

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position AC2-103***

***Beaver – Davis Bessie 345kV***

**August 2017**

## Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, 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 impact study is performed.

The Feasibility 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.

The conduct of light load analysis as required under the PJM planning process is not performed during the Generation Interconnection Feasibility Study phase of the PJM study process. Additional reinforcement requirements for this Interconnection Request may be defined during the conduct of the light load analysis which shall be performed following execution of the System Impact Study agreement.

## General

The Interconnection Customer (IC), has proposed a solar generating facility located in Erie County, Ohio. The installed facilities will have a total capability of 297.66 MW with 38.69 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is December 31, 2021. **This study does not imply a ATSI commitment to this in-service date.**

### Point of Interconnection

AC2-103 will interconnect with the American Transmission Systems Inc.(ATSI) transmission system along the Beaver – Davis Besse 345kV line.

### Cost Summary

The AC2-103 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 0
Direct Connection Network Upgrades	\$ 2,322,400
Non Direct Connection Network Upgrades	\$ 0

<b>Description</b>	<b>Total Cost</b>
<b>Total Costs</b>	<b>\$ 2,322,400</b>

In addition, the AC2-103 project may be responsible for a contribution to the following costs:

<b>Description</b>	<b>Total Cost</b>
New System Upgrades	\$ 41,800
Previously Identified Upgrades	\$ 636,200
<b>Total Costs</b>	<b>\$ 678,000</b>

Cost allocations for these upgrades will be provided in the System Impact Study Report.

## **Attachment Facilities**

No Attachment Facilities are required to support this interconnection request.

## Direct Connection Cost Estimate

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

Description	Activity Cost	Tax (if applicable)	Total Cost
Expanding the Beaver-Davis Besse (X1-027A) 345kV three circuit breaker ring bus into 345kV four circuit breaker ring bus to accommodate one 345kv circuit breaker and a 345kV generation-tie line exit.	\$ 2,322,400	\$ 304,100	\$ 2,626,500
<b>Total Direct Connection Facility Costs</b>	<b>\$ 2,322,400</b>	<b>\$ 304,100</b>	<b>\$ 2,626,500</b>

## Non-Direct Connection Cost Estimate

No Non-Direct Connection Facilities are required to support this interconnection request.

## Interconnection Customer Facilities

The proposed project consists of a wind farm with 82 Wind Turbine Generator Systems (WTGs), 3.63MW each, with a total maximum facility output of 297.7MW. The Interconnection Customer collector substation will consist of one collector substation at a voltage level of 34.5kV and two transformers will be stepping up the collector substation voltage (34.5kV) to the transmission voltage (345kV). The Interconnection Customer Farm collection facility site GPS location is (41.2922000, -82.7304890), the facility is located 5.25Miles from the POI. A 5.25miles 345kV generator-tie transmission line will be built by Interconnection Customer to interconnect their wind farm facility to the POI (Beaver-Davis Besse 345kV AC2-103).

## Transmission Owner Scope of Work

To interconnect the Beaver-Davis Besse (AC2-103) project into the Beaver-Davis Besse 345kV line, it is required to expand the Beaver-Davis Besse 345kV (X1-027A) POI to accommodate one additional 345kV circuit breaker and a new 345kV line exit to the Beaver-Davis Besse 345kV (AC2-103) 345kV generation tie-line (shown in attachment 2). It is required to install standard 345kV line protection panel, 345kV circuit breaker relay, communication equipment, and to adjust terminal end relay setting. Interconnection Customer shall design and build a 5.25 miles 345kV generator-tie line from their collector facility to the POI. Any cost estimate and scope of work in this report doesn't include the customer collector facility and the 5.28 miles 345kV generation-tie transmission line.

Interconnection Customer LLC, is responsible for any cost incurred by FE for the construction of the Beaver-Davis Besse (AC2-103) point of interconnection.

This report contains detailed connection requirements, direct connection costs and schedule, power flow analysis, short circuit analysis, and a cost and schedule for any associated system reinforcements for the requested POI.

Interconnection Customer will be responsible for acquiring all easements, properties and permits that may be required to construct the proposed 345kV generation tie-line and associated generation facilities.

The Beaver – Davis Besse 345kV (AC2-103) project direct connection and attachment facilities includes:

- Expanding the Beaver-Davis Besse (X1-027A) 345kV three circuit breaker ring bus into 345kV four circuit breaker ring bus to accommodate one 345kV circuit breaker and a 345kV generation-tie line exit.
- Installing a 345kV line dead-end structure, 345kV circuit breaker, DSW's, MOABS, CVT'S and arresters.
- Installing 345kV line relay & control panel over fiber.
- Installing standard dual pilot 345kV SEL411L line relay & control and SEL501 breaker failure to trip (BFT).
- Install and terminate fiber communication at the POI. The 345kV generation tie-line fiber communication will be provided by the Interconnection Customer .
- Prepare foundation, conduit and grounding for 345kV breaker, line dead-end and support structure.

