

***Generation Interconnection
System Impact Study Report***

For

***PJM Generation Interconnection Request
Queue Position AA2-117***

Sussex

April 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 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 will be deferred until the System Impact Study is performed.

The System Impact 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 may be included in the study.

General

GE Solar Farm LC, the Interconnection Customer (IC), has proposed a storage facility located in Sussex County, NJ. The installed facilities will have a total capability of 16 MW with 0 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is May 2016. **This study does not imply a Jersey Central Power & Light (JCPL) commitment to this in-service date.**

Point of Interconnection

AA2-117 will interconnect with the Sussex Rural Electric Cooperative system, which is served by JCPL.

Cost Summary

The AA2-117 project will be responsible for the following costs:

Description	Cost
Attachment Facilities	\$ 0
Direct Connection Network Upgrades	\$ 0
Non Direct Connection Network Upgrades	\$ 4,054,700
Allocation for New System Upgrades	\$ 3,279,436
Contribution for Previously Identified Upgrades	\$ 0
Total Costs	\$ 7,334,136

Attachment Facilities

There are no Attachment Facilities required to support this interconnection request.

Direct Connection Cost Estimate

No Direct Connection facilities are required to support this interconnection.

Non-Direct Connection Cost Estimate

The Sussex REC is an independent consumer-owned local distribution entity that receives its energy supply solely from three 34.5 kV transmission line interconnections with JCP&L. JCP&L is therefore directly impacted by any generation connections to the Sussex REC system that impact its tie line flows. The Sussex 34.5 kV (AA2-117) Generation Project will therefore receive its local transmission service from the Sussex REC and its PJM interconnection service through the JCP&L tie lines with the Sussex REC.

Due to the tie line impact, the installation of the (AA2-117) Project by the Interconnection Customer will also impact the existing JCP&L wheeling and supply interconnection agreement with the Sussex REC.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Activity Cost	Tax (if applicable)	Total Cost
Construct 5 breaker ring bus- Sussex Junction 34.5 kV Substation. (n4964)	\$ 3,653,900	\$ 1,186,100	\$ 4,840,000
Terminate 5 lines into Sussex Junction 34.5 kV Substation (n4965)	\$ 375,000	\$ 120,600	\$ 495,600
Adjust Remote Relay Settings at Franklin and Branchville 34.5 kV substations. (n4966)	\$ 25,800	\$ 8,400	\$ 34,200
Total Non-Direct Connection Facility Costs	\$ 4,054,700	\$ 1,315,100	\$ 5,369,800

Transmission Owner Scope of Work

The proposed POI for the AA2-117 generation project will be located on the Sussex REC system. Attachment 1 provides the proposed location for the POI on the Sussex REC system. The Sussex REC interconnection with JCP&L will be used to wheel the output of the AA2-117 generation project to PJM through the Sussex REC 34.5 kV substation. The JCP&L delivery point for the AA2-117 generation project will be modeled at the Sussex REC 34.5 kV substation.

The Sussex REC will be responsible for the installation of any Direct Connection facilities to support the AA2-117 generation project by means of a two party agreement between Sussex REC and FE Solar Farm. Sussex REC and the Interconnection Customer will be expected to comply with the FE “Requirements for Transmission Connected Facilities” document at this delivery point.

- The FE analysis shows the need for a new ring bus substation at the Sussex REC delivery point attributable to the addition of the AA2-117 generation project for the conditions studied. The JCP&L facilities required to be upgraded for the interconnection at the Sussex REC 34.5 kV substation due to the generation project, and the associated cost estimates are listed in Attachment 5. The new connection location is designated as Sussex Junction Substation, a JCP&L owned facility, for the purposes of this report. The resulting local system configuration is also shown in Attachment 2.

