INTERCONNECTION FACILITIES STUDY REPORT

GEN-2014-074

(IFS-2015-001-17)

Published March 2017

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
2/10/2017	SPP	Initial draft report issued.	
3/31/2017	SPP	Initial final report issued.	Share Network Upgrade costs updated for Kress – Swisher 115kV CKT 1 Updated ratings mitigation

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SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2014-074/IFS-2015-001-17 is for a 152 MW generating facility located in Floyd 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). The Interconnection Customer's requested in-service date is December 31, 2017.

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. SPP has determined that full Interconnection Service will be available after the assigned Transmission Owner Interconnection Facilities, Shared Network Upgrade(s), Non-Shared Network Upgrade(s) and Other Network Upgrades are completed.

The primary objective of the IFS is to identify necessary Transmission Owner Interconnection Facilities, Network Upgrades, other direct assigned upgrades, cost estimates, and associated upgrade lead times needed to grant the requested Interconnection Service.

INTERCONNECTION CUSTOMER INTERCONNECTION FACILITIES

The Generating Facility is proposed to consist of seventy-six (76) 2.0 MW Vestas wind generators for a total generating nameplate capacity of 152.00 MW.

The Interconnection Customer's Interconnection Facilities to be designed, procured, constructed, installed, maintained, and owned by the Interconnection Customer at its sole expense include:

- A 34.5kV collector system
- One (1) 345/34.5kV 105/140/175 MVA (ONAN/ONAF/ONAF) step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation.
- A four (4) mile overhead 345kV transmission line to connect the Interconnection Customer's substation to the Point of Interconnection (POI) at the 345 kV bus in a new SPS substation ("Dougherty") to be owned and maintained by SPS.
- All transmission facilities required to connect the Interconnection Customer's substation to the Point of Interconnection (POI).
- Equipment at the Interconnection Customer's substation necessary to maintain a power factor at the POI between 95% lagging and 95% leading, including approximately 8.9Mvars[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.

The Interconnection Customer shall coordinate relay, protection, control, and communication system configurations and schemes with the Transmission Owner.

[1] This approximate minimum reactor amount is needed for the current configuration of the wind farm as studied in the DISIS-2015-001 Impact Study.

TRANSMISSION OWNER INTERCONNECTION FACILITIES AND NON-SHARED NETWORK UPGRADES

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 and provides an estimated lead time for completion of construction. The estimated lead times begin when the Generator Interconnection Agreement has been fully executed.

Table 1: Transmission Owner Interconnection Facilities

Description	Allocated Cost Estimate	Allocation	Total Cost Estimate	Construction Lead Time Estimate
345kV Line Terminal at Dougherty switching station: Construct one (1) 345kV line terminal, line switches, dead-end structure, line relaying, communications, revenue metering, line arrestors, and all facilities necessary to accept transmission line from Interconnection Customer's Generating Facility	$337,375	100%	$337,375	36 Months

Table 2 lists the Interconnection Customer's estimated cost responsibility for Non-Shared Network Upgrades and provides an estimated lead time for completion of construction. The estimated lead times begin when the Generator Interconnection Agreement has been fully executed.

Table 2: Non-Shared Network Upgrades

Description	Allocated Cost Estimate	Allocation	Total Cost Estimate	Construction Lead Time Estimate
SPS Dougherty Interconnection Substation Acquire twenty (20) acres of land for constructing a new substation, construct three (3) breaker ring 345kV bus, one (1) new line terminal, one (1) 4000A circuit breaker, control panel replacement, line relaying, disconnect switches, one (1) 35Mvar reactor, and associated equipment.	$17,389,971	100%	$17,389,971	36 Months
SPS Crawfish Draw 345/230kV Substation and Transformer Acquire land for constructing a new substation including a new three (3) 345kV breaker ring bus, new three (3) 230kV breaker ring bus, tap, loop-in, and re-terminate TUCO – Swisher 230kV and TUCO – Border 345kV transmission circuits at Crawfish Draw, build and install Crawfish Draw 345/230/13kV Transformer circuit #1, relocation of existing TUCO Interchange in-line reactors and associated terminal equipment for TUCO – Border 345kV to Crawfish Draw, foundations, structures, control panels, line relaying, disconnect switches, and associated equipment and materials	$24,764,205	100%	$24,764,205	36 Months
SPS Potter County 345/230/13kV Transformer circuit #2 Non-Shared Network Upgrades expand of existing substation configuration, construct one (1) 345kV terminal and one (1) 345kV breaker, one (1) 230kV terminal and one (1) 230kV breaker , one (1) new line terminal, one (1) 2000A circuit breaker, control panel replacement, line relaying, disconnect switches, and associated equipment and materials.	$5,924,670	100%	$5,924,670	36 Months
Total Non-Shared Network Upgrades	**$48,078,846**	**100%**	**$48,078,846**	**36 Months**

SHARED NETWORK UPGRADE(S)

The Interconnection Customer's share of costs for Shared Network Upgrades is estimated in Table 3 below.

