INTERCONNECTION FACILITIES STUDY REPORT

GEN-2015-022

(IFS-2015-001-19)

Published July 2018

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
2/10/2017	SPP	Initial draft report issued.	
3/28/2017	SPP	Initial final report issued.	Share Network Upgrade costs updated for Kress – Swisher 115kV CKT 1 Updated ratings mitigation
2/13/2018	SPP	Initial final revision 1 report issued.	Accounted for DISIS-2015-001-3 cost allocation
7/2/2018	SPP	Final revision 1 report issued.	Added Z2 Type for Network Upgrades and correction in Shared Network Upgrades table

CONTENTS

SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2015-022/IFS-2015-001-19 is for a 112.00 MW solar farm facility located in Randall County, Texas. The Interconnection Request was studied in the DISIS-2015-001 Impact Study for Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). 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 October 1, 2018. 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 "Previous 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 creditable type 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 twenty-eight (28) 4.0 MW General Electric (G.E.) inverters for a total generating nameplate capacity of 112.00 MW. The 34.5kV collector system is planned to be connected to one (1) 115/34.5kV 69/92/115 MVA (ONAN/ONAF/ONAF) step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation. A short (<1) mile overhead 115kV transmission line will connect the Interconnection Customer's substation to the Point of Interconnection (POI) at the existing SPS owned and maintained 115kV bus located at the Swisher Substation. 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 1.8Mvars[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.

Table 1 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	Z2 Type[2]	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	N/A	$260,000	100%	$260,000	30 Months

[1] This approximate minimum reactor amount is needed for the current inverter configuration of the solar facility.
[2] Indicates the method used for calculating credit impacts under Attachment Z2 of the Tariff.

TOIF and Non-Shared Network Upgrades Description	Z2 Type[2]	Allocated Cost Estimate ($)	Allocated Percent (%)	Total Cost Estimate ($)	Estimated Lead Time
SPS Interconnection Substation - Non-Shared Network Upgrades: convert existing 115kV bus configuration to a new three (3) breaker ring 115kV bus, three (3) 3000A circuit breakers, control panel replacement, line relaying, disconnect switches, and associated equipment.	Non-Creditable	$4,009,716	100%	$4,009,716	
Total		**$4,269,716**	**100%**	**$4,269,716**	

SHARED NETWORK UPGRADE(S)

The Interconnection Customer requested a Material Modification analysis to withdrawal Network Resource Interconnection Service (NRIS) after an executed IFS agreement. As a result of Material Modification, DISIS-2015-001-2, and DISIS-2015-001-3 analyses, the Interconnection Request is assigned allocated cost responsibilities for Oklaunion 345kV Capacitor Bank installation.

The Interconnection Customer's share of costs for Shared Network Upgrades is estimated in **Table 2** 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.	$1,867,063	21.57%	$8,654,413
Total	**$1,867,063**	**21.57%**	**$8,654,413**

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.

PREVIOUS NETWORK UPGRADE(S)

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

1) Wolfforth – Terry County 115kV circuit #1 terminal equipment upgrade assigned in the 2016 Integrated Transmission Planning Near Term Assessment (2016 ITPNT) per SPP-NTC-200395. 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 Previous Network Upgrades.

CONCLUSION

After all Interconnection Facilities, Shared Network Upgrades, and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 112.00 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.

Table 3: Cost Summary

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilities	$260,000
Network Upgrades	$5,876,779
Total	**$6,136,779**

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-2015-022
Total Output is 112 MW
Swisher County, Texas

Xcel Energy Services, Inc.

Transmission Planning South

January 4, 2016

Executive Summary

Interconnection Customer (IC) in 2015 requested the interconnection of a 112 MW solar energy generation facility, located in Swisher County, Texas, to the Southwestern Public Service Company (SPS) 115 kV transmission network. To accommodate the IC's request, SPS will convert the existing Swisher County substation 115 kV single bus to a 3-breaker ring bus configuration. After the conversion, the IC will connect to the SPS 115 kV bus. The IC's requested commercial operation date is December1, 2016.

The Southwest Power Pool (SPP) evaluated the request (GEN-2015-022) to interconnect the solar 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 GE LV5 Inverters for 112 MW. The IC is required to build 115 kV transmission line from their substation solar farm facility to the SPS's Swisher Interchange. 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 for SPS found in the Xcel Energy Interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW at the following link: http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf. 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 Swisher Interchange.

