Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position X1-020

Dumont-Greentown 765 kV

December/2015

Revised December 17, 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.

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General

Community Energy Wind, LLC proposes to install PJM Project #X1-020, a 1500 MW (195 MW capacity) wind generating facility connecting to the American Electric Power (AEP) Dumont – Greentown 765 kV Circuit (see Figure 2). The location of the wind generating facility is in Miami County, IN approximately 39 miles from the Dumont and Greentown 765 kV stations (see Figure 1).

The requested in service date is June, 2015.

The objective of this impact study is to determine budgetary cost estimates and approximate construction timelines for identified transmission facilities required to connect the proposed generating facilities to the AEP transmission system. These reinforcements include the Attachment Facilities, Local Upgrades, and Network Upgrades required to maintain the reliability of the AEP transmission system.

Attachment Facilities

The point of interconnection is approximately 39 miles from either the Greentown or Dumont 765 kV station via a new in-line 765 kV switching station on the Dumont – Greentown 765 kV line. This new station is to consist of four (4) 765 kV circuit breakers configured in a breaker and one half bus arrangement operated as a ring-bus to accommodate two connections to Community's collector station (Exhibit 2). Protection schemes will need to be modified.

The station also includes 765 kV revenue metering, SCADA, and associated equipment. Community is expected to obtain, at their cost, an 800' x 800' (minimum) station site for the AEP facilities. Community shall obtain all necessary permits. Ownership of the in-line facilities shall be transferred from Community to AEP upon successful completion of the work.

A 765 kV line extension is required to loop through the proposed station. The AEP switching station is assumed to be located immediately adjacent to the existing transmission lines. A supplemental line easement for the tap structures will be required. It is expected that Community will obtain the supplemental easement when the station property is purchased.

Changes to relay equipment at Dumont and Greentown stations are required. However, the Greentown 765 kV station is owned by Duke Energy Indiana and AEP. Therefore, coordination between PJM, MISO and Duke Energy Indiana will be required for any relay upgrades/changes at Greentown station.

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The following work is required to connect to the Greentown – Dumont 765 kV line:

- Install a new 4-breaker 765 kV switching station laid out in a breaker and one-half arrangement including associated disconnect switch bus work, SCADA and 765 kV revenue metering. Estimated Cost: $30,092,000

- Modify relaying at Dumont 765 kV Station. Estimate Cost: $554,400

- Modify relaying at Greentown 765 kV Station. Estimated Cost: $727,400 (Based on AEP estimates – may also involve DE-I and MISO)

Total Estimated Point of Interconnection Cost: $31,373,800*

It is understood that Community Energy Wind LLC is responsible for all costs associated with this connection. The costs above are reimbursable to AEP. Cost of the Community Energy Wind LLC collector station for 1500 MW of generation and costs for the line connection from the collector station to the AEP switching station are not included in this report, these are assumed to be Community Energy Wind LLC's responsibility.

The Generation interconnection agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. The metering work above and cost indicated below does not include any potential work or cost to address metering requirements of the local service provider. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Local and Network Impacts

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet required performance criteria in accordance with the AEP FERC Form 715. Therefore, this criterion was used to assess the impact of the proposed facility on

* The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

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the AEP System. The Community Energy Wind LLC project was studied as a 1500 MW (195 MW capacity) generating facility consistent with the interconnection application. Project #X1-020 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

Potential network impacts for the points of interconnection were as follows:

<u>Normal System (2015 Summer Conditions Capacity Level)</u>

- No problem identified

<u>Single Contingency (2015 Summer Conditions Capacity Level)</u>

- No problem identified

<u>Multiple Contingency (2015 Summer Conditions Capacity Level)</u>

- No problem identified

<u>Contribution to Previously Identified Overloads (2015 Summer Conditions Capacity Level)</u>

- No problem identified

<u>Normal System (2015 Summer Conditions Full Output)</u>

- No problem identified

<u>Single Contingency (2015 Summer Conditions Full Output)</u>

- No problem identified

<u>Multiple Contingency (2015 Summer Conditions Full Output)</u>

- No problem identified

<u>Contribution to Previously Identified Overloads (2015 Summer Conditions Full Output)</u>

- No problem identified

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Light Load Analysis

- No Problem identified

Voltage

- No Problem identified

Short Circuit Analysis

- No Problem identified

Stability Analysis

The concern regarding stability for this project is the N-2 condition involving outage of X1-020 POI to Dumont 765 kV and Greentown-Jefferson 765 kV where the wind generation ends up radial to Greentown 138 kV and 230 kV outlets.

It is found that this condition is of low enough system short circuit ratio (system short circuit MVA/MW generation) as to begin to exhibit signs of wind farm control instability, but it is not to the point of being a stability problem.

