INTERCONNECTION FACILITIES STUDY REPORT

GEN-2015-014

(IFS-2015-001-20)

Published February 2018

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
2/10/2017	SPP	Initial draft report issued.	
3/21/2017	SPP	Initial final report issued.	
2/13/2018	SPP	Initial final revision 1 report issued.	Account for DISIS-2015-001-3 cost allocation

CONTENTS

SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2015-014/IFS-2015-001-20 is for a 150.00 MW wind farm facility located in Cochran County, Texas. The Interconnection Request was studied in the DISIS-2015-001 Impact Study for Energy Resource Interconnection Service (ERIS). After the posting of the Impact Study, the Interconnection Customer executed the IFS Agreement per Appendix 4 or Appendix 4A, as applicable, and provided deposit securities as required by Section 8.9 of the GIP to proceed to the IFS. The GIP is covered under Attachment V of the SPP Open Access Transmission Tariff (OATT). The request for interconnection was placed with SPP by the requesting customer (Interconnection Customer) in accordance with the OATT, which covers new generation interconnections on SPP's transmission system.

The interconnecting Transmission Owner, Southwestern Public Service Company (SPS), performed a detailed IFS at the request of SPP. The full report is included in Appendix A. Interconnection Customer's requested in-service date is December 1, 2017. SPP has determined that full Interconnection Service will be available after the assigned Transmission Owner Interconnection Facilities, Shared Network Upgrade(s), and Non-Shared Network Upgrade(s) are completed. Full interconnection service will require completion of all Network Upgrade(s) listed in the "Other Network Upgrade(s)" section.

The primary objective of the IFS is to identify necessary Transmission Owner Interconnection Facilities, Network Upgrade(s), other direct assigned upgrade(s), and associated upgrade lead times needed to grant the requested Interconnection Service at the specified Point of Interconnection (POI).

PHASE(S) OF INTERCONNECTION SERVICE

It is not expected that Interconnection Service will occur in phases. However, Interconnection Service will not be available until all Interconnection Facilities and Network Upgrade(s) can be placed in service.

CREDITS/COMPENSATION FOR AMOUNTS ADVANCED FOR NETWORK UPGRADE(S)

Interconnection Customer shall be entitled to compensation in accordance with Attachment Z2 of the SPP OATT for the cost of SPP Network Upgrades, including any tax gross-up or any other tax-related payments associated with the Network Upgrades, that are not otherwise refunded to the Interconnection Customer. Compensation shall be in the form of either revenue credits or incremental Long Term Congestion Rights (iLTCR).

INTERCONNECTION CUSTOMER INTERCONNECTION FACILITIES

The Generation Facility is proposed to consist of seventy-five (76) 2.0 MW Vestas wind generators for a total generating nameplate capacity of 150.00 MW. The 34.5kV collector system is planned to be connected to two (2) 115/34.5kV 54/72/90 MVA (ONAN/ONAF/ONAF) step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation. A eight (8) mile overhead 115kV transmission line will connect the Interconnection Customer's substation to the Point of Interconnection (POI) at a new SPS owned and maintained 115kV bus located at the new Lost Draw Substation. Lost Draw Substation will tap and loop in the Lehman – Cochran 115kV transmission circuit. Lost Draw Substation is planned to be located approximately nine-and-a-half (9.5) miles from Cochran 115kV on the Lehman – Cochran 115kV transmission circuit. The Interconnection Customer will be responsible for all of the transmission facilities required to connect the Interconnection Customer's substation to the Point of Interconnection (POI).

The Interconnection Customer will be responsible for installing any and all equipment at the Interconnection Customer's substation necessary to maintain a power factor at the POI between 0.95 lagging and 0.95 leading, including approximately 7.0Mvars[1] of reactors to compensate for injection of reactive power into the transmission system under no/reduced generating conditions. The Interconnection Customer may use wind turbine manufacturing options for providing reactive power under no/reduced generation conditions. The Interconnection Customer will be required to provide documentation and design specifications demonstrating how the requirements are met. Also, the Interconnection Customer shall coordinate relay, protection, control, and communication system configurations and schemes with the Transmission Owner.

TRANSMISSION OWNER INTERCONNECTION FACILITIES AND NON-SHARED NETWORK UPGRADE(S)

To facilitate interconnection, the interconnecting Transmission Owner will perform work as shown below necessary for the acceptance of the Interconnection Customer's Interconnection Facilities.

Error! Reference source not found. lists the Interconnection Customer's estimated cost responsibility for Transmission Owner Interconnection Facilities (TOIF) and Non-Shared Network Upgrade(s) and provides an estimated lead time for completion of construction. The estimated lead time begins when the Generator Interconnection Agreement has been fully executed.

