Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA2-146

Catoctin 34.5 kV

May 2016

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate Interconnected Transmission Owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation, if any, is included in the System Impact Study.

The Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs associated with them will be addressed when seeking an Interconnection Agreement as outlined below. Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

CERSM, LLC ("Interconnection Customer" or "CERSM") has proposed a solar generating facility located at approximately 3.5 miles south from Catoctin substation, on the east side of Catoctin Furnace Road, Frederick County, Maryland. The installed facilities will have a total capability of 20 MW with 10.9 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is September 15, 2016. **This study does not imply a Potomac Edison Company commitment to this in-service date.**

Point of Interconnection (POI)

For AA2-146 project, the connection from the Potomac Edison distribution system to CERSM's facilities will be provided by tapping the nearby Catoctin – Monocacy 34.5 kV line and constructing a radial attachment connection line to the Point of Interconnection as shown in Appendix 2. POI coordinates: 39.571748°, -77.430539°. This is a FERC jurisdictional POI.

Transmission Owner Scope of Work and Costs Estimation

The Potomac attachment facilities and network upgrades as well as related costs estimates required for AA2-146 interconnection project are shown in below table. Please note that these costs do not include CIAC Tax Gross-up:

Project Costs Description	Amount
Attachment Facilities Metering 34.5 kV metering package to be installed inside CERSM's facilities. Inline facilities from tap point to POI: Attachment line from tap point at Catoctin-Monocacy 34.5 kV line to POI.	$ 58,500
Direct Connection Network Upgrades None.	$ 0
Non-Direct Connection Network Upgrades *NUN** — *Description* n4885 — Two (2) fully rated disconnect switches to be installed at tap point in the Catoctin – Monocacy 34.5 kV line. Cost estimate: $75,700. n4886 — Adjust remote relay and metering settings. Cost estimate: $12,300.	$ 88,000
Direct Connection Local Upgrades None.	$ 0
Non-Direct Connection Local Upgrades None.	$ 0
Contributions for Previously Identified Upgrades None.	$ 0
Total Costs	**$ 205,000**

***** *NUN means Network Upgrade Number*

Interconnection Customer Requirements

CERSM, LLC will be responsible for meeting all criteria as specified in the applicable sections of the Interconnected Transmission Owner "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 34.5 kV circuit breaker on the high side of the (AA2-146) step-up transformer.
2. The purchase and installation of the minimum required Interconnected Transmission Owner generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
3. The purchase and installation of supervisory control and data acquisition (SCADA) equipment.
4. The establishment of dedicated communication circuits for SCADA.
5. A compliance with the Interconnected Transmission Owner and PJM generator power factor and voltage control requirements.
6. The execution of a back-up service agreement to serve the customer load supplied from the (AA2-146) generation project interconnection point when the units are out-of-service.

The above requirements are in addition to any metering or other requirements required by PJM.

Schedule of Work

Based on the scope of interconnection attachment facilities, direct and non-direct system upgrades, it is expected to take a minimum of twelve (12) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes a preliminary payment that compensates the Interconnected Transmission Owner for the first three months of the engineering design work that is related to the interconnection facilities of the Project. It also assumes that the Interconnection Customer will provide the property for the Project direct connection facilities and all right-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection facilities and that transmission system outages will be possible when requested.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer 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 Sections 24.1 and 24.2.

Transmission Owner Requirements

The Interconnection Customer will be required to comply with all Interconnected Transmission Owner revenue metering requirements for generation interconnection customers. The Interconnected Transmission Owner revenue metering requirements may be found in the FE "Requirements for Transmission Connected Facilities" document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Network Impacts

The Queue Project AA2-146 was evaluated as a 20.0 MW (Capacity 10.9 MW) injection into the Catoctin 34.5 kV substation in the APS area. Project AA2-146 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA2-146 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Case Study Year Summer Peak Analysis - 2019

Generator Deliverability
(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

Multiple Facility Contingency
(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

Contribution to Previously Identified Overloads
(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

