System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC1-168

Kewanee—Streator

February, 2019

Revised March 2019

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 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.
Cost allocation rules can be found in PJM Manual 14A, Attachment B.

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.

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

Queue AC1-168 Kewanee-Streator project is a Big Bureau Wind, LLC ("Interconnection Customer" or "IC"), a Windworks Power owned LLC, proposal to connect a 78.65 Energy (10.2 MW Capacity) windfarm to be located in Putnam County, IL. The IC has proposed a service date for this project of November 15, 2019, and is under review. The requested backfeed date has yet to be determined.

It is proposed in theAC1-168 Interconnection Request (Attachment N) that the customer is selecting The project will connect on the Streator side of the Hennepin Tap point (east of the Hennepin Tap). The exact distance from Hennepin Tap is 5.7 miles. This point will be 41.3 miles from the Kewanee Substation and 21 miles to the Streator Substation. It should be noted that Hennepin is owned by Ameren Illinois (Ameren Illinois has MISO as their RTO).

This Generation Interconnection System Impact Study provides analysis results to aid the IC in assessing the practicality and cost of incorporating the facility into the PJM system.

Point of Interconnection

The Interconnection Customer (IC) AC1-168 proposes to interconnect with the ComEd transmission system by tapping into Streator TSS 61 to Kewanee TSS 74 138kV transmission line.

Attachment Facilities

The IC AC1-168 generator lead will interconnect to a new 138kV Interconnection Substation, TSS 919 Coleman Lake. The Attachment Facilities include one 138kV line MOD, a dead-end structure and revenue metering as shown in the one line diagram.

The cost for the attachment facilities is estimated at $1M.

Scope of Work	Cost Estimate
Installation of one 138kV line MOD, one dead-end structure and one set of revenue metering (see notes below on cost estimate)	$1.0M

Direct Connection Network Upgrades

In order to accommodate interconnection of AC1-168, a new 138kV Interconnection Substation, TSS 919 Coleman Lake, would be built close to 138kV Line 6101 between TSS 61 Streator and TSS 74 Kewanee, to interconnect developer's generator lead.

The scope of work includes installation of three 138kV circuit breakers in "breaker-and-a-half" bus configuration and tie in the Interconnection Substation to 138kV Line 6101 between TSS 61 Streator and TSS 74 Kewanee, as shown in the one line diagram below.

The Interconnection Customer is responsible for constructing all of the facilities on the Interconnection Customer side of the point of interconnection outside of the substation. It will be the Interconnection Customer's responsibility to obtain the site for the Interconnection Substation and right-of-way between the Interconnection Substation and the transmission lines.

In the event that the IC exercises the option to build the Interconnection Substation, the IC will be required to construct all interconnection facilities that will be turned over to ComEd in accordance with ComEd published standards.

ComEd would design, engineer and construct the tie in of the Interconnection Substation to 138kV Line 6101 between TSS 61 Streator and TSS 74 Kewanee. The preliminary cost estimate for Direct Connection Network Upgrade is given in the following tables.

For Option to Build Direct Connection cost estimates:

Scope of Work	Cost Estimate
Installation of a new 138kV substation as described above	N/A
Transmission line tie in work (foundations, structures, conductors)	$ 2,500,000
ComEd oversight and testing	$ 1,000,000
Total Cost Estimate (see notes below on cost estimate)	$ 3,500,000

For ComEd building the interconnecting substation cost estimates:

Scope of Work	Cost Estimate
Installation of a new 138kV substation as described above	$16,000,000
Transmission line tie in work (foundations, structures, conductors)	$2,500,000
Total Cost Estimate (see notes below on cost estimate)	$18,500,000

Normally it takes about 24-months to engineer, design, procure material and construct 138kV facilities after the ISA/ICSA are signed.

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following table below:

Scope of Work	Cost Estimate
Relay/communications/SCADA upgrades at TSS 61 Streator	$1,000,000
Relay/communications/SCADA upgrades at TSS 74 Kewanee	$1,000,000
Total Cost Estimate (see notes below on cost estimate)	$2,000,000