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

It is anticipated that the entire process of converting 115 kV single bus to a 3-breaker ring bus 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 Solar 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:	**$**	**TBD**
Network Upgrades:	**$**	**4,009,716**
Transmission Owner Interconnection Facilities:	**$**	**260,000**
Total:	**$**	**4,269,716**

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

General Description of SPS[b] Facilities

1. **Construction of the 115 kV at Swisher Interchange:** 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 115 kV at Swisher Interchange which includes three (3) new 115 kV breakers. Appendix A, Figure A-2, shows a preliminary one-line of the new 115 kV at Swisher Interchange, 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 configuration at Swisher will be built to accommodate the output from the solar 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 Swisher Interchange 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. Pulses out of the 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.

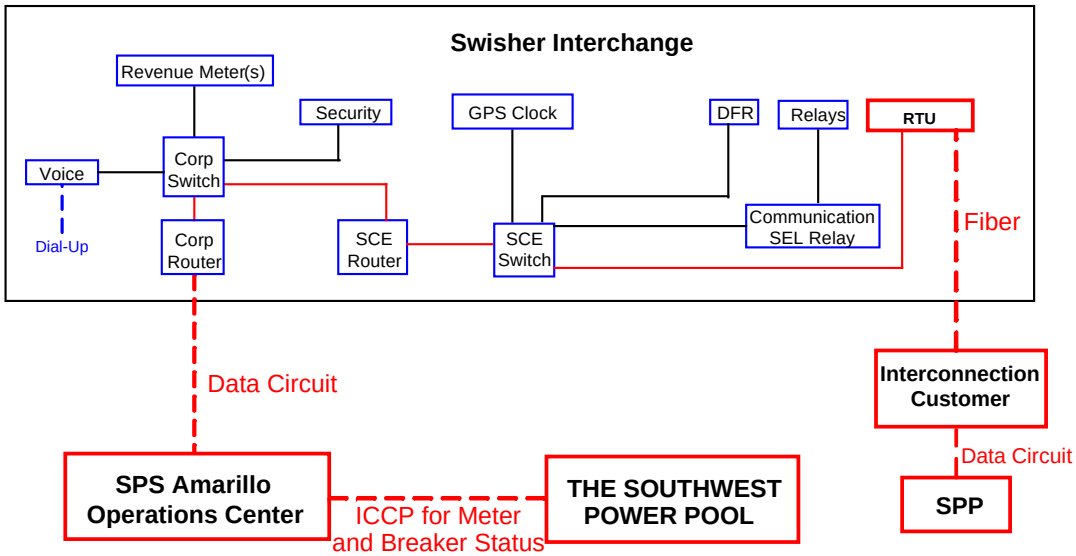
   1.7. Remote Terminal Unit (RTU): A new RTU will be utilized with communications for the new 115 kV breakers. A Communication SEL Relay will be installed for relay communications and other functions as required; these costs will be directly assigned to the IC. The IC will provide and install an RTU for 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 Swisher Interchange. 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 Swisher Interchange 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 Swisher Interchange.

3.2 **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 Swisher Interchange, 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 2015-022)				
Fault Location	Fault Current (Amps)		Impedance (Ω)	
	Line-to-Ground	3–Phase	Z^+	Z^0
115 kV Bus	1,896	1,962	1.53 + j6.72	0.88 + j7.61

Estimated Construction Costs

The projects required for the interconnection of 112 MW Solar 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)	$ 222,121
3	Reroute V-76 115 kV line	$ 369,793
4	Convert 115 kV bus to 3-breaker ring at Swisher Interchange.	$ 3,417,802
	Subtotal:	**$ 4,009,716**
	Transmission Owner Interconnection Facilities (at the Interconnection Customer's expense)	
5	Communications [d]	*$ See footnote*
6	Revenue metering	$ 230,000
7	115 kV Line arrestors	$ 30,000
	Subtotal:	**$ 260,000**
	Total Cost	**$ 4,269,716**

