Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA1-114

Harwood-East Hazelton #2 69kV

July 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

EDF Renewable Development, LLC, the Interconnection Customer (IC), has proposed a wind generating facility located in Carbon County, PA. The installed facilities will have a total capability of 60 MW with 7.72 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 2017. **This study does not imply a PPL Electric Utilities (PPL EU) commitment to this in-service date.**

Point of Interconnection

AA1-114 will interconnect with the PPL EU system along the Harwood-East Hazelton #2 69kV line.

Cost Summary

The AA1-114 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 984,124
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 155,321
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 1,139,445**

Attachment Facilities

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

Description	Total Cost
New 69kV Transmission Tap (PJM Network Upgrade Number n4652)	$ 984,124
Total Attachment Cost Estimate	**$ 984,124**

Direct Connection Cost Estimate

There are no Direct Connection Facilities required to be constructed by the Transmission Owner.

Non-Direct Connection Cost Estimate

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	Total Cost
Harwood substation protection work	$ 155,321
Total Non-Direct Facilities Cost Estimate	**$ 155,321**

Schedule

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

The estimated PPL EU elapsed time to complete the 69 kV Attachment Facilities and Non-Direct connection substation work is approximately 12 months after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV substation work to accommodate AA1-114 would depend on the project's start date. The work to accommodate AA1-114 will require substation facility outages. PPL EU's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

The transmission and substation work can be completed concurrently. PPL EU will commence siting, engineering design, material purchase and construction of the facilities identified in this study after receiving written authorization by PJM to begin work. This time frame is contingent upon the acquisition of all ROW in the stated time frame before the start of construction and detailed design.

ISA/ICSA Executed	August 21, 2016
Receive IPP down payment to proceed	August 31, 2016

Begin Engineering	September 1, 2016
Complete Engineering	March 31, 2017
Begin Construction	May 1, 2017
Complete Construction	June 30, 2017
Back-feed to IPP	September 29, 2017
Commercial Operation	December 29, 2017

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.

PPL EU Requirements

Telephone Circuit Requirements (At the IPP)

PPL EU will require a communication path for SCADA, DTT, and voice circuits. PPL EU anticipates that either telephone circuits or IP will be required to establish these paths. The Interconnection Customer will be responsible to procure the following:

- SCADA – either a 4-wire dedicated FDDA-type phone line or DNP over IP. It is at PPL's discretion as to which SCADA (4 wire or DNP/IP) is required to be provided.
- DTT – 4 wire dedicated PRDA-type Phone Line.
- A normal dialup telephone line for voice communication.

Phone lines tend to be long lead-time items and must be in place and operational for equipment testing. The Interconnection Customer should investigate with the local phone company the possibility of obtaining this type of service at their facility.

All installation, maintenance, and monthly lease or billing charges for communications facilities are the responsibility of the Interconnection Customer.

Metering Equipment Installation at the POI (Point of Interconnection)

Installation of revenue grade bi-directional metering equipment will be required at the AA1-114 Point of Interconnection at the Interconnection Customer deadend structure to measure KWh and KVARh. PPL EU will design and supply the required metering equipment but all the installation cost would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment must provide bi-directional revenue metering (KWH and KVARH) and real-time data (KW, KVAR, circuit breaker status, and generator bus voltages) for the developer's generating resource. The metering equipment should

be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

The developer is also required to provide revenue metering (KWH and KVARH) and real-time telemetry data (KW, KVAR, and KV) to PJM in compliance with the requirements listed in PJM Manuals M-01 and M-14. Any data from the PPL EU revenue meters can be transferred by fiber optic link to the PJM RTU located at the IPP facility.

SCADA Equipment Requirements

PPL EU will require installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system to provide real time values of KW, KVAR, and kV metering data at the POC. SCADA equipment will also provide capability to trip and the status monitoring of the POC isolating circuit breaker. In addition to that, monitoring of other abnormal conditions at the developers plant will be provided where deemed necessary. PPL EU will provide detailed specifications and design drawings for this equipment.

Interconnection Customer Requirements

AA1-114 Generator, GSU, and Line Modeling

The Interconnection Customer will be responsible for the construction of all their generating station facilities on the Interconnection Customer side of the POI.

AA1-114 Generator modeling (Vestas V110):

- Number of Turbines: 30
- Size: 2 MW per turbine
- MVA Base: 2.08 MVA
- 0.90 lead to 0.90 lag power factor at 69 kV bus

AA1-114 GSU modeling

- GSU (Generator Step Up Transformer):
    - Number of machines per GSU: 30
    - MVA Base: 40 MVA
    - Voltage Level: 34.5/69 kV
    - Impedance: 8.0%
- GSU (Wind Turbine Unit):
    - MVA Base: 2.1 MVA
    - Voltage Level: 34.5/0.69 kV

AA1-114 Transmission Line modeling

- Voltage Level: 69 kV
- MVA Base: 100 MVA
- Length: 0.04 mile
- Positive sequence impedance: 0.00016+j0.0006
- Zero sequence impedance: 0.00056+j0.0022

The AA1-114 Interconnection Customer must provide PPL EU and PJM with the transformer test reports once they are available in order to perform a more detailed short circuit analysis.

Intertie and POC Protective Relaying Equipment

The Interconnection Customer will need to install suitable protection and control equipment at its facilities based on PPL EU parallel generation requirements. This includes both Intertie Protective Relaying (IPR) and Point of Contact (POC) relaying. Please refer to the PPL EU web site for the IPR and POC requirements. The website addresses are shown below:

IPR Requirements:
https://www.pplelectric.com/at-your-service/electric-rates-and-rules/customer-owned-generation.aspx

POC Requirements:
https://www.pplelectric.com/at-your-service/electric-rates-and-rules/point-of-contact-requirements-for-high-voltage-facilities.aspx

Isolation Breaker Requirement at the Interconnection Customer's Substation

Per the customer's preliminary sketches, the customer is planning to provide a high side circuit breaker at 69 kV with a manually operated 69 kV disconnect switch on the PPL EU line side of this breaker. Unless otherwise indicated, it is assumed that this be will be the "Isolation Circuit Breaker" and will be operated by the IPR relay and the DTT signal. It is requested that the customer confirm this or provide alternate isolation breaker.

AA1-114 Generator Harmonic and Flicker Requirements

On the PPL EU 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from AA1-114's equipment, the Queue AA1-114 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the Interconnection Customer must limit the severity of their voltage variation to within a level which will not cause objectionable flickers to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation will be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curves as a guideline to determine if the system is operating within acceptable limits. PPL EU will require corrective actions by the Interconnection Customer if their operation causes flickers that exceed PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

AA1-114 Generator Regulation or Reactive Support Requirements

As specified in Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the AA1-114 Project shall design its Facility to meet the following power factor requirement:

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system Feasibility study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars)."

The IC will be asked to hold voltage constant at the point of interconnection to the PPL EU 69 kV system. In order to minimize significant voltage deviation, PPL EU load flow studies indicate that the AA1-114 facility will need to operate at a unity power factor as measured at the 69 kV point of interconnection (POI). This POI power factor should be maintained for all levels of generation output from the AA1-114 facility. In general, at MW output levels greater than 0 MW, PPL EU load flow studies suggest AA1-114 generation will need to hold a unity power factor to maintain approximately 67.3 kV at the high side of the interconnection transformer during peak load and approximately 66.1 kV at the high side of the interconnection transformer during light load.

Distribution Service Requirements

The Interconnection Customer must submit a request for electric service through PPL EU‟s Industrial and Commercial Services (ICS) group if the queue AA1-114 requires back-up electric service at a voltage less than 69 kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost for distribution electric service is NOT included in the PPL scope of work transmission or substation estimates.

