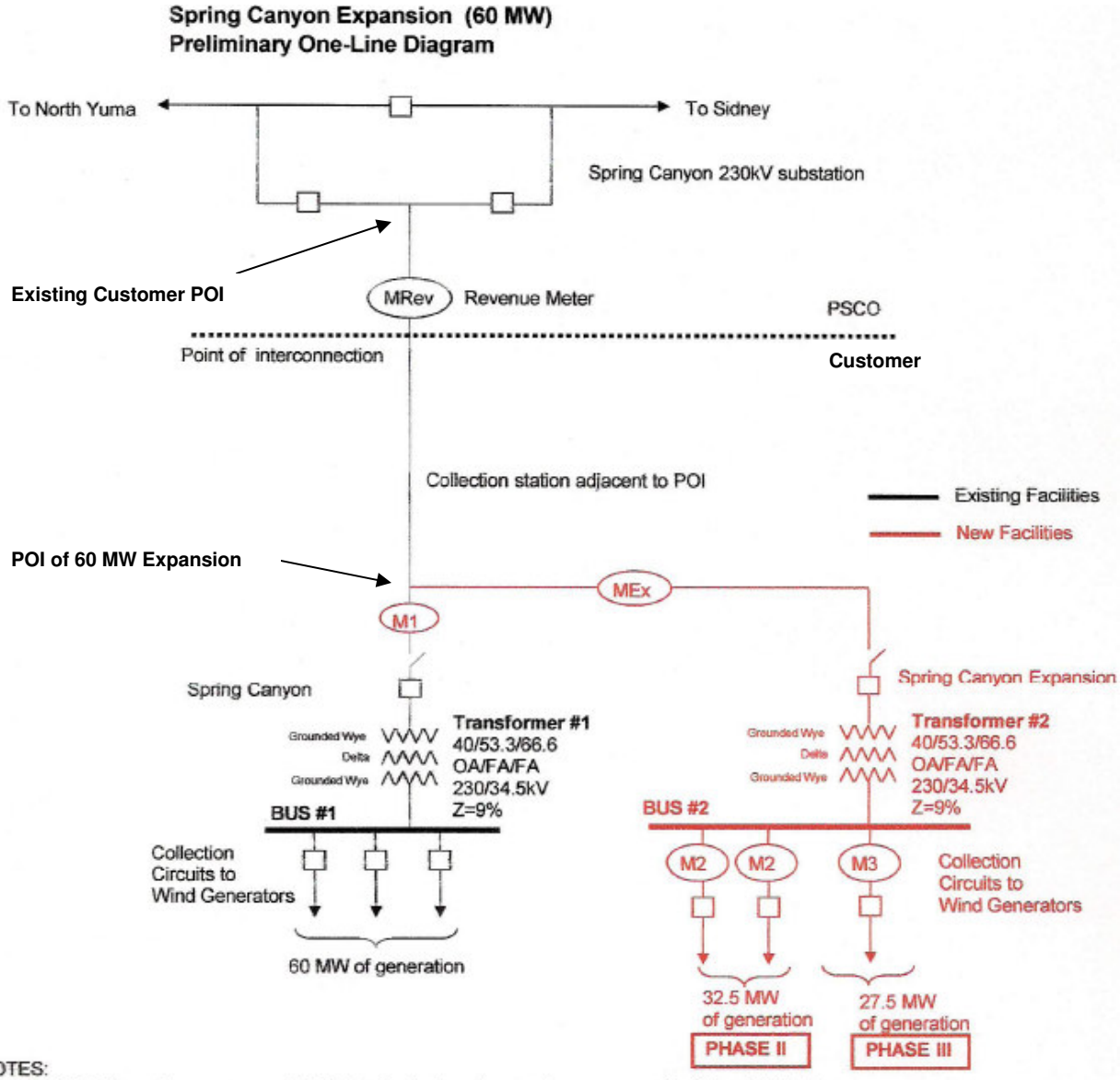
No PSCo Network Upgrades for Delivery are required for this Interconnection.