Steady-State Voltage Requirements

None

Short Circuit
(Summary of impacted circuit breakers)

None

Affected System Analysis & Mitigation

Delivery of Energy Portion of Interconnection Request
PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission

Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

None

Light Load Analysis - 2019

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

System Reinforcements

Short Circuit

None

Stability and Reactive Power Requirement

Not Required

Summer Peak Load Flow Analysis Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None

Light Load Load Flow Analysis Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

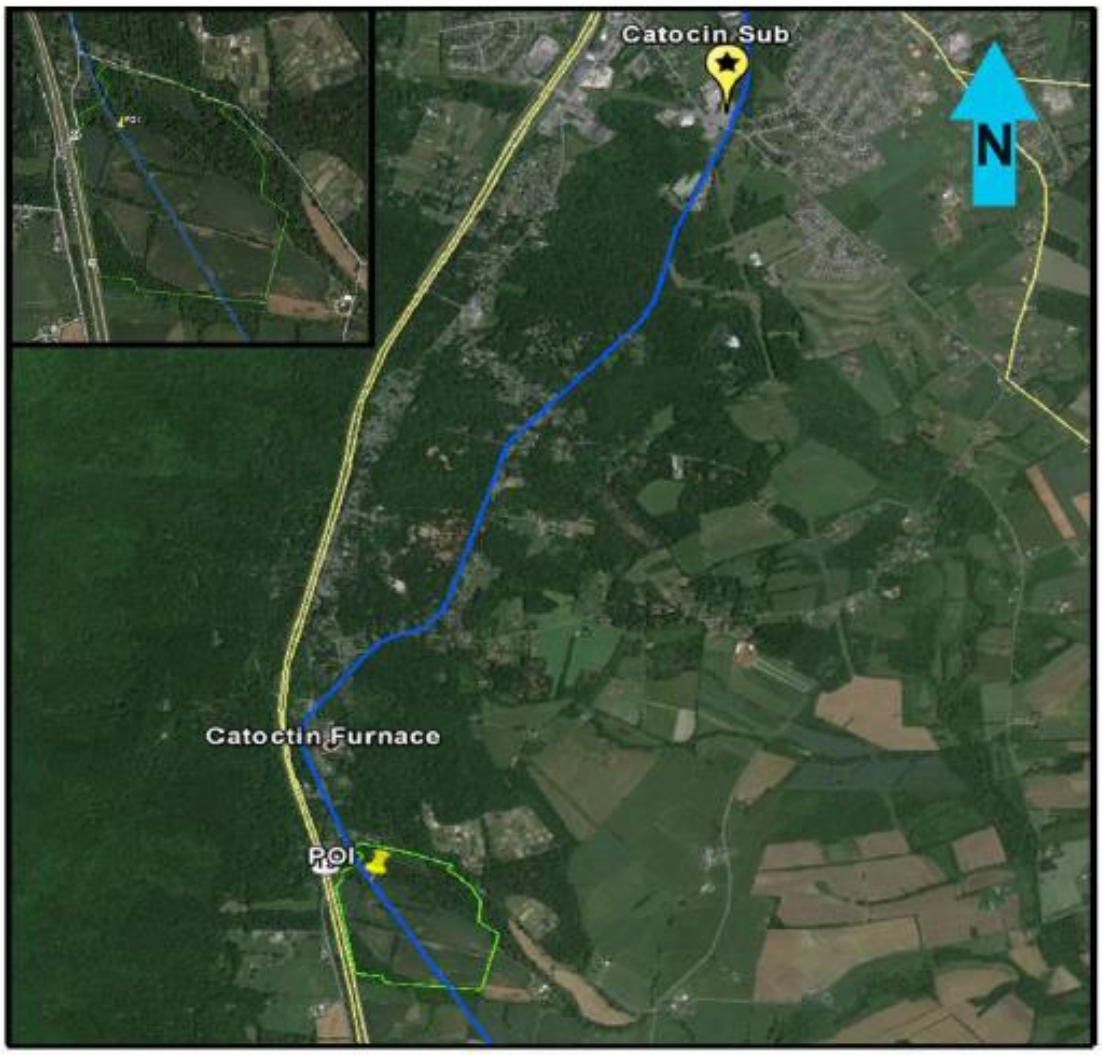
Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