Future Conversion of line to 138 kV from 69 kV

PPL EU presently has no plans to convert this line to 138 kV in the next 15-20 years. If the transmission system in this area is converted to 138 kV in the future, the Interconnection Customer would be responsible for conversion of its substation to 138kV at that time.

Network Impacts

The Queue Project AA1-114 was studied as a 68.0 MW (Capacity 8.8 MW) injection as a tap of the Harwood – East Hazelton #2 69 kV line in the PPL area. Project AA1-114 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA1-114 was studied with a commercial probability of 100% using a Summer Peak 2018 case. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
PJM69	CONTINGENCY 'PJM69' DISCONNECT BRANCH FROM BUS 200021 TO BUS 200009 CKT 1 /* SUNBURY JUNIATA 500 500 DISCONNECT BRANCH FROM BUS 200021 TO BUS 200022 CKT 2 /* SUNBURY SUSQHANA 500 500 / CKT 1 -> 2 DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 24 /* SUNBURY SUNBURY 500 230 END

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.

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

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

See Attachment 2

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.

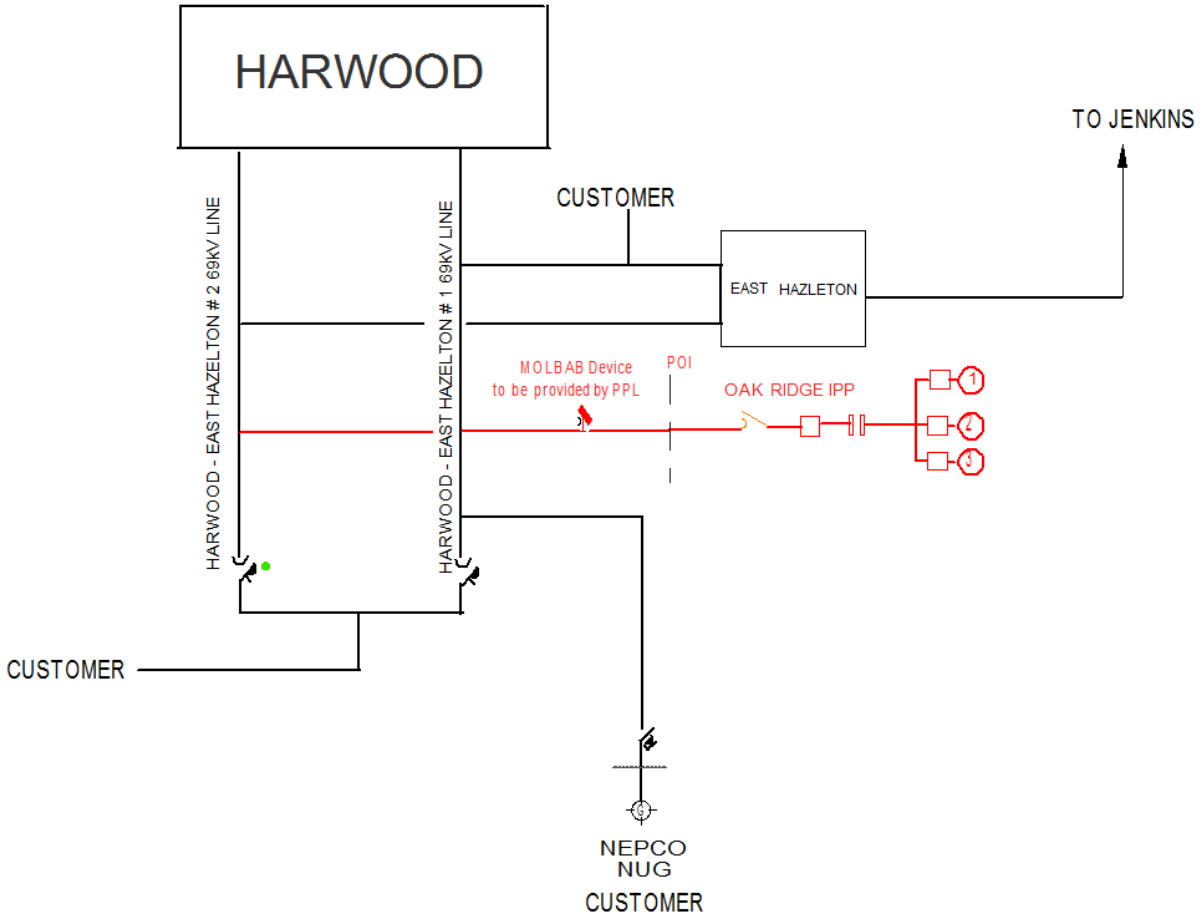
Potential Congestion due to Local Energy Deliverability

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.

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	N-1	PJM69	PL	SUSQHANA 500/230 kV transformer	208116	200022	21	AC	108.57	109.96	ER	1165	19.08	

Attachment 1. Single Line Diagram



Attachment 2. Low Voltage Ride-Through Study

Executive Summary

Generator Interconnection Request AA1-114 is for a 60 MW (30 x 2 MW Vestas V110 wind turbines) Maximum Facility Output (MFO) wind farm. AA1-114 will have a Point of Interconnection (POI) on the Harwood - East Hazelton 69 kV circuit #2 in the PPL system, Carbon County, Pennsylvania.

This Light Load (LL) study is based on the RTEP 2018 light load case v04_2015_05_20 in which generation dispatch is modified to reach a transfer level of 4040 MW at the Northeast PA (NEPA) interface. The modification is based on the dispatch information and voltage schedule for light load conditions provided by PPL. No modification is made to the network and loads. PJM queue project AA1-114 was dispatched at a maximum power transfer of 60 MW total and POI voltage of 67.2 kV (0.974 p.u.), consistent with the default generator reference voltage specified in PJM Manual 03 Transmission Operations Section 3.3.3 for generator connections to the PPL 69 kV system

AA1-114 was tested under light load conditions for compliance with NERC, PJM and other applicable criteria. 46 contingencies were studied, each with a 15 second simulation time period, except for contingencies P1-01 and P4-03, as shown in Appendix A. Appendix B shows the AA1-114 plant model. Appendix C lists the parameters given in the impact study data and the corresponding parameters of the AA1-114 powerflow and dynamic models.

The dynamic models for AA1-114 plant are based on Vestas V110 2.0 MW User-Defined models for use in PSS/E V32, with parameters supplied by the Developer in the System Impact Study Data Form.

Note: The contingencies results show some prolonged power oscillations that clearly decay over about 30 seconds. A 3 phase fault on Harwood – Berwick 69kV circuit with simulation time of 30 seconds (case AA1-114-LL-P1-01) showed all oscillations damped out completely. The power oscillations were also observed and investigated in the PJM Queue Project Z2-009 (68MW) and in the AA1-114 SP which deploy the same Vestas V110 2.0 MW PSS/E model with its POI on the Harwood - East Hazelton 69 kV circuit #2. It was concluded in both studies that “these oscillations are not related to the POI but are due to machine dynamic models controls” and that “a further study will be required once another model is available but at this time no mitigation is required”. The power oscillation issue is not revisited in the AA1-114-LL study.

Based on the contingencies tested, AA1-114-LL meets criteria for all the contingencies tested.

Description

This study evaluates the stability and low voltage ride-through (LVRT) capability for PJM queue project AA1-114. PJM Queue project AA1-114 is a request for a wind farm facility with 60 MW net injection to the PPL system, consisting of 30 Vestas V110 2.0 MW wind turbines, The POI is

a tap/substation on Harwood – East Hazelton 69 kV circuit #2 in the PPL transmission system, Carbon County, Pennsylvania. The dynamic models for AA1-114 plant are based on Vestas V110 2.0 MW User-Defined models for use in PSS/E V32, with parameters supplied by the Developer in the System Impact Study Data Form.