The total estimated cost of the recommended system upgrades to interconnect the project is approximately **$ 83,000** and includes:

- $0.083 million for PSCo Owned, Customer Funded Interconnection Facilities. This includes 230kV high side and revenue metering checks, current transformer and potential transformer (CT/PT) ratio adjustments, communications, relay setting changes, testing and commissioning.
- $0.00 million for PSCo Owned, PSCo Funded Interconnection Facilities.
- $0.00 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: Diagram of the GI-2014-4 Interconnection at Spring Canyon 230 kV



NOTES:
- M2 and M3 will require revenue quality CTs in feeder breakers and revenue quality PT on 34.5kV bus

BASIC METERING LOGIC:

SC1 = MREv - MEx
SC2 = (M2/(M2+M3)) x MEx
SC3 = (M3/(M2+M3) x MEx

M1 not necessary for calculations, but prudent to have as check to MEx and MRev

B. Introduction

On May 5, 2014, Public Service Company of Colorado (PSCo) and a Generation Provider (Customer) signed an Interconnection Facilities Study request to provide cost estimates, a project schedule and address the impacts of interconnecting a 60 MW wind generation expansion to the existing 60 MW Spring Canyon Energy wind generation facility, as identified in the System Impact Study, at PSCo's 230 kV Spring Canyon Substation. The Customer's project facility would consist of thirty-three (33) GE 1.7-100 1.79 MW wind turbines and would be located immediately adjacent to the existing Spring Canyon Energy Facility, near Peetz, Colorado, in Logan County. Generation from the expansion was modeled as supplying the PSCo Balancing Authority (BA) and was delivered to PSCo native load customers. Platte River Power Authority (PRPA) has indicated they have executed a Power Purchase Agreement (PPA) with the Customer for 32.5 MW of the 60 MW expansion; therefore, 32.5 MW will be provided to PRPA through Western Area Power Administration (Western) and will be dynamically metered into the PSCo BA. The remaining 27.5 MW remains out for bid. The Customer requested a primary Point of Interconnection (POI) on the 230 kV bus at the existing Spring Canyon Substation. No alternative POI was requested.

The Spring Canyon Substation consists of a 230 kV yard with three (3) power circuit breakers in a ring configuration. The new 60 MW wind generation expansion will utilize the Customers existing Point of Interconnection (POI) and termination on the 230 kV bus at the Spring Canyon Substation. No new power circuit breakers will be required for interconnection.

The Feasibility Study was completed on June 12, 2013, subsequent to which the proposed commercial operation date and back-feed (for site energization) were postponed until December 31, 2014 and June 30, 2014 respectively. Power flow analysis indicated that the Sidney 230/115 kV transformer overloaded by 115.5% when the North Yuma – Spring Canyon 230 kV line was taken out of service and the Alvin – Wauneta 115 kV line overloaded by 110% when the North Yuma – Wray 230 kV line was taken out of service. Tri-State Generation and Transmission (TSGT) and Western were notified of these impacts as affected parties. Discussions were held between the Customer, PSCo and the affected parties. The Customer, TSGT and PSCo have developed an acceptable generation curtailment scheme to mitigate the Sidney 230/115 kV transformer overload, and the Customer and Western have developed a schedule for the replacement or upgrade of the Alvin – Wauneta 115 kV line.

The System Impact Study was completed on December 3, 2013 and found no criteria violations in the pre-project or post-project analysis for any of the studied outages.

Subsequent to the System Impact Study, conversations between PSCo and the Customer led to a request that the Customer submit a new interconnection request, GI-2014-4, indicating the new large generation facility will be an expansion of the existing 60 MW Spring Canyon Energy facility, utilizing the Customers existing POI. During the scoping meeting held on April 24, 2014, the Customer agreed to use and accept the

results of the Feasibility and System Impact Studies developed under GI-2012-3 in order to proceed with this Facilities Study.