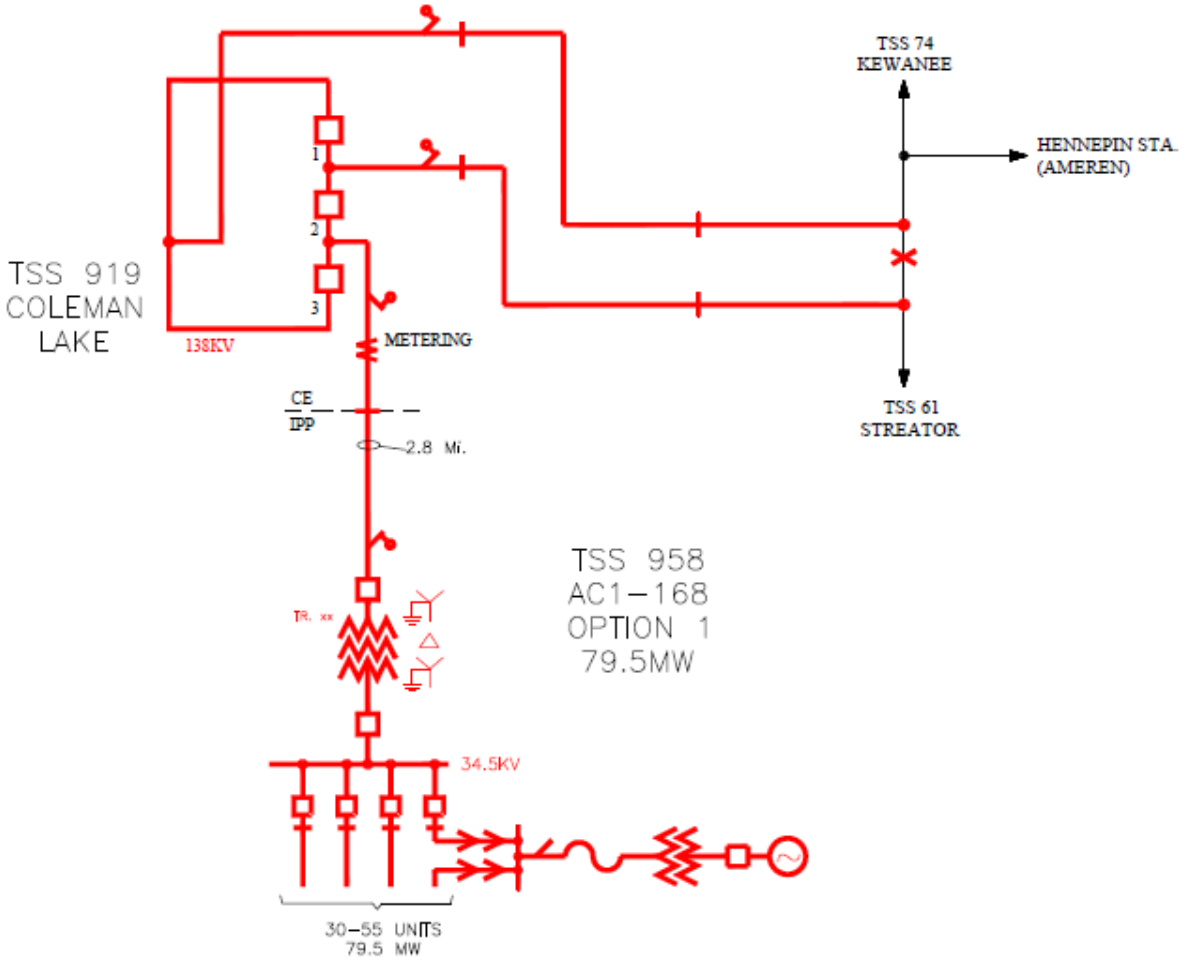

Figure 1. Single Line Diagram

Notes on Cost Estimate:

1) These estimates are Order-of-Magnitude estimates of the costs that ComEd would bill to the customer for this interconnection. These estimates are based on a one-line electrical diagram of the project and the information provided by the Interconnection Customer.

2) These cost estimates do not include cost of acquiring right-of-way for the transmission line and purchasing any additional land, if needed, for the line terminations. The need and cost of acquiring property and associated legal costs will be investigated during Facilities Study for this project.

3) There were no site visits performed for these estimates. There may be costs related to specific site related issues that are not identified in these estimates. The site reviews will be performed during the Facilities Study or during detailed engineering.

4) These estimates are not a guarantee of the maximum amount payable by the Interconnection Customer and the actual costs of ComEd's work may differ significantly from these estimates. Per the PJM Tariff, Interconnection Customer will be responsible for paying all actual costs of ComEd's work.

5) The Interconnection Customer is responsible for all engineering, procurement, testing and construction of all equipment on the Interconnection Customer's side of the Point of Interconnection (POI).