The cost does not include communications installation and termination at the POI.

## **Transmission Owner Schedule**

Based on the scope of the direct connection and attachment facility required for the Beaver-Davis Besse 345kV (AC2-103) interconnection project, it is expected to take a minimum of eighteen (18) months from the signing of a Connection Service Agreement (CSA) to complete the direct connection and attachment facilities. The schedule assumes that there will be no environmental issues with any of the properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection, attachment facility and network upgrades, and that PJM will allow all transmission system outages when requested. The schedule assumes engineering start date of 09/01/2020 to meet the requested in-service date.

## **Interconnection Customer Requirements**

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

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

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.
3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.
4. The purchase and installation of a fully rated 345kV circuit breaker to permit tripping of the entire plant.
5. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.
6. The purchase and installation of a 345kV interconnection metering instrument transformer. FE will provide the ratio and accuracy specifications based on the customer generation levels.
7. The purchase and installation of a revenue class meter for each unit to measure the power delivered in compliance with the FE standards.
8. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center.
9. The establishment of dedicated communication circuits for SCADA report to the FE Transmission System Control Center.
10. A compliance with the FE and PJM generator power factor and voltage control requirements.
11. The execution of a back-up retail service agreement with the electric distribution company to serve the customer load supplied from the AC2-103 generation project interconnection point when the units are out-of-service.
12. Interconnection Customer will be responsible for meeting all FE criteria as defined in the FE Requirements for Transmission Connected Facilities document, including dynamic reactive capability. The FE dynamic reactive capability requires that a power factor range of 0.95 leading (absorbing Vars) to 0.95 lagging (producing Vars) must be met at the generator's terminals.

# **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.

## **ATSI Requirements**

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

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

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

## **System Protection Analysis and Requirements**

The Beaver-Davis Besse 345kV (AC2-103) project will require a standard dual pilot SEL 411L line relay & control and a SEL501 breaker failure to trip (BFT) over fiber relay.

FE requires that all proposed facilities including the POI and the customer facilities must be designed in accordance with the FirstEnergy "Requirements for Transmission Connected Facilities" document, which can be found using the links above (ATSI Requirements).

## **Compliance Issues**

Interconnection Customer will be responsible for meeting all FE criteria as defined in the "FE Requirements for Transmission Connected Facilities" document. FE requires that a power factor range of 0.95 leading (absorbing Vars) to 0.95 lagging (producing Vars) must be met at the Generator's Terminals.

Interconnection Customer must also meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures required for standards compliance. For example, the Developer will need to properly locate and report the over and under-voltage and over and under-frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

## Network Impacts

The Queue Project AC2-103 was evaluated as a 297.7 MW (Capacity 38.7 MW) injection tapping the Davis Besse – Beaver 345 kV line in the ATSI area. Project AC2-103 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-103 was studied with a commercial probability of 53%. Potential network impacts were as follows:

### Summer Peak Analysis - 2020

#### Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
B2-SYS-345-810	CONTINGENCY 'B2-SYS-345-810' /* LINE 02HAYES TO 02DAV-BE 345 CK 1  DISCONNECT BRANCH FROM BUS 239289 TO BUS 238654 CKT 1 /* 02HAYES 345 02DAV-BE 345 END
B3-SYS-345-700	CONTINGENCY 'B3-SYS-345-700' /* TRAN 02AVON 345 TO 02AVON 138 CK 91  DISCONNECT BRANCH FROM BUS 238551 TO BUS 238552 CKT 91 /* 02AVON 345 02AVON 138 END
B3-SYS-345-701	CONTINGENCY 'B3-SYS-345-701' /* TRAN 02AVON 345 TO 02AVON 138 CK 92  DISCONNECT BRANCH FROM BUS 238551 TO BUS 238552 CKT 92 /* 02AVON 345 02AVON 138 END
C2-CEI-345-001	CONTINGENCY 'C2-CEI-345-001' /* BREAKER FAILURE ON S145 BREAKER AT AVON 345KV  DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 1 /* 02LAKEAVE 345 02AVON 345 DISCONNECT BRANCH FROM BUS 239725 TO BUS 238551 CKT 2 /* 02LAKEAVE 345 02AVON 345 END

