Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AD1-041

Harmony Village - Shackleford 115kV
30 MW Capacity / 50 MW Energy

July, 2020

General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Carvers Creek LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). Virginia Electric and Power Company is the Interconnected Transmission Owner (ITO) and provided the input to develop this study.

The IC has proposed a solar generating facility located in Gloucester Courthouse, VA (Gloucester County). The installed facilities will have a total capability of 50 MW with 30 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 03/31/2022. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AD1-041 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Harmony Village – Shackleford 115kV line #85.

Cost Summary

The AD1-041 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$548,161
Direct Connection Network Upgrades	$5,973,113
Non Direct Connection Network Upgrades	$1,764,458
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$0
Total Costs	**$8,285,732**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AD1-141 is a request to interconnect a 50 MW new solar generating facility to be located in Gloucester County, Virginia. AD1-041 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Harmony Village – Shackleford 115kV line #85.

Attachment Facility and Network Upgrade construction is estimated to be 14 - 24 months from ISA execution, and is highly dependent on outage availability.

2. Amendments to the System Impact Study data or System Impact Study Results

None

3. Interconnection Customer's Milestone Schedule

- Plan to break ground January 1, 2021
- Permits – state level Permit By Rule and county level final site plan approval complete December 15, 2020
- Substantial site work completed January 31, 2022
- Delivery of major electrical equipment October 31, 2021
- Back Feed Power December 15, 2021
- Commercial Operation May 31, 2022

4. Scope of Customer's Work

IC will build a solar generating facility in Gloucester County, Virginia. The generating facility will be comprised of solar arrays. AD1-041 consists of 23 x SMA Sunny Central 2500-US solar inverters rated at 2.202 MW each. The 23 x 34.5/0.55 kV GSU transformers each with a rating of 2.5 MVA (OA) will connect to the solar inverters to the 34.5 kV collector system. The generating facility will connect to the Point of Interconnection (POI) via a 115/34.5/13.8 kV wye ground/wye ground/delta main transformer with a rating of 34/45/56 MVA.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AD1-041 three-breaker ring bus switching station adjacent to the # 85 line between the existing Harmony Village and Shackleford substations. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from Carvers Creek LLC Collector Station for the new 50MW Solar Farm. The new 115kV Three Breaker Ring Substation will share a common footprint and fence line with Carvers Creek LLC Collector Station. The demarcation point between the two stations will be the 115kV Breaker Disconnect Switch 4-hole pad in the Carvers Creek LLC Collector Station by the common fence. Dominion Energy will bring its bus to the demarcation point. The bus, structures, disconnect switch, metering accuracy CCVT's,

metering accuracy CT's, protection and metering equipment will be Attachment Facilities. The grounding systems for each station will be tied together.

Transmission Lines to renumber will be the existing line segment between the new Three Breaker Ring Substation and Harmony Village Substation. The existing line segment between the new Three Breaker Ring Substation and Lanexa Substation shall remain Line 85.

Line 85 is insulated at 230kV to allow for a future line rating increase. Therefore, this project will be insulated at 230kV as well. All structures, buswork, and switches will be 230kV, while all apparatus, e.g. breakers, CCVT's, wave traps, PT's, surge arrestors, etc., will be 115kV rated.

There will be transmission line protection and anti-islanding work required at the remote line terminals at Harmony Village, Lanexa, Westport, and Shackleford substations. Site plan (Attachment 2) was developed by the ITO during PJM's generation queue process. The single line is shown in Attachment 1.

6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities	$266,345	$207,698	$46,340	$27,778	$548,161
Total Attachment Facilities Cost	$266,345	$207,698	$46,340	$27,778	$548,161
AD1-041 115 kV Switching Station (n6704)	$2,607,161	$2,635,056	$433,349	$297,547	$5,973,113
Line #85 Transmission work (n6705)	$851,722	$517,767	$153,013	$52,926	$1,575,428
Remote relay (n6706)	$102,269	$54,478	$22,813	$9,470	$189,030
Total Network Upgrades	$3,561,152	$3,207,301	$609,175	$359,943	$7,737,571
Total Project Costs	$3,827,497	$3,414,999	$655,515	$387,721	$8,285,732

7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

Facilities are estimated to take 14 - 24 months to construct and this is based on the ability to obtain outages to construct and test the proposed facilities.