Appendix 1

Project Location

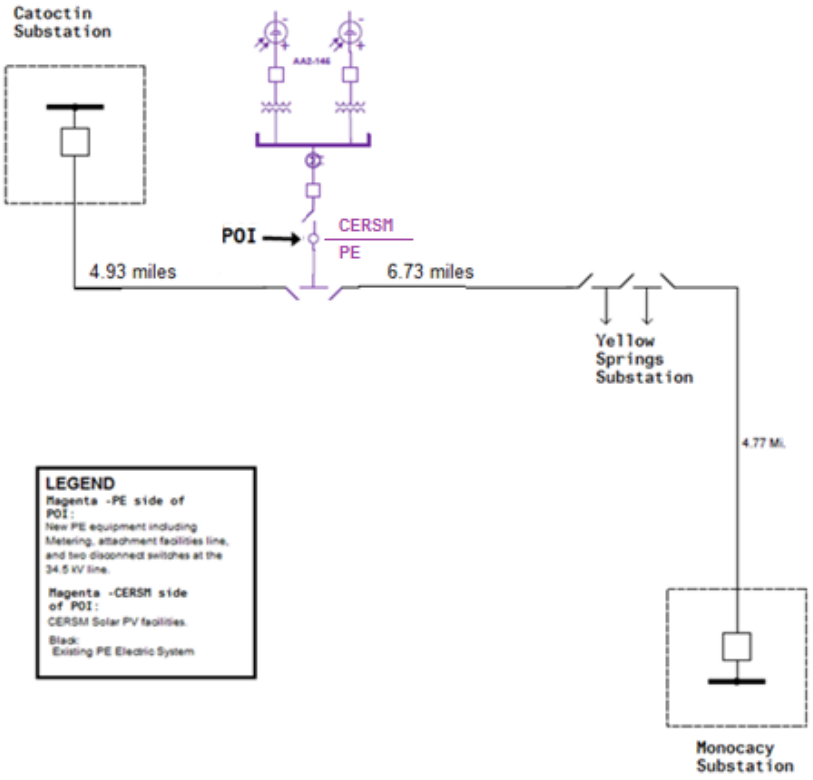


AA2-146

POI: 39.571748°, -77.430539°

Appendix 2

System Configuration – Single Line Diagram



Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA2-146

Catoctin 34.5kV

March 2016

Preface

The intent of the Combined Feasibility/System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate Interconnected Transmission Owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation, if any, is included in the System Impact Study.

The Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs associated with them will be addressed when seeking an Interconnection Agreement as outlined below. Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

CERSM, LLC ("Interconnection Customer" or "CERSM") has proposed a solar generating facility located at approximately 3.5 miles south from Catoctin substation, on the east side of Catoctin Furnace Road, Frederick County, Maryland. The installed facilities will have a total capability of 20 MW with 10.9 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is September 15, 2016. **This study does not imply a Potomac Edison Company commitment to this in-service date.**

Point of Interconnection (POI)

For AA2-146 project, the connection from the Potomac Edison distribution system to CERSM's facilities will be provided by tapping the nearby Catoctin – Yellow Springs 34.5 kV line and constructing a radial attachment connection line to the Point of Interconnection; coordinates: 39.571748°, -77.430539°. See Appendix 2 for POI location and system configuration. Note that this project's POI is FERC jurisdictional.