Contingency Name	Description
C2-OEC-345-023	CONTINGENCY 'C2-OEC-345-023' /* BEAVER 345KV BRK B-121  DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 1 /* 02BEAVER 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238569 TO BUS 238607 CKT 1 /* 02BEAVER 345 02CARLIL 345 END
C2-OEC-345-031	CONTINGENCY 'C2-OEC-345-031' /* HAYES 345KV BRK B-3_6_12  DISCONNECT BRANCH FROM BUS 239289 TO BUS 238654 CKT 1 /* 02HAYES 345 02DAV-BE 345 DISCONNECT BRANCH FROM BUS 239289 TO BUS 238569 CKT 1 /* 02HAYES 345 02BEAVER 345 DISCONNECT BRANCH FROM BUS 239289 TO BUS 239290 CKT 1 /* 02HAYES 345 02HAYES 138 END
C5-CEI-345-001	CONTINGENCY 'C5-CEI-345-001' /* AVON-BEAVER #1 AND #2 345KV LINE OUTAGES  DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 1 /* 02AVON 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238551 TO BUS 239725 CKT 2 /* 02AVON 345 02LAKEAVE 345 END
C5-OEC-345-001	CONTINGENCY 'C5-OEC-345-001' /* BEAVER-LAKAVE 345 CK 1 & 2  DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 1 /* 02BEAVER 345 02LAKEAVE 345 DISCONNECT BRANCH FROM BUS 238569 TO BUS 239725 CKT 2 /* 02BEAVER 345 02LAKEAVE 345 END

## Generator Deliverability

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

#	Contingency		Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
	Type	Name			From	To	Circuit		Initial	Final	Type	MVA		
1	N-1	B3-SYS-345-700	FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	99.31	100.07	ER	270	2.04	
2	LFFB	C2-CEI-345-001	FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	226.7	233.24	ER	270	39.19	7
3	DCTL	C5-CEI-345-001	FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	226.7	233.24	ER	270	39.19	
4	LFFB	C2-CEI-345-001	FE	02AD Q-2-02AVON 138 kV line	238524	238552	1	DC	103.17	107.28	ER	316	28.84	2
5	DCTL	C5-CEI-345-001	FE	02AD Q-2-02AVON 138 kV line	238524	238552	1	DC	103.17	107.28	ER	316	28.84	
6	LFFB	C2-CEI-345-001	FE	02LRN Q2-02AD Q-2 138 kV line	238915	238524	1	DC	103.23	107.34	ER	316	28.84	6
7	DCTL	C5-CEI-345-001	FE	02LRN Q2-02AD Q-2 138 kV line	238915	238524	1	DC	103.23	107.34	ER	316	28.84	
8	DCTL	C5-OEC-345-001	FE	02BEAVER-02BLKRVR 138 kV line	238570	239728	1	DC	113.43	116.2	ER	387	23.8	

Note: Please see Attachment 3 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.

## Multiple Facility Contingency

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

#	Contingency		Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
	Type	Name			From	To	Circuit		Initial	Final	Type	MVA		

#	Contingency		Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
	Type	Name			From	To	Circuit		Initial	Final	Type	MVA		
9	LFFB	C2-OEC-345-031	FE	X1-027A TAP-02BEAVER 345 kV line	907060	238569	1	DC	92.87	101.86	ER	1742	156.68	1

*Note: Please see Attachment 3 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

### **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)*

#	Contingency		Affected Area	Facility Description	Bus			Power Flow	Loading %		Rating		MW Contribution	Ref
	Type	Name			From	To	Circuit		Initial	Final	Type	MVA		
10	DCTL	C5-OEC-345-001	FE	02BEAVER-02CARLIL 345 kV line	238569	238607	1	DC	106.79	114.47	ER	1139	87.52	3
11	LFFB	C2-OEC-345-023	FE	02BEAVER-02LAKEAVE 345 kV line	238569	239725	2	DC	101.7	108.12	ER	1742	111.77	4
12	LFFB	C2-CEI-345-001	FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	214.81	221.35	ER	270	39.19	8
13	DCTL	C5-CEI-345-001	FE	02USSTEEL-02LRN Q2 138 kV line	239734	238915	1	DC	214.81	221.35	ER	270	39.19	

*Note: Please see Attachment 3 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper table in the Attachment.*

### **Short Circuit**

*(Summary of impacted circuit breakers)*

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 Type	Contingency Name	Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution	Ref
					From	To			Initial	Final	Type	MVA		
14	N-1	B3-SYS-345-701	FE	02BLKRVR-02USSTEEL 138 kV line	239728	239734	1	DC	104.01	106.68	ER	270	15.99	
15	N-1	B2-SYS-345-810	FE	X1-027A TAP-02BEAVER 345 kV line	907060	238569	1	DC	91.87	100.94	ER	1742	157.94	