This result is sensitive to the wind turbine dynamic modeling data and the line and transformer r+jx values. This study was conducted based on the data available at this time and any small changes in the wind turbine dynamic modeling data and the line and transformer r+jx values may cause wind farm control instability. The complete Stability Analysis can be found in Attachment 1 at the end of this report.

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Additional Limitations of Concern

MISO analysis has identified potential overloading of the Sturgis-Howe-LaGrange 69 kV AEP-NIPSCO tieline. AEP owns 2.83 miles of the Howe – Sturgis 69 kV line and the summer emergency rating is 50 MVA. We will have to rebuild 2.83 miles of the existing Howe – Sturgis 69 kV line. Estimated Cost to rebuild is $3.4 Million.

Local/Network Upgrades

- None

Schedule

The standard time required for interconnection station construction is 18 - 24 months after signing an interconnection agreement. The required line upgrades are more significantly affected by availability of construction outages and other details normally addressed in the Facilities Study or when finalizing the ISA/ICSA, but could be expected to take somewhat longer.

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Conclusion

Based upon the results of this Impact Study, the construction of the Community Energy Wind LLC (PJM Project #X1-020) wind generation project will require additional interconnection charges. Local network upgrades will also be required for this project.

Network Upgrade Number	Description	Estimate
n4742	Construct Interconnection Substation with Revenue Metering	$30,092,000
n4743	Modify relaying at Dumont 765 kV Station	$554,000
n4744	Modify relaying at Greentown 765 kV Station	$727,400
	Total	**$31,373,400**

Table 1 - Interconnection Costs

Network Upgrade Number	Description	Estimate
~~n4730~~	~~Rebuild/Reconductor approximately 30 miles of the R60/S72 Tap -East Lima 345 kV line section~~	~~$60,000,000~~
n4713	Rebuild 2.83 miles of the existing Howe – Sturgis 69 kV line (AEP portion)	$3,400,000
	Total	**$3,400,000**

Table 2 – Local Network Upgrade Costs

Network Upgrade Number	Description	Estimate
n4740	Rebuild 2.76 miles of the existing Howe – Sturgis 69 kV line (MISO portion)	$2,208,000
n4741	Rebuild of 1.91 miles of 69kV circuit	$1,524,000
	Total	**$3,732,000**

Table 3 – Affected System Upgrade Costs

- **Estimated interconnection cost: $31,373,800.**
- **Estimated local network upgrade cost**: **$3,400,000.**
- **Estimated Affected System upgrade cost**: **$3,732,000.**
- **Total estimated cost for project X1-020: $38,505,400.**

These estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to refine final construction requirements. Per the PJM Tariff, the customer is responsible for the actual costs incurred.

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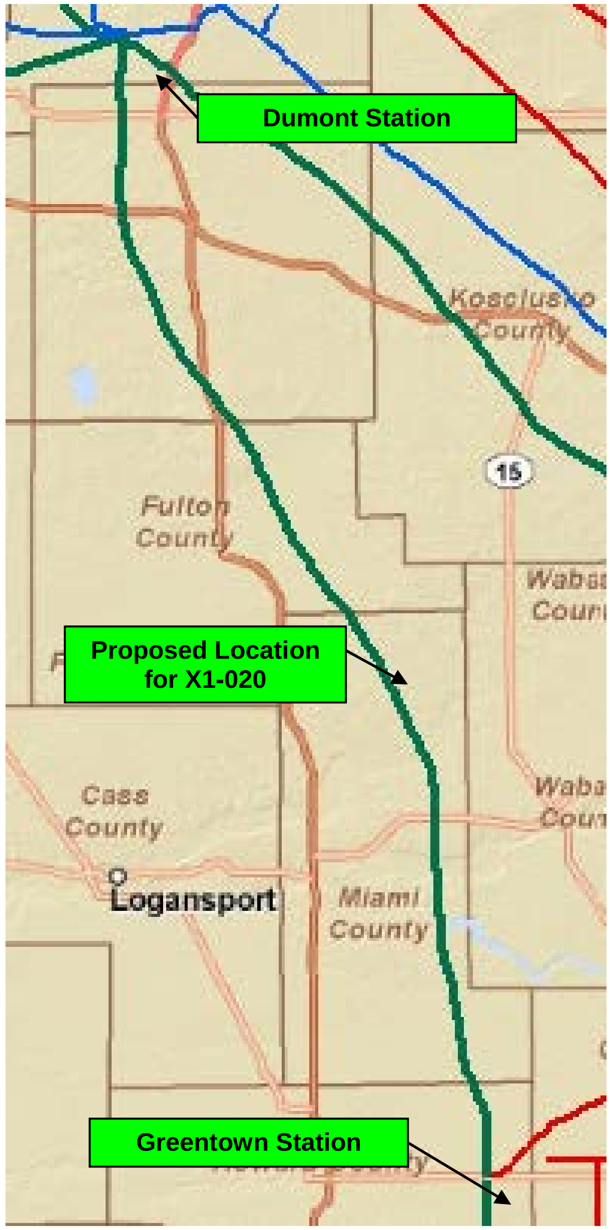