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 6.0[1], 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

The Customer will be increasing generation on the existing 5923 line. Transmission engineering will not be installing any additional meters. The existing feed to the Customer will be modified to handle the additional generation. Xcel Energy scope of work will involve revising the relay settings for the 230kV 5923 line in order to accommodate an increase in power from the connected Customer's wind farm. There will also be hard wire contacts that Xcel Energy will provide Spring Canyon II Substation. Spring Canyon II will also provide similar contacts for Xcel Energy. The only metering data Xcel Energy will be responsible for modifying will be the one located in Xcel Energy switchyard at the point of interconnection. All material needed inside the Xcel Energy substation is included in this estimate. Xcel Energy is assuming the existing conduit is sufficient.

Background

The Customer will be increasing their power generation on the 230kV 5923 line by 60 MW. This is being accomplished by the Customer adding thirty three (33) GE 1.7-100, 1.79 MW wind turbines. The only work that is required by Xcel Energy is to modify minor wiring changes, relay setting modifications and changing metering unit taps. Xcel Energy would like to review the settings at Spring Canyon Substation.

Distribution and/or Transmission Asset Ownership and Cost Responsibility

The project cost will be funded by PSCo.

Interconnection / Customer Cost Responsibility

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

The project cost will be responsible of the Customer.

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

The CIP status of this substation has not been verified at this time. This verification will take place during the appropriation estimate phase of the project.

Facility Ratings and One-Lines

A one-line diagram already exists for the Spring Canyon substation. This one-line has dual differentials wrapping Xcel Energy's two circuit breakers 5922 and 5920, Spring Canyon I and Spring Canyon II. This is a total of 4 current transformer inputs in both the primary and secondary relaying. The existing one-line will be updated to include the changes made by this project.

III. Right of Way/Permitting

Right of way permitting will not be required as part of this project.

IV. Electrical Features

Fault Current

A fault study was conducted on the future system with the proposed wind generation facility interconnected at the Spring Canyon 230kV bus. The study found that for the system, the three-phase fault and the single-line-to-ground fault currents are expected to be 4,134.5 amps and 4,127.7 amps, respectively, at the proposed Spring Canyon 230 kV bus. These values can be found in Table 1 below.

Table 1: Fault Current Information for the Spring Canyon 230kV Bus with GI-2014-4 Contribution Represented

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) in per unit	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) in per unit
System Intact	I_1=4,134.5 I_2=I_0=0.0 I_A=I_B=I_C=4,134.5	Z_1(pos)= 0.0074683,0.0600136 Z_2(neg)= 0.0078200,0.0656363 Z_0(zero)= 0.0250209,0.1799366	I_1=I_2=1,375.9 3I_0=4,127.7 I_A=4,127.7 I_B=I_C=0.0	Z_1(pos)= 0.0074683,0.0600136 Z_2(neg)= 0.0078200,0.0656363 Z_0(zero)= 0.0250209,0.1799366

The fault current values listed in Table 1 may increase as additional generators and transmission lines are added to the system.

V. Protection Features

Transmission Line Protection (230 kV)

The existing 230kV 5923 line to the Customer is currently being protected by a BE1-P (primary) and a B-PRO (secondary). The settings for these relays will need to be changed in order to accommodate the new additional 60MW that will be put on this line. Minor wiring modifications will also be needed.

Outages/Temporary Configurations

A short outage is required to change the metering unit ratio from 200 to 400.

VI. Related Projects

No related work-orders (WOs) exist at this time.

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 2 below.

Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Xcel Energy/PSCo Engineering. The cost estimates are in 2014 dollars with escalation and contingency applied (AFUDC is not 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 and construction of these new PSCo 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 **$83,000.** Figure 1 above represents a conceptual one-line of the proposed expansion/interconnection at the Spring Canyon 230kV Substation/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.