Proposed Schedule

- Detailed design: 6-12 months
- Permitting: 6-12 months (Timeline runs concurrent with design)
- Construction 8-12 months

ITO requires the site to be fully graded and permitted site so they can start construction by January 2021.

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

The Attachment Facilities include the portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities collector station. The equipment associated with the Attachment Facilities include the metering accuracy CCVT's, metering accuracy CT's, disconnect switch, conductors and connectors.

Purchase and install substation material:

1. One (1), 230kV, 3000A 3-Phase Center Break Gang Operated Switch.
2. Three (3), 115kV, Metering Accuracy CCVT's.
3. Three (3), 115kV, 500:5 Metering Accuracy CT's.
4. Conductor, connectors, conduits, control cables, foundations, steel structures and grounding material as per engineering standards.

Purchase and install relay material:

1. One (1), 1109 – 28" Dual SEL-587Z Transmission Bus Panel
2. One (1), 4200 – Bus Differential C.T. M.U. Box
3. One (1), 1425 – 28" Dual SEL-735 Transmission & Generator Interconnect Metering Pnl.
4. One (1), 4524 – Revenue Metering C.T. M.U. Box
5. One (1), 4506 – CCVT Potential M.U. Box
6. One (1), 1323 – 28" SEL-487E/735 PMU & PQ Monitoring Panel
7. Two (2), 4541 - Control Cable M.U. Box

2. Transmission Line – Upgrades

PJM Network Upgrade #n6705 - Re-arrange line #85 to loop into and out of the new three breaker AD1-041 115 kV switching station

Constructed in 1979 on double-circuit steel H-frames, Line 85 is an existing 115kV line that runs parallel with Line 2016 from Lanexa Substation to Harmony Village Substation. Project number AD1-041 provides for the construction of a new Substation between structures 85/161 and 85/162 in Gloucester County, Virginia to support the new 50MW Solar Farm built by Carvers Creek LLC.

The transmission line work associated with this project includes the installation of one heavy duty backbone structure, two static pole structures, and two engineered double-circuit monopole structures, as well as the removal of two existing double-circuit H-frame structures (85/161 and 85/162). The existing line segment between the proposed Substation and Harmony Village will need to be renumbered, while the existing line segment between the proposed Substation and Lanexa Substation shall remain Line 85.

The conceptual design and estimate includes costs for the following:

ESTIMATE OF FACILITIES TO BE INSTALLED:

1. Install one (1) Heavy Duty DC Steel Backbone structure w/ foundation.
2. Install two (2) steel static pole structures w/ foundations.

3. Install two (2) DC Engineered DDE Steel Monopoles structures w/ foundations.
4. Install approximately 0.3 miles of 3-phase 1033.5 ACSS (45/7) conductor.
5. Install approximately 0.15 miles of single-phase 3#6 AW static wire.
6. Install approximately 0.27 miles of single-phase 7#7 AW static wire

ESTIMATE – FACILITIES TO BE REMOVED:

1. Remove two (2) existing steel DC H-frame structures (existing structures 2016, 85/161 and 2016, 85/162).
2. Remove approximately 0.3 miles of 3-phase 1033.5 ACSS (45/7) conductor.
3. Remove approximately 0.6 miles of single-phase 3#6 AW static wire.

ESTIMATE – FACILITIES TO BE MODIFIED:

1. Renumber approximately 52 existing structures.
2. Transfer four (4) spans of existing 3-phase 1033.5 ACSS (45/7) conductor and four (4) spans of single-phase 3#6 AW static wire to new monopole structures.