The Interconnection Customer requested a Material Modification analysis to withdraw Network Resource Interconnection Service (NRIS) after executing the IFS agreement. The analysis showed that the modification would be material. The Interconnection Customer elected to not procced with the Material Modification..

An Electro-Magnetic Transient Program (EMTP) Study will be required after a GIA is signed to finalize any 345kV voltage shunt reactor configuration design, sizes, costs, and/or delivery.

Table 3: Shared Network Upgrades

Shared Network Upgrades Description	Allocated Cost Estimate	Allocation	Total Cost Estimate
SPS Sundown Interchange 230/115/13kV Transformer Circuit #1 Replacement Uninstall the existing Sundown Interchange 230/115/13kV transformer circuit #1 and replace it with a new 250MVA capacity 230/115/13kV transformer. One (1) 115kV breaker will need to be replaced with a 3000 continuous ampacity breaker. The Sundown Substation will require two (2) new control panels, updating protective and metering equipment, and associated and miscellaneous material.	$2,938,708	65.31%	$4,499,695
SPS Wolfforth Interchange 230/115/13kV Transformer Circuit #1 Replacement Uninstall the existing Wolfforth Interchange 230/115/13kV transformer circuit #1 and replace it with a new 250MVA capacity 230/115/13kV transformer. The Wolfforth Substation will require one (1) new control panel, switches, updating protective and metering equipment, and associated and miscellaneous. material.	$2,819,758	74.40%	$3,790,207
AEP-PSO Oklaunion 345kV Capacitor Bank(s): Install two (2) 130Mvar Capacitor Banks at Oklaunion, 2 additional 345kV breakers, expand 3-breaker 345kV ring bus configuration to 5-breaker 345kV ring bus, switches, relays, and any associated equipment.	$2,581,076	27.58%	$9,359,504
Total	**$8,339,542**	**40.70%**	**$17,649,406**

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 UPGRADES

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

Table 4: Other Network Upgrades Required for Full Interconnection Service

Description	Current Cost Assignment	Estimate In-Service Date
Tolk – Plant X 230kV circuit #1 and circuit #2 rebuilds.	DISIS-2014-002 Customers	6/1/2018
TUCO Interchange 345/230/13.2 kV transformer circuit #1 replacement.	DISIS-2014-002 Customers	6/1/2018
Wolfforth-Terry County 115 kV Circuit #1 terminal equipment upgrade per SPP NTC #200395.	2016 ITP-Near-Term	6/1/2018

CREDITS/COMPENSATION FOR AMOUNTS ADVANCED FOR NETWORK UPGRADES

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).

CONCLUSION

After all Interconnection Facilities, Shared Network Upgrades, and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 152.00 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 5: Cost Summary

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilities	$337,375
Network Upgrades	$56,418,388
Total	**$56,755,763**

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-2014-074
Total Output is 152 MW
Floyd County, Texas

Xcel Energy Services, Inc.

Transmission Planning South

January 4, 2016

Executive Summary

Interconnection Customer (IC) in 2015 requested an interconnection of a wind energy facility located in Floyd 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 152 MW. The IC's facility will connect to SPS's existing TUCO to Oklaunion J01 345 kV transmission line which is located approximately forty-four (44) miles east of TUCO Station at Dougherty Switching Station. The IC's requested commercial operation date is 12-31-2016.

The Southwest Power Pool (SPP) evaluated the request (GEN-2014-074) 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-six (76) turbines, which are Vestas V110 2.0 MW wind turbines for a total of 152 MW. The IC is required to build 345 kV transmission line from their substation wind farm facility to the SPS's new Dougherty Switching Station. 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 345 kV to interconnect at SPS's Dougherty Switching Station.

