# *Generation Interconnection System Impact Study Report*

# *For*

# *PJM Generation Interconnection Request Queue Position AD2-191*

# *Melmore 138 kV*

**April 2020**

# 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: (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. 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 or merchant transmission upgrade, may also contribute to the need for the same network reinforcement.

The System Impact Study estimates do not include the 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.

© PJM Interconnection 2020. All rights reserved.

# General

Seneca Wind, LLC proposes to install PJM Project #AD2-191, a 170.0 MW (22.1 MW Capacity) Wind generating facility in Seneca County, Ohio (see Figure 2). The point of interconnection is a direct connection to AEP's Melmore 138 kV substation utilizing the same gen lead of the previously proposed PJM Projects #U4-028 and #U4-029 (see Figure 1).

The requested in service date is September 1, 2021.

# Attachment Facilities

**Point of Interconnection (Melmore 138 kV)**

To be constructed by PJM Project #U4-028 and #U4-029.

**Note:** It is assumed that the 138 kV revenue metering and gen lead installed for the #U4-028 and U4-029 will be adequate for the additional generation since AD2-191 will be utilizing the same gen lead.

# Interconnection Customer Requirements

It is understood that Seneca Wind, LLC is responsible for all costs associated with this interconnection. The cost of Seneca Wind generating plant and the costs for the line connecting the generating plant to the point of interconnection are not included in this report; these are assumed to be Seneca Wind'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. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

**Requirement from the PJM Open Access Transmission Tariff:**

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.

© PJM Interconnection 2020. All rights reserved.

# 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.

## AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

© PJM Interconnection 2020. All rights reserved.

## Network Impacts

The Queue Project AD2-191 was evaluated as a 170.0 MW (Capacity 22.1 MW) injection into the Melmore 138 kV substation in the AEP area. Project AD2-191 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-191 was studied with a commercial probability of 100%. Potential network impacts were as follows:

# Summer Peak Load Flow Analysis - 2021

## 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)*

1. (AEP - AEP) The 05AIRCO8-05W.END 138 kV line (from bus 242953 to bus 243137 ckt 1) loads from 96.94% to 119.61% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 39.04 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

Please refer to Appendix 1 for a table containing the generators having contribution to this flowgate.

2. (AEP - AEP) The 05FREMCT-05FRMNT 138 kV line (from bus 243008 to bus 243009 ckt 1) loads from 86.31% to 103.62% (AC power flow) of its emergency rating (251 MVA) for the bus fault outage of 'AEP_P2-2_#7118_05HOWARD 138'. This project contributes approximately 48.66 MW to the thermal violation.

CONTINGENCY 'AEP_P2-2_#7118_05HOWARD 138'
OPEN BRANCH FROM BUS 238586 TO BUS 243024 CKT 1 / 238586 02BRKSID 138 243024 05HOWARD 138 1
OPEN BRANCH FROM BUS 932050 TO BUS 243024 CKT 1 / 932050 AC2-015 TAP 138 243024 05HOWARD 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243050 CKT 1 / 243024 05HOWARD 138 243050 05NBELVL 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243100 CKT 1 / 243024 05HOWARD 138 243100 05SHELGH 138 1

© PJM Interconnection 2020. All rights reserved.

OPEN BRANCH FROM BUS 243024 TO BUS 247542 CKT Z1 / 243024 05HOWARD 138 247542 U4-001 C 138 Z1
OPEN BRANCH FROM BUS 247542 TO BUS 247934 CKT 1 / 247542 U4-001 C 138 247934 U4-001 E 138 1
REMOVE UNIT 1C FROM BUS 247542 / 247542 U4-001 C 138
REMOVE UNIT 1E FROM BUS 247934 / 247934 U4-001 E 138
END

3. (AEP - AEP) The 05MELMOR-05CHATFL 138 kV line (from bus 243039 to bus 242984 ckt 1) loads from 86.72% to 102.08% (AC power flow) of its emergency rating (245 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 41.31 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

Please refer to Appendix 2 for a table containing the generators having contribution to this flowgate.

4. (AEP - AEP) The 05MELMOR-05STIFFI 138 kV line (from bus 243039 to bus 243110 ckt 1) loads from 82.79% to 100.39% (AC power flow) of its emergency rating (245 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 44.75 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

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

5. (AEP - AEP) The 05STIFFI-05AIRCO8 138 kV line (from bus 243110 to bus 242953 ckt 1) loads from 96.94% to 119.61% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 39.04 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

© PJM Interconnection 2020. All rights reserved.