The Queue Project AC1-168 was evaluated as a 78.65 MW (Capacity 10.2 MW) injection into a tap of the Hennepin Tap – Streator 138 kV line in the ComEd area. Project AC1-168 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-168 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

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

None

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

None

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

None

Stability and Steady-State Voltage Requirements
(Results of the steady-state voltage studies should be inserted here)

Generator Interconnection Request AC1-168 is for a 79.4 MW Maximum Facility Output (MFO) Wind Turbine plant. AC1-168 consists of 25 x AWT-VAR_Model_V905-3 AW3150, 3.37 MVA Wind Turbines.

AC1-168 has a Point of Interconnection (POI) on the Streator-Kewanee 138 kV circuit, in the Commonwealth Edison Company (ComEd) transmission system, Putnam County, Illinois.

This report describes a dynamic simulation analysis of AC1-168 as part of the overall system impact study.

The load flow scenario for the analysis is based on the RTEP 2020 Summer Peak case, modified to include applicable queue projects. AC1-168 was set to maximum power output. AC1-168 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. Each contingency was studied over a 20 second simulation time interval. The studied contingencies include:

a) Steady state operation;

b) Three phase faults with normal clearing time on intact network and during a scheduled outage of a transmission or generation element;

c) Three-phase faults with three-phase delayed clearing due to a stuck breaker (for gang-operated breakers);

d) Three-phase faults with single line to ground delayed clearing due to a stuck breaker (for independent pole breakers);

e) Three-phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from fault due to primary communications/relaying failure;

f) Three phase faults with loss of multi-circuit tower line with normal clearing time;

g) Single-phase fault at substation bus with normal clearing time.

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

For the fault contingencies tested on the 2020 Summer Peak case:

1. Post-contingency oscillations were positively damped with a damping margin of at least 3% for all contingencies.
2. AC1-168 exhibited slow active power and reactive power recovery post-fault for the duration of the 20 second simulations. This did not result in any network stability issues and would require tuning of the model to decrease recovery time.
3. AC1-168 and/or P10 tripped for the following contingencies simulated on a prior outage case:
    - AC1-168 and P10 tripped for MA.3N.23:
        - Fault at Kickapoo Creek 138 kV on La Salle Co. Sta 1 circuit 0112.
    - P10 tripped for MB.3N.23:
        - Fault at AC1-168 POI on Streator circuit 6101.
    - AC1-168 and P10 tripped for MD.3N.03:
        - Fault at AC1-168 POI 138 kV on tap of Hennepin – Kewanee circuit 6101.

- AC1-168 and P10 tripped for MD.3N.06:
  - Fault at Hennepin 138 kV on AC1-168 POI – Kewanee circuit 6101.
- AC1-168 and P10 tripped for MD.3N.18:
  - Fault at Kewanee 138 kV on AC1-168 POI – Hennepin circuit 6101.

The above contingencies were tested with P10 and N15 placed offline. In this configuration, the AC1-168 tripping issue was resolved however low magnitude oscillations were observed in the voltage plots of AC1-168 for the MA and MD contingencies. The TO indicated that an anti-islanding transfer trip scheme and/or a revision to SPOG 2-41 would be required to resolve the issues with the P6 contingencies. The details will be finalized in the facility study phase.

4. AC1-168 was able to ride through all remaining faults (except for faults where protective action trips a generator(s)).
5. Excluding contingencies listed in (c) for which AC1-168 and/or P10 tripped, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds of the fault being cleared (except where protective action isolates that bus).
6. No transmission element trips, other than those either directly connected or designed to trip as a consequence of the fault.
7. Non-convergence was observed at O-029 at the instance of fault application for a number of contingencies under intact network conditions and maintenance outages. This did not result in any network instability.

AC1-168 exhibited slow active power and reactive power recovery post-fault for the duration of the 20 second simulations. This did not result in any network stability issues and would require tuning of the model to reduce recovery time.

Anti-islanding transfer trip scheme and/or a revision to SPOG 2-41 would be needed to resolve the issues resulting when AC1-168 is separated from the BES and islanded with nearby load.

Short Circuit
(Summary of impacted circuit breakers)

No issues identified.