Exhibit 1: Approximate interconnection location of the proposed facilities

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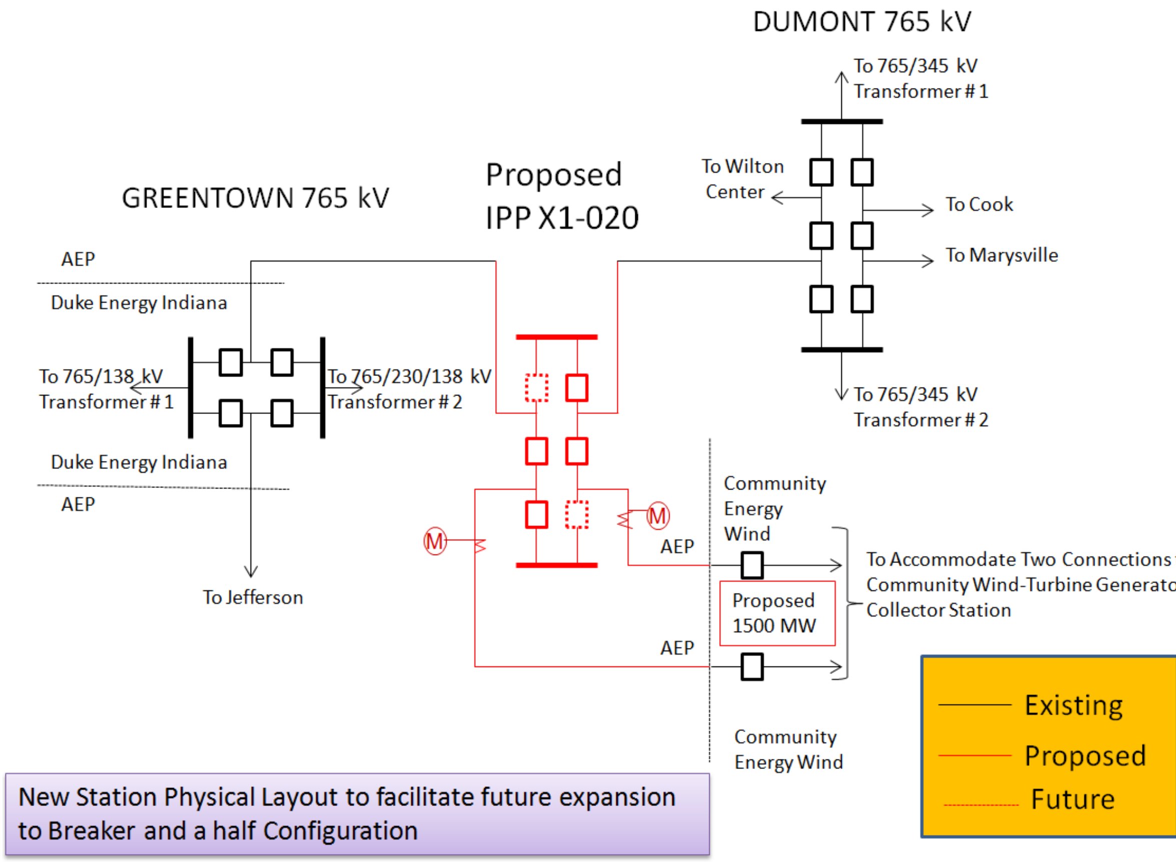

Exhibit 2: Simplified diagram of proposed 765 kV in-line switching station

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Attachment 1 – Stability Analysis

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Executive Summary

Generation Interconnection Request X1-020 is for a 1500 MW (maximum facility output) wind farm consisting of 612 × 2.5 MW wind turbine generators with a Point of Interconnection (POI) on the Dumont – Greentown 765 kV circuit in the American Electric Power (AEP) network.

X1-020 is now at the system impact study phase of PJM's Generation and Transmission Interconnection Process. This report describes a dynamic simulation analysis of X1-020 as part of the overall system impact study.

The load flow scenario for analysis was the RTEP 2015 summer peak load case, with the addition of the X1-020 models at maximum power output and unity power factor at the collector buses.

27 contingencies were studied, each with a 10 second simulation time period. Studied faults included:

a) Steady state operation
b) Three phase faults with normal clearing time
c) Single phase faults with single phase stuck breaker

Selected contingencies were also run under a maintenance outage of the 765 kV Dumont – X1-020 POI circuit. Single phase faults with delayed clearing were omitted as the AEP clearing times indicate that dual primary communication systems are used at 765 kV.