Table 1: Interconnection Customer TOIF and Non-Shared Network Upgrade(s)

TOIF and Non-Shared Network Upgrades Description	Allocated Cost Estimate ($)	Allocated Percent (%)	Total Cost Estimate ($)	Estimated Lead Time
SPS Interconnection Substation: Transmission Owner Interconnection Facilities 115kV Substation work for one (1) new line terminal, line switch, dead end structure, line relaying, communications, revenue metering, and line arrestor	$260,000	100%	$260,000	30 Months

[1] This approximate minimum reactor amount is needed for the current configuration of the wind farm as studied in the addendum

TOIF and Non-Shared Network Upgrades Description	Allocated Cost Estimate ($)	Allocated Percent (%)	Total Cost Estimate ($)	Estimated Lead Time
SPS Interconnection Substation - Non-Shared Network Upgrades Acquire five (5) acres of land for constructing a new substation, tapping, looping in, and re-terminating Cochran – Lehman 115kV transmission circuit, construct a new three (3) breaker ring 115kV bus, two (2) line terminals, three (3) 3000A circuit breaker, control panel replacement, line relaying, disconnect switches, and associated equipment.	$5,750,184	100%	$5,750,184	
Total	**$6,010,184**	**100%**	**$6,010,184**	

SHARED NETWORK UPGRADE(S)

The Interconnection Customer's share of costs for Shared Network Upgrades is estimated in **Error! Reference source not found.** below.

Table 2: Interconnection Customer Shared Network Upgrades

Shared Network Upgrades Description	Allocated Cost Estimate ($)	Allocated Percent (%)	Total Cost Estimate ($)
AEP-PSO Oklaunion 345kV Capacitor Bank(s): Install Oklaunion 50Mvars Capacitor Bank(s). AEP Public Service of Oklaunion (PSO) to install one (1) steps of 50Mvars of capacitor bank(s) at Oklaunion Substation on the Oklaunion 345kV bus. Oklaunion 345kV bus would require expanding from three (3) breaker ring to five (5) 345kV breaker ring, installing capacitors, associated switches, foundations, protective and control relaying equipment, and all associated and miscellaneous materials.	$2,063,083	33.82	$6,100,000
Total	**$2,063,083**	**33.82**	**$6,100,000**

All studies have been conducted assuming that higher-queued Interconnection Request(s) and the associated Network Upgrade(s) will be placed into service. If higher-queued Interconnection Request(s) withdraw from the queue, suspend or terminate service, the Interconnection Customer's share of costs may be revised. Restudies, conducted at the customer's expense, will determine the Interconnection Customer's revised allocation of Shared Network Upgrades.

OTHER NETWORK UPGRADE(S)

Certain Other Network Upgrades are currently not the cost responsibility of the Interconnection Customer but will be required for full Interconnection Service.

1) National Enrichment Plant – Targa – Cardinal 115kV circuit #1 rebuild assigned in the 2015 Integrated Transmission Plan Near Term Assessment (2015 ITPNT) per SPP-NTC-200360. Currently, the anticipated in-service date is 6/1/2018.
2) Tolk – Plant X 230kV circuit #1 and circuit #2 rebuilds assigned to DISIS-2014-002 Interconnection Customer(s). Currently, the anticipated in-service date is 6/1/2018.

Depending upon the status of higher- or equally-queued customers, the Interconnection Request's in-service date is at risk of being delayed or Interconnection Service is at risk of being reduced until the in-service date of these Other Network Upgrades.

CONCLUSION

After all Interconnection Facilities, Shared Network Upgrades, and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 150.00 MW can be granted. Interconnection Service will be delayed until the Transmission Owner Interconnection Facilities, Shared Network Upgrades, and Non-Shared Network Upgrades are completed. The Interconnection Customer's estimated cost responsibility for Transmission Owner Interconnection Facilities, Non-Shared Network Upgrades and Shared Network Upgrades is summarized in the table below.

Description	Allocated Cost Estimate ($)
SPS Interconnection Substation: Transmission Owner Interconnection Facilities	$260,000
SPS Interconnection Substation - Non-Shared Network Upgrades	$5,750,184
AEP-PSO Oklaunion 345kV Capacitor Bank(s)	$2,063,083
Total	**$8,073,267**

A draft Generator Interconnection Agreement will be provided to the Interconnection Customer consistent with the final results of this IFS report. The Transmission Owner and Interconnection Customer will have 60 days to negotiate the terms of the GIA consistent with the SPP OATT.

APPENDICES

A: TRANSMISSION OWNER'S INTERCONNECTION FACILITIES STUDY REPORT

See next page for the Transmission Owner's Interconnection Facilities Study Report.

Facilities Study For
Southwest Power Pool (SPP)

GEN-2015-014
Total Output is 150 MW
Cochran County, Texas

Xcel Energy Services, Inc.

Transmission Planning South

January 6, 2016

Executive Summary

Interconnection Customer (IC) in 2015 requested an interconnection of a wind energy facility located in Cochran County, Texas to the Southwestern Public Service Company (SPS) transmission network. SPS is a New Mexico Corporation and wholly owned subsidiary of Xcel Energy Inc. This facility has a net capacity of 150 MW. The IC's facility will connect to SPS's existing Cochran Interchange to Lehman V36 115 kV transmission line located approximately 9.5 miles from Cochran Interchange. The IC's requested commercial operation date is December1, 2017.