ESTIMATE ASSUMPTIONS

1. Structures were spotted inside the substation using a preliminary general arrangement. Estimate assumes that detailed substation drawings with exact locations of structures, equipment, and fence will be provided during detailed design.
2. Access costs are elevated as a result of the assumption that clearing for the proposed substation will not be complete at the time of line work. This estimate is factoring in access needing to enter from Glenns Road, which is approximately 4 spans to the East. If the proposed substation is cleared and access to the line is available, the access cost will be significantly lower.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n6704 - Build a three breaker AD1-041 115 kV switching station. The site is located along Dominion Energy's existing 115kV, 85 Line from Harmony Village Substation to Shackleford Substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from Carvers Creek LLC Collector Station for the new 50MW Solar Farm.

The new 115kV Three Breaker Ring Substation will share a common footprint and fence line with Carvers Creek LLC Collector Station. The demarcation point between the two stations will be the 115kV Breaker Disconnect Switch 4-hole pad in the Carvers Creek LLC Collector Station by the common fence. Dominion Energy will bring its bus to the demarcation point. The bus, structures, disconnect switch, metering accuracy CCVT's, metering accuracy CT's, protection and metering equipment will be Attachment Facilities. The grounding systems for each station will be tied together. Transmission Lines to renumber the existing line segment between the new Three Breaker Ring Substation and Harmony Village Substation. The existing line segment between the new Three Breaker Ring Substation and Lanexa Substation shall remain Line 85. The developer will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the developer.

Security and Fence Type – Design Level 4.

Line 85 is insulated at 230kV to allow for a future line rating increase. Therefore, this project will be insulated at 230kV as well. All structures, buswork, and switches will be 230kV, while all apparatus, e.g. breakers, CCVT's, wave traps, PT's, surge arrestors, etc., will be 115kV rated.

Note: Currently, the scope and estimate assume DVP standard spread footer foundations. Once the soil information is received and if it is decided to change that to "pile foundations" then DVP team should be informed at the earliest to adjust the project estimate.

The work required is as follows:

Purchase and install substation material - Direct Network Upgrade:

1. Approximately 275' x 300' site preparation and grading as required for installation of the switching station (by the developer).
2. Approximately 1,500 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the station along with the security cameras and integrators as per Design 4 fence standards.
3. Three (3), 115kV, 2000A, 40kAIC, SF-6 Circuit Breakers.
4. Six (6), 230 kV, 3000A, 3-Phase Center Break Gang Operated Switches.
5. Six (6), 115kV, Relay Accuracy CCVTs.
6. Two (2), 115kV, 2000 A Wave Traps.
7. Two (2), Line Tuners.
8. Nine (9), 90kV,MCOV surge arresters.
9. Two (2), 230kV, 3000A, 2-Phase Center Break Gang Operated Switches (for PVT's).
10. Four (4), 115kV, 100KVA Power PT's for Station Service.
11. Oil Containment for 115kV PVT's.
12. One (1), 230kV, Heavy Duty Steel Backbone (by Transmission).
13. Two (2) shield wire poles and three span of shield wires (by Transmission).
14. One (1), 24' x 40' control enclosure.
15. One (1), 125 VDC, 300 Ah Station Battery and 50 Amp Charger (size to be verified during detail engineering).
16. Approximately 220 FT of Cable Trough, with a 20FT road crossing section.
17. Station Stone as required.
18. Station Lighting as required.
19. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports.
20. Foundations as required including control house, equipment and bus support stands.
21. Conductor, connectors, conduit, control cables, cable trough, and grounding materials as per engineering standards.

Purchase and install relay material - Direct Network Upgrade:

1. Three (3), 1510 – 28" Dual SEL-351-7 Transmission Breaker w/ Reclosing Panel
2. Three (3), 4510 - SEL-2411 Breaker Annunciator
3. Two (2), 1320 – 28" Dual SEL-421-5 DCB Line Panel
4. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box
5. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel
6. Two (2), 4000 – Station Service Potential M.U. Box
7. Two (2), 4018 – 500A Station Service AC Distribution Panel
8. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD
9. Two (2), 4019 – 225A Three Phase Throwover Switch
10. Two (2), 4016 – 600A PVT Disconnect Switch
11. One (1), 4153 – Wall Mount Station Battery Monitor
12. One (1), 5612 - SEL-3530 Data Concentrator Panel
13. One (1), 1255 – Station Annunciator Panel
14. One (1), 5021 – SEL-2411 RTU Panel
15. One (1), 5609 – Fiber Optic Management Panel
16. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box
17. One (1), 5202 – 26" APP 601 Digital Fault Recorder
18. One (1), 5603 – Station Network Panel No. 1
19. One (1), 5603 – Station Network Panel No. 2
20. One (1), 4523 – Security Camera Interface Box
21. One (1), 5616 – Station Security Panel
22. One (1), High Voltage Protection (HVP) Box (Provided by IT)
23. One (1), Telephone Interface Box