Table 2: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Spring Canyon 230kV Transmission Substation	Interconnect/Upgrade Customer to the 230kV bus at the Spring Canyon 230kV Substation. The new activities include: • Metering adjustments • Relay settings changes • Drawing revisions	**$0.083**
Time Frame	Design and construct	**6 Months**

Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities

	Description	Cost Estimate (Millions)
PSCo's Spring Canyon 230kV Transmission Substation	• Not Applicable	**$0**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$0**
Time Frame	Site, design, procure and construct	

Table 4: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	Not Applicable	
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$0**
Time Frame	**Site, design, procure and construct**	
	Total Project Estimate	**$0.083**

Cost Estimate Assumptions

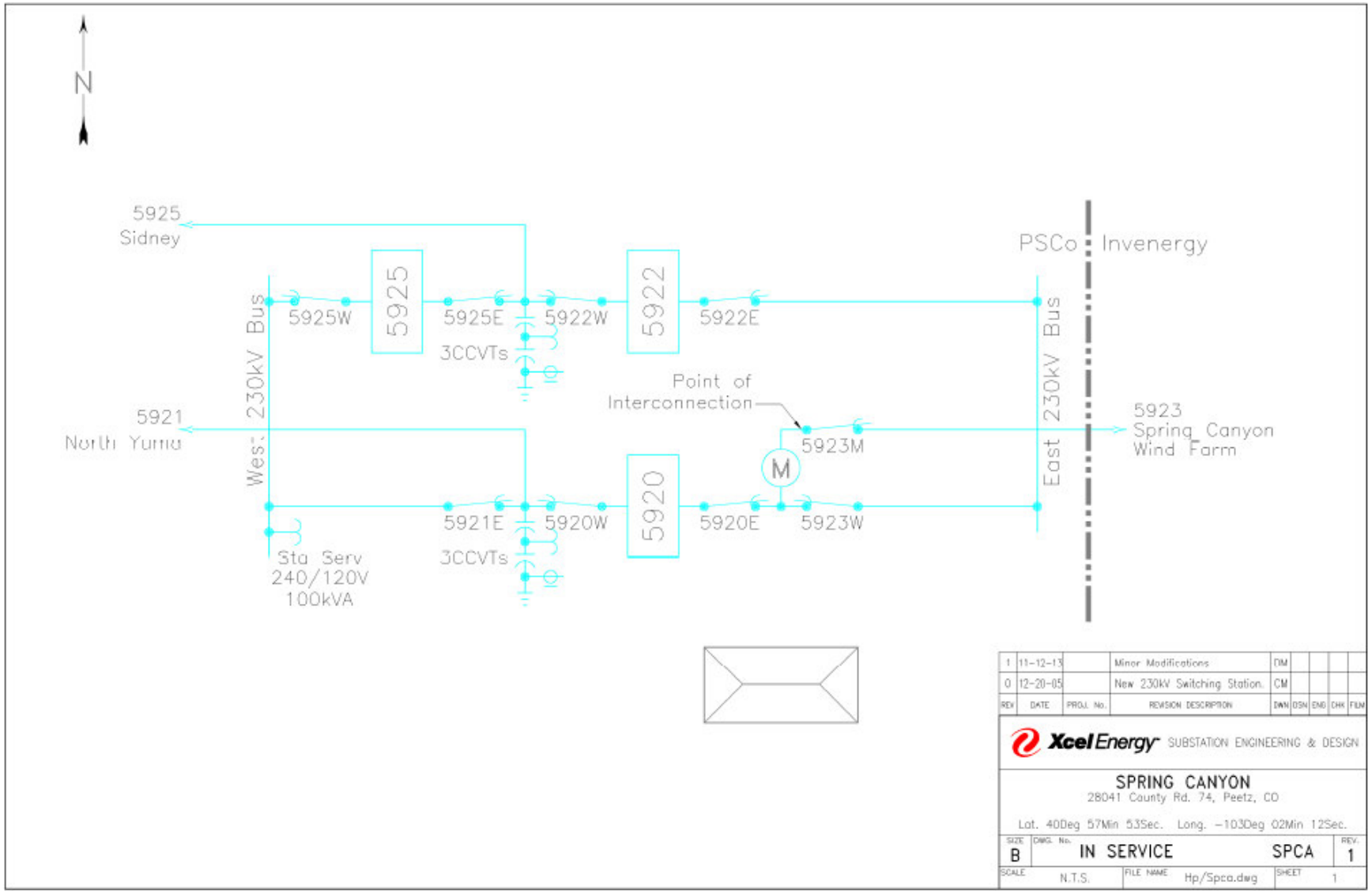
- Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Xcel Energy/PSCo Engineering.