The Southwest Power Pool (SPP) evaluated the request (GEN-2015-014) to interconnect the wind generation facility to the SPS transmission system in a Definitive Interconnection System Impact Study (DISIS-2015-001-1), which was completed in December 2015. The interconnection request was studied using seventy-five (75) turbines, which are Vestas V110 2.0 MW wind turbines for a total of 150 MW. The IC is required to build 115 kV transmission line from their wind farm substation facility to the SPS's new Lost Draw Substation. The IC will be required to maintain a Power Factor between 0.95 lagging and 0.95 leading at the Point of Interconnection (POI).

SPP requires that each generator shall implement automatic Under Frequency Load Shedding (UFLS) according to the SPP UFLS Plan at the following link: http://www.xcelenergy.com/Energy_Portfolio/Electricity/Power_Generation/Generation_Owners/Interconnections_for_Transmission. To fulfill this requirement, coordination with Xcel Energy is required during the under-frequency relay-setting phase for the generation. The Interconnection Customer is required to report their generation off-nominal frequency tripping relay settings to SPP and SPS. SPS specifies that generators shall not trip at frequencies above 58.5 Hz unless exceptions in the Transmission Provider Criteria are met. The Interconnection Customer agrees that the energy generating units installed at this interconnection will not be tripped for under-frequency conditions above 58.5 Hz in compliance with Transmission Provider criteria. This means that the generation subject to this Interconnection Agreement may not trip for under-frequency conditions on the transmission system until all under-frequency load shedding relays have operated. SPS will also require that the Interconnection Customer be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Corporation (NERC), SPP, and the Federal Energy Regulatory Commission (FERC) or their successor organizations.

The Interconnection Customer is responsible for all the cost of the Interconnection Facilities, installation of the Direct Assigned Interconnection Facilities; inclusive of all construction required for the 115 kV to interconnect at SPS's Lost Draw Substation.

The shared network upgrades will be determined at a later date by SPP and may impact the total overall costs for interconnection for the IC.

It is anticipated that the entire process of building a new 3-ring 115 kV breaker at Lost Draw Substation for the acceptance of the IC facility output and the network upgrades allocated to this project will require approximately 30 months to complete after an Interconnection Agreement is signed and an authorization to proceed is received. The Interconnection Customer's cost for the interconnection of this Wind Farm facility is shown below in Table 1, with the detailed description of the cost shown in Table 3.

Table 1, Cost Summary[a]

Shared Network Upgrades Total:	**$**	**TBD**
Network Upgrades:	**$**	**5,750,184**
Transmission Owner Interconnection Facilities:	**$**	**260,000**
Total:	**$**	**6,010,184**

[a] The cost estimates are 2015 dollars with an accuracy level of ±20%.

General Description of SPS[b] Facilities

1. **Construction of New Lost Draw Substation:** See Appendix A, Figure A-1 for general vicinity location map.

   1.1. **Location:** Customer will build a new 115 kV line from their substation to SPS's new 115 kV Lost Draw Substation which includes three (3) 115 kV breakers. Appendix A, Figure A-2, shows a preliminary one-line of Lost Draw Substation, while Figure A-3 shows a typical elevation view of the normal Point of Interconnection (POI).

   1.2. **Bus Design:** The new 115 kV three-breaker ring-bus Substation will be built to accommodate the output from the wind energy facility. This is shown in Appendix A, Figure A-2.

   1.3. **Line Terminals:** The 115 kV lines and static wire terminals will be designed to accommodate 14,000 pounds per phase conductor (28,000 Bundle) at maximum tension, with a maximum 15-degree pull off from normal.

   1.4. Relay and Protection Scheme: The new 115 kV breaker line terminal primary protection to the interconnection customer 115 kV transmission line will use line current differential relaying over optical fiber installed in the static of the customer's 115 kV transmission line. Secondary relaying will use mirrored bit, Permissive Overreaching Transfer Trip (POTT) over the optical fiber. An SEL 411L and an SEL 311C will be used as primary and secondary relays, respectively. The SEL 351S will be used for breaker SCADA closing conditions for the 115 kV breakers and for breaker failure.

   An SEL 411L will display the line voltage, line amps, MW, MVAR, and fault location. A communication relay will be installed and for other functions as required.

   1.5. Revenue Metering: An individual billing meter will be installed at Lost Draw Substation on the 115 kV line terminal from the IC's substation, which meets the standards: ANSI C12.1 accuracy class 0.2 (3-PT's IEEE C57.13 accuracy class 0.3 and 3-CT's IEEE C57.13 accuracy class 0.15) for full 3-phase 4-wire metering. There will be two meters per line terminal: one will be primary and the other will be back up, each will have full 4 quadrant metering. Pulses out of the primary billing meter will be sent via SCADA to the Transmission Owner's Control Center in Amarillo, Texas.

   1.6. Disturbance Monitoring Device: A Disturbance Fault Recorder (DFR), capable of recording faults, swings, and long term trending, will be installed to monitor and record conditions in the substation and on the transmission lines. The disturbance equipment shall also be equipped with a GPS time synching clock. This equipment will have communication capability with a dedicated communication circuit. The disturbance equipment will have its own dedicated communications circuit.