## New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#1, 2, 3	02USSTEEL-02LRN Q2 138 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: <ul style="list-style-type: none"> <li>PJM baseline project (b2559) will not eliminate the identified overloads; the new rating is 435/500 SN/SE. The actual in service date is 05/31/2017.</li> <li>PJM baseline project (b2896) will eliminate the identified overloads; the new rating for the Black River – US Steel 138 kV line will be 552/659 SN/SE. The scheduled in service date is 06/1/2021.</li> </ul>	b2559  b2896	\$ 0
#4, 5, 6, 7	02AD Q-2-02AVON 138 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: <ul style="list-style-type: none"> <li>PJM baseline project (b2897) will eliminate the identified overloads; the new rating for the Admiral – Avon Q2 138 kV line will be 435/500 SN/SE. The scheduled in service date is 06/1/2021.</li> </ul>	b2897	\$ 0

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#8	02BEAVER-02BLKRVR 138 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: <ul style="list-style-type: none"> <li>PJM baseline project (b2673) and other upgrades will eliminate the identified overloads; the new rating for the Beaver – Black River 138 kV line will be 540/540 SN/SE. The scheduled in service date is 06/1/2020.</li> </ul>	b2673	\$ 0
#9	X1-027A TAP-02BEAVER 345 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: <ul style="list-style-type: none"> <li>ATSI will propose to re-conductor the Beaver substation conductor (SCCIR) 954Kcmil ACSR 45/7 strand (the limiting element) with bundle 954kcmil ACSS 48/7 strand conductor, 2184MVA summer normal &amp; 2326MVA summer emergency rating. After the proposed re-conductoring projects have been completed, the X1-027A-Beaver 345kV new line rating would be 1524MVA summer normal and 1878MVA summer emergency and the new limiting element will be the transmission line 954Kcmil ACSR 45/7 strand conductor.</li> <li>The estimated cost to re-conductor the Beaver substation conductor on Beaver-X1-027(Davis Bessie) 345kV line is \$41,800 (without tax).</li> </ul>	TBD	\$ 41,800
<b>Total New Network Upgrades</b>				<b>\$ 41,800</b>

### 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)*

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
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Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#10	02BEAVER-02CARLIL 345 kV line	<p>In order to mitigate the overloads of facilities above, the following reinforcements are required:</p> <ul style="list-style-type: none"> <li>• ATSI will propose to upgrade the limiting elements at Beaver and Carlisle 345 kV substation on Beaver-Carlisle 345 kV line. The limiting elements are GCY51 ZR3 relay at Beaver and relay thermal (RT) CEYB, impedance relay (ZR) GCY and relay thermal blinder (RT BDD) at Carlisle 345kV substation. A new Dual SEL 345kV relay with UPLC will be installed at Beaver and Carlisle substation, the Carlisle 345/138kV transformer #1 over current differential relay (BDD) setting will be adjusted. After all proposed upgrade projects have been completed, the Beaver-Carlisle 345kV line new rating would be 1228 MVA summer normal and 1424 MVA summer emergency rating, the limiting element would be a wave-trap at Carlisle.</li> <li>• The estimated cost to upgrade the Beaver-Carlisle 345kv line relay is \$504,700 (without tax).</li> </ul>	TBD	\$ 504,700
#11	02BEAVER-02LAKEAVE 345 kV line	<p>In order to mitigate the overloads of facilities above, the following reinforcements are required:</p> <ul style="list-style-type: none"> <li>• ATSI will propose to re-conductor the existing (2) 954Kcmil ACSR substation conductor (SCCIR) at Beaver 345kV substation with (2) 954kcmil ACSS 48/7 strand conductor, 2156 MVA summer normal &amp; 2295 MVA summer emergency rating and the Beaver - Lake Ave 345 kV ckt 2 (2) 954Kcmil ACSR 45/7 strand conductor line drop at Beaver with (2) 954Kcmil 54/7 ACSS conductor, 2184 MVA summer normal rating and 2326 MVA summer emergency rating. After the proposed conductor work has been completed, the Beaver - Lake Ave 345 kV ckt2 new line rating would be 1555 MVA summer normal and 1892 MVA summer emergency, the limiting element will be a substation conductor (SCCIR) 3500 SAC 127 conductor at Beaver substation.</li> <li>• The estimated cost to re-conductor the Beaver 345kV substation and line drop conductor on the Beaver-Lake Ave # 345kV line is \$45,000 (without tax).</li> </ul>	TBD	\$ 45,000

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost
#12, 13	02USSTEEL-02LRN Q2 138 kV line	In order to mitigate the overloads of facilities above, the following reinforcements are required: <ul style="list-style-type: none"> <li>PJM baseline project (b2559) will not eliminate the identified overloads; the new rating is 435/500 SN/SE. The actual in service date is 05/31/2017.</li> <li>PJM baseline project (b2896) will eliminate the identified overloads; the new rating for the US Steel – Lorain Q2 138 kV line will be 498/593 SN/SE. The scheduled in service date is 06/1/2021.</li> <li>The proposed mitigation is to re-conductor the Lorain substation conductor (the limiting element). Once the proposed mitigation and the PJM RTEP b2896 work have been completed, the US Steel - Lorain Q2 138kV line rating would be 548/688 SN/SE. The estimated cost to re-conductor the Lorain substation conductor on the US Steel - Lorain 138kV line is \$86,500 (without tax).</li> </ul>	b2559  b2896  TBD	\$ 86,500
<b>Total New Network Upgrades</b>				<b>\$ 636,200</b>