Affected System Analysis & Mitigation

MISO Impacts:

No issues were identified.(Ref: MISO's PJM April 2017 Queue Generation Affected System Impact Study

Delivery of Energy Portion of Interconnection Request
PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

1. (CE - CE) The LASCO STA; B-MAZON ; B 138 kV line (from bus 271908 to bus 271986 ckt 1) loads from 104.51% to 110.6% (AC power flow) of its emergency rating (223 MVA) for the single line contingency outage of 'TR81_LASCO_B-S'. This project contributes approximately 13.86 MW to the thermal violation.

```
CONTINGENCY 'TR81_LASCO_B-S'
 TRIP BRANCH FROM BUS 270802 TO BUS 270803 CKT 1          / LASCO STA; B 345 LASCO STA; R 345
 TRIP BRANCH FROM BUS 270802 TO BUS 271908 CKT 1          / LASCO STA; B 345 LASCO STA; B 138
 END
```

2. (CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 158.0% to 161.73% (AC power flow) of its emergency rating (223 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 9.77 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1          / O29 ; 138 NELSO;RT 138
 END
```

3. (CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 102.01% to 104.79% (AC power flow) of its normal rating (173 MVA) for non-contingency condition. This project contributes approximately 5.67 MW to the thermal violation.

4. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 186.62% to 190.68% (AC power flow) of its emergency rating (214 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 10.22 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1          / O29 ; 138 NELSO;RT 138
 END
```

5. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 126.48% to 129.45% (AC power flow) of its normal rating (173 MVA) for non-contingency condition. This project contributes approximately 6.04 MW to the thermal violation.

6. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 155.08% to 158.35% (AC power flow) of its emergency rating (264 MVA) for the single line contingency outage of '133-CB_23___'. This project contributes approximately 10.14 MW to the thermal violation.

```
CONTINGENCY '133-CB_23___'
 TRIP BRANCH FROM BUS 272367 TO BUS 293510 CKT 1          / R FAL; R 138 O9 138
 END
```

7. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 124.07% to 126.48% (AC power flow) of its normal rating (208 MVA) for non-contingency condition. This project contributes approximately 5.9 MW to the thermal violation.

8. (CE - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 927780 to bus 271655 ckt 1) loads from 93.1% to 128.02% (AC power flow) of its emergency rating (184 MVA) for the single line contingency outage of '138-L0112__B-S'. This project contributes approximately 75.22 MW to the thermal violation.

```
CONTINGENCY '138-L0112__B-S'
 TRIP BRANCH FROM BUS 271844 TO BUS 271908 CKT 1              / KICKA; B 138 LASCO; B 138
 END
```

Light Load Analysis - 2020

Generator Deliverability

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

1. (AREA14 - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 926490 to bus 271655 ckt 1) loads from 76.07% to 103.87% (AC power flow) of its emergency rating (184 MVA) for the single line contingency outage of '138-L0112__B-S'. This project contributes approximately 59.66 MW to the thermal violation.

```
CONTINGENCY '138-L0112__B-S'
 TRIP BRANCH FROM BUS 271844 TO BUS 271908 CKT 1              / KICKA; B 138 LASCO; B 138
 END
```

Multiple Facility Contingency

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

1. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 96.0% to 98.67% (AC power flow) of its load dump rating (275 MVA) for the tower line contingency outage of '138-L15509GR-R_+_138-L15518GB-R'. This project contributes approximately 7.65 MW to the thermal violation.

```
CONTINGENCY '138-L15509GR-R_+_138-L15518GB-R'                / CONTINGENCY # 123
 TRIP BRANCH FROM BUS 272095 TO BUS 272367 CKT 1             / NELSON ; R 138 ROCK FALL; R 138
 TRIP BRANCH FROM BUS 272367 TO BUS 274244 CKT 7             / ROCK FALL; R 138 ROCK FALL; 34.5
 TRIP BRANCH FROM BUS 272094 TO BUS 272366 CKT 1             / NELSON ; B 138 ROCK FALL; B 138
 TRIP BRANCH FROM BUS 272366 TO BUS 272512 CKT 1             / ROCK FALL; B 138 ESS H71 ;BT 138
 TRIP BRANCH FROM BUS 272512 TO BUS 271543 CKT 1             / ESS H71 ;BT 138 GARDEN PL; 138
 TRIP BRANCH FROM BUS 272512 TO BUS 272514 CKT 1             / ESS H71 ;BT 138 ESS H71 ; B 138
 MOVE 100 PERCENT LOAD FROM BUS 272514 TO BUS 272515          / ESS H71 ; B 138 ESS H71 ; R 138
 CLOSE LINE FROM BUS 272366 TO BUS 272367 CKT 1             / ROCK FALL; B 138 ROCK FALL; R 138
 END
```