Criteria

The light load stability study for AA1-114 was performed on a RTEP 2018 Light load case v04_2015_05_20 in which generation dispatch is modified to reach a transfer level of 4040 MW at the Northeast PA (NEPA) interface. The modification is based on the dispatch information and voltage schedule for light load conditions provided by PPL. No modification is made to the network and loads. The range of contingencies evaluated was limited to those necessary to assess compliance with NERC, PJM and other applicable criteria. Simulation time was 15 seconds for all contingencies, except for contingencies P1-01 and P4-03, as noted in Appendix A.

Simulated NERC Standard TPL-001faults include:

1. Three-phase (3ph) fault with normal clearing (Category P1)
2. Single- line-to-ground (slg) on a bus section with normal clearing (Category P2)
3. Single-line-to-ground (slg) with delayed clearing as a result of breaker failure (Category P4)
4. Single-line-to-ground (slg) with delayed clearing as a result of protection failure (Category P5)
5. Single-line-to-ground (slg) with normal clearing for common structure (Category P7)

Note: For generator interconnection studies, Category P3 and P6 faults will be studied on an as needed basis.

Other applicable criteria tested include:

1. Transmission Owner (TO) specific criteria

2. Other criteria

The system was tested for an all lines in service condition and the faults listed above. Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

All generators were monitored to assess transient stability and satisfactory post-contingency conditions.

Case Setup

The case for AA1-114-LL study was set up to reach a transfer level of about 4040 MW at the NEPA Interface as described in the Criteria.

Specific dispatch conditions at the generator terminals for the AA1-114-LL generators, as obtained in the power flow solution, are illustrated below:

AA1-114-LL	V110 2.0
Gross power output (MW)	60.00
Reactive power output (MVARS)	10.9
Auxiliary Load (MW/MVARS)	0.00
Station Service Load (MW/MVARS)	0.00
Net real power injection (MW)	60.00
Voltage at the POI (P.U.)	0.974

NEPA Interface Flow in AA1-114-LL Study

The NEPA Interface is monitored by summing up the power flows in the following lines:

- Montour – Saegers (X2-012 Tap) 230 kV Circuit #1
- Montour – Saegers (X2-012 Tap) 230 kV Circuit #2
- Sunbury – Elimsport 230 kV Circuit #1
- Sunbury – Juniata 500 kV Circuit #1
- Lackawanna – Peckville 230 kV Circuit #3
- Harwood – Siegfried 230 kV Circuit #1
- Harwood – East Palmerton 230 kV Circuit #1
- Frackville – Siegfried 230 kV Circuit #1
- Susquehanna – Wescosville 500 kV Circuit #1
- Lackawanna – Oxbow 230 kV Circuit #1
- Lackawanna – Hopatcong 500 kV Circuit #1

From Bus		To Bus		CKT	MW FLOW
Number	Name	Number	Name		
200074	LACKAW 500	200098	LACKJEFF_TIE500	1	874.2
200021	SUNBURY 500	200009	JUNIATA 500	1	1317.8
200022	SUSQHANA 500	200023	WESCOVLE 500	1	871.7
208040	MONT 230	909020	X2-012 TAP 230	1	284.9
208040	MONT 230	909020	X2-012 TAP 230	2	193.2
208109	SUNB 230	207968	ELIM 230	1	-244.9
208009	LACK 230	208049	PAUP 230	1	6.7
208009	LACK 230	200708	26OXBOW 230	1	319.2
207980	HARW SIE 230	918840	AA1-103_TAP 230	1	25.5
207979	HARW EPA 230	207960	EPAL TR2 230	1	193.5
207973	FRAC 230	208072	SIEG FRA 230	1	198.6
NEPA Interface Flow (MW)					4040.4

Results

Simulation Initialization

The case was initialized successfully. No errors were reported.

20 second no fault test (Steady State evaluation)

The system successfully met the 20 second run test without any significant deviations in system states.

Simulation Results

Dynamics and stability was tested using Siemens/PTI PSS/E Version 32, the 2018 case v04_2015_05_20 with a Light Load condition and the data supplied by the developer.

Low Voltage Ride Through: For the cases studied, the AA1-114 queue project rides through the faults shown in Appendix A thus meeting the LVRT test specified in FERC order 661 and 661A.

Transient Stability: For all cases studied, transient stability is maintained, with all oscillations stabilized as noted below; and the voltage levels returned to acceptable levels following the fault clearance.

Note: The contingencies results show some prolonged power oscillations that clearly decay over about 30 seconds. A 3 phase fault on Harwood – Berwick 69kV circuit with simulation time of 30 seconds (case AA1-114-LL-P1-01) showed all oscillations damped out completely. The power oscillations were also observed and investigated in the PJM Queue Project Z2-009 (68MW) and in the AA1-114 SP which deploy the same Vestas V110 2.0 MW PSS/E model with its POI on the Harwood - East Hazelton 69 kV circuit #2. It was concluded in both studies that "these oscillations are not related to the POI but are due to machine dynamic models controls" and that "a further study will be required once another model is available but at this time no mitigation is required". The power oscillation issue is not revisited in the AA1-114-LL study.

Small Signal (if applicable):

SPS:

Maintenance outage: No maintenance outage conditions were evaluated.

Conclusion

No issues were identified for the stability study performed for PJM queue project AA1-114. PJM requests an updated Vestas dynamic model be provided for evaluation, as stated in the Requirements section below.

Mitigations:

None required.

Requirements:

An updated dynamic model will need to be submitted to PJM to evaluate and confirm that the prolonged power oscillations attributed to the machine dynamic models controls of the Vestas V110 2.0 MW model provided to PJM at the time of this study is resolved.

Recommendations:

1. Installation of out-of-step protection is recommended: This study was made using a certain set of operating conditions. There may be other operating conditions, although less probable, that can create stability problems. It is the Customer's responsibility to protect their own equipment from damage due to disturbances on the transmission system by installing out-of-step protection on their generators.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system load levels and operating conditions may disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in that or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and plant specific dynamic data for the plant and its controls are available, it must be forwarded to PJM. If it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall be performed to verify impact on the dynamic performance of the system. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