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

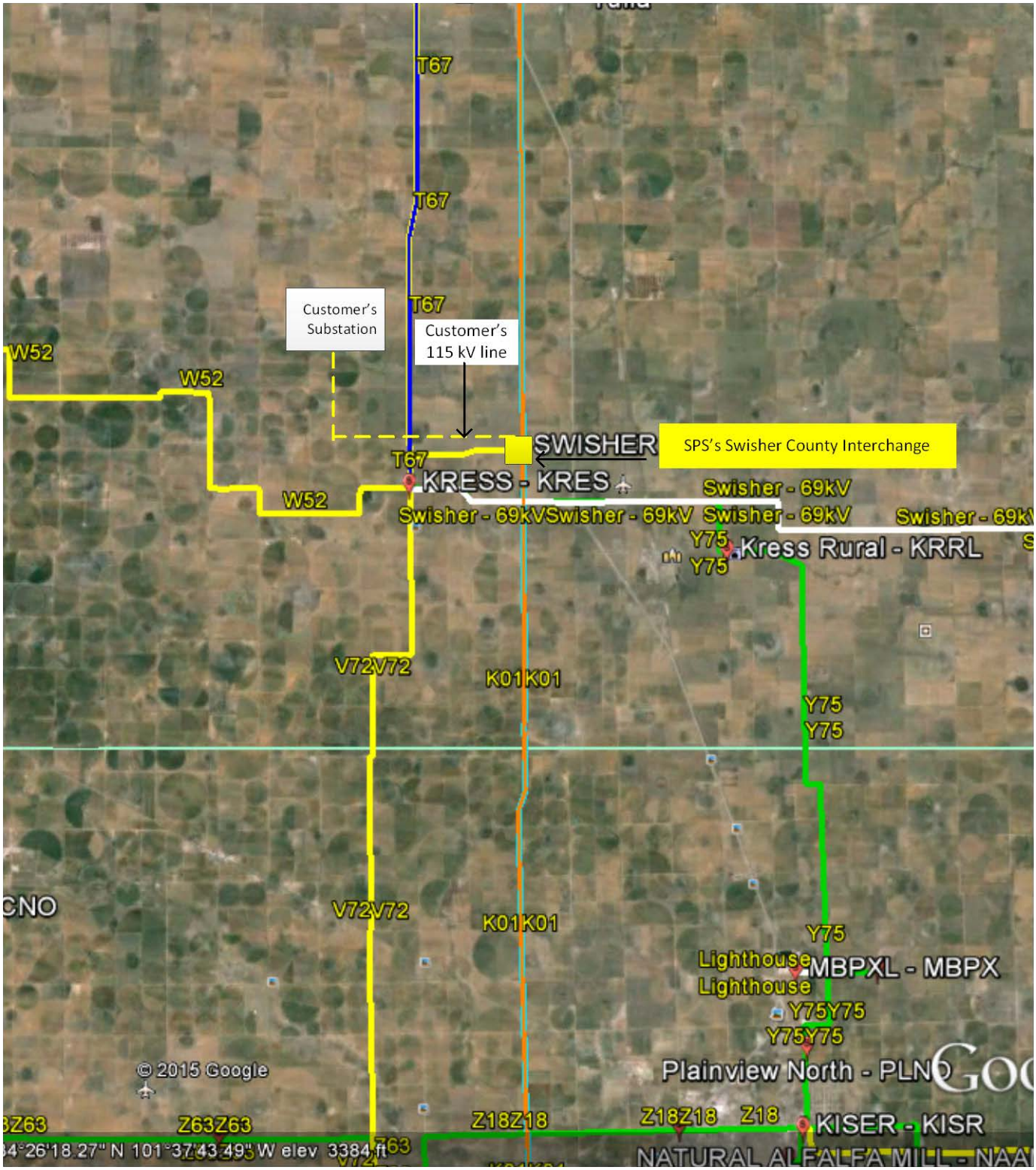


Figure A-1. Approximate location of GEN-2015-022 Swisher Interchange and IC's Solar Farm