System Protection Analysis

An analysis was conducted to assess the impact of the AA2-117 generation project on the system protection requirements in the area. Protection requirements for the new Sussex Junction Substation are as follows. These protection requirements correspond to the network upgrade shown on Attachment 2:

1. Branchville – Sussex Junction Substation 34.5 kV line:
 - a. Sussex Junction Substation: (2) SEL-421 for line protection, and (2) SEL-501 for (top & mid left) breaker failure protection
 - b. Branchville: Existing Q745 line protection (REL 301/302 and SEL-2PG10 relays)
2. Sussex Junction Substation – Franklin 34.5 kV line (former Q745 line):
 - a. Sussex Junction Substation: (2) SEL-421 for line protection, and (1) SEL-501 for (bottom left) breaker failure protection
 - b. Franklin: Existing Q745 line protection (KD-4 and IRP-9 relays)
3. Sussex Junction Substation – Sussex REA 34.5 kV line:
 - a. Sussex Junction Substation: (2) SEL-421 OR (2) SEL-411L for line protection
4. Sussex Junction Substation – Franklin 34.5 kV line (former R746 line):
 - a. Sussex Junction Substation: (2) SEL-421 for line protection, and (1) SEL-501 for (right) breaker failure protection
 - b. Franklin: Existing R746 line protection (KD-10 and IRP-9 relays)
5. Sussex Junction Substation – Ames REA 34.5 kV line:
 - a. Sussex Junction Substation: (2) SEL-421 for line protection

The Interconnection Customer will need to work in conjunction with Sussex REC to insure compliance with any Sussex REC system protection requirements.

JCP&L Facility Upgrades and Costs

The results of the FE analysis of the transmission system less than 100 kV show that transmission thermal violations occur while the AA2-117 generation project battery installation absorbs energy from the JCP&L transmission system (see Attachment 4). Therefore The Interconnection Customer will have an allocated cost responsibility for the transmission network upgrades required to mitigate the violations. The upgrades are as follows.

- Rebuild 4.1 miles of the Branchville to North Newton (F708) 34.5 kV line as double ckt 556 ACSR to extend the L766 34.5 kV line to the AA2 queue projects along this section of the F708 34.5 kV line. See Attachment 3 for a one line of this network upgrade.
- Accelerate the project to replace the existing Franklin 50 MVA, 115-34.5 kV #2 transformer with a 90 MVA nameplate transformer, the 795 ACSR substation conductor leads with 1590 ACSR conductor, and the installation of a high-side breaker and associated relays.
- Replace the existing Newton 230-34.5 kV, 45 MVA #1 transformer with a 75 MVA nameplate transformer and upgrade associated relay panels.

Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. The Interconnection Customer will be responsible for the actual cost of the Direct Connection that is implemented by Sussex REC and an allocated actual cost for the network upgrades required by JCP&L. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

Schedule

Based on the extent of the JCP&L system upgrades required to support the AA2-117 generation project, it is expected to take a minimum of 39 months from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement that is related to the construction of the Non-Direct Connection and Network Upgrade facilities. It further assumes that The Interconnection Customer will provide all rights-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 Non-Direct Connection and Network Upgrades, and that all system outages will be allowed when requested.

Interconnection Customer Requirements

In addition to the JCP&L facilities, The Interconnection Customer will also be responsible for meeting all criteria as specified in the applicable sections of the FE "Requirements for Transmission Connected Facilities" document including:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units

(PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.
3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.
4. The Interconnection Customer will be required to fund all of the Sussex REC interconnection and JCP&L network upgrades that will be required for the (AA2 117) Project. This includes the provision of any permits, easements and properties that may be required. The Interconnection Customer must work directly with Sussex REC since Sussex REC is exempt from the PJM Interconnection Process.
5. The purchase and installation of a revenue class meter for the AA2-117 generation project interconnection in coordination with the Sussex REC to measure the power delivered to the PJM system in compliance with the FE standards. The installation must comply with all Sussex REC metering requirements.
6. A compliance with the Sussex REC generator power factor and voltage control requirements. Note that the AA2-117 generation project may need to absorb reactive power to minimize the voltage change should the units rapidly reduce their output or trip off line.
7. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by The Interconnection Customer. The correction may include changing operation, reducing generation, disconnecting the generators, or other measures.
8. The purchase and installation of supervisory control and data acquisition (“SCADA”) equipment that will provide revenue quality data and system information to FE in a compatible format to the FE Transmission System Control Center and Billing standards. The RTU, the communications channel and all related equipment will be furnished and maintained by the Interconnection Customer. The RTU must communicate with the FirstEnergy Energy Management System (EMS) via DNP 3.0 protocol.
9. The following status and metering points will be required:
 - Interconnection breaker position status and trip control. If trip control is not provided to FE, under emergency conditions FE may need to open the Sussex REC delivery point.
 - Generator real and reactive power output measured at the high-side of the generator step-up transformer.
 - Generator voltage at the point of interconnection.