2. (AREA14 - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 926490 to bus 271655 ckt 1) loads from 76.07% to 103.87% (AC power flow) of its emergency rating (184

MVA) for the line fault with failed breaker contingency outage of '941-38-L0112__'. This project contributes approximately 59.66 MW to the thermal violation.

```
CONTINGENCY '941-38-L0112__'
 TRIP BRANCH FROM BUS 271844 TO BUS 271908 CKT 1              / KICKA; B 138 LASCO; B 138
 END
```

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

3. (AREA14 - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 926490 to bus 271655 ckt 1) loads from 76.04% to 103.81% (AC power flow) of its emergency rating (184 MVA) for the line fault with failed breaker contingency outage of '001-38-L0108__'. This project contributes approximately 59.66 MW to the thermal violation.

```
CONTINGENCY '001-38-L0108__'
 TRIP BRANCH FROM BUS 271908 TO BUS 271986 CKT 1              / LASCO; B 138 MAZON; B 138
 DISCONNECT BUS 271908                              / LASCO; B 138
 END
```

4. (AREA14 - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 926490 to bus 271655 ckt 1) loads from 76.04% to 103.81% (AC power flow) of its emergency rating (184 MVA) for the bus fault outage of '001_LA-138B__1'. This project contributes approximately 59.66 MW to the thermal violation.

```
CONTINGENCY '001_LA-138B__1'
 DISCONNECT BUS 271908                              / LASCO STA; B 138
 END
```

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)

1. (CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 114.43% to 117.66% (AC power flow) of its emergency rating (223 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 7.48 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1              / O29 ; 138 NELSO;RT 138
 END
```

Please refer to Appendix 4 for a table containing the generators having contribution to this flowgate.

2. (CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 105.88% to 108.97% (AC power flow) of its emergency rating (223 MVA) for the single line contingency outage of '138-L15508_R-R'. This project contributes approximately 7.15 MW to the thermal violation.

```
CONTINGENCY '138-L15508_R-R'
```

```
 TRIP BRANCH FROM BUS 271331 TO BUS 271333 CKT 1          / DIXON;8R 138 DIXON; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 271331 CKT 1          / NELSO;RT 138 DIXON;8R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 272095 CKT 1          / NELSO;RT 138 NELSO; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 293710 CKT 1          / NELSO;RT 138 O29 138
 MOVE 100 PERCENT LOAD FROM BUS 271331 TO BUS 271330      / DIXON;8R 138 DIXON;7B 138
 END
```

3. (CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 101.52% to 104.52% (AC power flow) of its load dump rating (230 MVA) for the tower line contingency outage of '138-L15507_B-R_+_138-L15508_R-R'. This project contributes approximately 7.14 MW to the thermal violation.

```
CONTINGENCY '138-L15507_B-R_+_138-L15508_R-R'
 TRIP BRANCH FROM BUS 271330 TO BUS 271332 CKT 1          / DIXON;7B 138 DIXON; B 138
 TRIP BRANCH FROM BUS 272094 TO BUS 271330 CKT 1          / NELSO; B 138 DIXON;7B 138
 MOVE 100 PERCENT LOAD FROM BUS 271330 TO BUS 271331      / DIXON;7B 138 DIXON;8R 138
 TRIP BRANCH FROM BUS 271331 TO BUS 271333 CKT 1          / DIXON;8R 138 DIXON; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 271331 CKT 1          / NELSO;RT 138 DIXON;8R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 272095 CKT 1          / NELSO;RT 138 NELSO; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 293710 CKT 1          / NELSO;RT 138 O29 138
 MOVE 100 PERCENT LOAD FROM BUS 271331 TO BUS 271330      / DIXON;8R 138 DIXON;7B 138
 END
```

4. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 134.86% to 138.38% (AC power flow) of its emergency rating (214 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 7.82 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1          / O29 ; 138 NELSO;RT 138
 END
```

Please refer to Appendix 5 for a table containing the generators having contribution to this flowgate.

5. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 128.06% to 131.47% (AC power flow) of its emergency rating (214 MVA) for the single line contingency outage of '138-L15508_R-R'. This project contributes approximately 7.57 MW to the thermal violation.

```
CONTINGENCY '138-L15508_R-R'
 TRIP BRANCH FROM BUS 271331 TO BUS 271333 CKT 1          / DIXON;8R 138 DIXON; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 271331 CKT 1          / NELSO;RT 138 DIXON;8R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 272095 CKT 1          / NELSO;RT 138 NELSO; R 138
 TRIP BRANCH FROM BUS 272097 TO BUS 293710 CKT 1          / NELSO;RT 138 O29 138
 MOVE 100 PERCENT LOAD FROM BUS 271331 TO BUS 271330      / DIXON;8R 138 DIXON;7B 138
 END
```

6. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 117.39% to 120.55% (AC power flow) of its load dump rating (230 MVA) for the tower line contingency outage of '138-L15507_B-R_+_138-L15508_R-R'. This project contributes approximately 7.55 MW to the thermal violation.

```
CONTINGENCY '138-L15507_B-R_+_138-L15508_R-R'
 TRIP BRANCH FROM BUS 271330 TO BUS 271332 CKT 1          / DIXON;7B 138 DIXON; B 138
 TRIP BRANCH FROM BUS 272094 TO BUS 271330 CKT 1          / NELSO; B 138 DIXON;7B 138
```

```
MOVE 100 PERCENT LOAD FROM BUS 271330 TO BUS 271331        / DIXON;7B 138 DIXON;8R 138
TRIP BRANCH FROM BUS 271331 TO BUS 271333 CKT 1            / DIXON;8R 138 DIXON; R 138
TRIP BRANCH FROM BUS 272097 TO BUS 271331 CKT 1            / NELSO;RT 138 DIXON;8R 138
TRIP BRANCH FROM BUS 272097 TO BUS 272095 CKT 1            / NELSO;RT 138 NELSO; R 138
TRIP BRANCH FROM BUS 272097 TO BUS 293710 CKT 1            / NELSO;RT 138 O29 138
MOVE 100 PERCENT LOAD FROM BUS 271331 TO BUS 271330        / DIXON;8R 138 DIXON;7B 138
END
```

7. (CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 101.37% to 104.06% (AC power flow) of its normal rating (173 MVA) for non-contingency condition. This project contributes approximately 4.84 MW to the thermal violation.

8. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 108.3% to 111.1% (AC power flow) of its emergency rating (264 MVA) for the single line contingency outage of '133-CB_23___'. This project contributes approximately 7.67 MW to the thermal violation.

```
CONTINGENCY '133-CB_23___'
 TRIP BRANCH FROM BUS 272367 TO BUS 293510 CKT 1                / R FAL; R 138 O9
138
 END
```

Please refer to Appendix 6 for a table containing the generators having contribution to this flowgate.

9. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 105.74% to 108.53% (AC power flow) of its emergency rating (264 MVA) for the single line contingency outage of '138-L15509GR-R'. This project contributes approximately 7.66 MW to the thermal violation.

```
CONTINGENCY '138-L15509GR-R'
 TRIP BRANCH FROM BUS 272095 TO BUS 272367 CKT 1            / NELSO; R 138 R FAL; R 138
 TRIP BRANCH FROM BUS 272367 TO BUS 274244 CKT 7            / R FAL; R 138 R FAL; 34.5
 END
```

10. (CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 108.96% to 110.51% (AC power flow) of its load dump rating (275 MVA) for the line fault with failed breaker contingency outage of '187-38-BT2-3__'. This project contributes approximately 5.17 MW to the thermal violation.

```
CONTINGENCY '187-38-BT2-3__'
 TRIP BRANCH FROM BUS 272367 TO BUS 293510 CKT 1            / R FAL; R 138 O9 138
 MOVE 100 PERCENT LOAD FROM BUS 272111 TO BUS 272110        / NORMA; R 138 NORMA; B 138
 DISCONNECT BUS 272111                          / NORMA; R 138
 END
```

System Reinforcements

Short Circuit

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

None

Stability and Reactive Power Requirement
(Results of the dynamic studies should be inserted here)

Anti-islanding transfer trip scheme and/or a revision to SPOG 2-41 would be needed to resolve the issues resulting when AC1-168 is separated from the BES and islanded with nearby load.

Summer Peak Load Flow Analysis Reinforcements

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

None

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

None

Light Load Flow Analysis Reinforcements

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

1. **To relieve the AC1-168 TAP – Hennepin 138 kV line overload**

   Reinforcement: Upgrade the line overhead conductor. Upon completion the ratings will be 173/223/223/230 MVA (SN/SLTE/SSTE/SLD). PJM Upgrade **N5908.**

   Estimated Cost: $2,800,000
   Estimated Time: 24 months

   This overload is driven by AC1-168 therefore, based on PJM's cost allocation criteria; AC1-168 is responsible for the cost of this upgrade.