Appendix A: Fault Table

No	Contingency ID	Standard TPL-001 faults	Fault Description	Clearing time		Results
				Normal (cycles)	Delayed (cycles)	
1	AA1-114-P1-01	P1	Harwood - Berwick 69 kV (30s simulation)	12	N/A	Stable
2	AA1-114-P1-02	P1	Harwood - East Hazleton #1 69 kV	12	N/A	Stable
3	AA1-114-P1-03	P1	Harwood - Jenkins #2 69 kV	12	N/A	Stable
4	AA1-114-P1-04	P1	Harwood - Harwood138 69 kV	12	N/A	Stable
5	AA1-114-P1-05	P1	Harwood138 - Valmont 69 kV	12	N/A	Stable
6	AA1-114-P1-06	P1	Harwood138 - Jenkins#1 69 kV	12	N/A	Stable
7	AA1-114-P1-07	P1	Harwood - Humboldt#1 69 kV	12	N/A	Stable
8	AA1-114-P1-08	P1	Harwood138 - Humboldt#2 69 kV	12	N/A	Stable
9	AA1-114-P1-09	P1	Harwood 69/12.2 kV T1	12	N/A	Stable
10	AA1-114-P1-10	P1	Harwood 69/230 kV T5	12	N/A	Stable
11	AA1-114-P1-11	P1	Harwood 69/230 kV T6	12	N/A	Stable
12	AA1-114-P1-12	P1	Harwood138 69/230 kV T4	12	N/A	Stable
13	AA1-114-P1-13	P1	Berwick - Columbia 69 kV	12	N/A	Stable
14	AA1-114-P1-14	P1	Berwick - Hunlock 69 kV	12	N/A	Stable
15	AA1-114-P1-15	P1	Harwood to SUSQ ckt 1, loss of T5@Harwood	8	N/A	Stable
16	AA1-114-P1-16	P1	Harwood to SUSQ ckt 2, loss of T5@Harwood	8	N/A	Stable
17	AA1-114-P1-17	P1	Harwood to E Palm, loss of T2@EPAL & T6 @Harwood	8	N/A	Stable
18	AA1-114-P1-18	P1	Harwood to AA1-103 POI 230 kV	8	N/A	Stable
19	AA1-114-P1-19	P1	AA1-103 POI to Siegfried 230kV	8	N/A	Stable
20	AA1-114-P1-20	P1	Harwood 69kV Bus#1	12	N/A	Stable
21	AA1-114-P2-01	P2	SLG on Harwood 69kV Bus1, loss of Bus 1 and all elements connected to Bus 1.	12	N/A	Stable
22	AA1-114-P2-02	P2	SLG on Harwood 69kV Bus N, loss of Harw-Humb#2 69kV.	12	N/A	Stable
23	AA1-114-P2-03	P2	SLG on Harwood 69kV Bus S, loss of TR4 and Cap @ Harwood.	12	N/A	Stable
24	AA1-114-P4-01	P4	SLG on Harwood 69/230kV T5, SB@Harwood, loss of Harwood 69kV Bus#1	12	60	Stable
25	AA1-114-P4-02	P4	SLG on Harwood 69kV yard span@Harwood138, loss of 69/230 kV T4.	12	60	Stable
26	AA1-114-P4-03	P4	SLG on Harwood 69kV yard span @Harwood138, loss of Harw-Valm 69kV (30s simulation).	12	60	Stable
27	AA1-114-P4-04	P4	SLG on Harw-Jenkin#1, sb@Harwood138, loss of Harw-Humb2 69kV.	12	60	Stable
28	AA1-114-P4-05	P4	SLG on Harw-Valm, sb@Harwood138, loss of Harw-Humb2 69kV.	12	60	Stable
29	AA1-114-P4-06	P4	SLG on Harw-Jenkin#1, sb@Harwood138, loss of 69/230kV4.	12	60	Stable
30	AA1-114-P4-07	P4	SLG on Harwood - AA1-103 POI 230kV, SB@Harwood, loss of Harwood - SUSQ CKT 1 230kV and T5@Harwood.	8	17	Stable

No	Contingency ID	Standard TPL-001 faults	Fault Description	Clearing time		Results
				Normal (cycles)	Delayed (cycles)	
31	AA1-114-P4-08	P4	SLG on Harwood - AA1-103 POI 230kV, SB@Harwood, loss of Harwood - SUSQ CKT 2 230kV (LEO@H), T4 and Cap @Harwood.	8	17	Stable
32	AA1-114-P4-09	P4	SLG on Harwood - East Palmerton 230kV, loss of T6@Harwood, SB@Harwood, loss of Harwood - SUSQ CKT 2 230kV (LEO@Harwood), T4 and Capacitor @Harwood.	8	17	Stable
33	AA1-114-P4-10	P4	SLG on Harwood - East Palmerton 230kV, loss of T6@Harwood, SB@Harwood, loss of Harwood - SUSQ CKT 1 230kV, and T5 @Harwood.	8	17	Stable
34	AA1-114-P4-11	P4	SLG on SUSQ - Harwood CKT1 230kV, loss of T5@Harwood, SB@SUSQ, loss of SUSQ - Sunbury CKT 1 230kV, and T22@SUNB.	8	17	Stable
35	AA1-114-P4-12	P4	SLG on SUSQ - Harwood CKT1 230kV, loss of T5@Harwood, SB@SUSQ, loss of SUSQ - Mountain 230kV(LEO@SUSQ), and Capacitor @SUSQ.	8	17	Stable
36	AA1-114-P4-13	P4	SLG on SUSQ - Harwood CKT2 230kV, SB@SUSQ, loss of SUSQ - SQ10 230kV (LEO).	8	17	Stable
37	AA1-114-P4-14	P4	SLG on Siegfried - East Palmerton 230 kV, loss of T3@ Siegfried, SB@ Siegfried, loss of Siegfried - AA1-103 POI(LEO@ Siegfried), Siegfried - Martins Creek CKT 2 (LEO, only connected to T2@ Siegfried) and T4@ Siegfried	8	17	Stable
38	AA1-114-P4-15	P4	SLG on Siegfried - Frackville 230 kV, SB@ Siegfried, loss of Siegfried - AA1-103 POI (LEO@S), Siegfried - Martins Creek CKT 2 (LEO, only connected to T2@ Siegfried), T4@Siegfried	8	17	Stable
39	AA1-114-P4-16	P4	SLG on Siegfried - Frackville 230 kV, SB@ Siegfried, loss of Siegfried - Martins Creek CKT 1 (LEO, only connected to T1@ Siegfried), and T5 @ Siegfried.	8	17	Stable
40	AA1-114-P5-01	P5	SLG on Harwood 69kV due to protection failure	60	N/A	Stable
41	AA1-114-P7-PL100390	P7	SLG on HARWOOD to E_PAL & HARWOOD to AA1-114 POI@Harwood.	8	N/A	Stable
42	AA1-114-P7-PL100391	P7	SLG on SIEGFRIED to E_PAL & SIEGFRIED to AA1-114 POI@ Siegfried.	8	N/A	Stable
43	AA1-114-P7-PL100392	P7	SLG SUSQ-HARW #1 & SUSQ-HARW #2 230 kV@Harwood	8	N/A	Stable
44	AA1-114-P7-PL100483	P7	SLG on MOUNTAIN-SUSQ #T10 & SUSQ-MOUNTAIN 230KV @ SUSQ	8	N/A	Stable
45	AA1-114-P7-PL100484	P7	SLG on MONTOUR-SUSQ 230KV & MONTOUR-SUSQ T10 230KV @ SUSQ	8	N/A	Stable
46	AA1-114-P7-PL101343	P7	SLG on X2-012 TAP-CLINTON & X2-012 TAP-ELIMSPORT 230 kV@X2-012TAP	8	N/A	Stable