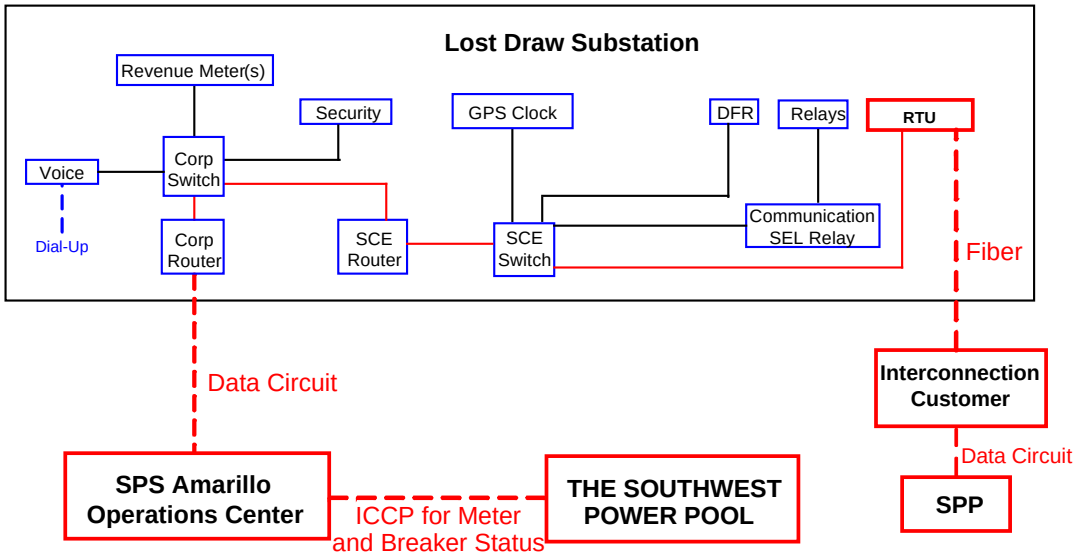
   1.7. Remote Terminal Unit (RTU): A new RTU will be utilized with communications for the new SPS switching station. A Communication SEL Relay will be installed for relay communications and other functions as required; these costs will be directly assigned to the IC. The IC will provide and install an RTU for metering and telemetry at the IC's facility as required by the latest Xcel Energy Interconnection Guidelines.

[b] All modifications to SPS facilities will be owned, maintained and operated by SPS.

1.8. **Communications:** To meet its Communications obligations, the Interconnection Customer shall be responsible for making arrangements with the local phone company to provide a communication circuit as required by the Transmission Owner. Transmission Owner equipment may include, but is not limited to the following: relay communication equipment, RTU, and disturbance monitoring equipment at Lost Draw Substation. Prior to any construction, the IC is required to contact the Transmission Owner substation-engineering department for all communication details and provide detail of the method to be used in communication.

The following communications schematic diagram, which includes communication equipment information for the IC, Transmission Provider (Southwest Power Pool) and Transmission Owner (Southwestern Public Service), is provided to assist the Parties as a template.

A schematic outlining the proposed communications is provided below:



Interconnection Customer shall be responsible for providing fiber optic communication circuit installed in the overhead transmission line static wire from the customer substation to Lost Draw Substation for protective relaying, and for transmitting metering and status data to SPS. Utilizing this fiber optic connection, SPS will establish a direct connection to the IC's RTU.

SPS will not serve as a proxy for communication from the IC to SPP.

2. Transmission Work:

2.1 The SPS transmission design group prior to any construction by the Interconnection Customer or its contractor on any customer 115 kV transmission lines, or doing work in close proximity to any SPS transmission line, will require an engineering review of the customer's design. It is the Interconnection Customer's responsibility to initiate the design review in a timely manner before construction of any transmission line begins. If the review has not been made or the design at any of the aforementioned locations is deemed inadequate, the crossing(s) and or termination into the interchange will be delayed until the matters are resolved. SPS will not be held responsible for these delays.

3. Right-Of-Way:

3.1 **Permitting**: The IC will be responsible for any permitting and right of way of their substation and their transmission line from their substation to the Point of Interconnection at SPS's Switching Station.

Construction Power and Retail Service: It is the sole responsibility of the IC to make arrangements for both construction and station power. The IC needs to make arrangements for retail service from the local retail provider. Retail provider and Customer will be responsible for making any necessary transmission service arrangements as required under the SPP OATT.

4. Project and Operating Concerns:

4.1 Close work between the Transmission group, the Interconnection Customer's personnel and local operating groups will be imperative in order to meet any in-service date that has been established.

4.2 The Interconnection customer will be required to maintain a Power Factor between 0.95 lagging and a 0.95 leading at the Point of Interconnection (POI). All capacitors required will be installed on the lower voltage bus 34.5 kV at IC's substation. This is required to maintain acceptable dynamic voltage rise as per latest revision of the Xcel Energy Interconnection Guidelines for Transmission Interconnection Producer-Owned Generation Greater than 20 MW. If switched reactive devices are used on the IC's system, they need to be switched in stages where the voltage rise is less than 3%.