   PJM has issued this System Impact Study without ICTR determinations. PJM will work with each customer to identify the Customer-Funded Upgrade(s) and LDAs (no more than three)

for which the customer wants PJM to determine ICTRs. PJM will provide that determination as quickly as practicable following issuance of this System Impact Study.

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)

1. **To relieve the Rock Fall - Nelson 138 kV line overload**

   Reinforcement: Baseline Upgrade **B2959** - Install a new 138 kV circuit 18702 from Schauff Road to Rock Falls and install a fourth breaker and a half run at Schauff Road.

   AC1-168 is currently not responsible for cost towards this baseline upgrade.
   AC1-168 may need this upgrade in-service to be deliverable to the PJM system and an interim study may be required.

   Estimated Cost: $20,000,000
   Required IS Date: 11/1/2019

2. **To relieve the O09 – Rock Fall 138 kV line overload**

   Reinforcement: Baseline Upgrade **B2959** - Install a new 138 kV circuit 18702 from Schauff Road to Rock Falls and install a fourth breaker and a half run at Schauff Road.

   AC1-168 is currently not responsible for cost towards this baseline upgrade.
   AC1-168 may need this upgrade in-service to be deliverable to the PJM system and an interim study may be required.

   Estimated Cost: $20,000,000
   Required IS Date: 11/1/2019

3. **To relieve the O29 – Nelson 138 kV line overload**

   Reinforcement: Baseline Upgrade **B2959** - Install a new 138 kV circuit 18702 from Schauff Road to Rock Falls and install a fourth breaker and a half run at Schauff Road.

   AC1-168 is currently not responsible for cost towards this baseline upgrade.
   AC1-168 may need this upgrade in-service to be deliverable to the PJM system and an interim study may be required.

   Estimated Cost: $20,000,000
   Required IS Date: 11/1/2019

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 3

(AREA14 - CE) The AC1-168 TAP-HENNEPIN ; T 138 kV line (from bus 926490 to bus 271655 ckt 1) loads from 76.07% to 103.87% (AC power flow) of its emergency rating (184 MVA) for the line fault with failed breaker contingency outage of '941-38-L0112__'. This project contributes approximately 59.66 MW to the thermal violation.

```
CONTINGENCY '941-38-L0112__'
 TRIP BRANCH FROM BUS 271844 TO BUS 271908 CKT 1              / KICKA; B 138 LASCO; B 138
 END
```

Bus Number	*Bus Name*	*Full Contribution*
274871	*GR RIDGE ;2U*	*11.02*
293061	*N-015 E*	*9.56*
294392	*P-010 E*	*12.14*
LTF	*AC1-056*	*0.03*
926491	*AC1-168 C OP*	*7.74*
926492	*AC1-168 E OP*	*51.92*

Appendix 4

(CE - CE) The ROCK FALL; R-NELSON ; R 138 kV line (from bus 272367 to bus 272095 ckt 1) loads from 114.43% to 117.66% (AC power flow) of its emergency rating (223 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 7.48 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1              / O29 ; 138 NELSO;RT 138
 END
```

Bus Number	*Bus Name*	*Full Contribution*
274877	*BISHOP HL;1U*	*1.84*
274878	*BISHOP HL;2U*	*1.84*
294401	*BSHIL;1U E*	*2.03*
294410	*BSHIL;2U E*	*2.03*
274848	*CAMPGROVE;RU*	*2.46*
274849	*CRESCENT ;1U*	*1.16*
990901	*L-005 E*	*2.71*
293513	*O-009 C1*	*8.32*
293514	*O-009 C2*	*4.22*
293515	*O-009 C3*	*4.67*
293516	*O-009 E1*	*33.29*
293517	*O-009 E2*	*16.91*
293518	*O-009 E3*	*18.62*
293712	*O-029 C*	*4.41*
293713	*O-029 C*	*2.41*
293714	*O-029 C*	*2.23*
293715	*O-029 E*	*4.86*
293716	*O-029 E*	*2.66*
293717	*O-029 E*	*2.45*
293771	*O-035 E*	*1.26*
274851	*PROVIDENC;RU*	*1.14*
916211	*Z1-072*	*0.21*
919621	*AA2-039 C*	*3.59*
919622	*AA2-039 E*	*24.02*
926051	*AC1-033 C*	*2.41*
926052	*AC1-033 E*	*16.13*
926491	*AC1-168 C OP*	*0.97*
926492	*AC1-168 E OP*	*6.51*
926501	*AC1-171 C OP*	*0.92*
926502	*AC1-171 E OP*	*6.12*
926641	*AC1-214 C OP*	*3.04*
926642	*AC1-214 E OP*	*9.22*

Appendix 5

(CE - CE) The O09 OP1 138-ROCK FALL; R 138 kV line (from bus 293510 to bus 272367 ckt 1) loads from 134.86% to 138.38% (AC power flow) of its emergency rating (214 MVA) for the single line contingency outage of '187-L15508__'. This project contributes approximately 7.82 MW to the thermal violation.