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n6706 - Remote protection and communication work. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Lanexa, West Point, Shackleford, and Harmony Village 115kV substations. These costs include the following:

Lanexa 115 kV Substation

Project Summary:

Includes the drawing work, relay resets, and field support necessary to change Line 85 destination from Harmony Village to AD1041 Substation. Also install Line 85 Islanding Transfer Trip scheme to work with the new AD1041 Substation. This project is the on-Direct Network Upgrade for the AD1041 Generator Interconnect project.

Purchase and install relay material:

1. One (1), 1604 – 24" Transmission Transfer Trip Panel

West Point 115 kV Substation

Project Summary:

Includes the drawing work, relay resets, and field support necessary to change the Line 85 destination from Harmony Village Substation to the new AD1041 Generator Interconnect Substation. This project is the Non-Direct Connect for the AD1041 Generator Interconnect project.

Purchase and install relay material:

1. No Relay Material

Shackleford 115 kV Substation

Project Summary
Includes the drawing work, relay resets, and field support necessary to change Line 85 destination from Harmony Village to AD1041 Substation. Also receive Line Breaker Failure Transfer Trip via PLC from AD1041, formerly received from Harmony Village. This project is the Non-Direct Network Upgrade for the AD1041 Generator Interconnect project.

Purchase and install relay material:

1. No Relay Material

Harmony Village 115 kV Substation

Project Summary
Includes the drawing work, relay resets, and field support necessary to change Line 85 destination from Lanexa to AD1041 Substation. Also install Line 85 Islanding Transfer Trip scheme to work with the new AD1041 Substation. This project is the Non-Direct Network Upgrade for the AD1041 Generator Interconnect project.

Purchase and install relay material:

1. One (1), 1604 – 24" Transmission Transfer Trip Panel

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
West Point Protection	$11,563	$0	$2,689	$0	$14,252
Shackleford Protection	$16,052	$0	$3,540	$0	$19,592
Harmony Village Protection	$37,327	$27,239	$8,292	$4,735	$77,593
Lenexa Protection	$37,327	$27,239	$8,292	$4,735	$77,593
Total Remote Relay Upgrades	$102,269	$54,478	$22,813	$9,470	$189,030

5. Metering & Communications

PJM Requirements

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 8 of Attachment O Appendix 2.

ITO Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Interconnection Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

At the IC's expense, the ITO will supply and own at the Point of Interconnection bi-directional revenue metering equipment that will provide the following data:

a. Hourly compensated MWh received from the Customer Facility to the ITO;
b. Hourly compensated MVARh received from the Customer Facility to the ITO;
c. Hourly compensated MWh delivered from the ITO to the Customer Facility; and
d. Hourly compensated MVARh delivered from the ITO to the Customer Facility.

The IC will supply and own metering equipment that will provide Instantaneous net MW and MVar per unit values in accordance with PJM Manuals M-01 and M-14D, and Sections 8.1 through 8.5 of Appendix 2 to the ISA;

The IC will access revenue meter via wireless transceivers or fiber cabling to meter with RS-485 or Ethernet communication port for dial-up reads. IC must provide revenue and real time data to PJM from Interconnection Customer Market Operations Center per "PJM Telemetry Data Exchange Summary" document available at PJM.com.