Transmission Owner Scope of Work and Costs Estimation

The Potomac attachment facilities and network upgrades as well as related costs estimates required for AB1-126 interconnection project are shown in below table. Please note that these costs do not include CIAC Tax Gross-up:

Project Costs Description	Amount
Attachment Facilities Metering 34.5 kV metering package installations inside CERSM's facilities. Inline facilities from tap point to POI: Attachment line from tap point at Catoctin-Monocacy 34.5 kV line to POI.	$ 75,500
Direct Connection Network Upgrades *NUN* — *Description* n4885 — Two (2) fully rated disconnect switches to be installed at tap point in the Catoctin – Yellow Springs 34.5 kV line.	$ 117,200
Non-Direct Connection Network Upgrades *NUN* — *Description* n4886 — Adjust remote relay and metering settings at the Catoctin and Monocacy 34.5 kV substations.	$ 12,300
Allocation for New System Upgrades None.	$ 0.0
Contributions for Previously Identified Upgrades None.	$ 0.0
Total Costs	**$ 205,000**

NUN means Network Upgrade Number.

Interconnection Customer Requirements

Orion Solar Northeast, LLC will be responsible for meeting all criteria as specified in the applicable sections of the First Energy “Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 34.5 kV circuit breaker on the high side of the (AA2-146) step-up transformer.
2. The purchase and installation of the minimum required Interconnected Transmission Owner generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
3. The purchase and installation of supervisory control and data acquisition (SCADA) equipment.
4. The establishment of dedicated communication circuits for SCADA.
5. A compliance with the Interconnected Transmission Owner and PJM generator power factor and voltage control requirements.
6. The execution of a back-up service agreement to serve the customer load supplied from the (AA2-146) generation project interconnection point when the units are out-of-service. This

The above requirements are in addition to any metering or other requirements required by PJM.

Schedule of Work

Based on the scope of interconnection attachment facilities, direct and non-direct system upgrades, it is expected to take a minimum of twelve (12) months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes a preliminary payment that compensates the Interconnected Transmission Owner for the first three months of the engineering design work that is related to the interconnection facilities of the Project. It also assumes that the IC will provide the property for the Project direct connection facilities and all right-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection facilities and that transmission system outages will be possible when requested.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer 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 Sections 24.1 and 24.2.

Transmission Owner Requirements

The IC will be required to comply with all First Energy revenue metering requirements for generation interconnection customers. The FirstEnergy revenue metering requirements may be found in the FE "Requirements for Transmission Connected Facilities" document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Network Impacts

The Queue Project AA2-146 was evaluated as a 20.0 MW (Capacity 10.9 MW) injection into the Catoctin 34.5 kV substation in the APS area. Project AA2-146 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA2-146 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2019

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit

(Summary of impacted circuit breakers)

None

Affected System Analysis & Mitigation

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission

Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

None

Light Load Analysis - 2019

Light Load Studies to be conducted during later study phases (as required by PJM Manual 14B).

System Reinforcements

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

None

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

All fault contingencies tested on the 2019 summer peak case met the recovery criteria. No mitigations were found to be required. See Appendix 3 for more details.

Summer Peak Load Flow Analysis Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

Light Load Load Flow Analysis Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

