Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AC1-120 / AC1-121

Mitchell – Mountain Run 115kV
53.2 MW Capacity / 80 MW Energy

February, 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 Cricket Solar 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.

IC has proposed a solar generating facility located on Crystal Hill Road, Culpepper County, Virginia. The installed facilities will have a total capability of 80 MW with 53.2 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 6/1/2022. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AC1-120 \ AC1-121 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects onto the Mitchell – Mountain Run 115kV line # 2.

Cost Summary

The AC1-120 \ AC1-121 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 488,920
Direct Connection Network Upgrades	$ 5,324,506
Non Direct Connection Network Upgrades	$ 1,595,989
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$7,409,415**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AC1-120 \ AC1-121 is a request to interconnect an 80 MW new solar generating facility to be located in Culpepper County, Virginia. The proposed generating facility will interconnect with the ITO's new AC1-120 115kV switching station via a new three breaker ring-bus switching station. Attachment Facility and Network Upgrade construction is estimated to be 8 – 12 months.

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

None

3. Interconnection Customer's Milestone Schedule

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

4. Scope of Customer's Work

IC will build a solar generating facility in Culpepper County, Virginia. The generating facility will be comprised of solar arrays. AC1-120 \ AC1-121 consists of 34 x 2.7 MVA TMEIC Solar Ware 2700 PVH-L2700GR inverters. The 34 x 34.5 / 0.600 kV grounded wye / delta 2.7 MVA generator step up (GSU) transformers 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 power transformer with a rating of 53/70.5/88 MVA. The AC1-120 \ AC1-121 POI will be at a tap of the Mitchell – Mountain Run 115kV line # 2.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AC1-120 ring bus switching adjacent to the # 2 line. The site is located along the ITO's 115kV line # 2 between existing Mitchell and Mountain Run substations. The switching station will be positioned in such a way that the new backbone structure will be between existing structures 2/542 and 2/543. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. The lines will consume two of the three positions in the ring bus. The third position will be for the 115 kV feed from the collector station for the solar farm.

The Point of Interconnection between the switching station and the collector station will be the 115kV breaker disconnect switch 4-hole pad in the Cricket Solar, LLC's collector station by the common fence. The ITO will bring its bus to the demarcation point. Metering equipment will be installed in the ITO switching station. The grounding systems for both stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC. There will be transmission line protection and anti-islanding work required at the remote lines terminals at Oak Green, Mountain Run and Remington 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	$275,616	$149,022	$47,584	$16,698	$488,920
Total Attachment Facilities Cost	$275,616	$149,022	$47,584	$16,698	$488,920
AC1-120 115 kV Switching Station (n6336)	$2,446,354	$2,030,429	$581,603	$266,120	$5,324,506
Line #2 Transmission work (n6335)	$815,735	$351,076	$126,712	$54,868	$1,348,390
Remote relay (n6334)	$136,332	$74,435	$25,256	$11,576	$247,599
Total Network Upgrades	$3,398,421	$2,455,940	$733,571	$332,564	$6,920,495
Total Project Costs	$3,674,037	$2,604,962	$781,155	$349,262	$7,409,415

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 to 12 months

ITO requires the site to be fully graded and permitted site so they can start construction by April 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 Point of Interconnection with the generator will be the 115kV breaker disconnect switch 4-hole pad in the

Cricket Solar, LLC's Collector Station by the common fence. ITO will bring its bus to the demarcation point. Metering equipment will be installed in the ITO switching station. The equipment associated with the Attachment Facilities includes the following. 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) 115 kV, 2000A, 3-phase center break gang operated switch
2. Three (3) 115 kV metering accuracy CCVT's
3. Three (3) 115 kV metering accuracy CT's
4. Conductors, connectors, conduits, control cables, foundations, steel structures and grounding material

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 Metering Panel (Transmission & Generation Interconnect)
4. One (1), 4524 – Revenue Metering C.T. M.U. Box
5. One (1), 4531 – Generator Interconnect 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 #n6335 - Re-arrange line #2 to loop into and out of the new three breaker AC1-120 115 kV switching station between existing Mitchell and Mountain Run substations. The line connection will require the installation of (1) backbone structure and two (2) static pole structures. The conceptual design and estimate includes costs for the following:

STRUCTURE INSTALLATIONS:

1. Install (1) 230KV Galvanized Double Circuit Steel Backbone Structure (no switches) with 38'-0" spacing with foundations.
2. Install (2) Galvanized Static Pole Structure with Foundations.
3. Renumber approximately 40 structures with the new line number between the AC1-120 substation and Oak Green substation.

CONDUCTOR/SHIELD WIRE INSTALLATIONS:

1. Cut and Transfer (4) existing spans of 3-Phase 2-636 ACSR conductor to the new double circuit backbone structures (two spans will run from Ex. Str. 2/543 – Proposed BB, the other two spans will run from Str. Proposed BB – 2/544).
2. Cut and Transfer (2) existing spans of OPGW to the new backbone structures (two spans will run from Ex. Str. 2/543 – Proposed BB, the other two spans will run from Str. Proposed BB – 2/544).
3. Install approximately 0.12 miles (3 pans) of 1-7#7 static wire from the Proposed Backbone Structure to the Proposed Static poles.
4. Move existing structure 2/543 approximately 260 ft. towards existing structure 2/542 and replace anchor bolt cage.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n6336 - Build a three breaker AC1-120 115 kV switching station. The site is located along the ITO's 115kV line #2 from Mitchell and Mountain Run substations.