### **Light Load Analysis - 2020**

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

### **Stability and Reactive Power Requirement**

Stability and Reactive study to be completed during later study phases

### **Steady-State Voltage Requirements**

Steady-State Voltage study to be completed during later study phases

### **Affected System Analysis & Mitigation**

#### **MISO Impacts:**

MISO Impacts to be determined during later study phases (as applicable).

## Attachment 1. Flowgate Details

### Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

### Appendix 1

(FE - FE) The X1-027A TAP-02BEAVER 345 kV line (from bus 907060 to bus 238569 ckt 1) loads from 92.87% to 101.86% (**DC power flow**) of its emergency rating (1742 MVA) for the line fault with failed breaker contingency outage of 'C2-OEC-345-031'. This project contributes approximately 156.68 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
241902	02_Y1-069 GE	29.8
238564	02BAYSG1	25.09
240968	02BG2 GEN	1.26
240969	02BG4 G1	0.32
240970	02BG4 G2&3	0.63
240971	02BG4 G4&5	0.63
240950	02BG5	3.86
240973	02BG6 AMPO	5.61
239276	02COLLW 11	-3.2
239297	02CPPW41	-3.93
238670	02DVBSG1	46.33
238885	02LEMOG1	5.72
238886	02LEMOG2	5.72
238887	02LEMOG3	5.72
238888	02LEMOG4	5.72
238979	02NAPMUN	6.34
240975	02PGE GEN	8.71
931791	AC2-103 C	20.37
931792	AC2-103 E	136.31

Bus Number	Bus Name	Full Contribution
907062	X1-027A E1	57.27
907065	X1-027A E2	57.27
907067	X1-027A E3	57.27
907069	X1-027A E4	57.27
LTF	Y3-032	43.08
701261	Y4-027 C	0.3
701262	Y4-027 E	1.2
701341	Y4-035 C	0.1
701342	Y4-035 E	0.4
701421	Y4-043 C	0.07
701422	Y4-043 E	0.2
701431	Y4-044 C	2.56
701432	Y4-044 E	7.67
701491	Y4-050 C	1.7
701492	Y4-050 E	5.11
701531	Y4-054 C	0.89
701532	Y4-054 E	2.66
701571	Y4-058	8.6
701581	Y4-059	26.08

Bus Number	Bus Name	Full Contribution
998321	J496	13.69
998541	J533	11.83
998571	J537	17.63
998581	J538	11.61
998591	J540	2.45
961591	J589	12.69
961341	J601	9.01
961351	J602	14.33
961401	J608	5.28
247567	V2-006 C	2.14
247961	V2-006 E	14.33
901803	W1-072A	8.12
907061	X1-027A C1	1.5
907064	X1-027A C2	1.5
907066	X1-027A C3	1.5
907068	X1-027A C4	1.5

Bus Number	Bus Name	Full Contribution
701601	Y4-061	13.1
701662	Y4-067 E	23.51
701781	Y4-079	10.5
701791	Y4-080	2.71
701851	Y4-086	8.23
701861	Y4-087	7.88
701881	Y4-089	13.21
701891	Y4-090	2.48
701901	Y4-091	0.12
LTF	Z1-043	13.96
921102	AA1-056	9.75
923092	AB1-107 CT1	49.68
923094	AB1-107 CT2	57.13
923096	AB1-107 ST1	68.09
LTF	AB2-013	7.98
926941	AC1-181	0.7

## Appendix 2

(FE - FE) The 02AD Q-2-02AVON 138 kV line (from bus 238524 to bus 238552 ckt 1) loads from 103.17% to 107.28% (**DC power flow**) of its emergency rating (316 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 28.84 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	9
238571	02BEAVGA	1.37
238572	02BEAVGB	1.43
240968	02BG2 GEN	0.45
240969	02BG4 G1	0.11
240970	02BG4 G2&3	0.23
240971	02BG4 G4&5	0.23
240950	02BG5	1.39
240973	02BG6 AMPO	2.03
239276	02COLLW 11	-2.2
239297	02CPPW41	-2.86
238979	02NAPMUN	2.15