X1-020 was modeled in voltage control mode, per the Impact Study data supplied by the developer. For the intact system, the fault simulations met the fault recovery criteria:

a) X1-020 rode through the faults (except for faults where protective action tripped some machines of X1-020),
b) the system with X1-020 included was found to be transiently stable,
c) a new steady state was reached,
d) voltages at the POI and nearby buses returned to an acceptable range, with system stability being maintained. No mitigations were found to be required.

Several tested under the maintenance outage of the Dumont – X1-020 POI circuit did not run to completion due to non-convergence of the simulation, and inter-tripping of X1-020 would be required for these contingencies. This is the case for contingencies at the X1-020 POI and at Greentown. For these instances, the windfarm is required to be curtailed.

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1. Introduction

Generation Interconnection Request X1-020 is for a 1500 MW wind farm consisting of 612 × 2.5 MW wind turbine generators with a Point of Interconnection (POI) on the Dumont – Greentown 765 kV circuit in the American Electric Power (AEP) network.

As the Regional Transmission Operator, PJM Interconnection is responsible for planning the incorporation of generators into the grid. X1-020 is now at the system impact study phase of PJM's Generation and Transmission Interconnection Process.

PJM contracted Power Systems Consultants (PSC) to carry out this dynamic simulation analysis of X1-020 as part of the overall system impact study. This analysis is effectively a screening study to determine whether the addition of X1-020 will meet the dynamics requirements of the NERC and PJM reliability standards.

In this report the X1-020 project and how it is proposed to be connected to the grid are first described, followed by a description of how the project is modeled in this study. The fault cases are then described and analyzed, and lastly a discussion of the results is provided.

2. Description of the Project

The proposed X1-020 project is specified in the Impact Study data provided in Attachment 1. Attachment 2 shows the one line diagram of the AEP network in the vicinity of X1-020.

X1-020 is connected to the AEP system via the existing 78 mile 765 kV circuit between Greentown 765 kV Substation and Dumont 765 kV Substation, approximately 35 miles from Greentown Substation. The project includes the establishment of a new in-line switching station based on a breaker and one half bus arrangement but configured as a ring bus with four circuit breakers.

Figure 1 shows how X1-020 has been modeled in this study. Table 1 lists the parameters given in the impact study data and the corresponding parameters of the X1-020 load flow model. Attachment 3 provides a diagram of the PSS/E model in the vicinity of X1-020; Attachment 4 gives the X1-020 PSS/E load flow model.

The dynamic model for the X1-020 plant is based on a GEWT 2.5 MW PSS/E model supplied by PJM. The dynamic model of the X1-020 plant is given in Attachment 5.