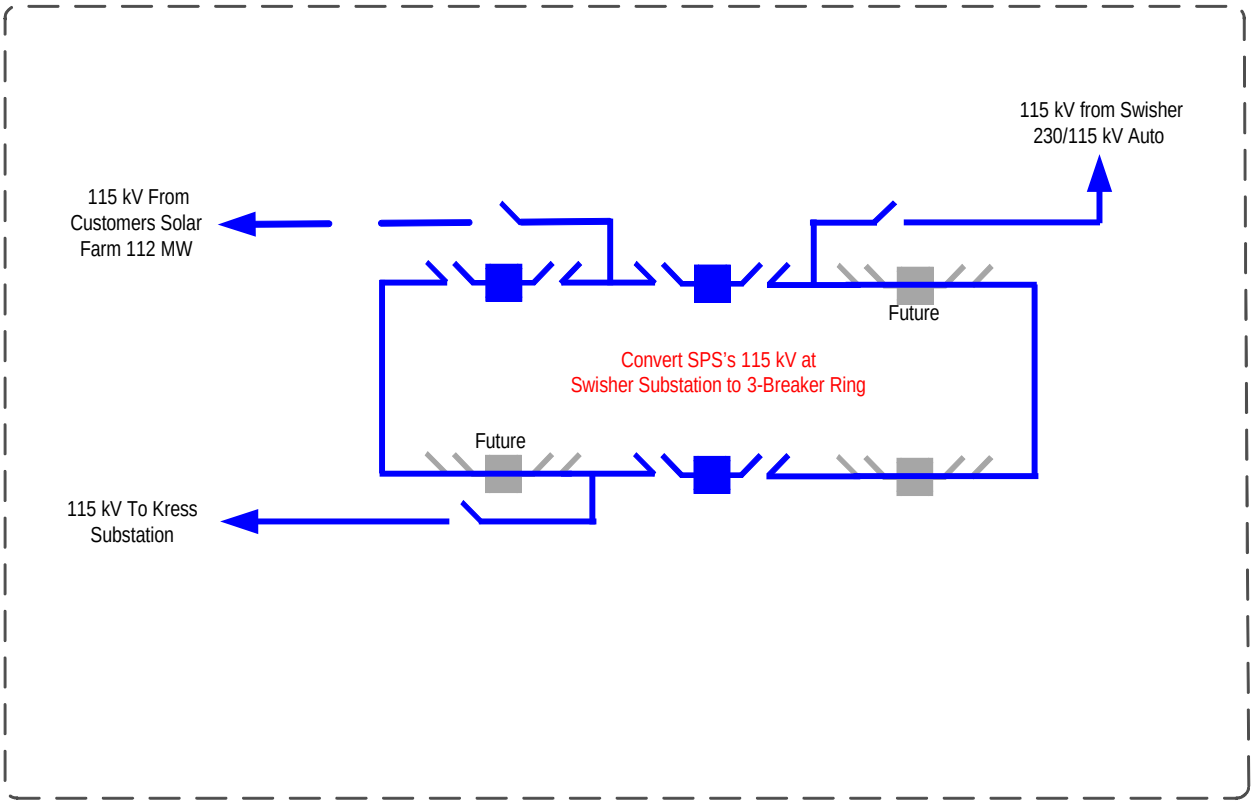


Figure A-2. One-line Diagram of Swisher County Interchange

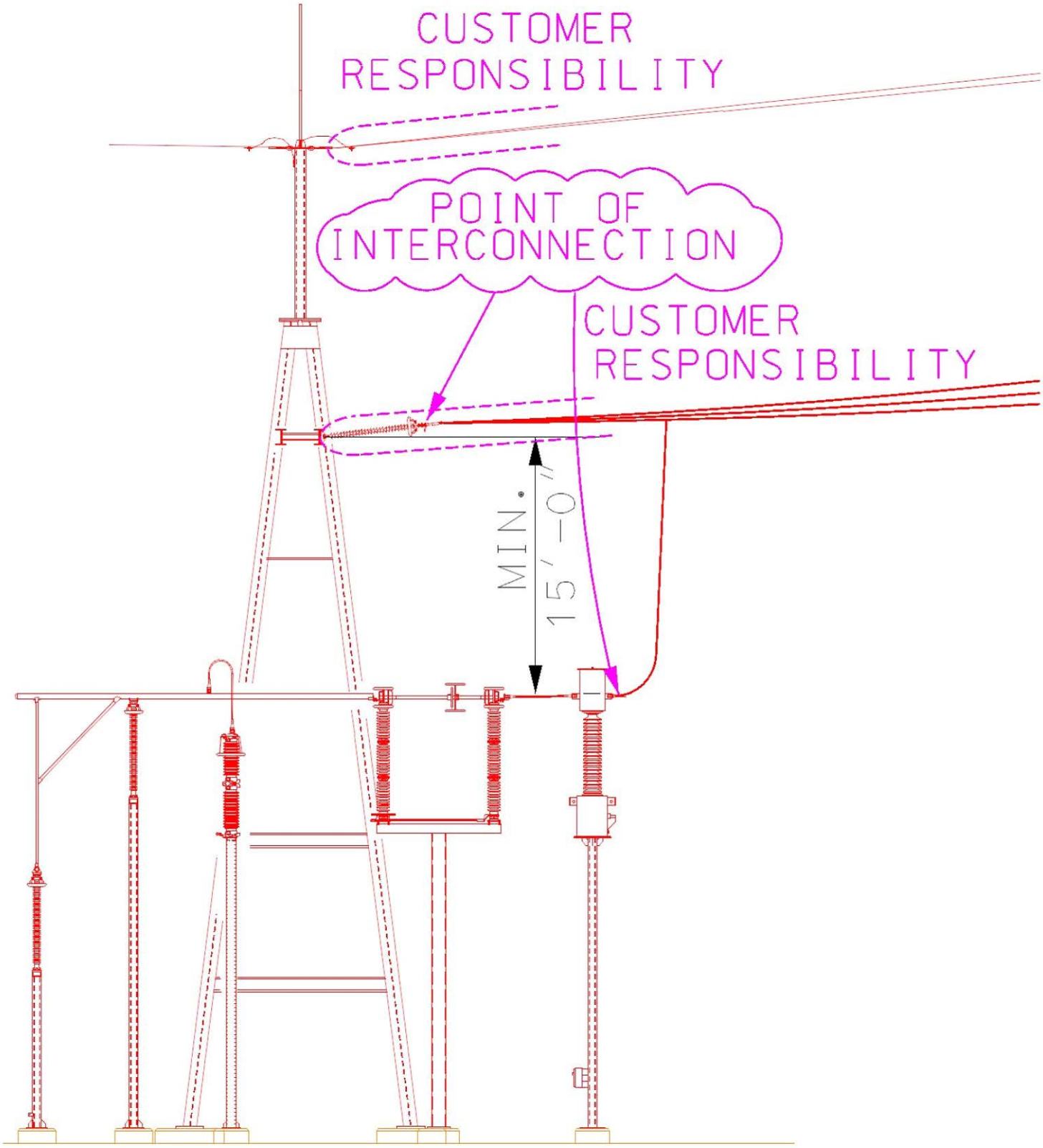


Figure A-3 Point of Interconnection & Change of Ownership (Typical)

– 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-2015-022/IFS-2015-001-19

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-2015-022 (112.00 MW/ Solar) Interconnection Request. SPP performed this no/reduced generation analysis for excessive capacitive charging current for the addition of the GEN-2015-022 facilities. The high side of the one (1) 115/34.5kV 69/92/115 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 the existing Southwestern Public Service Company (SPS) owned and maintained 115kV bus at Swisher Substation. A short (<1) 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-2015-022 is approximately 1.8 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-2015-022 with generator off and no shunt reactor(s)