10. A compliance with the inverter standard UL 1741 and IEEE 1547 in addition to the power quality standards defined by ReliabilityFirst and PJM.
11. The provision of a telephone number for the AA2-117 generation project Plant Operator who must be available on a 24/7 basis to respond to FE or PJM dispatch orders and requests for information.
12. The above requirements are in addition to any metering or other requirements imposed by PJM.

Note that an assumption of this study is that the AA2-117 generation project generation will automatically be disconnected whenever the local area network is islanded. If this assumption is not correct, a direct transfer trip scheme will need to be implemented for such situations at the Interconnection Customer cost.

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.

JCPL Requirements

The Interconnection Customer will be required to comply with all FE Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "FirstEnergy Requirements for Transmission Connected Facilities" document located at the following links:

<http://www.firstenergycorp.com/feconnect>

<http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx>

Network Impacts

The Queue Project AA2-117 was evaluated as a 16.0 MW (Capacity 0.0 MW) injection/withdrawal at the Sussex 34.5kV substation in JCPL. Project AA2-117 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA2-117 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Generator Deliverability

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

None.

Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

None.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None.

Short Circuit

(Summary of impacted circuit breakers)

None.

First Energy Short Circuit Analysis

In accordance with the RTEP process, a short circuit analysis was not conducted by PJM since the AA2-117 generation project connection is to the Jersey Central Power & Light less than 100 kV transmission system. Therefore, the FE Protection staff conducted a short circuit review of the project connection.

Section 14.2.6 of the FE “Requirements for Transmission Connected Facilities” document states that the winding configurations for the transformer connecting to a non-effectively grounded portion of the FE Transmission System shall be determined by FE on a case by case basis.

This project, modeled per Attachment N as wye (non-grounded) on the 34.5 kV side, would have a significant impact on the ground currents for faults on the tapped line if this 34.5 kV side wye is grounded. To avoid creating possible miscoordination, which could trigger the need for a substation ring bus connection rather than a tap connection, this project will need to maintain the specified wye (non-grounded) configuration at the 34.5 kV connection.

Evaluation of the connection of the AA2-117 generation project to the 34.5 kV system as an ungrounded connection indicated there were no overdutied breakers.

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AA2-117 Allocation
6	Franklin 115/34.5kV Transformer #2	<p>In order to mitigate the overloads of facilities above, the following reinforcements are required:</p> <ul style="list-style-type: none"> Franklin SS. Base Line Upgrade b2496 Acceleration- Replace existing Franklin 115-34.5 kV 50 MVA Transformer #2 with a 90 MVA nameplate transformer and replace 795 ACSR substation conductor with 1590 ACSR conductor. Install a high-side breaker and associated relays. <p>The estimated cost is \$149,300, and it will take 18 months to complete.</p>	n4911	\$ 149,300	\$ 32,488
7	Newton 230/34.5kV Transformer #1	<p>In order to mitigate the overloads of facilities above, the following reinforcements are required:</p> <ul style="list-style-type: none"> Replace existing Newton Bank #1 230/34.5kV Transformer At the Newton 34.5 kV substation with a new 75/100/125 MVA Transformer. Replacement existing transformer relaying. <p>The estimated cost is \$2,616,800, and it will take 13 months to complete.</p>	n4998	\$ 2,616,800	\$ 2,616,800
Total New Network Upgrades					\$ 3,279,436

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.

Potential Congestion due to Local Energy Deliverability

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.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified

None.