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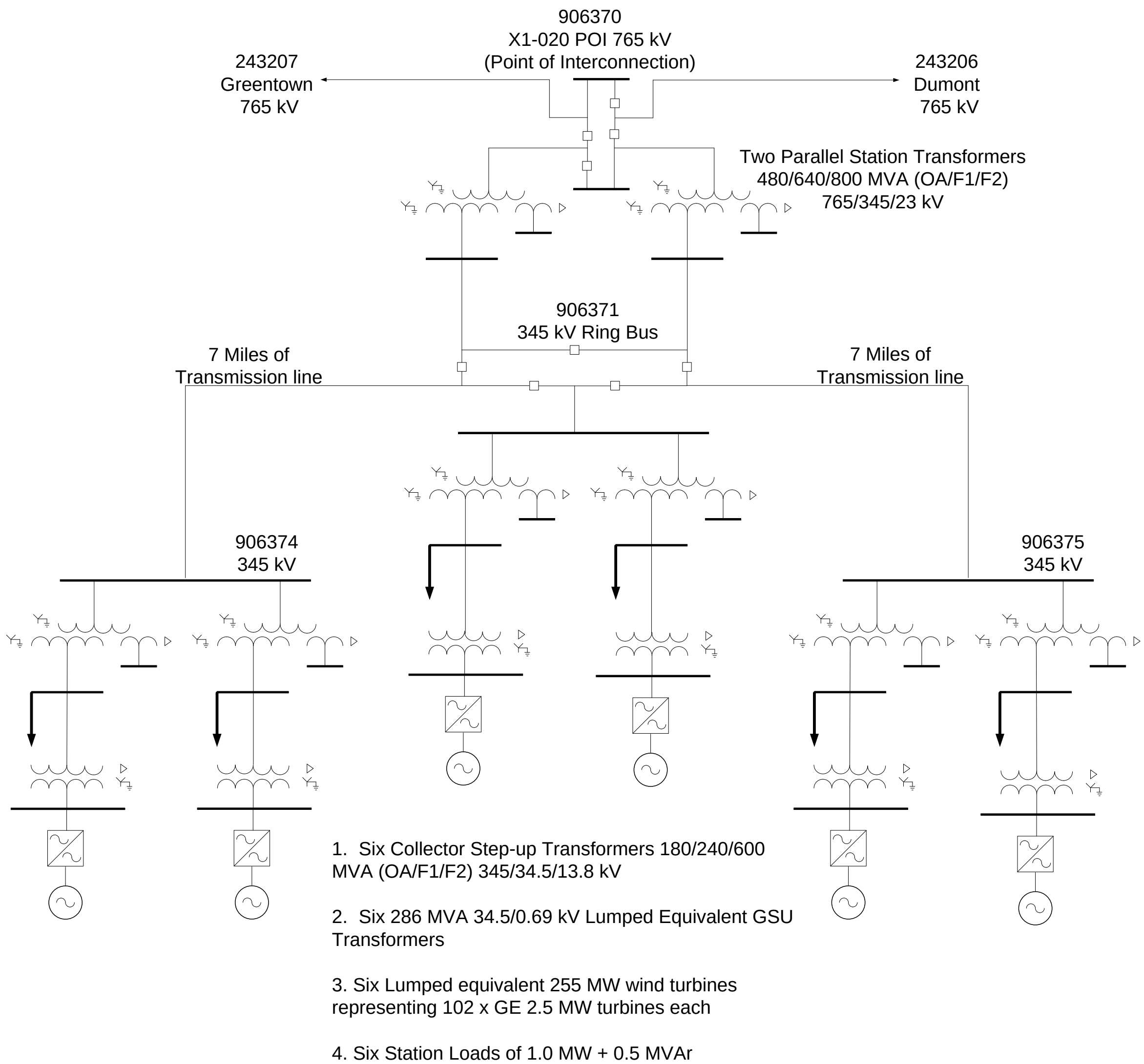

Figure 1: X1-020 Model

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Table 1: X1-020 Plant Model

	Impact Study Data	Model
Wind turbine generator	612 x GE 2.5 MW wind turbines MVA base 3.0 MVA Vt = 0.69kV +/- 1.2 MVAr / turbine Saturated subtransient reactance not given – proponent referred to manufacturer specifications.	6 Lumped equivalents representing 102 x 2.5 MW GE Wind Turbines Pgen 255 MW Pmax 255 MW Pmin 0 MW Qgen 15.1 MVAr Qmax 122.4 MVAr* Qmin -122.4 MVAr* Mbase 306 MVA Zsorce[1] 0.0 + j99999 pu
GSU transformer	612 x 2.8 MVA 34.5/0.69 kV 0.8 % + j 6.0 % @ 2.8 MVA Number of taps = 5 Tap Step Size = 2.5 % OA 2.8 MVA	6 Lumped equivalents representing 102 x 2.8 MVA GSU transformers. 285.6 MVA 34.5/0.69 kV 0.008 + j0.06 pu @ 285.6 MVA 5 taps Tap step size = 2.5%

[1] Source reactance of the GE wind turbine model is set to a large number as per the Siemens User Guide – PSS/E Wind Modelling Package for GE 2.5 MW Wind turbines.

Collector step-up transformer	345/34.5/13.8 kV Yyd 180/240/300 MVA (OA/F1/F2) Collector bus off-nominal turns ratio: 1.0 Impedances (pu @ 180 MVA) HV-MV 0.00167 + j0.10 MV-Tertiary 0.00117 + j0.07 HV-Tertiary 0.003 + j0.18	345/34.5/13.8 kV Yyd 180/240/300 MVA (OA/F1/F2) Positive Sequence pu @ 180 MVA HV-MV 0.00167 + j0.10 MV-Tertiary 0.00117 + j0.07 HV-Tertiary 0.003 + j0.18
Station transformer	765/345/23 kV Yyd 480/640/800 MVA (OA/F1/F2) Number of taps = 5 Tap Step Size = 2.5 % Collector bus off-nominal turns ratio: 1.0 Impedances (pu @ 480 MVA) HV-MV 0.0015 + j0.09 MV-Tertiary 0.00105 + j0.063 HV-Tertiary 0.0027 + j0.162	765/345/23 kV Yyd 480/640/800 MVA (OA/F1/F2) Number of taps = 5 Tap Step Size = 2.5 % Positive Sequence pu @ 480 MVA HV-MV 0.0015 + j0.09 MV-Tertiary 0.00105 + j0.063 HV-Tertiary 0.0027 + j0.162
Collector cables		Not modeled
Station demand	1.0 MW + 0.5 MVAr at low voltage side of GSU	6 × 0.167 MW/0.083 MVAr at 34.5 kV busbars

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Transmission line	2 × 7 mile 345 kV 795 kcmil ACSR conductor MVA Base 1000 MVA Z1 = 0.000548+j0.00388 pu/mile Z0 = 0.00520+j0.01407 pu/mile Y1 = 0.00085 pu/mile	MVA Base 100 MVA Z1 = 0.0004+j0.0027 pu Y1 = 0.0595 pu

* Qmax = 15.1MVAr and Qmin = 0 MVAr when running X1-020 study in order to make a conservative assessment of LV ride-through capability by having unity power factor at the collector bus.