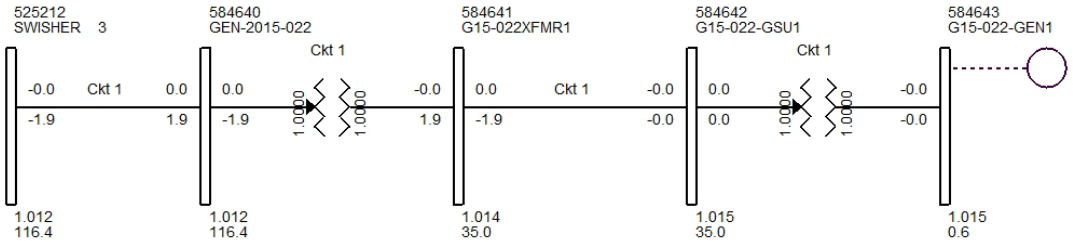


Figure 2: GEN-2015-022 with generators turned off and shunt reactors added to the low side of the GEN-2015-022 substation 115/34.5kV transformer

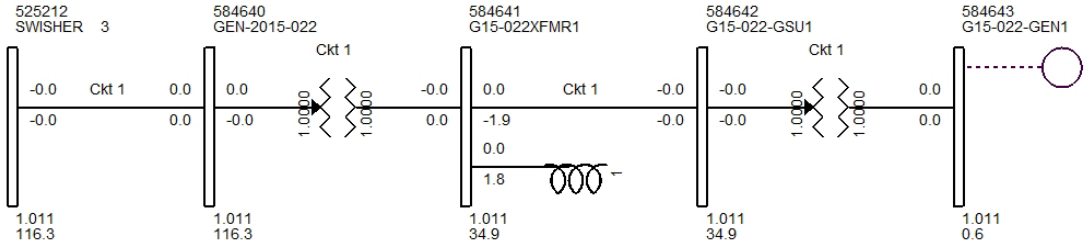


Table 1: No/Reduced Generation Analysis

Request	Size (MW)	Point of Interconnection	Shunt Reactive Mvar Requirement
GEN-2015-022	112.00	Swisher 115kV	1.8

Conclusion

A no/reduced generation analysis for wind or solar generating facilities has been performed for the GEN-2015-022 Interconnection Request. SPP performed this no/reduced generation analysis analysis for excessive capacitive charging current for the addition of the GEN-2015-022 facilities.

The no/reduced generation analysis has determined the need for the GEN-2015-022 Interconnection Request to install approximately 1.8 Mvars of reactor bank(s).