5. **Fault or Short Circuit Study:** The available fault current at the interconnection location using the 2015 MDWG 2020S with MMWG 2019S on the 115 kV at Lost Draw Substation located approximately 9.5 miles from Cochran Interchange towards Lehman Tap on circuit V-36, without any contribution from the new generator facilities, is shown in Table 2.

Table 2, - Available fault current at interconnection location

Short Circuit Information without contribution from new Generator Facilities (GEN 2015-014)				
Fault Location	Fault Current (Amps)		Impedance (Ω)	
	Line-to-Ground	3–Phase	Z^+	Z^0
115 kV Bus	3,544	4,974	4.27 + j12.54	6.83 + j28.58

Estimated Construction Costs

The projects required for the interconnection of 150 MW Wind Generation facilities consist of the projects summarized in the table below.

Table 3, Required Interconnection Projects[c]

Project	Description	Estimated Cost
	Shared Network Upgrades:	
1	The current estimated shared network upgrades to be determined (TBD)	$ TBD
	Subtotal:	**$ TBD**
	Network Upgrades (at the Interconnection Customer's expense)	
2	Communication Equipment (DFR, RTU and other related items)	$ 341,000
3	Land Approximately 5 acre	$ 46,124
4	Build new 3-ring bus for new Lost Draw Substation with three new 115 kV breakers.	$ 4,208,561
5	Tap V-36 into and out Lost Draw from Cochran to Lehman	$ 1,154,499
	Subtotal:	**$ 5,750,184**
	Transmission Owner Interconnection Facilities (at the Interconnection Customer's expense)	
6	Communications [d]	*$ See footnote*
7	Revenue metering	$ 230,000
8	115 kV Line arrestors	$ 30,000
	Subtotal:	**$ 260,000**
	Total Cost	**$ 6,010,184**

Engineering and Construction:

An engineering and construction schedule for this project is estimated at approximately 30 months. Other factors associated with clearances, equipment delays and work schedules could cause additional delays. This is applicable after all required agreements are signed and internal approvals are granted.

All additional cost for work not identified in this study is the sole responsibility of the IC unless other arrangements are made.

[c] The cost estimates are 2015 dollars with an accuracy level of ±20%.

[d] It is the Requester's responsibility to provide both the data circuit and communication circuits, see Section 1.8.