```
CONTINGENCY '187-L15508__'
 TRIP BRANCH FROM BUS 293710 TO BUS 272097 CKT 1              / O29 ; 138 NELSO;RT 138
 END
```

Bus Number	*Bus Name*	*Full Contribution*
274877	*BISHOP HL;1U*	*1.92*
274878	*BISHOP HL;2U*	*1.92*
294401	*BSHIL;1U E*	*2.12*
294410	*BSHIL;2U E*	*2.12*
274848	*CAMPGROVE;RU*	*2.57*
274849	*CRESCENT ;1U*	*1.21*
990901	*L-005 E*	*2.84*
293513	*O-009 C1*	*8.7*
293514	*O-009 C2*	*4.41*
293515	*O-009 C3*	*4.88*
293516	*O-009 E1*	*34.82*
293517	*O-009 E2*	*17.69*
293518	*O-009 E3*	*19.48*
293712	*O-029 C*	*4.61*
293713	*O-029 C*	*2.53*
293714	*O-029 C*	*2.34*
293715	*O-029 E*	*5.08*
293716	*O-029 E*	*2.79*
293717	*O-029 E*	*2.56*
293771	*O-035 E*	*1.32*
274851	*PROVIDENC;RU*	*1.19*
916211	*Z1-072*	*0.22*
919621	*AA2-039 C*	*3.75*
919622	*AA2-039 E*	*25.12*
926051	*AC1-033 C*	*2.52*
926052	*AC1-033 E*	*16.87*
926491	*AC1-168 C OP*	*1.01*
926492	*AC1-168 E OP*	*6.81*
926501	*AC1-171 C OP*	*0.96*
926502	*AC1-171 E OP*	*6.4*
926641	*AC1-214 C OP*	*3.18*
926642	*AC1-214 E OP*	*9.64*

Appendix 6

(CE - CE) The O29-NELSON ;RT 138 kV line (from bus 293710 to bus 272097 ckt 1) loads from 108.3% to 111.1% (AC power flow) of its emergency rating (264 MVA) for the single line contingency outage of '133-CB_23___'. This project contributes approximately 7.67 MW to the thermal violation.

```
CONTINGENCY '133-CB_23___'
 TRIP BRANCH FROM BUS 272367 TO BUS 293510 CKT 1              / R FAL; R 138 O9 138
 END
```

Bus Number	*Bus Name*	*Full Contribution*
274877	*BISHOP HL;1U*	*1.89*
274878	*BISHOP HL;2U*	*1.89*
294401	*BSHIL;1U E*	*2.08*
294410	*BSHIL;2U E*	*2.08*
274848	*CAMPGROVE;RU*	*2.52*
274849	*CRESCENT ;1U*	*1.19*
990901	*L-005 E*	*2.78*
293513	*O-009 C1*	*8.46*
293514	*O-009 C2*	*4.29*
293515	*O-009 C3*	*4.74*
293516	*O-009 E1*	*33.84*
293517	*O-009 E2*	*17.19*
293518	*O-009 E3*	*18.93*
293712	*O-029 C*	*4.58*
293713	*O-029 C*	*2.51*
293714	*O-029 C*	*2.32*
293715	*O-029 E*	*5.05*
293716	*O-029 E*	*2.77*
293717	*O-029 E*	*2.55*
293771	*O-035 E*	*1.29*
274851	*PROVIDENC;RU*	*1.17*
916211	*Z1-072*	*0.22*
919621	*AA2-039 C*	*3.68*
919622	*AA2-039 E*	*24.63*
926051	*AC1-033 C*	*2.47*
926052	*AC1-033 E*	*16.54*
926491	*AC1-168 C OP*	*0.99*
926492	*AC1-168 E OP*	*6.67*
926501	*AC1-171 C OP*	*0.94*
926502	*AC1-171 E OP*	*6.28*
926641	*AC1-214 C OP*	*3.12*
926642	*AC1-214 E OP*	*9.45*