The site is located along ITO's existing 115kV, #2 line from Oak Green substation to Mountain Run substation. The cut line will consume two of the positions in the ring bus. The third position will be for the 115kV feed from ICs collector station for the new solar facility. The new 115kV three breaker ring substation will share a common foot print and fence line with IC's collector station. The grounding systems for each station will be tied together.

Detail engineering to inquire if pre-ordered material is available, otherwise the project will follow the current long lead time material ordering process.

Currently, the scope and estimate assumes the use of ITO standard spread footer foundations. Once the soil information is received and pile foundations may be required. The change to pile foundations will require adjustment to the project cost estimate.

The work required is as follows:

Purchase and install substation material:

1. Approximately 300' X 175' site preparation and grading as required for installation of the switching station (by the IC)
2. Three (3), 115kV, 3000A, 40 kA, SF-6 Circuit Breakers
3. Six (6), 115kV, 2000A Center Break Switches
4. Two (2), 115kV, 2000A, 2-Pole Center Break Switches (for PVT's)
5. Six (6), 115kV, CCVT's relay accuracy
6. Two (2), 2000A, Vertically Mounted, Wave Traps
7. Two (2), Line Tuners
8. Six (6), 90kV MO, Station Class, 74kV MCOV Surge Arresters
9. Four (4), 115kV, 100KVA Power PT's for Station Service
10. One (1), 24' x 40' Control Enclosure, prewired by Trachte
11. One (1), 135VDC, 577Ah Batteries with Charger
12. Oil Containment as required for 115kV PVT's.
13. Cable Trough as required
14. Tubular bus as required
15. Ground Grid as required
16. Fence as required (Security Design Level 4)
17. Steel Structures as required
18. Conductor, connectors, conduit, control cable, foundations and grounding material as required per engineering standards

Purchase and install relay material:

1. Three (3), 1510 – 28" Dual SEL-351-7 Transmission Breaker w/ Reclosing Panel
2. Three (3), 4510 - SEL-2411 Breaker Annunciator
3. One (1), 1320 – 28" Dual SEL-421-5 DCB Line Panel
4. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel

5. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box
6. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel
7. Two (2), 4000 – Station Service Potential M.U. Box
8. Two (2), 4018 – 500A Station Service AC Distribution Panel
9. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD
10. Two (2), 4019 – 225A Three Phase Throwover Switch
11. Two (2), 4016 – 600 A Disconnect Switch Fused @ 500A
12. One (1), 4153 – Wall Mount Station Battery Monitor
13. One (1), 5612 - SEL-3530 Data Concentrator Panel
14. One (1), 1255 – Station Annunciator Panel
15. One (1), 5021 – SEL-2411 RTU Panel
16. One (1), 5609 – Fiber Optic Management Panel
17. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box
18. One (1), 5202 – 26" APP 601 Digital Fault Recorder
19. One (1), 5603 – Station Network Panel 1
20. One (1), 5603 – Station Network Panel 2
21. One (1), 4523 – Security Camera Interface Box
22. One (1), 5616 – Station Security Panel
23. One (1), High Voltage Protection (HVP) Box
24. One (1), Telephone Interface Box

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n6334 - 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 Oak Green, Mountain Run, and Remington 115kV substations. These costs include the following:

Oak Green 115 kV Substation

Project Summary
Drawing work, relay resets, and field support necessary to change line #2 destination from Mountain Run substation to the AC1-120 substation. Also install line #2 breaker failure & islanding transfer trip scheme to work with the new AC1-120 substation. The Line 2 Wave Trap at Oak Green would need to be replaced. The estimated cost of this scope is $127,491.

Purchase and install relay material:
1. One (1), 2000A, 115-300KHz Wave Trap
2. One (1), 1604 – Islanding Transfer Trip Panel 24"

Mountain Run 115 kV Substation

Project Summary
Drawing work, relay resets, and field support necessary to change line #2 destination from Oak Green substation to the AC1-120 substation. Also install line #2 breaker failure & islanding transfer trip scheme to work with the new AC1-120 substation. Note that since Mountain Run only has a line tie breaker, the islanding scheme will need to extend to the next substation, Remington (line #70). Breaker positions at Remington will transmit to Mountain Run to pass

through along with the breaker position at Mountain Run to AC1-120. Due to the lack of relay panel space, the islanding schemes will be installed in the existing sectionalizing panel. The estimated cost of this scope is $55,339.

Purchase and install relay material:

1. One (1), CT-51C Islanding Transfer Trip Transmit Set
2. One (1), CR-51C Islanding Transfer Trip Receive Set
3. One (1), SEL-2411 94/ITR

Remington 115 kV Substation

Project Summary
Installation of line #70 islanding transfer trip scheme to work with the new AC1-120 generator interconnect substation. Note that since Mountain Run substation (AC1-120 is between Mountain Run and Mitchell substation on the #2 line) only has a line tie breaker, the islanding scheme will need to extend to the next substation, Remington (line #70). Breaker positions at Remington will transmit to Mountain Run to pass through along with the breaker position at Mountain Run to AC1-120 for islanding conditions.