Bus Number	Bus Name	Full Contribution
247551	U4-028 C	0.72
247940	U4-028 E	4.84
247552	U4-029 C	0.72
247941	U4-029 E	4.84
247548	V4-010 C	1.57
247947	V4-010 E	10.51
901803	W1-072A	2.54
907062	X1-027A E1	10.54
907065	X1-027A E2	10.54
907067	X1-027A E3	10.54
907069	X1-027A E4	10.54
LTF	Y3-032	13.66

Bus Number	Bus Name	Full Contribution
240975	02PGE GEN	3.14
239175	02WLORG-6	2.26
931791	AC2-103 C	3.75
931792	AC2-103 E	25.09

Bus Number	Bus Name	Full Contribution
921102	AA1-056	2.99
923092	AB1-107 CT1	17.74
923094	AB1-107 CT2	17.51
923096	AB1-107 ST1	20.86

## Appendix 3

(FE - FE) The 02BEAVER-02CARLIL 345 kV line (from bus 238569 to bus 238607 ckt 1) loads from 106.79% to 114.47% (**DC power flow**) of its emergency rating (1139 MVA) for the tower line contingency outage of 'C5-OEC-345-001'. This project contributes approximately 87.52 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	22.44
240968	02BG2 GEN	1.13
240969	02BG4 G1	0.28
240970	02BG4 G2&3	0.57
240971	02BG4 G4&5	0.57
240950	02BG5	3.45
240973	02BG6 AMPO	5.02
238670	02DVBSG1	34.4
238979	02NAPMUN	5.41
240975	02PGE GEN	7.78
239171	02WLORG-2	5.47
239172	02WLORG-3	5.62
239173	02WLORG-4	5.6
239174	02WLORG-5	5.62
931051	AC2-015 C OP	4.83
931052	AC2-015 E OP	5.63
931791	AC2-103 C	11.38
931792	AC2-103 E	76.15
998321	J496	11.23
998571	J537	14.47
998581	J538	9.63
961591	J589	10.43
961341	J601	7.39
961351	J602	11.77
247926	U1-059 E	3.51

Bus Number	Bus Name	Full Contribution
907068	X1-027A C4	0.84
907062	X1-027A E1	31.99
907065	X1-027A E2	31.99
907067	X1-027A E3	31.99
907069	X1-027A E4	31.99
LTF	Y3-032	35.02
701261	Y4-027 C	0.25
701262	Y4-027 E	0.99
701341	Y4-035 C	0.08
701342	Y4-035 E	0.33
701421	Y4-043 C	0.06
701422	Y4-043 E	0.17
701431	Y4-044 C	2.1
701432	Y4-044 E	6.29
701491	Y4-050 C	1.4
701492	Y4-050 E	4.19
701531	Y4-054 C	0.73
701532	Y4-054 E	2.18
701571	Y4-058	7.06
701581	Y4-059	21.4
701601	Y4-061	10.75
701781	Y4-079	8.65
701791	Y4-080	2.22
701861	Y4-087	6.48
701881	Y4-089	10.84

Bus Number	Bus Name	Full Contribution
247551	U4-028 C	1.53
247940	U4-028 E	10.23
247552	U4-029 C	1.53
247941	U4-029 E	10.23
247567	V2-006 C	1.83
247961	V2-006 E	12.27
247548	V4-010 C	3.32
247947	V4-010 E	22.2
247942	W1-056 E	1.29
901803	W1-072A	6.59
907061	X1-027A C1	0.84
907064	X1-027A C2	0.84
907066	X1-027A C3	0.84

Bus Number	Bus Name	Full Contribution
701891	Y4-090	2.04
701901	Y4-091	0.1
921102	AA1-056	7.83
922573	AA2-186 E	1.71
923092	AB1-107 CT1	44.29
923094	AB1-107 CT2	45.86
923096	AB1-107 ST1	54.65
925751	AC1-051 C	0.72
925752	AC1-051 E	4.82
926941	AC1-181	0.6
927071	AC1-195 C	0.73
927072	AC1-195 E	5.32

## Appendix 4

(FE - FE) The 02BEAVER-02LAKEAVE 345 kV line (from bus 238569 to bus 239725 ckt 2) loads from 101.7% to 108.12% (**DC power flow**) of its emergency rating (1742 MVA) for the line fault with failed breaker contingency outage of 'C2-OEC-345-023'. This project contributes approximately 111.77 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
241902	02_Y1-069 GE	30.51
238564	02BAYSG1	28.48
240968	02BG2 GEN	1.43
240969	02BG4 G1	0.36
240970	02BG4 G2&3	0.72
240971	02BG4 G4&5	0.72
240950	02BG5	4.38
240973	02BG6 AMPO	6.38
239276	02COLLW 11	-4.21
239297	02CPPW41	-5.18
238670	02DVBSG1	43.84
238979	02NAPMUN	6.91
240975	02PGE GEN	9.89
239171	02WLORG-2	6.99
239172	02WLORG-3	7.18
239173	02WLORG-4	7.17