First Energy Power Flow Analysis

The power flow analysis was performed using a 2019 summer peak load base case provided by the PJM staff. This base case included a detailed representation of the Jersey Central Power & Light transmission network in the area of the proposed AA2 117 generation project. A simulation of all single, bus, stuck breaker and common structure contingencies within the NERC and FE Planning Standards that are impacted by the project was conducted to test for criteria compliance. Note that in accordance with PJM RTEP study procedures, the AA2-117 generation project under study and earlier active queue projects are considered to be in service. Therefore, all active queue projects after the AA2-117 generation project are considered not in service.

For the point of interconnection, the AA2-117 generation project was studied at Sussex REC 34.5 kV substation with the ring bus configuration shown in Attachment 2 in place.

The results of the analysis show that there are transmission network upgrades required for the deliverability of the AA2-117 generation project to the JCP&L transmission system due to thermal overloads occurring while the battery installation absorbs energy from the JCP&L transmission system. Table 1 on Attachment 4 lists the resulting thermal overloads identified in the power flow study.

Table 2 on Attachment 4 lists an unresolved (non-solved) case/contingency scenario attributed to the AA2-117 generation project while the battery installation absorbs energy from the JCP&L transmission system.

A light load power flow study was conducted to determine the reliability impact of the proposed AA2-117 generation project on the JCP&L transmission system. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM, or FE Planning Criteria and are attributable to this project.

The results of the light load analysis show that there are no thermal overloads or voltage violations identified.

A review of the AA2-117 System Impact Study Data Sheet identified the total reactive power capability at maximum gross energy output listed at ± 2.27 Mvar. This value corresponds to a 0.99 leading/lagging power factor and is not sufficient to support the variability of system voltage.

The FE study shows that the addition of inverter based projects without continuous regulation can cause significant voltage swings as its output responds to charge and discharge signals from the regulation market in conjunction with other inverter based generation, and system voltages can

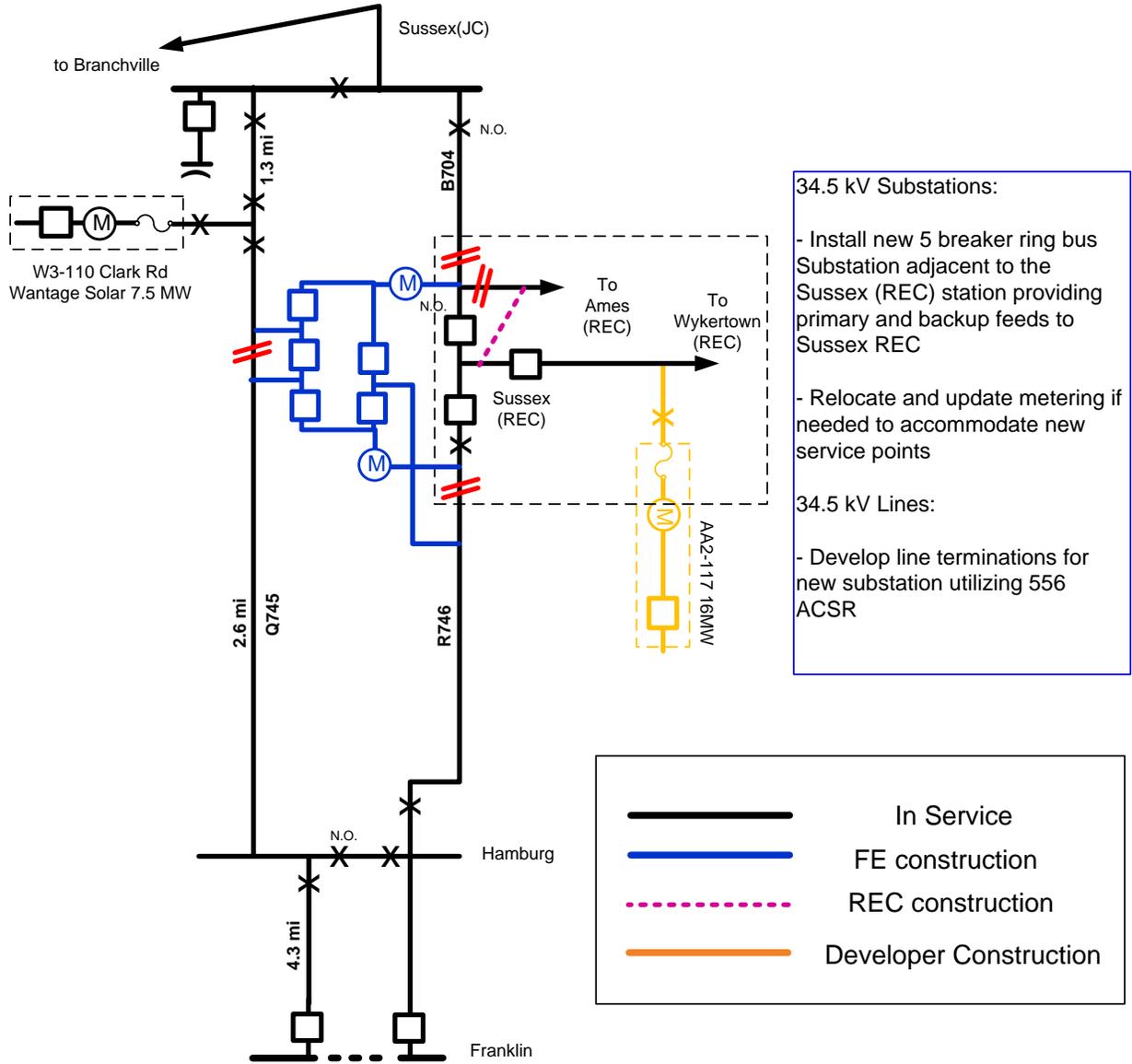
exceed the established limits. The Interconnection Customer shall design the AA2-117 generation project with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the POI.