The existing control enclosure at Remington substation will not accommodate the additional relays. ITO project 992523 (PJM Network Upgrade b2686) at Remington will install a new transmission control enclosure that is scheduled for an April, 2020 completion. It is assumed that the timing of this project will allow this relay addition to be installed in that new control enclosure. If not, alternative plans will be needed that will affect the cost of the project. The estimated cost of this scope is $64,769.

Purchase and install relay material:

1. One (1), 1604 – 28" Transmission Transfer Trip Panel

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Oak Green	$78,339	$31,428	$12,812	$4,912	$127,491
Mountain Run	$29,018	$17,631	$5,934	$2,756	$55,339
Remington	$28,975	$25,376	$6,510	$3,908	$64,769
Total Remote Relay Upgrades	$136,332	$74,435	$25,256	$11,576	$247,599

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

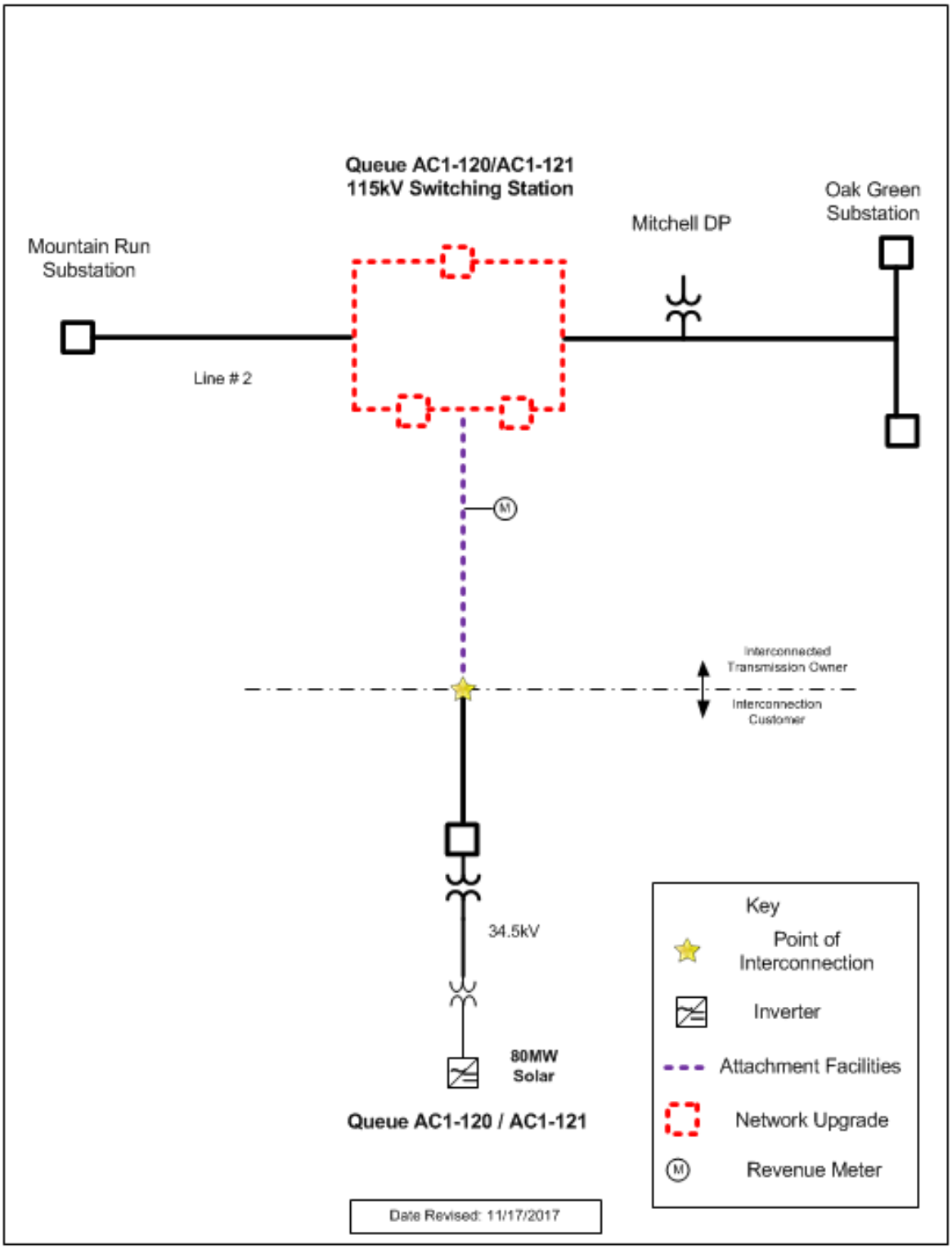
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- 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 300'x 175' 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 March 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 then 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.
AC1-120 \ AC1-121 Switching Station General Arrangement