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

It is anticipated that the entire process of building a new 345 kV, 3-breaker ring kV switching station at Dougherty for the acceptance of the IC facility output and the network upgrades allocated to this project will require approximately 36 months to complete after an Interconnection Agreement is signed and an authorization to proceed is received. The IC'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:	**$**	**TBD**
Network Upgrades:	**$**	**17,389,971**
Transmission Owner Interconnection Facilities:	**$**	**337,375**
Total:	**$**	**17,727,346**

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

General Description of SPS[b] Facilities

1. **Construction of New Dougherty Switching Station:** See Appendix A, Figure A-1 for general vicinity location map.

   1.1. **Location:** Customer will build a new 345 kV line from their substation to SPS's new 345 kV Dougherty Switching Station which includes three (3) 345 kV breakers. Appendix A, Figure A-2, shows a preliminary one-line of Dougherty Switching Station, while Figure A-3 shows a typical elevation view of the normal Point of Interconnection (POI).

   1.2. **Bus Design:** The new 345 kV three-breaker ring-bus switching station 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 345 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 345 kV breaker line terminal primary protection to the interconnection customer 345 kV transmission line will use line current differential relaying over optical fiber installed in the static of the customer's 345 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 345 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 Dougherty Switching Station on the 345 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.

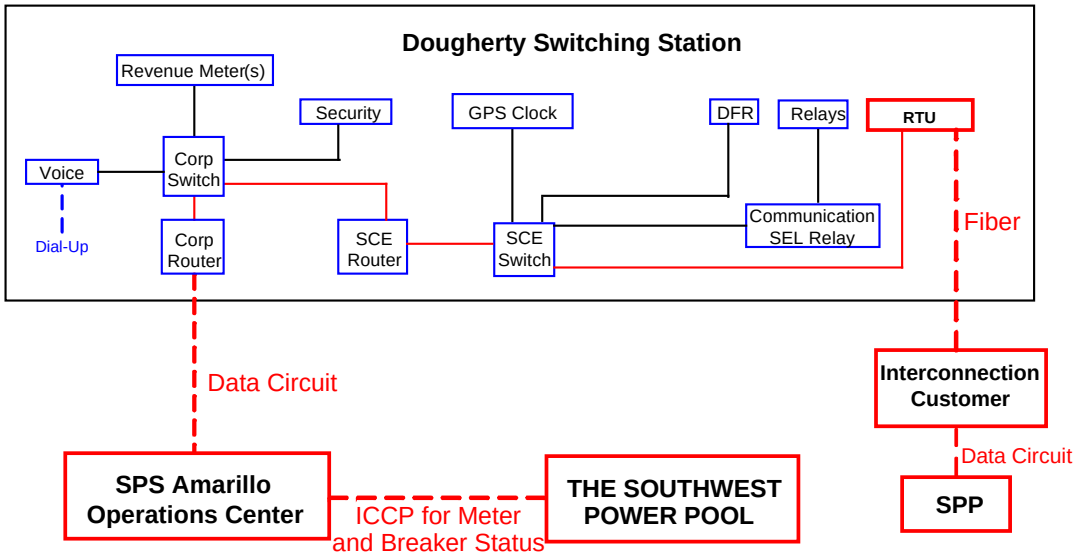
   1.7. Remote Terminal Unit (RTU): A new RTU will be utilized with communications for the new SPS switching station. A Communication SEL Relay will be installed for relay communications and other functions as required; these costs will be directly assigned to the IC. The IC will provide and install an 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 Dougherty Switching Station. 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 Dougherty Switching Station for protective relaying and for transmitting metering and status data to SPS.

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 345 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 345 kV at Dougherty Switching Station located approximately 44 miles east of TUCO Station towards Oklaunion on circuit J-1, 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 2014-074)				
Fault Location	Fault Current (Amps)		Impedance (Ω)	
	Line-to-Ground	3–Phase	Z^+	Z^0
345 kV Bus	2,599	3,450	4.03 + j35.95	16.14 + j71.48