3. Load flow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 30.3.1.

The load flow scenario and fault cases for this study are based on PJM's Region Transmission Planning Process[2] and discussions with PJM.

This study is focused on the ability of the plant to ride through faults. The selected load flow scenario is the RTEP 2015 summer peak load case, provided by PJM from the W3-088 study, with the following modifications:

a) Modeling of X1-020 at the Point of Interconnection between Greentown 765 kV Substation and Dumont 765 kV Substation
b) Removal of withdrawn and subsequent queue projects in the vicinity of X1-020
c) Connection and disconnection of some distant generation units in the PJM system in order to maintain slack units within limits
d) Deactivation of bus 243462 (an AEP 242 kV bus connected only to a transformer and solving at > 1.4 pu voltage) to improve load flow convergence

In the load flow the X1-020 generators are set to maximum power output (total 1530 MW) with unity power factor at the collector buses (34.5 kV) and approximately 0.96 and 0.95 pu voltage at the generator buses and collector buses respectively.

[2] Manual 14B: PJM Region Transmission Planning Process, Rev 19, September 15 2011, Attachment G : PJM Stability, Short Circuit, and Special RTEP Practices and Procedures.

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Generation within the PJM500 system (area 225 in the PSS/E case) and within a 5 bus radius of X1-020 has been dispatched online at maximum output. Exceptions are listed in Table 2.

Table 2: Generation at reduced output within 5-bus radius of X1-020

Bus	**Name**	**Unit**	**PGEN (MW)**	**PMAX (MW)**	**Reason**
248000	06CLIFTY 345.00	A	110	124.715	Initialization issue
248000	06CLIFTY 345.00	B	110	124.715	
243225	05KEYSTN 345.00	1	50	59	GGOV1 Trate=51 MW limits output
243225	05KEYSTN 345.00	2	50	60	
243225	05KEYSTN 345.00	3	50	60	
243225	05KEYSTN 345.00	4	50	59	
243187	05GVG2 26.000	2H	657.2	667	Conflict with governor model

In order to achieve an acceptable voltage profile across the 765 kV network, the 765 kV shunt reactors listed in Table 3 were switched out of service.

Table 3: 765 kV Shunt reactors switched out

From Bus Number	**From Bus Name**	**To Bus Number**	**To Bus Name**	**Id**	**Line B From (pu on 100 MVA) Removed**	**Line B To (pu on 100 MVA) Removed**
242509	05AXTON 765.00	242514	05J.FERR 765.00	1	-3	0
242510	05BAKER 765.00	242511	05BROADF 765.00	1	-3	-3
242512	05CLOVRD 765.00	242514	05J.FERR 765.00	1	-3	0
242512	05CLOVRD 765.00	242515	05JOSHUA 765.00	1	-3	0
242924	05HANG R 765.00	243208	05JEFRSO 765.00	1	-3	-3
242928	05MARYSV 765.00	243206	05DUMONT 765.00	1	-3	-3
243206	05DUMONT 765.00	906370	X1-020 MAIN 765.00	1	-3	0

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243207	05GRNTWN 765.00	243208	05JEFRSO 765.00	1	-3	-3

Modifications were made to the dynamics case to resolve initialization issues:

1. Removal of several distant generation units from the dynamic simulation to avoid initialization problems, including machines 3 and 5 at bus 345400 (ESST1A exciter models initializing out of limits).

2. Bus 347832 has been netted to avoid the following initialization issue, and a consequent significant DSTATE warning:
   ```
   MNLEX3 AT BUS 347832 [1NEWTON 1   24.000] MACHINE 1
   INITIALIZED ABOVE ZERO
   ```

3. For bus 270000 existing units 1, 2 & 3 and bus 270001 existing units 1 & 2, the saturation factors S(1.0) and S(1.2) were much higher than expected; it was assumed they are % rather than per unit values. These values were thus divided by 100 to set more realistic values.