Appendix A

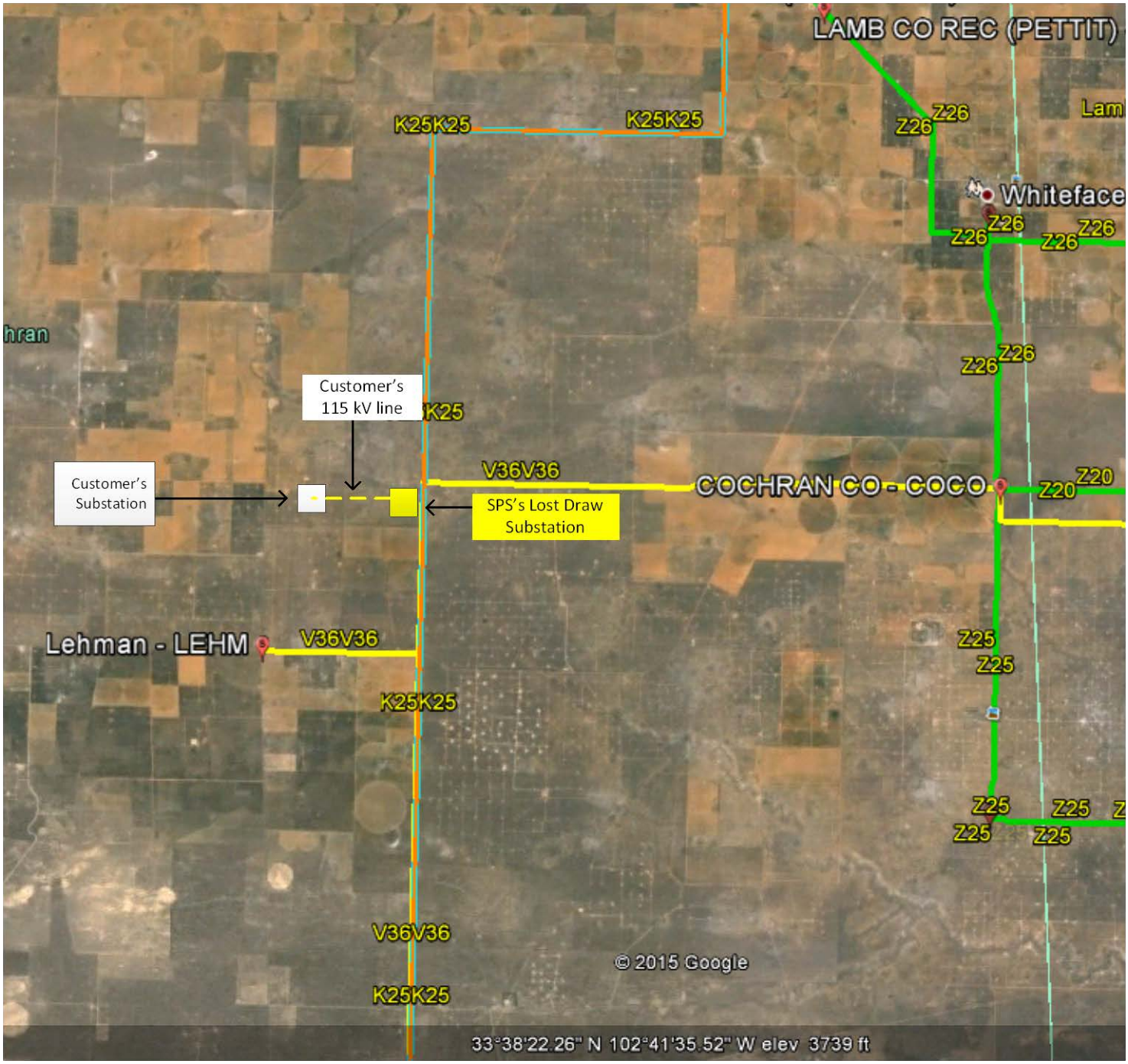


Figure A-1. Approximate location of Lost Draw Substation Station and IC's Wind Farm