Should The Interconnection Customer fail to provide dynamic reactive capability from the AA2 117 generation project for any reason once interconnected, the FE and/or PJM Dispatchers may need to take action to curtail output to prevent non-compliance with voltage criteria.

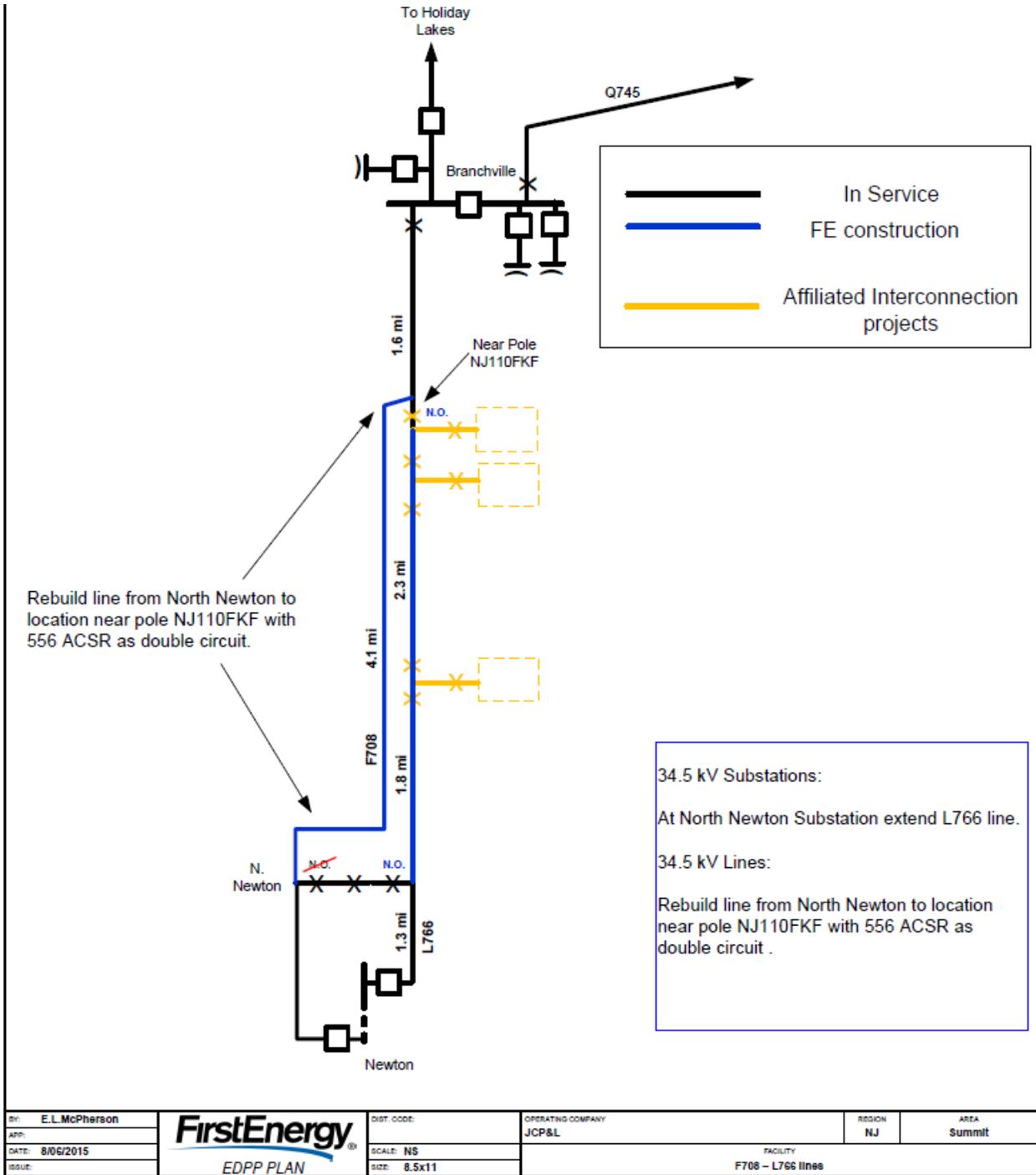
Attachment 1. Project Location



Attachment 2. Single Line Diagram



Attachment 3. Transmission Owner Network Upgrades L766 34.5 kV Line Extension Single Line Diagram



Attachment 4. Transmission Owner Network Upgrades Contingency Analysis Results

Table 1: Identified JCP&L overloads

	Outage Description	Outage Type	Overloaded Element	Rating (MVA)	Flow/CTG Flow (MVA)	% Rating
	Basecase	Operation/Single	Frankford (AA2-062) to North Newton 34.5 kV (F708) line	41	70	171.4