Estimated Construction Costs

The projects required for the interconnection of 152 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 shared network upgrades: (GEN-2014-074)	$ TBD
	Subtotal:	**$ TBD**
	Network Upgrades (at the Interconnection Customer's expense)	
2	Communication Equipment (DFR, RTU and other related items)	$ 484,099
3	Land Approximately 20 acre	$ 129,011
4	Build new 3-ring bus for new Dougherty Switching Station with three new 345 kV breakers.	$ 13,515,099
5	Install 35 MVAr Reactor on the Dougherty to Oklaunion 345 kV line.	$ 1,692,796
6	Relay settings at Oklaunion	$ 30,367
7	Tap J-01 into Dougherty	$ 774,435
8	Tap out of Dougherty to J-01	$ 764,164
	Subtotal:	**$ 17,389,971**
	Transmission Owner Interconnection Facilities (at the Interconnection Customer's expense)	
9	Communications [d]	*$ See footnote*
10	Revenue metering	$ 280,000
11	345 kV Line arrestors	$ 57,375
	Subtotal:	**$ 337,375**
	Total Cost	**$ 17,727,346**

An Electro-magnetic Transient Program (EMTP) Study will be required after an IA is signed. This will finalize any 345 kV or higher voltage shunt reactor sizes, cost and delivery. See item #5 above.

Engineering and Construction:

An engineering and construction schedule for this project is estimated at approximately 36 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

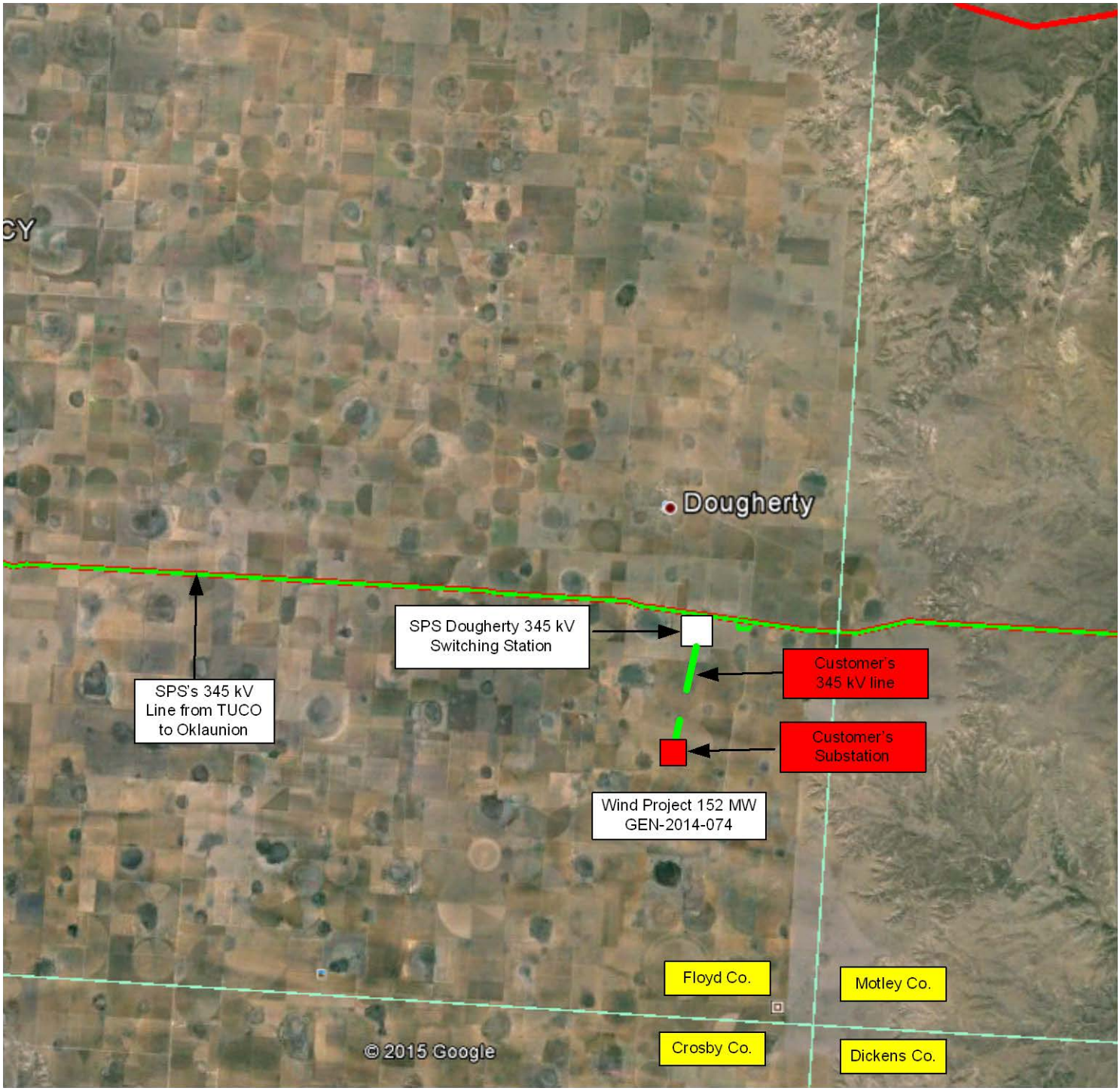


Figure A-1. Approximate location of Dougherty Switching Station and IC's Wind Farm