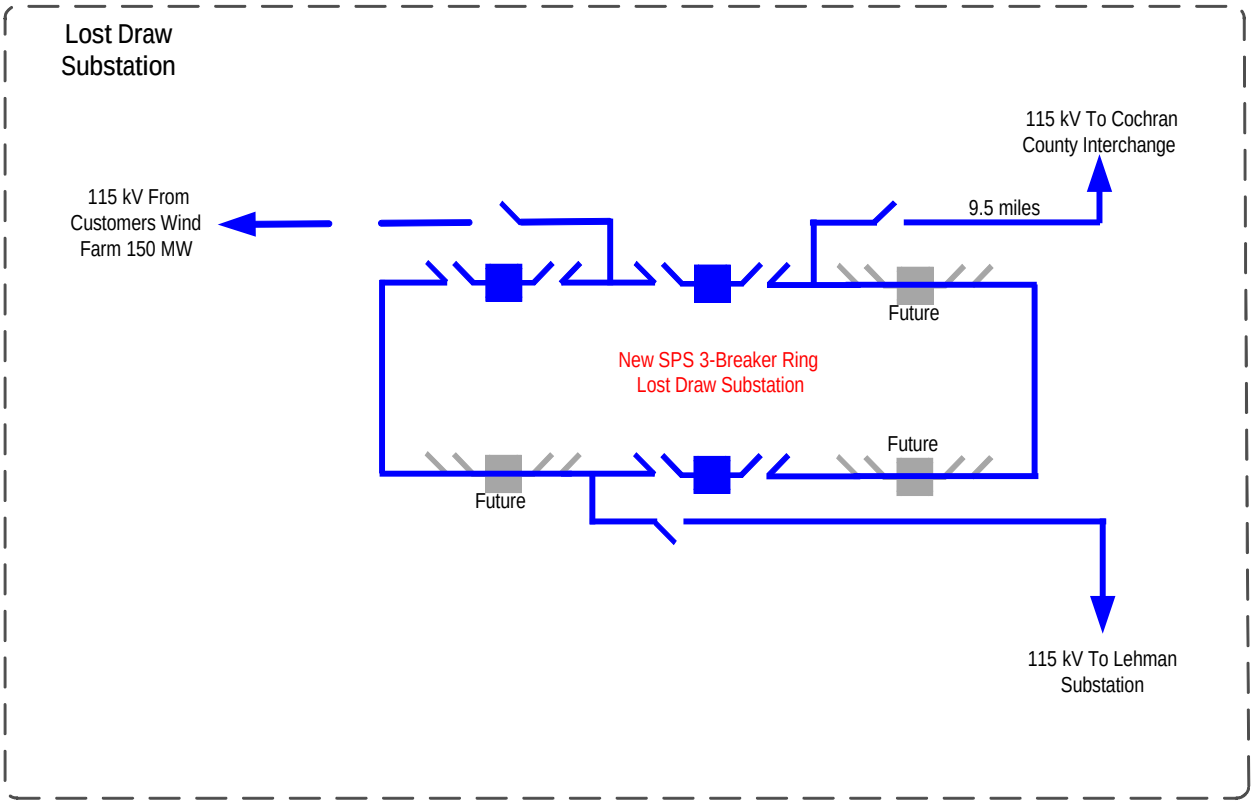


Figure A-2. One-line Diagram of New Lost Draw Substation

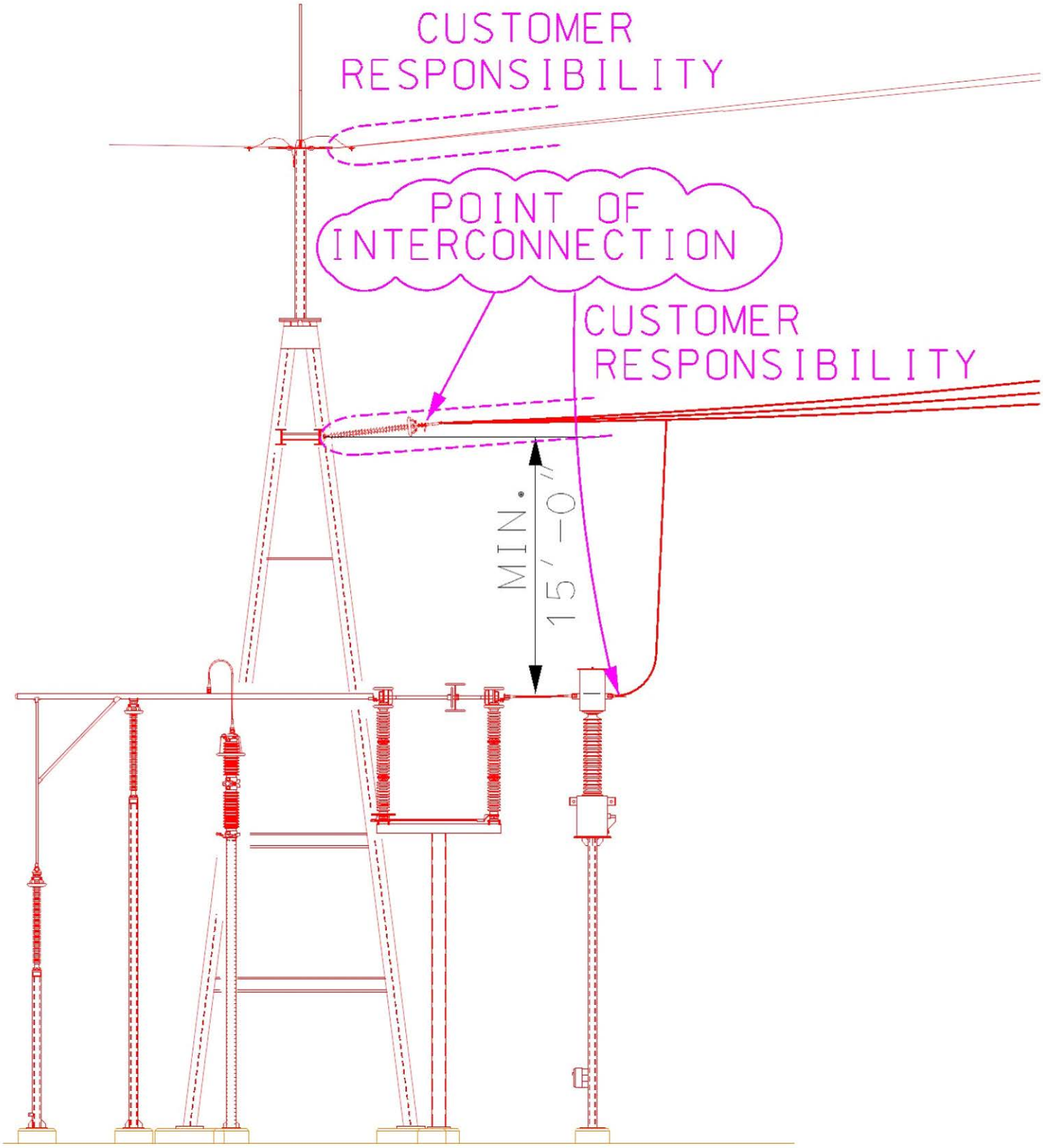


Figure A-3 Point of Interconnection & Change of Ownership (Typical)

– END OF REPORT –

B: SPP REDUCED GENERATION ANALYSIS STUDY REPORT

See next page for the SPP Reduced Generation Analysis Study Report.

Reduced Generation Analysis

GEN-2015-014/IFS-2015-001-20

DISIS 2015-001

February 2017
Generator Interconnection

SPP Southwest Power Pool

Revision History

Date	Author	Change Description
2/10/2017	SPP	No/Reduced Generation Analysis Completed

Reduced Generation Analysis

A no/reduced generation analysis for wind or solar generating facilities has been performed for the GEN-2015-014 (150.00 MW/ Wind) Interconnection Request. SPP performed this no/reduced generation analysis for excessive capacitive charging current for the addition of the GEN-2015-014 facilities. The high side of the two (2) 115/34.5kV 54/72/90 MVA (ONAN/ONAF/ONAF) Interconnection Customer owned and maintained transformers will interconnect to The Point of Interconnection (POI). The Point of Interconnection (POI) is at new Southwestern Public Service Company (SPS) owned and maintained 115kV bus at proposed new Lost Draw Substation. Lost Draw Substation will tap and loop in the Lehman – Cochran 115kV transmission circuit. Lost Draw Substation is planned to be located approximately nine-and-a-half (9.5) miles from Cochran 115kV on the Lehman – Cochran 115kV transmission circuit. An eight (8) mile overhead 115kV transmission circuit will connect the Generating Facility from the Interconnection Customer owned substation to the Point of Interconnection (POI).