Please refer to Appendix 8 for a table containing the generators having contribution to this flowgate.

## 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. (FE - FE) The 02LAKVEW-02GRNFLD 138 kV line (from bus 238874 to bus 238768 ckt 1) loads from 110.09% to 112.86% (AC power flow) of its emergency rating (316 MVA) for the tower line contingency outage of 'ADD202'. This project contributes approximately 9.5 MW to the thermal violation.

```
CONTINGENCY 'ADD202'
  DISCONNECT BRANCH FROM BUS 238654 TO BUS 239289 CKT 1          /* 02DAVIS
BESSE 345 02HAYES 345
  DISCONNECT BRANCH FROM BUS 238654 TO BUS 907060 CKT 1          /* 02DAVIS
BESSE 345 X1-027A TAP 345
  END
```

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

2. (FE - FE) The 02OTTAWA-02LAKVEW 138 kV line (from bus 239030 to bus 238874 ckt 1) loads from 108.87% to 111.18% (AC power flow) of its emergency rating (380 MVA) for the tower line contingency outage of 'ADD202'. This project contributes approximately 9.5 MW to the thermal violation.

```
CONTINGENCY 'ADD202'
  DISCONNECT BRANCH FROM BUS 238654 TO BUS 239289 CKT 1          /* 02DAVIS
BESSE 345 02HAYES 345
  DISCONNECT BRANCH FROM BUS 238654 TO BUS 907060 CKT 1          /* 02DAVIS
BESSE 345 X1-027A TAP 345
  END
```

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

3. (AEP - AEP) The 05CHATFL-AC2-015 TAP 138 kV line (from bus 242984 to bus 932050 ckt 1) loads from 101.82% to 122.13% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 36.95 MW to the thermal violation.

```
CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
  OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1              / 243006
05FOSTOR 138 243039 05MELMOR 138 1
  OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1              / 243024
05HOWARD 138 243039 05MELMOR 138 1
  END
```

© PJM Interconnection 2020. All rights reserved.

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

4. (AEP - AEP) The 05FREMCT-05FRMNT 138 kV line (from bus 243008 to bus 243009 ckt 1) loads from 105.02% to 131.08% (AC power flow) of its emergency rating (251 MVA) for the tower line contingency outage of 'AEP_P7-1_#7114'. This project contributes approximately 67.86 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#7114'
OPEN BRANCH FROM BUS 242953 TO BUS 243110 CKT 1 / 242953 05AIRCO8 138 243110 05STIFFI 138 1
OPEN BRANCH FROM BUS 242953 TO BUS 243137 CKT 1 / 242953 05AIRCO8 138 243137 05W.END 138 1
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243039 TO BUS 243110 CKT 1 / 243039 05MELMOR 138 243110 05STIFFI 138 1
OPEN BRANCH FROM BUS 243110 TO BUS 245630 CKT 1 / 243110 05STIFFI 138 245630 05S TIFFIN 69.0 1
END

Please refer to Appendix 7 for a table containing the generators having contribution to this flowgate.

5. (AEP - AEP) The 05FREMCT-05FRMNT 138 kV line (from bus 243008 to bus 243009 ckt 1) loads from 103.6% to 129.21% (AC power flow) of its emergency rating (251 MVA) for the tower line contingency outage of 'AEP_P7-1_#7731'. This project contributes approximately 66.76 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#7731'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243039 TO BUS 243110 CKT 1 / 243039 05MELMOR 138 243110 05STIFFI 138 1
END

Please refer to Appendix 8 for a table containing the generators having contribution to this flowgate.

6. (AEP - AEP) The AC2-015 TAP-05HOWARD 138 kV line (from bus 932050 to bus 243024 ckt 1) loads from 137.16% to 157.85% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 36.95 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1

© PJM Interconnection 2020. All rights reserved.

OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

Please refer to Appendix 9 for a table containing the generators having contribution to this flowgate.

## Steady-State Voltage Requirements

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

None

## Stability and Reactive Power Requirement

*(Results of the dynamic studies should be inserted here)*

This system impact study will be performed for generation interconnection request AD2-191.