6. Environmental, Real Estate and Permitting Issues

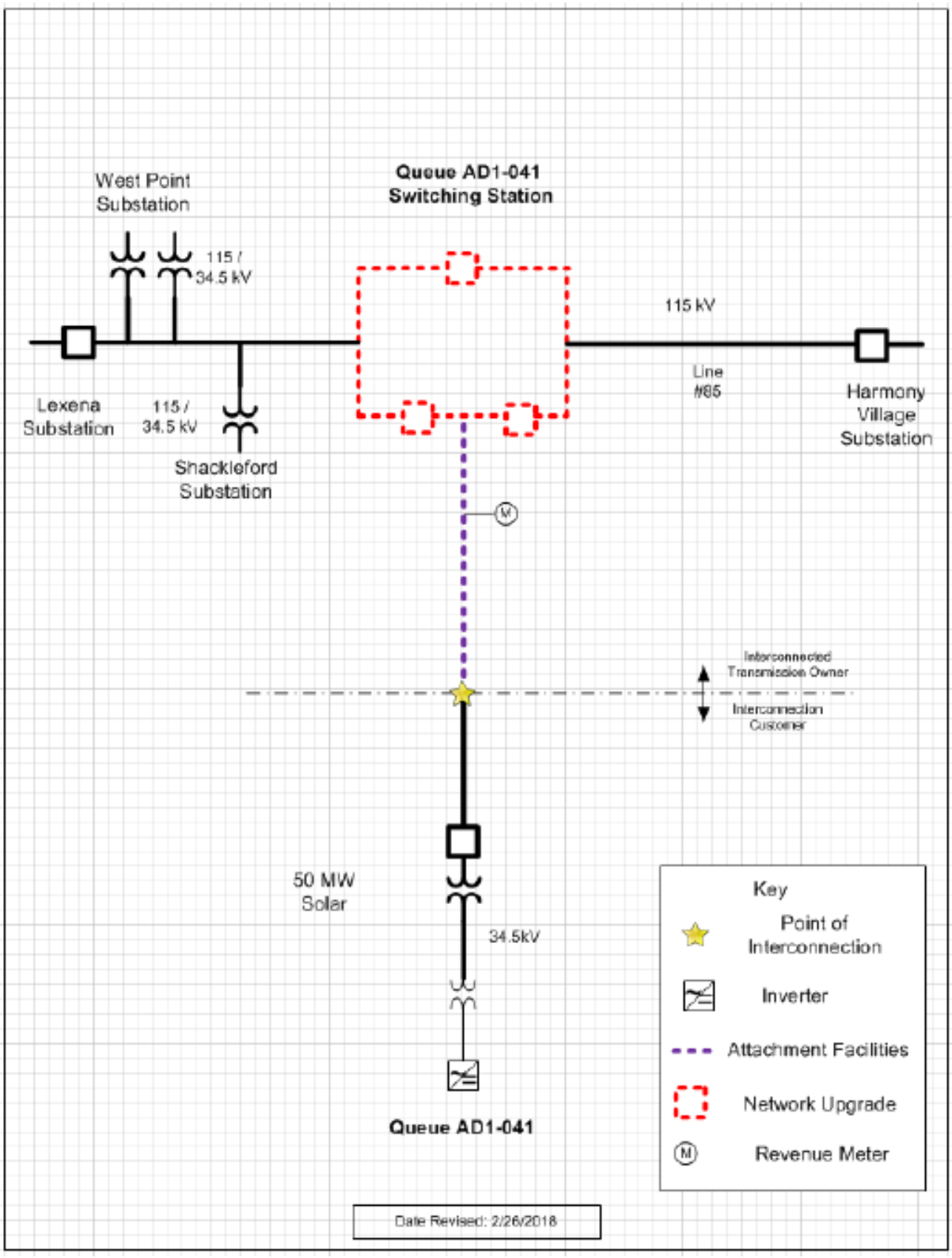
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a Virginia State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.

ITO Real Estate Needs:

- The substation layout is complete and ITO requires a 275'x 300' piece of property (title in fee) to build the substation. The property includes the piece of property between the substation and collector station for the strain bus.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by January 2021.
    - The size of the station assumes ITO will not need a separate storm water management system for the substation. If the county rules differently than the ITO will need to revisit the land requirements.
- ITO will need a letter similar to the zoning letter from the county stating that if the solar farm is retired and / or decommissioned the substation will remain.

Attachment 1.
Single Line



Attachment 2.
AD1-041 Switching Station General Arrangement