The project generators and capacitors (if any) were turned off in the base case as show in **Figure 1**. The resulting reactive power injection into the transmission network comes from the capacitance of the project's transmission lines and collector cables.

Shunt reactors were added at the study project substation 34.5 kV bus to bring the Mvar flow into the POI down to approximately zero as show in **Figure 3**. Final shunt reactor requirement for GEN-2015-014 is approximately 7.0 Mvars. The one-line diagram in **Figure 3** shows actual Mvar output at the specific voltages in the base case. The results shown are for the 2025SP case.

The other two cases (2016WP and 2017SP) were almost identical since the Interconnection Request facilities design is the same in all cases.

Figure 1: GEN-2015-014 with generator off and no shunt reactor(s)

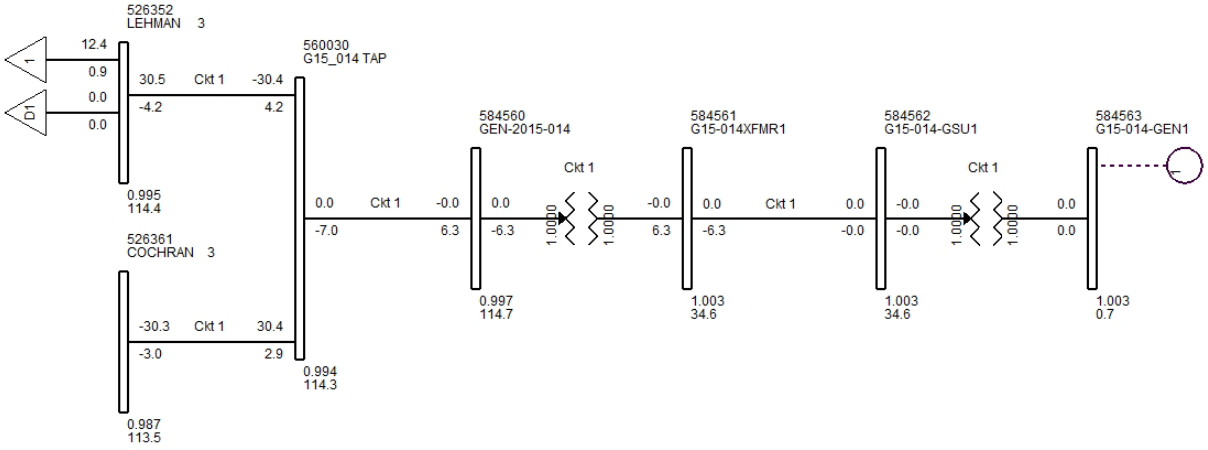


Figure 2: GEN-2015-014 with generators turned off and shunt reactors added to the low side of the GEN-2015-014 substation 115/34.5kV transformer

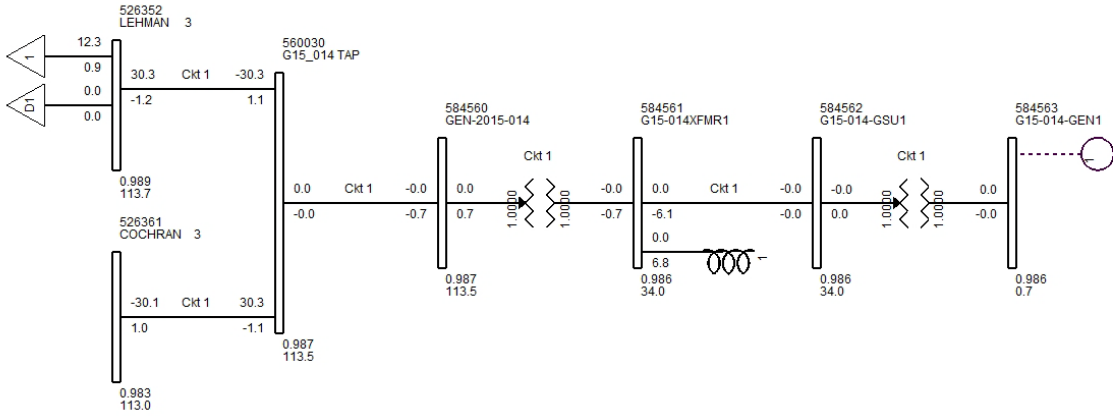


Table 1: No/Reduced Generation Analysis

Request	Size (MW)	Point of Interconnection	Shunt Reactive Mvar Requirement
GEN-2015-014	150.00	Tap Lehman – Cochran 115kV	7.0

Conclusion

A no/reduced generation analysis for wind or solar generating facilities has been performed for the GEN-2015-014 Interconnection Request. SPP performed this no/reduced generation analysis analysis for excessive capacitive charging current for the addition of the GEN-2015-014 facilities.

The no/reduced generation analysis has determined the need for the GEN-2015-014 Interconnection Request to install approximately 7.0 Mvars of reactor bank(s).