Appendix B: AA1-114 Plant Model

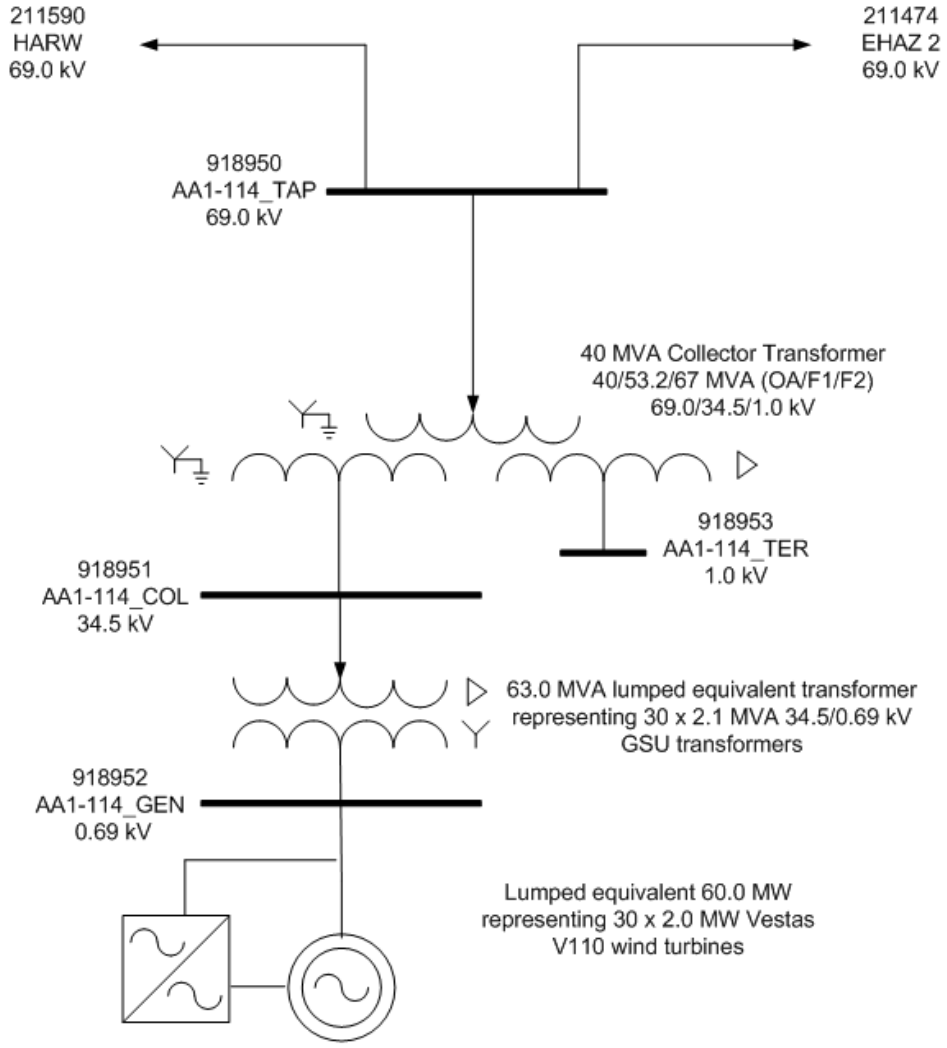


Figure B-1: PJM AA1-114 plant model

Appendix C: Power Flow and Dynamic Models

C.1) PSS/E Models

PSS/E Models for Vestas V110 2.0 MW Wind Turbine

VestasWT_7_6_0_PSSE32.lib

C.2) Power Flow Model Data

```
Version 32
BAT_LTAP,211707,211474,'1', 0.26,918950,'AA1-114_TAP',0.0
RDCH
1
918950,'AA1-114_TAP ',  69.0000,1, 229, 239,   2,1.01449, -25.3380
918951,'AA1-114_COL ',  34.5000,1,   1,   1,   1,1.02585, -18.7886
918952,'AA1-114_GEN ',   0.6900,2,   1,   1,   1,1.04261, -14.9801
918953,'AA1-114_TER ',   1.0000,1,   1,   1,   1,1.02496, -18.3693
0 / END OF BUS DATA, BEGIN LOAD DATA
0 / END OF LOAD DATA, BEGIN FIXED SHUNT DATA
0 / END OF FIXED SHUNT DATA, BEGIN GENERATOR DATA
918952,'1 ',    60.000,    11.498,    12.180,   -17.520,1.01449,918950,    60.000, 5.00000E-3,
1.99100E-1, 0.00000E+0, 0.00000E+0,1.00000,1,  100.0,    60.000,     0.000,   1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
211474,918950,'1 ', 8.58400E-3, 3.32260E-2,   0.00067,   97.00,  124.00,    0.00,  0.00000,
0.00000,  0.00000,  0.00000,1,1,   2.21,   2,1.0000
211707,918950,'1 ', 3.01600E-3, 1.16740E-2,   0.00023,   97.00,  124.00,    0.00,  0.00000,
0.00000,  0.00000,  0.00000,1,2,   0.77,   2,1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
918950,918951,918953,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   2,1.0000
 2.50000E-3, 7.99000E-2,    40.00, 2.50000E-3, 3.21200E-2,    40.00, 2.50000E-3, 1.22030E-1,
40.00,1.02496, -18.3693
1.00000,   0.000,   0.000,    40.00,    53.20,    67.00, 0,      0, 1.05000, 0.95000, 1.05000,
0.95000,   5, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000,   0.000,     0.00,     0.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000,
0.90000,  33, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000,   0.000,     0.00,     0.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000,
0.90000,  33, 0, 0.00000, 0.00000,  0.000
918951,918952,     0,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   1,1.0000
 6.30000E-3, 7.58000E-2,    63.00
1.00000,   0.000,   0.000,    63.00,     0.00,     0.00, 0,      0, 1.05000, 0.95000, 1.05000,
0.95000,   5, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
 229,     0,     0.000,     0.000,'PL          '
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
   1,'CHICAGO     '
 239,'CENTRAL     '
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
   1,'CENT HUD    '
   2,'EXT_RFC     '
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA, BEGIN SWITCHED SHUNT DATA
0 / END OF SWITCHED SHUNT DATA, BEGIN GNE DATA
0 / END OF GNE DATA
Q
```

C.3) Dynamic Data

```
/*****************************************************************************
/*
/*   AA1-114 - 60 MW - 30 x 2 MW V110 Wind Turbines
/*
/*****************************************************************************
/*
/*   MODULE: Vestas Generic Model Dynamic Data Template for PSS/E
/*   Model revision: 7.6
/*   WTG type: V110 VCSS 2.0 MW 60 Hz Mk10
/*
/*****************************************************************************
918952 'USRMDL' '1' 'VWCOR6' 1 1 2 45 23 104 1 0
2000.0000 690.0000 903.3041 700.0000 2.6200 0.9676 0.0232
1.9807 8.3333 1.9807 8.3333 30.0000 0.2000 1.2000
0.1000 0.0012 0.9925 0.0474 1.6118 0.0000 351.8584
161.5343 0.0300 0.0000 0.0300 0.3000 0.0000 1.0000
0.3183 4.9736 2812227.1900 43.2960 90.0120 600000.0000 3.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVAR6' 8 0 2 0 0 30 918952 '1' /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 918952 '1' 1
0.9000 0.0010 0.1500 18.6316 74.5430 74.5430 74.5430
0.5000 1.0000 2.6200 0.9676 1.2000 0.5000 690.0000
903.3041 0.3500 0.0500 0.2500 0.0200 3.0000 4.0000
9999.0000 0.0232 0.9000 0.9000 0.0500 0.0000 0.0100
0.0000 2.0000 0.0000 1.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 /
0 'USRMDL' 0 'VWPWR6' 8 0 3 30 7 10 918952 '1' 0
1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
0.2000 0.2000 1.0000 1.0000 0.0000 0.0000 0.1000
0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 /
0 'USRMDL' 0 'VWMEC6' 8 0 2 10 8 0 918952 '1'
2000.0000 422.2301 4736.7543 420.7500 83.5000 6188.8071 39.3992
0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 918952 '1'
0.1000 0.1000 0.1000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 918952 '1' 1 1 0 0 0
0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
0.9000 5.0000 /
0 'USRMDL' 0 'VWFPR6' 0 2 3 12 0 7 918952 '1' 0
56.4000 0.2000 56.4000 0.2000 56.4000 0.2000 63.6000
0.2000 63.6000 0.2000 63.6000 0.2000 /
/*****************************************************************************
```