- Estimates are based on 2014 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Engineering will be completed in-house (PSCo).
- Work scope is limited to Spring Canyon 230kV Substation and no evaluation of adequacy of proposed interconnection increase of 60 MWs.
- No new substation facility upgrades required.
- Changes are limited to metering adjustments, relay settings and drawing revisions.
- The Wind Generation Facility is not in PSCo's retail service territory.
- PSCo (or its Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Labor is estimated for straight time only – no overtime included.
- The estimated time to design and construct the interconnection facilities is approximately 6 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISDs.
- A CPCN will not be required for the interconnection facilities construction.
- A short outage will be required to change the metering ratios.

Appendix

Xcel Energy

A. Project One-Line of the Spring Canyon Substation



B. 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

C. Customer Questions and Comments

Question / Comments:

1. During the review of the facilities study, the Customer has indicated the commercial operation date (December 31, 2014) and back-feed date (June 30, 2014) proposed in the study may no longer be feasible and need to be revised. The Customer has requested that the commercial operation date be accelerated two months from December 31, 2014 to October 31, 2014.

    a. PSCo agrees that the back-feed date of June 30, 2014 is no longer feasible since it has already passed; however, since there is no change to the requested POI, service for site energization is already being provided and is accessible for the Customer's new facility. Moving forward, PSCo will target a completion date of October 31, 2014 for the Customer requested accelerated commercial operation date; however, meeting this date is contingent on the availability and support of other affected utilities for the protection and coordination review, implementation and compliance. Should the work not be completed by October 31, 2014, PSCo will continue to target the original December 1, 2014 commercial operation date.