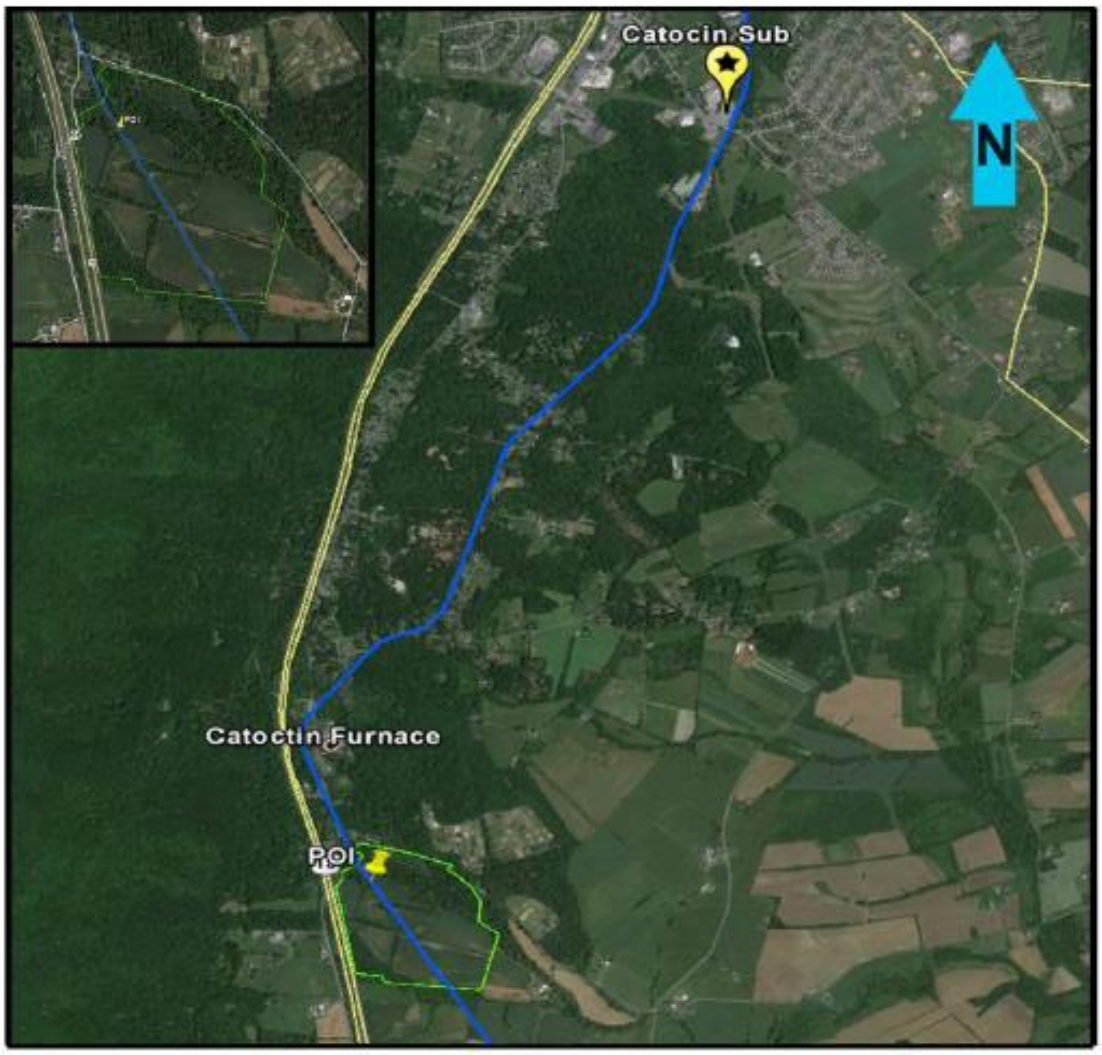
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Appendix 1