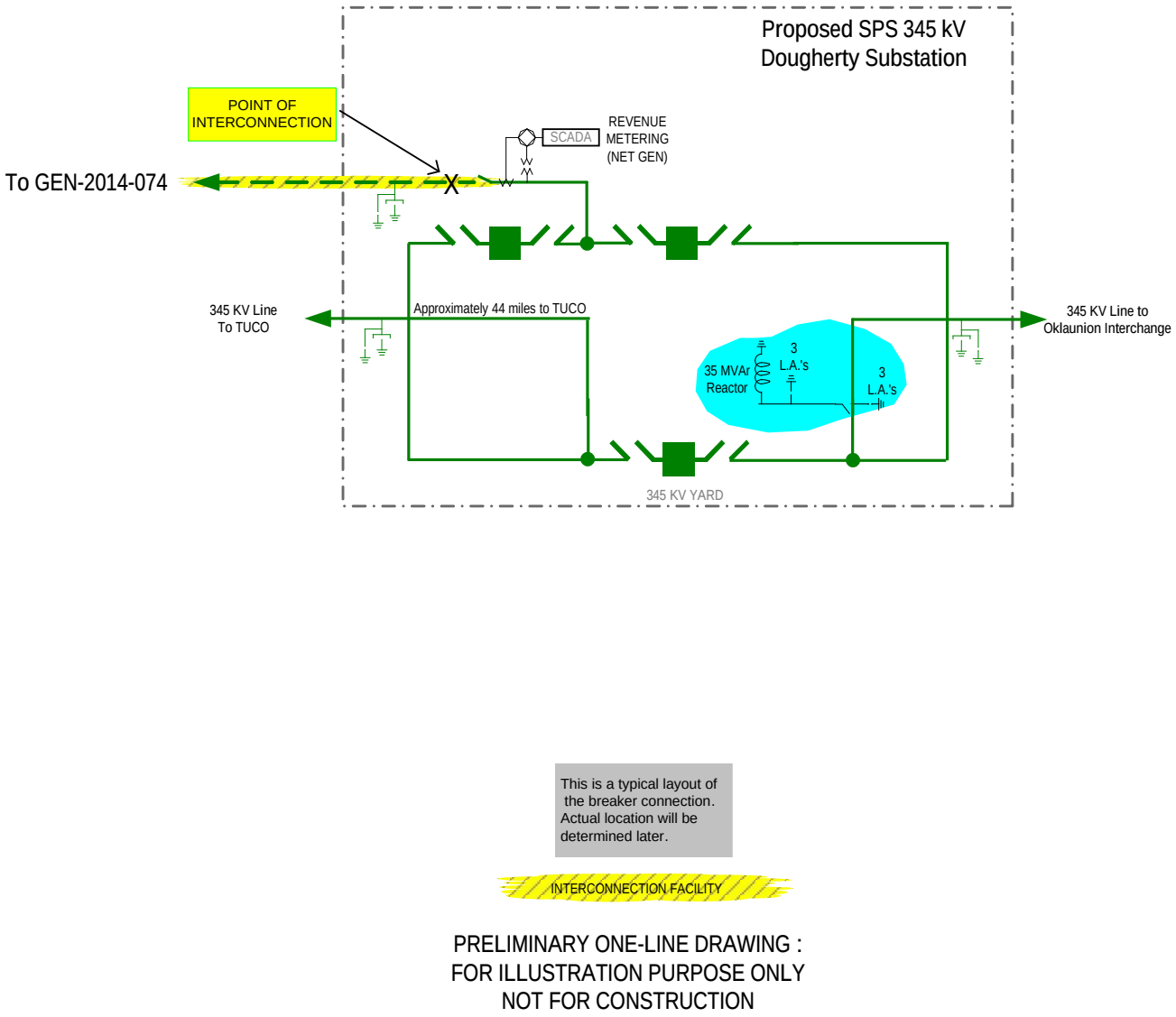
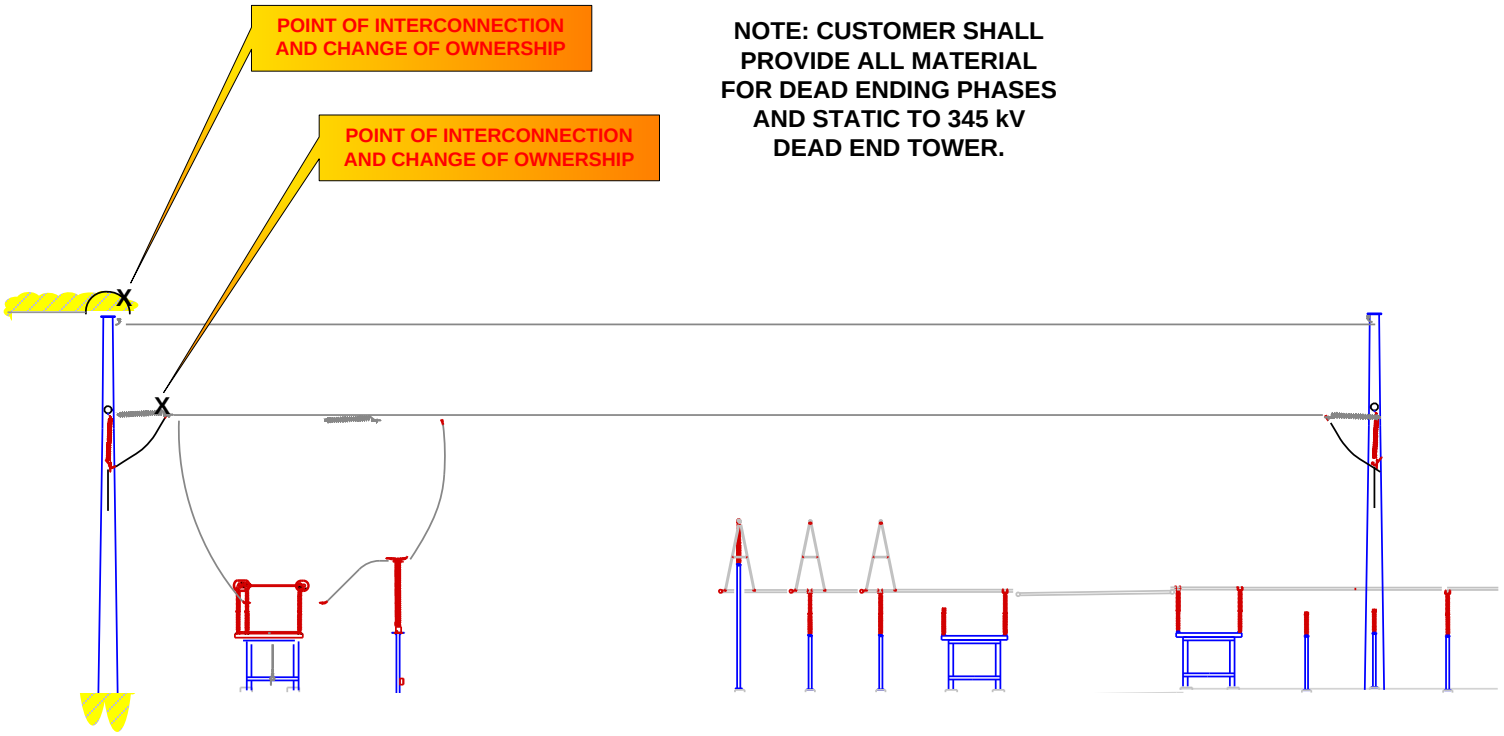


Figure A-2. One-line Diagram of New Dougherty Switching Station



NOTE: CUSTOMER SHALL PROVIDE ALL MATERIAL FOR DEAD ENDING PHASES AND STATIC TO 345 kV DEAD END TOWER.

THIS DRAWING ILLUSTRATES ONLY THE POINT OF INTERCONNECTION AND THE BOUNDARIES OF CUSTOMERS RESPONSIBILITY. IT MAY NOT BE USED FOR CONSTRUCTION

Customer's Responsibility

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

– END OF REPORT –