Bus Number	Bus Name	Full Contribution
907068	X1-027A C4	1.07
907062	X1-027A E1	40.85
907065	X1-027A E2	40.85
907067	X1-027A E3	40.85
907069	X1-027A E4	40.85
LTF	Y3-032	44.85
701261	Y4-027 C	0.31
701262	Y4-027 E	1.23
701341	Y4-035 C	0.1
701342	Y4-035 E	0.41
701421	Y4-043 C	0.07
701422	Y4-043 E	0.21
701431	Y4-044 C	2.61
701432	Y4-044 E	7.84
701491	Y4-050 C	1.74
701492	Y4-050 E	5.22

Bus Number	Bus Name	Full Contribution
239174	02WLORG-5	7.19
931051	AC2-015 C OP	6.11
931052	AC2-015 E OP	7.13
931791	AC2-103 C	14.53
931792	AC2-103 E	97.24
998321	J496	13.99
998541	J533	12.12
998571	J537	18.02
998581	J538	11.99
998591	J540	2.52
961591	J589	13
961341	J601	9.21
961351	J602	14.67
961401	J608	5.42
247551	U4-028 C	1.93
247940	U4-028 E	12.92
247552	U4-029 C	1.93
247941	U4-029 E	12.92
247567	V2-006 C	2.38
247961	V2-006 E	15.9
247548	V4-010 C	4.17
247947	V4-010 E	27.9
901803	W1-072A	8.41
907061	X1-027A C1	1.07
907064	X1-027A C2	1.07
907066	X1-027A C3	1.07

Bus Number	Bus Name	Full Contribution
701531	Y4-054 C	0.91
701532	Y4-054 E	2.72
701571	Y4-058	8.79
701581	Y4-059	26.66
701601	Y4-061	13.39
701662	Y4-067 E	24.11
701781	Y4-079	10.77
701791	Y4-080	2.76
701851	Y4-086	8.44
701861	Y4-087	8.07
701881	Y4-089	13.5
701891	Y4-090	2.54
701901	Y4-091	0.12
LTF	Z1-043	15.19
LTF	Z1-112	5.75
921102	AA1-056	9.98
LTF	AA1-071	3.84
922573	AA2-186 E	2.21
923092	AB1-107 CT1	56.21
923094	AB1-107 CT2	58.48
923096	AB1-107 ST1	69.69
LTF	AB2-013	8.68
925751	AC1-051 C	0.91
925752	AC1-051 E	6.11
926941	AC1-181	0.77

## Appendix 5

(FE - FE) The 02BEAVER-02BLKRVR 138 kV line (from bus 238570 to bus 239728 ckt 1) loads from 113.43% to 116.2% (**DC power flow**) of its emergency rating (387 MVA) for the tower line contingency outage of 'C5-OEC-345-001'. This project contributes approximately 23.8 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	7.58
238571	02BEAVGA	2.04

Bus Number	Bus Name	Full Contribution
931791	AC2-103 C	3.09
931792	AC2-103 E	20.71

Bus Number	Bus Name	Full Contribution
238572	02BEAVGB	2.12
240968	02BG2 GEN	0.38
240969	02BG4 G1	0.1
240970	02BG4 G2&3	0.19
240971	02BG4 G4&5	0.19
240950	02BG5	1.17
240973	02BG6 AMPO	1.7
239276	02COLLW 11	-1.56
239297	02CPPW41	-1.97
240975	02PGE GEN	2.63
239175	02WLORG-6	3.37

Bus Number	Bus Name	Full Contribution
247548	V4-010 C	1.33
247947	V4-010 E	8.92
901803	W1-072A	2.12
907062	X1-027A E1	8.7
907065	X1-027A E2	8.7
907067	X1-027A E3	8.7
907069	X1-027A E4	8.7
921102	AA1-056	2.5
923092	AB1-107 CT1	14.95
923094	AB1-107 CT2	14.62
923096	AB1-107 ST1	17.43

## Appendix 6

(FE - FE) The 02LRN Q2-02AD Q-2 138 kV line (from bus 238915 to bus 238524 ckt 1) loads from 103.23% to 107.34% (**DC power flow**) of its emergency rating (316 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 28.84 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	9
238571	02BEAVGA	1.37
238572	02BEAVGB	1.43
240968	02BG2 GEN	0.45
240969	02BG4 G1	0.11
240970	02BG4 G2&3	0.23
240971	02BG4 G4&5	0.23
240950	02BG5	1.39
240973	02BG6 AMPO	2.03
239276	02COLLW 11	-2.2
239297	02CPPW41	-2.86
238979	02NAPMUN	2.15
240975	02PGE GEN	3.14
239175	02WLORG-6	2.26
931791	AC2-103 C	3.75
931792	AC2-103 E	25.09