4. For bus 248000 machine C (+ machine 6), the IEEEG1 governor model was suppressed to avoid initializing out of limits.

4. Fault Cases

Tables 4 – 6 list the contingencies that were studied, with representative worst case total clearing times provided by PJM. Each contingency was studied over a 10 second simulation time interval. Faults were applied to transmission circuits and transformers connected to the Point of Interconnection or one bus removed[3].

The studied faults included:

a) Steady state operation
b) Three phase faults with normal clearing time
c) Single phase faults with single phase stuck breaker

[3] One bus removed from the POI refers to buses with transmission circuit breakers, not tee-offs or buses with only supply circuit breakers.

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Selected faults were also run under a maintenance outage of the 765 kV Dumont – X1-020 POI circuit.

Single phase faults with delayed clearing were omitted as the AEP clearing times indicated that dual primary communication systems are used at 765 kV.

The one line diagram of the AEP network in Attachment 2 shows where faults were applied.

The positive sequence fault impedances for single line to ground faults were derived from a separate short circuit case provided by PJM, modified by PSC to ensure that connected generators in the vicinity of X1-020 have not withdrawn from the PJM queue, and are not greater than the queue position under study.

The two 765/345 kV transformers at Dumont had different impedance values in the X1-020 short circuit case. This resulted in different fault admittance for contingencies 1B.13 and 1B.14. The greater of the two fault admittances was used for both contingencies to provide a conservative outcome.

5. Fault Recovery Criteria

The fault recovery criteria applicable to this study are as per PJM's Region Transmission Planning Process:

a) Post-contingency voltages should remain within +/- 0.05 pu of the pre-contingency voltages at transmission level buses.
b) Post-contingency oscillations should be positively damped with a damping margin of at least 3%.
c) The X1-020 generators should maintain their pre-contingent power output following the fault.

6. Summary of Results

Plots from the dynamic simulations are provided in Attachment 6, with results summarized in Tables 4 – 7.

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For the intact system, the fault simulations met the fault recovery criteria:

a) the system with X1-020 included in voltage control mode was found to be transiently stable,
b) a new steady state was reached,
c) voltages at the POI and nearby buses returned to an acceptable range,
   with X1-020 riding through the fault (except for faults where protective action tripped some machines of X1-020) and system stability being maintained. No mitigations were found to be required.

For the system under a maintenance outage of the 765 kV circuit between Dumont and the X1-020 POI, test contingencies involving faults at the X1-020 POI and at Greentown 765 kV did not run to completion. All of the maintenance outage contingencies tested at these locations require inter-tripping of X1-020. A contingency involving the same maintenance outage and a fault on the Jefferson to Hanging Rock 765 kV circuit was found to meet criteria.

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Table 4: Steady State Operation

Fault ID	Duration	X1-020 No Mitigation
SS.01	Steady state 20 sec	Stable

Table 5: Three-phase Faults with Normal Clearing

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	X1-020 No Mitigation
3N.01	Fault at X1-020 765 kV POI on X1-020 765/345 kV Transformer 1 circuit.	3.5 / 3.5	Stable
3N.02	Fault at X1-020 765 kV POI on Greentown circuit.	3.5 / 3.5	Stable
3N.03	Fault at X1-020 765 kV POI on Dumont circuit.	3.5 / 3.5	Stable
3N.04	Fault at X1-020 345 kV on circuit to 1/3 of X1-020 turbines.	3.5 / 3.5	Stable
3N.05	Fault at Greentown 765 kV on X1-020 circuit.	3.5 / 3.5	Stable
3N.06	Fault at Greentown 765 kV on Jefferson circuit.	3.5 / 3.5	Stable
3N.07	Fault at Greentown 765 kV on 765/138 kV Transformer 1.	3.5 / 3.5	Stable
3N.08	Fault at Greentown 765 kV on 765/230/138 kV Transformer 2.	3.5 / 3.5	Stable
3N.09	Fault at Dumont 765 kV on X1-020 circuit.	3.5 / 3.5	Stable
3N.10	Fault at Dumont 765 kV on Marysville circuit.	3.5 / 3.5	Stable
3N.11	Fault at Dumont 765 kV on Cook circuit.	3.5 / 3.5	Stable
3N.12	Fault at Dumont 765 kV on Wilton Centre circuit.	3.5 / 3.5	Stable
3N.13	Fault at Dumont 765 kV on 765/345 kV Transformer 1.	3.5 / 3.5	Stable