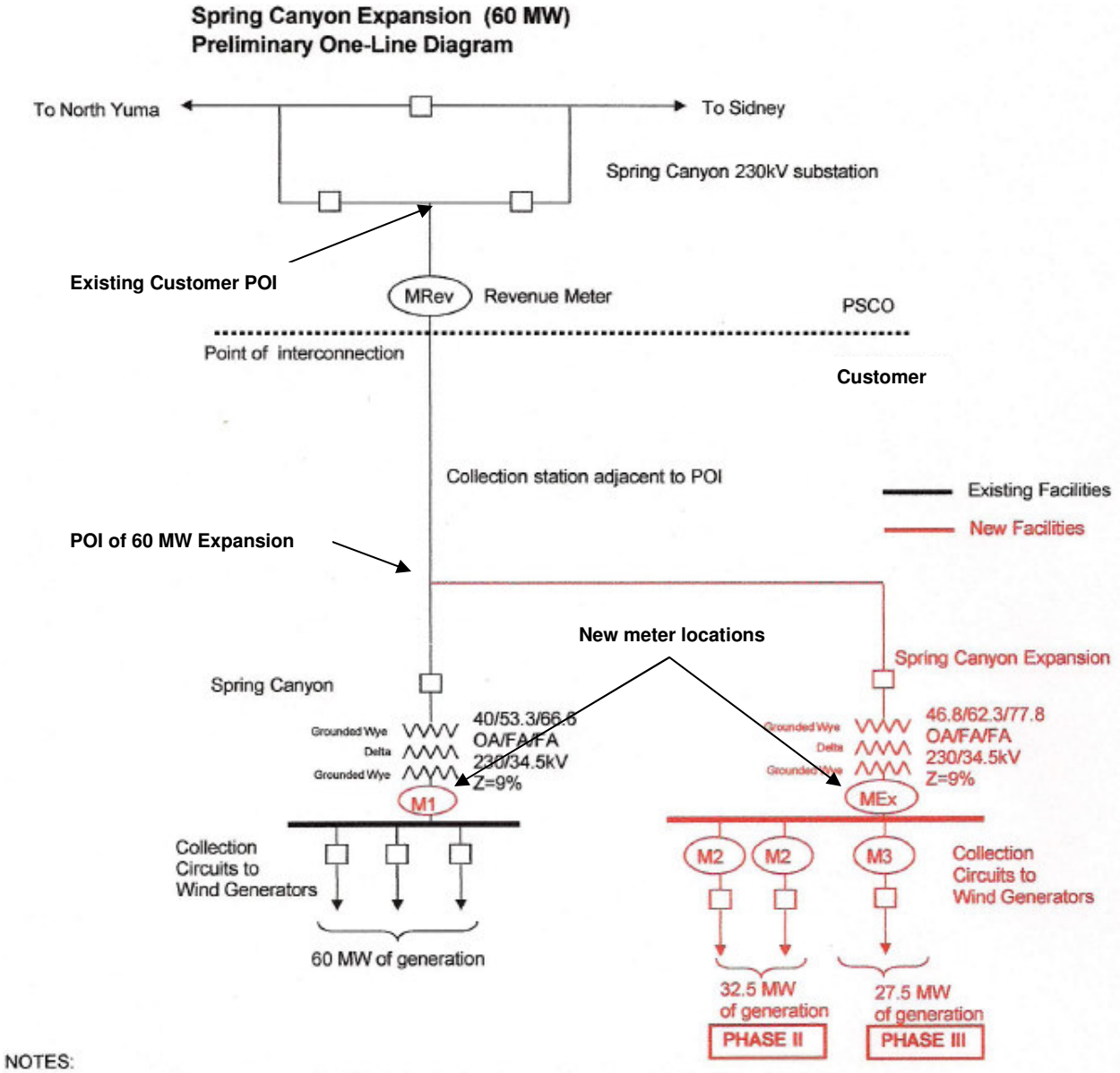
2. The Customer has indicated that the rating of the Alvin – Wauneta 115 kV line has been uprated from 40 MVA to 68 MVA after completing the upgrade of the SCADA transducers/panel meters supplied by WAPA breakers 262 and 362 bushing CT's, eliminating the overload seen in the feasibility study.

    a. In an e-mail dated 7/2/14, Mark Stout from TSGT verified that the Alvin – Wauneta 115 kV line rating has been increased to 68 MVA and is reflected in their most recent version of FAC-008.

3. The Customer has requested that Figure 1 on page 3 be updated to show a new location of meters M1 and MEx from the line side of the generator step-up transformers to the generation side.

    a. PSCo recommends that meters M1 and MEx remain on the line side of the generator step-up transformers in order to capture the transformer losses between the generation facilities and the revenue meter. Additionally, PSCo recommends that a way to determine retail load service behind the revenue meter is accounted for in the LGIA.
    b. The Customers proposed revised diagram with the new metering locations can be seen below.

Customer Proposed Revised Diagram of the GI-2014-4 Interconnection at Spring Canyon 230 kV with New Metering Locations



NOTES:
- M2 and M3 will require revenue quality CTs in feeder breakers and revenue quality PT on 34.5kV bus

BASIC METERING LOGIC:

SC1 = MREv - MEx
SC2 = (M2/(M2+M3)) x MEx
SC3 = (M3/(M2+M3) x MEx

M1 not necessary for calculations, but prudent to have as check to MEx and MRev
M1 and MEx need to be adjusted to account for transformer losses