Bus Number	Bus Name	Full Contribution
247551	U4-028 C	0.72
247940	U4-028 E	4.84
247552	U4-029 C	0.72
247941	U4-029 E	4.84
247548	V4-010 C	1.57
247947	V4-010 E	10.51
901803	W1-072A	2.54
907062	X1-027A E1	10.54
907065	X1-027A E2	10.54
907067	X1-027A E3	10.54
907069	X1-027A E4	10.54
LTF	Y3-032	13.66
921102	AA1-056	2.99
923092	AB1-107 CT1	17.74
923094	AB1-107 CT2	17.51
923096	AB1-107 ST1	20.86

## Appendix 7

(FE - FE) The 02BLKRVR-02USSTEEL 138 kV line (from bus 239728 to bus 239734 ckt 1) loads from 226.7% to 233.24% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 39.19 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	12.23
238571	02BEAVGA	1.85
238572	02BEAVGB	1.93
240968	02BG2 GEN	0.62
240969	02BG4 G1	0.16
240970	02BG4 G2&3	0.31
240971	02BG4 G4&5	0.31
240950	02BG5	1.89
240973	02BG6 AMPO	2.75
239276	02COLLW 11	-2.85
239297	02CPPW41	-3.63
238979	02NAPMUN	2.92
240975	02PGE GEN	4.26
239175	02WLORG-6	3.06
931051	AC2-015 C OP	3.46
931052	AC2-015 E OP	4.03
931791	AC2-103 C	5.09
931792	AC2-103 E	34.09
247542	U4-001 C	1.54
247934	U4-001 E	10.33
247551	U4-028 C	0.98
247940	U4-028 E	6.58
247552	U4-029 C	0.98

Bus Number	Bus Name	Full Contribution
247941	U4-029 E	6.58
247567	V2-006 C	1.04
247961	V2-006 E	6.98
247548	V4-010 C	2.13
247947	V4-010 E	14.27
901803	W1-072A	3.45
907062	X1-027A E1	14.32
907065	X1-027A E2	14.32
907067	X1-027A E3	14.32
907069	X1-027A E4	14.32
LTF	Y3-032	18.53
915951	Y3-092	31.54
915952	Y3-092 E	31.54
921102	AA1-056	4.06
922573	AA2-186 E	1.07
923092	AB1-107 CT1	24.11
923094	AB1-107 CT2	23.77
923096	AB1-107 ST1	28.33
923821	AB2-019	1.77
925751	AC1-051 C	0.51
925752	AC1-051 E	3.39
926941	AC1-181	0.33

## Appendix 8

(FE - FE) The 02USSTEEL-02LRN Q2 138 kV line (from bus 239734 to bus 238915 ckt 1) loads from 214.81% to 221.35% (**DC power flow**) of its emergency rating (270 MVA) for the line fault with failed breaker contingency outage of 'C2-CEI-345-001'. This project contributes approximately 39.19 MW to the thermal violation.

Bus Number	Bus Name	Full Contribution
238564	02BAYSG1	12.23
238571	02BEAVGA	1.85
238572	02BEAVGB	1.93
240968	02BG2 GEN	0.62
240969	02BG4 G1	0.16
240970	02BG4 G2&3	0.31
240971	02BG4 G4&5	0.31
240950	02BG5	1.89
240973	02BG6 AMPO	2.75
239276	02COLLW 11	-2.85
239297	02CPPW41	-3.63
238979	02NAPMUN	2.92
240975	02PGE GEN	4.26
239175	02WLORG-6	3.06
931051	AC2-015 C OP	3.46
931052	AC2-015 E OP	4.03
931791	AC2-103 C	5.09
931792	AC2-103 E	34.09
247542	U4-001 C	1.54
247934	U4-001 E	10.33
247551	U4-028 C	0.98
247940	U4-028 E	6.58
247552	U4-029 C	0.98

Bus Number	Bus Name	Full Contribution
247941	U4-029 E	6.58
247567	V2-006 C	1.04
247961	V2-006 E	6.98
247548	V4-010 C	2.13
247947	V4-010 E	14.27
901803	W1-072A	3.45
907062	X1-027A E1	14.32
907065	X1-027A E2	14.32
907067	X1-027A E3	14.32
907069	X1-027A E4	14.32
LTF	Y3-032	18.53
915951	Y3-092	31.54
915952	Y3-092 E	31.54
921102	AA1-056	4.06
922573	AA2-186 E	1.07
923092	AB1-107 CT1	24.11
923094	AB1-107 CT2	23.77
923096	AB1-107 ST1	28.33
923821	AB2-019	1.77
925751	AC1-051 C	0.51
925752	AC1-051 E	3.39
926941	AC1-181	0.33