Table 6: Single-phase Faults with Stuck Breaker

Fault ID	Fault description	Clearing Time Normal / Stuck Breaker (Cycles)	X1-020 No Mitigation
1B.01	Fault at X1-020 765 kV POI on X1-020 765/345 kV Transformer 1 circuit. Breaker stuck to Dumont circuit. Fault cleared with loss of 765 kV Dumont circuit.	3.5 / 13	Stable
1B.02	Fault at X1-020 765 kV POI on X1-020 765/345 kV Transformer 2 circuit. Breaker stuck to Greentown circuit. Fault cleared with loss of 765 kV Greentown circuit.	3.5 / 13	Stable
1B.03	Fault at X1-020 765 kV POI on Dumont circuit. Breaker stuck to X1-020 765/345 kV Transformer 1 circuit. Fault cleared with the loss of X1-020 765/345 kV Transformer 1.	3.5 / 13	Stable
1B.04	Fault at X1-020 765 kV POI on Greentown circuit. Breaker stuck to X1-020 765/345 kV Transformer 2 circuit. Fault cleared with the loss of X1-020 765/345 kV Transformer 2.	3.5 / 13	Stable
1B.05	Fault at X1-020 345 kV on circuit to 1/3 of X1-020 turbines. Breaker stuck. Fault cleared with the loss of further 1/3 of X1-020 turbines.	3.5 / 13	Stable
1B.06	Fault at Greentown 765 kV on X1-020 circuit. T2 breaker stuck. Fault cleared with the loss of 765/230/138 kV Greentown Transformer 2.	3.5 / 13	Stable
1B.07	Fault at Greentown 765 kV on Jefferson circuit. S2 breaker stuck. Fault cleared with the loss of 765/230/138 kV Greentown Transformer 2.	3.5 / 13	Stable
1B.08	Not used	N/A	N/A
1B.09	Fault at Dumont 765 kV on X1-020 circuit. B breaker stuck to 765 kV Wilton circuit. Fault cleared with loss of 765 kV Wilton circuit.	3.5 / 13	Stable
1B.10	Fault at Dumont 765 kV on Marysville circuit. A breaker stuck to 765 kV Cook circuit. Fault cleared with the loss of 765 kV Cook circuit.	3.5 / 13	Stable
1B.11	Fault at Dumont 765 kV on Cook circuit. A1 breaker stuck to Dumont 765/345 kV Transformer 1. Fault cleared with the loss of Dumont 765/345 kV Transformer 1.	3.5 / 13	Stable
1B.12	Fault at Dumont 765 kV on Wilton Center circuit. B1 breaker stuck to Dumont 765/345 kV Transformer 1. Fault cleared with the loss of Dumont 765/345 kV Transformer 1.	3.5 / 13	Stable
1B.13	Fault at Dumont 765 kV on 765/345 kV Transformer 1. A1 breaker stuck to Cook. Fault cleared with loss of 765 kV Cook circuit.	3.5 / 13	Stable
1B.14	Fault at Dumont 765 kV on 765/345 kV Transformer 2. B2 breaker stuck to X1-020. Fault cleared with loss of 765 kV X1-020 circuit.	3.5 / 13	Stable

Table 7: Faults under Maintenance Outage of 765 kV Dumont – X1-020 POI circuit

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	X1-020 No Mitigation
MA.SS.01	Steady state 20 sec	N/A	Stable

MA.3N.02	Three-phase fault at X1-020 765 kV POI on Greentown circuit.	3.5 / 3.5	Unstable – PSS/E aborted on non-convergence during fault clearing
MA.3N.06	Three-phase fault at Greentown 765 kV on Jefferson circuit.	3.5 / 3.5	Unstable – PSS/E aborted on non-convergence during fault clearing
MA.3N.15	Three-phase fault at Jefferson 765 kV on Hanging Rock circuit.	3.5 / 3.5	Stable
MA.1B.04	SLG fault at X1-020 765 kV POI on Greentown circuit. Breaker stuck to X1-020 765/345 kV Transformer 2 circuit. Fault cleared with the loss of X1-020 765/345 kV Transformer 2.	3.5 / 13	Unstable – PSS/E aborted on non-convergence during fault clearing
MA.1B.06	SLG fault at Greentown 765 kV on X1-020 circuit. T2 breaker stuck. Fault cleared with the loss of 765/230/138 kV Greentown Transformer 2.	3.5 / 13	Unstable – PSS/E aborted on non-convergence during fault clearing

Attachment 1. X1-020 Impact Study Data

Attachment 2. AEP One Line Diagram

Attachment 3. PSS/E Model One Line Diagram

Attachment 4. X1-020 PSS/E Case Data

Attachment 5. X1-020 PSS/E Dynamics Data

Attachment 6. Plots from Dynamic Simulations

Attachment 2 – Light Load Analysis

Network Impacts

The queue X1-020 project was studied as a 1500MW injection into AEP system tapping Dumont - Greentown 765kV line. Project X1-020 was evaluated for compliance with reliability criteria for **Light Load conditions** in 2015. Potential network impacts were as follows:

Generator Deliverability

None

Contribution to Previously Identified Overloads

None

Steady-State Voltage Requirements

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

None

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

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