Project Location

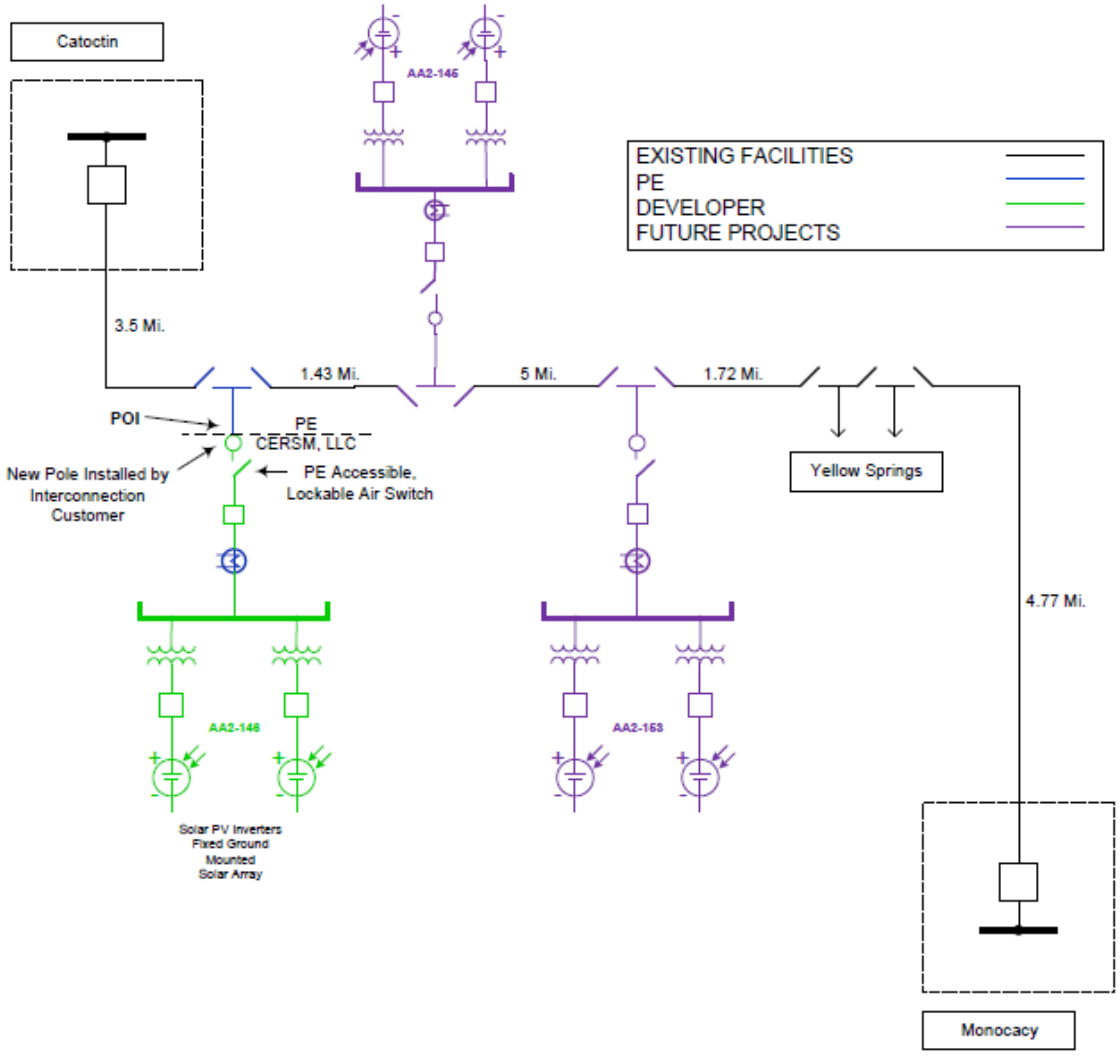


AA2-146

POI: 39.571748°, -77.430539°

Appendix 2

System Configuration – Single Line Diagram



Appendix 3

Dynamic Simulation Analysis Summary

AA2-146 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. 60 contingencies were studied, each with a 10 second simulation time period1. Studied faults included:

a) Steady state operation (20 second simulation);
b) Three-phase faults with normal clearing time;
c) Single-phase faults with phase delayed clearing due to a stuck breaker;
d) Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from fault due to primary communications/relay failure;
e) Single-phase faults with loss of multiple-circuit tower line.
f) Single-phase Bus Faults With Normal Clearing;

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

All 60 fault contingencies tested on the 2019 summer peak case met the recovery criteria:
a) Post-contingency oscillations were positively damped with a damping margin of at least 3%.
b) The AA2-146 generator was able to ride through all faults (except for faults where protective action trips a generator(s)).

Faults which result in protective tripping for AA2-146 are :
- 3N.01, 3N.02, 3N.10
- 1B.01, 1B.05
- 1D.01, 1D.07

c) Due to the long clearing times used, voltages in the 34.5 kV system are noted to be depressed for long periods, as summarized in Table 1 below.

Table 1: Summary of voltages

Contingency	AA2-145 / AA2-146		
	Clearing time Near and remote (cycle)	Bus	Voltage (pu)
1B.01	52 / 1398	CATOCTIN 34.5 kV	0.65
1B.02	52 / 1398	CATOCTIN 34.5 kV	0.70
1B.05	52 / 1398	MONOCACY 34.5 kV	0.73
1D.07	52 / 1398	AA2-145 POI 34.5 kV	0.86