1	B10-JCN-34-08-02_NEWTON - LIMECREST (A703) 34.5 KV - AREA 08	Operation	Frankford (AA2-062) to North Newton 34.5 kV (F708) line	47	77	164.5
2	B3-JCN-115-063_FRANKLIN J 115/34.5 KV BANK 2	Single	Frankford (AA2-062) to North Newton 34.5 kV (F708) line	47	76	161.6
3	B10-JCN-34-08-05_FRANKLIN - HAMBURG (Q745) 34.5 KV - AREA 08	Single	Frankford (AA2-062) to North Newton 34.5 kV (F708) line	47	77	164.3
4	B2-JCN-34-08-998_FRANKLIN - HAMBURG (RXX) 34.5 KV - AREA 08	Single	Frankford (AA2-062) to North Newton 34.5 kV (F708) line	47	76	162.5
5	B3-JCN-230-026_NEWTON 230/34.5 KV BANK 2	Single	Newton 230 to 34.5 kV #1 Transformer	66	70	106
6	B3-JCN-115-062_FRANKLIN D 115/34.5 KV BANK 1	Single	Franklin J 115 to 34.5 kV #2 Transformer	66	76	114.5

Table 2: Identified JCP&L non-solved contingency scenarios

Outage Description	Battery Mode	Case
B10-JCN-34-08-03_NEWTON - NORTH NEWTON (F708) 34.5 KV - AREA 08	Sinking	Peak