C.5) Area Generation

Bus #	Bus Name	Voltage	Id	Pgen	Pmax
200030	CONE G1	22.00	H	443	455.4
200030	CONE G1	22.00	L	402	448
200031	CONE G2	22.00	2	0	11.2
200031	CONE G2	22.00	H	443	455.4
200031	CONE G2	22.00	L	402	445
200032	KEYS G1	20.00	2	11	11.2
200032	KEYS G1	20.00	H	430	455.5
200032	KEYS G1	20.00	L	415	455.5
200033	KEYS G2	20.00	H	432	455.5
200033	KEYS G2	20.00	L	400	455.5
200034	PCHBTM 2	22.00	1	596	1370
200035	PCHBTM 3	22.00	1	1128	1245
200036	SALEM-G1	22.00	1	1174	1253
200037	SALEM-G2	22.00	1	1150	1245
200038	SUSQ 2	24.00	1	1340	1354
200039	HOPE CG1	22.00	1	1155	1262
200040	C CLF G1	25.00	1	873	873
200041	C CLF G2	22.00	1	862	867
200042	LIMERCK2	22.00	1	1134	1225
200044	BETH CT1	13.80	1	121	118
200045	BETH CT2	13.80	1	121	127
200046	BETH CT3	13.80	1	121	127
200047	BETH CC4	18.00	1	177	195
200048	BETH CT5	13.80	1	121	118
200049	BETH CT6	13.80	1	121	127
200050	BETH CT7	13.80	1	121	127
200052	ROCKSP 1	18.00	1	155	192
200053	ROCKSP 2	18.00	1	155	191
200054	ROCKSP 3	18.00	1	155	190
200055	ROCKSP 4	18.00	1	155	190
200058	HUNTR101	18.00	1	163	168.8
200059	HUNTR201	18.00	2	164	168.8
200060	HUNTR301	18.00	3	165	168.8
200061	HUNTR401	22.00	4	310	322.9
200192	P-004 1CT	13.80	1	109	122
200193	P-004 2CT	13.80	1	109	122
200194	P-004 3CT	13.80	1	109	122
200195	P-004 4ST	18.00	1	169	188.9
207922	BRIS	30.00	1	0	8.2

Bus #	Bus Name	Voltage	Id	Pgen	Pmax
208769	SISO	12.47	1	1	1.2
208769	SISO	12.47	2	1	0.64
208769	SISO	12.47	3	1	0.64
208835	V3-051_C	12.47	1	2	0.4
208848	U1-067	12.47	1	0	1.8
208848	U1-067	12.47	2	0	1.8
208900	BRIS G1	18.00	1H	160	161
208900	BRIS G1	18.00	1L	160	160
208901	BRIS G2	18.00	2H	187	189
208901	BRIS G2	18.00	2L	187	189
208902	BRIS G3	24.00	3	748	749
208903	HOLT 695	12.47	1	10	11
208903	HOLT 695	12.47	13	1	1.5
208903	HOLT 695	12.47	2	11	11
208903	HOLT 695	12.47	3	11	11
208903	HOLT 695	12.47	4	11	11
208903	HOLT 695	12.47	5	11	11
208904	HOLT 696	13.20	10	14	13.5
208904	HOLT 696	13.20	11	1	1.5
208904	HOLT 696	13.20	6	11	11
208904	HOLT 696	13.20	7	11	11
208904	HOLT 696	13.20	8	11	11
208904	HOLT 696	13.20	9	13	13
208905	LMBE CT1	16.50	1	0	235
208906	LMBE CT2	16.50	1	0	235
208907	HOLT 697	13.20	18	66	74.292
208907	HOLT 697	13.20	19	66	74.292
208908	LMBE ST1	16.50	1	0	254
208909	MACR G3	24.00	3	850	850
208910	MACR G4	24.00	4	849	850
208911	MONT G1	24.00	1	745	758.5
208912	MONT G2	24.00	1	750	756.9
208913	SAHA 12	13.30	1	0	30
208913	SAHA 12	13.30	2	0	30
208914	SAHA 34	13.80	3	16	32.5
208914	SAHA 34	13.80	4	16	32.5
208915	SAHA 567	13.80	5	16	33
208915	SAHA 567	13.80	6	16	32
208915	SAHA 567	13.80	7	16	32
208916	SAHA8910	13.80	10	19	38.1
208916	SAHA8910	13.80	8	19	38.1
208916	SAHA8910	13.80	9	19	38.3

Bus #	Bus Name	Voltage	Id	Pgen	Pmax
208917	SAHA1112	13.80	11	19	38
208917	SAHA1112	13.80	12	19	38
208918	SUSQ 1	24.00	1	1340	1354
208920	WLPK	12.47	1	44	44
208941	FISH CT	12.47	1	30	28
208942	HARR CT	12.47	1	0	56
208943	HARW CT	12.47	1	27	28
208944	JENK CT	12.47	1	0	28
208945	LOHA CT	12.47	1	0	14
208946	MACR CT	12.47	CT	0	72
208947	WSHO CT	12.47	1	0	28
208948	WILL CT	12.47	1	0	28
208972	BECR K09	12.47	12	24	25.2
208980	BEPO IPP	12.47	1	187	195
208981	FOWH IPP	12.47	1	44	43
208982	GLBT IPP	12.47	1	93	94
208985	HMSW IPP	12.47	1	23	23
209003	KSTN IPP	13.80	1	0	5
209006	NEPC IPP	13.80	1	56	52
209007	NOEN IPP	13.80	1	115	108.2
209008	PAXT IPP	13.80	1	13	12
209009	PEIP 2	13.80	1	44	50
209010	PEIP 1	13.80	1	23	20
209010	PEIP 1	13.80	2	5	4.6
209010	PEIP 1	13.80	3	5	4.6
209013	SCEN IPP	13.80	1	96	97
209018	SUNBIPCT	12.47	1	0	36
209021	WEST IPP	13.80	1	34	32.5
209022	WHFR IPP	13.80	1	49	43
209023	WIENIPP1	13.80	1	62	59.8
209025	WIENIPP3	13.80	2	33	29.1
209025	WIENIPP3	13.80	3	33	31
209026	WIENIPP4	13.80	4	33	29.6
209027	LOR2_Q27	0.69	1	102	100
209028	N31 IPP	12.47	1	5	5
209029	WAYM IPP	34.50	1	70	8.9
209030	FRFA O01	12.47	1	2	1.6
209030	FRFA O01	12.47	2	2	1.6
211064	PSPA	69.00	1	0	10
212099	BRMO IPP	13.80	1	11	6.9
212174	INGE	0.48	1	8	8
212266	LOR1	0.69	1	28	27.7

Bus #	Bus Name	Voltage	Id	Pgen	Pmax
212449	SUNB CT	69.00	1	0	6
234305	HUN GEN4	13.80	4	45	44.7
204653	27PORT2GEN	15.50	H2	125.8	125.8
204653	27PORT2GEN	15.50	L2	125.8	125.8
206340	28GIL 4&5	13.80	4	49	49
206340	28GIL 4&5	13.80	5	49	49
206347	28GILCT1&2	13.80	1	23	23
206347	28GILCT1&2	13.80	2	25	25
206348	28GILCT3&4	13.80	3	25	25
206348	28GILCT3&4	13.80	4	25	25
208940	ALLE CT	12.47	1	56	56
917060	Z2-009 GEN	0.60	1	68	68
918844	AA1-103_GEN1	0.69	1	97.5	97.5
918845	AA1-103_GEN2	0.69	1	115	115

Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AA1-114

Oak Ridge

September 2015

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

EDF Renewable Development, LLC, the Interconnection Customer (IC), has proposed a wind generating facility located in Carbon County, PA. The installed facilities will have a total capability of 60 MW with 7.72 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 2017. **This study does not imply a PPL Electric Utilities (PPL EU) commitment to this in-service date.**

Point of Interconnection

AA1-114 will interconnect with the PPL EU system along the Harwood-East Hazelton #2 69kV line.

Cost Summary

The AA1-114 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 1,271,172
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 1,457,185
Allocation for New System Upgrades	$
Contribution for Previously Identified Upgrades	$
Total Costs	**$**

Overview

The AA1-114 project is located south east of the Harwood-East Hazelton #2 69 kV line. The Interconnection Customer's (IC's) facilities will be located approximately 0.4 miles from the transmission line. The AA1-114 project can be connected to PPL EU's 69kV transmission system by tapping the Harwood-East Hazleton #2 69kV line in the vicinity of 40°54'9.63"N75°58'22.93"W. In order to interconnect with the PPL EU transmission system, a new 69 kV line will be required. Please see Attachment 1 for a one-line diagram of the Point of Interconnection (POI). The POI will be where the 69 kV transmission lead line terminates onto the dead-end structure in the IC's yard.

Attachment Facilities

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

Description	Total Cost
New transmission tap line *PJM Network Upgrade Number n4652*	$ 1,271,172
Total Attachment Cost Estimate	**$ 1,271,172**

Design & Location Details

- Install new custom steel high low tap poles on concrete foundation 200 feet south east from 49096N27327 along current centerline. Install new LD steel pole angle structure 200 feet from new tap pole. Install substation DE angle structure 200 feet from previous angle structure. Install new MOLBAB 200' south east along current center line below new tap pole.

Steel Poles

- One (1) new 2 custom pole high low tap structures: 90' custom steel pole on foundation and 60' custom steel pole on foundation. Framing similar to 6-36-075
- One (1) new MOLBAB structures: 85' MOLBAB steel pole direct embedded. Framing per 6-33-033
- Two (2) new angle structures: 85' LD8 steel pole direct embedded. Framing per 6-36-050

Conductor & OHGW

- Conductor: 1800' 556.5 kcmil bare 24/7 ACSR (conductor length at 60˚ F for all phases)
- OPGW: 600' SFPOC 0.567" dia. 48 fiber OPGW (OPGW length at 60˚ F)

Termination

The OPGW will be terminated on the Interconnection Customer's deadend structure within their substation. A splice enclosure will be provided by PPL EU on the customer's deadend structure. The customer is to contact PPL EU as to which side of the deadend structure is preferred.

Direct Connection Cost Estimate

There are no Direct Connection facilities required to be constructed by the Transmission Owner.

Non-Direct Connection Cost Estimate

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	Total Cost
Rebuild portion of Nepco Tap 69kV *PJM Network Upgrade Number n4653*	$ 1,215,881
Harwood substation work *PJM Network Upgrade Number n4654*	$ 241,304
Total Non-Direct Facilities Cost Estimate	**$ 1,457,185**

Rebuild Nepco Tap

Design & Location Details

- 0.4 miles of the Nepco Tap 69kV line will be rebuilt to add a second circuit from grid 48958N27437 to 49096N27327. The second circuit will be an extension of the Consolidated Cigar 2 line. The Consolidated Cigar 2 line is fed from Harwood-East Hazelton 2 at grid 48655N28050.
- Replace 48958N27437 with new low tap structure. Replace 48984N27429 with new double circuit suspension structure. Replace 49096N27327 with new double circuit suspension structure.

Steel Poles

- Two (2) new 120' custom steel suspension poles on foundations: (2)11' arms for OPGW, (2)11' and (4)7' arms for conductor.
- One (1) Low tap structure 60' custom steel pole on foundation framing similar to low side of 6-36-075

Conductor & OHGW

- Conductor: 11000' 556.5 kcmil bare 24/7 ACSR (conductor length at 60˚ F for all phases)
- OPGW: 7000' SFPOC 0.567" dia. 48 fiber OPGW (OPGW length at 60˚ F)

Substation Work

- The protection system at the remote end of the 69kV line will be modified to support this interconnection. To accommodate AA1-114, the following upgrades are required at PPL EU's Harwood 230-69kV Substation.
- Install a fiber patch panel at Harwood's 69 kV control cubicle.
- Install fiber based Direct Transfer Trip (DTT) Cabinet SEL 2440, fuses and test switches at Harwood's 69 kV cubicle in new DTT box (see picture below)
- Install SEL 2830M in DTT box
- Install new control switches for test and blocking in DTT box.
- Run duplex Patch cord fiber optic cable from new SEL 2830 in the new DTT box to new fiber optic patch panel in the 69 kV control cubicle
- Connect contacts of East Hazleton #2 69kV primary and backup line relay to new SEL 2440 relay for trip (located in 69 kV cubicle).
- Connect contacts of Bus Tie 69kV primary and backup line relay to new SEL 2440 relay for trip (located in 69 kV cubicle).
- Install Bus Tie DTT Selector Switch to transfer control of the DTT scheme between the East Hazleton #2 69kV Line CB and the Bus Tie 69kV CB.
- Run a single mode 48 ADSS tie between patch panel (New) and splice box located in last transmission structure of the Harwood-East Hazleton #2 69 kV line (splice box will be provided by Transmission Dept.)
- Modify SCADA for new alarms (program new alarms in SCADA for IPP)
- Modify Alarm Management system (program new alarms in AMS for IPP)
- Review and acceptance of IPP's Intertie Protective Relaying (IPR) and Point of Contact (POC) design of their facility. – Relay Engineering – 60 hrs
- Perform system checks and test equipment in Harwood and the IPP site before placing in service Relay test hrs – 40 hrs at Harwood/40 hrs at IPP location

Substation Work for Mini Switching Yard

Outside the IPP customer substation, a mini switching yard with a motor-operated switch and 69 kV breaker will be installed in the future by PPL. A small control house will contain the circuit breaker relays and communication devices.

Preliminary Work Schedules

The estimated PPL EU elapsed time to complete the 69 kV Attachment Facilities and Direct and Non-Direct Connection substation work is approximately 36 months after the receipt of a fully executed ISA/CSA.

The schedule for the 69kV substation work to accommodate AA1-114 would depend on the project's start date. The work to accommodate AA1-114 will require both substation and transmission line facility outages. PPL EU's outage windows for construction are typically

available in the spring and fall of the year. Missing an outage window could result in project delays.

The transmission and substation work can be completed concurrently. PPL EU will commence siting, engineering design, material purchase and construction of the facilities identified in this study after receiving written authorization by PJM to begin work. This time frame is contingent upon the acquisition of all rights of way in the stated time frame before the start of construction and detailed design.

Transmission Owner Assumptions in Developing the Cost Estimates

- For the custom-designed steel transmission poles, the lead-time is approximately 32 to 42 weeks. It is estimated that custom designed steel poles will be needed for this project.
- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly delay the schedule.
- This magnitude estimate has been prepared without extensive research or field review.
- For the new 69 kV line to AA1-114, it is assumed that required ROW will be provided to PPL EU by the IC and the line would be owned by PPL EU.
- No environmental, real estate, or permitting issues were reviewed for the estimate of this project.
- This estimate assumes that suitable facility outages can be schedule as required to install the new switchyard. Failure to meet a scheduled facility outage may result in project delays.
- Excepting any operational, governmental, and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable PPL EU to decrease this construction period but no guarantees can be made. It is also assumed that all rights-of-way and easements are secured by the anticipated construction start dates.
- PPL EU recommends that an Interim ISA be completed during the Facilities Study stage to address critical path items, such as long lead-time purchases and any other compressed project schedule issues.
- The ISA/CSA or an Interim Interconnection Service Agreement (IISA) must be signed by the AA1-114 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Interconnection Customer Requirements

AA1-114 Generator, GSU, and Line Modeling

The turbines will be modeled as one unit and will inject 60 MW into PPL EU's system.

Per the AA1-114 supplied data the following was used in modeling the generator and the GSU:

AA1-114 Generator (Vestas V110):

- Number of Turbines: 30

- Size: 2 MW per turbine
- MVA Base: 2.08 MVA
- 0.90 lead to 0.90 lag power factor at 69 kV bus

Transformers:

- GSU (Generator Step Up Transformer):
- Number of machines per GSU: 30
- MVA Base: 40 MVA
- Voltage Level: 34.5/69 kV
- Impedance: 8.0%
- GSU (Wind Turbine Unit):
- MVA Base: 2.1 MVA
- Voltage Level: 34.5/0.69 kV

Transmission Line:

- Voltage Level: 69 kV
- MVA Base: 100 MVA
- Length: 1 mile
- Positive sequence impedance: 0.00450+j0.00550
- Zero sequence impedance: 0.0140+j0.04750

Intertie and POC Protective Relaying Equipment

The Interconnection Customer will need to install suitable protection and control equipment based on PPL EU Parallel generation requirements. The new 69 kV customer substation protection must meet all applicable PPL EU, NERC and FERC requirements. The protection equipment and schemes will be identified during the Facilities Study. This includes Intertie Protective Relaying (IPR) and Point of Contact (POC) relaying documents for voltages below 230 kV can be referred to on the PPL EU website. The website addresses are shown below:

IPR Requirements:
https://www.pplelectric.com/at-your-service/electric-rates-and-rules/customer-owned-generation.aspx

POC Requirements:
https://www.pplelectric.com/at-your-service/electric-rates-and-rules/point-of-contact-requirements-for-high-voltage-facilities.aspx

Direct Transfer Trip Relaying Equipment:

The OPGW will be terminated on the Interconnection Customer's deadend structure within their substation. A splice enclosure will be provided by PPL EU on the customer's deadend structure. The customer will be responsible to extend the fiber from the splice enclosure into their control house to tie into their DTT control scheme. PPL EU intends to install an SEL 2440 with an SEL

2830M fiber optic transceiver module at Harwood 230-69kV substation. The customer will be responsible to install a matching set of DTT equipment at their facility.

Isolation Breaker Requirement at the Interconnection Customer's Substation

Per the customer's preliminary sketches, the customer is planning to provide a high side circuit breaker at 69 kV with a manually operated 69 kV disconnect switch on the PPL EU line side of this breaker. Unless otherwise indicated, it is assumed that this be will be the "Isolation Circuit Breaker" and will be operated by the IPR relay and the DTT signal. It is requested that the customer confirm this or provide alternate isolation breaker.

AA1-114 Generator Harmonic and Flicker Requirements

On the PPL EU 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from AA1-114's equipment, the Queue AA1-114 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the Interconnection Customer must limit the severity of their voltage variation to within a level which will not cause objectionable flickers to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation will be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curves as a guideline to determine if the system is operating within acceptable limits. PPL EU will require corrective actions by the Interconnection Customer if their operation causes flickers that exceed PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

AA1-114 Generator Regulation or Reactive Support Requirements

As specified in Part IV, Subpart E at 54.7 of the PJM OATT, the Project AA1-114 generator shall design its "Facility" to maintain a composite power factor delivery at continuous rated power output at the generators terminals at a power factor of at least 0.95 leading (absorbing vars) to 0.95 lagging (supplying vars).

"For all new wind-powered and other non-synchronous generation facilities, if determined in the system Feasibility study to be required for the safety or reliability of the Transmission

System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging."

The PPL EU preliminary load flow studies have indicated that the AA1-114 generator will maintain the required voltage regulation within the required ranges. A MW/MVAR schedule will be developed at the time of the Facilities Study.

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.

PPL EU Requirements

SCADA Equipment Requirements

PPL EU will require installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system to provide real time values of KW, KVAR, and kV metering data at the POC. SCADA equipment will also provide capability to trip and the status monitoring of the POC isolating circuit breaker. In addition to that, monitoring of other abnormal conditions at developer's plant will be provided where deemed necessary. This connection will be a 4-wire dedicated FDDA-type phone line. PPL EU will provide detailed specifications and design drawings for this equipment.

Revenue Metering Equipment Installation at the Point of Interconnection

Installation of revenue grade Bi-directional Metering Equipment will be required at the Queue AA1-114 Point of Interconnection (POI) to measure KWh and KVARh. PPL EU will design and supply the required metering equipment but all the installation cost would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment must provide bi-directional revenue metering (KWH and KVARH) and real-time data (KW, KVAR, circuit breaker status, and generator bus voltages) for the developer's generating resource. The equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

Other Issues Impacting the Interconnection Customer

Distribution Service Requirements

The Interconnection Customer must submit a request for electric service through PPL EU's Industrial and Commercial Services (ICS) group if the queue AA1-114 requires back-up electric service at a voltage less than 69 kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost

for distribution electric service is NOT included in the PPL scope of work transmission or substation estimates.

Future Conversion of line to 138 kV from 69 kV

PPL EU presently has no plans to convert this line to 138 kV in the next 15-20 years. If the transmission system in this area is converted to 138 kV in the future, the Interconnection Customer would be responsible for conversion of its substation to 138 kV at that time.

PA PUC Certification & Environmental Issues

All required land and right of way will be made available to PPL EU at no cost from the Interconnection Customer developer. It is assumed here that the transmission tap would be owned by PPL EU.

Intertie 69-34.5 kV Transformer Turns Ratio

PPL EU typically procures the transformers with the following high side (69 kV) taps:

70.6 kV, 68.8 kV, 67.0 kV, 65.2 kV, 63.4 kV with nominal midpoint voltage is 67 kV, this provides a range of 5% above (in two 2.5% steps) and 5% below (in two 2.5% steps) to the mid-point range of 67 kV.

Alternate Outlet

The IC has not requested an alternate outlet for their generation. When the Harwood-E. Hazelton #2 69 kV line needs to come off line for any line maintenance or repair activities, the generator will be required to come off line. The IC will not be able to generate into the PPL EU network during maintenance on either the 69kV line to AA1-114 or during certain bus outages at the Harwood 230-69kV regional substation.

Maintenance Considerations

The Queue AA1-114 facility will not be able to generate into the PPL EU network during maintenance on the new 69 kV generator supply line. PPL EU on-going annual and long-term planned maintenance of this circuit will require PPL EU to remove the circuit from operation one (1) time every four (4) years, for an outage period of approximately two (2) weeks. The actual duration may be shorter. During maintenance periods, the circuit may or may not be returned to service during the evening hours. That decision depends on the type of work being performed. Unexpected and unplanned maintenance outages are not included in the one-in-four number and duration time. Annual inspections that uncover damaged poles, conductors, or hardware, which

require immediate repair, are scheduled as soon as practicable. These types of unplanned outages may last up to 16 hours.

Network Impacts

The Queue Project AA1-114 was studied as a 68.0 MW (Capacity 8.8 MW) injection as a tap of the Harwood – East Hazelton #2 69 kV line in the PPL area. Project AA1-114 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AA1-114 was studied with a commercial probability of 100% using a Summer Peak 2018 case. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
PJM69	CONTINGENCY 'PJM69' DISCONNECT BRANCH FROM BUS 200021 TO BUS 200009 CKT 1 /* SUNBURY JUNIATA 500 500 DISCONNECT BRANCH FROM BUS 200021 TO BUS 200022 CKT 2 /* SUNBURY SUSQHANA 500 500 / CKT 1 -> 2 DISCONNECT BRANCH FROM BUS 200021 TO BUS 208109 CKT 24 /* SUNBURY SUNBURY 500 230 END

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.

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

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

Will be performed during the Facilities Study stage.

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.

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.

	Contingency		Affected		Bus			Power	Loading %		Rating		MW	
#	Type	Name	Area	Facility Description	From	To	Circuit	Flow	Initial	Final	Type	MVA	Contribution	Ref
1	N-1	PJM69	PL	SUSQHANA 500/230 kV transformer	208116	200022	21	AC	108.57	109.96	ER	1165	19.08	

Attachment 1. Single Line Diagram