Generator Interconnection Request AD2-191 is for a 170 MW Maximum Facility Output (MFO) wind farm facility. AD2-191 consists of 75 x 2.5 MW GE 2.5-116 wind turbines with Point of Interconnection (POI) directly connecting to the Melmore 138 kV substation in Seneca County, Ohio, in the American Electric Power transmission system.

The power flow scenario for the analysis was based on the RTEP 2021 summer peak load case, modified to include applicable queue project. AD2-191, has been dispatched online at maximum facility output, with approximately unity power factor at the high-side of the station transformer.

AD2-191 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 106 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (20 second simulation)
- Three-phase faults with normal clearing time
- Single-phase faults with a stuck breaker
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure
- Single-phase fault with loss of multiple circuits caused by a common tower contingency

© PJM Interconnection 2020. All rights reserved.

The 106 fault contingencies tested on the 2021 summer peak load case met the recovery criteria:

- The AD2-191 generators were able to ride through the faults except for faults where protective actions trip one or more generator(s).
- All generators maintained synchronism and any post-contingency oscillations are positively damped with a damping margin of at least 3%.
- All bus voltages recover to 0.7 p.u. within 2.5 seconds and the final voltage is within the range of 0.92 p.u. to 1.05 p.u. excluding 500 kV buses. The final voltages for 500 kV buses should be within 1.02 p.u. to 1.08 p.u.
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

The queue project, AD2-191, met both the 0.95 leading and 0.95 lagging power factor requirements.

## Short Circuit

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:

None

## Affected System Analysis & Mitigation

### LGEE Impacts:

None

### MISO Impacts:

No impact in the preliminary study but MISO will be performing a retool. Study results will be addressed in the Facilities Study.

### Duke, Progress & TVA Impacts:

None

### OVEC Impacts:

None

© PJM Interconnection 2020. All rights reserved.

## 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. (AEP - AEP) The 05AIRCO8-05W.END 138 kV line (from bus 242953 to bus 243137 ckt 1) loads from 87.82% to 108.47% (AC power flow) of its emergency rating (167 MVA) for the single line contingency outage of 'AEP_P1-2_#7104'. This project contributes approximately 35.23 MW to the thermal violation.

CONTINGENCY 'AEP_P1-2_#7104'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
END

2. (AEP - AEP) The 05CHATFL-AC2-015 TAP 138 kV line (from bus 242984 to bus 932050 ckt 1) loads from 92.61% to 108.28% (AC power flow) of its emergency rating (167 MVA) for the single line contingency outage of 'AEP_P1-2_#7105'. This project contributes approximately 28.85 MW to the thermal violation.

CONTINGENCY 'AEP_P1-2_#7105'
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

3. (AEP - FE) The 05HOWARD-02BRKSID 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 98.41% to 109.82% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 20.35 MW to the thermal violation.

4. (AEP - AEP) The 05MELMOR-05FOSTOR 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 118.34% to 143.6% (AC power flow) of its emergency rating (245 MVA) for the single line contingency outage of '712_B3_05TIFFIN 138-1_WOMOAB'. This project contributes approximately 63.51 MW to the thermal violation.

CONTINGENCY '712_B3_05TIFFIN 138-1_WOMOAB'
OPEN BRANCH FROM BUS 243008 TO BUS 243009 CKT 1 / 243008 05FREMCT 138 243009 05FRMNT 138 1
OPEN BRANCH FROM BUS 243008 TO BUS 243130 CKT 1 / 243008 05FREMCT 138 243130 05TIFFIN 138 1
OPEN BRANCH FROM BUS 243015 TO BUS 243130 CKT 1 / 243015 05GREENL 138 243130 05TIFFIN 138 1

© PJM Interconnection 2020. All rights reserved.

OPEN BRANCH FROM BUS 243008 TO BUS 245614 CKT 1 / 243008 05FREMCT 138 245614 05FREMNT C 69.0 1
OPEN BRANCH FROM BUS 243130 TO BUS 245637 CKT 1 / 243130 05TIFFIN 138 245637 05TIFFIN C 69.0 1
OPEN BRANCH FROM BUS 247481 TO BUS 245637 CKT 1 / 247481 05HOLME STSS69.0 245637 05TIFFIN C 69.0 1
OPEN BRANCH FROM BUS 245648 TO BUS 245637 CKT 1 / 245648 05MAULE RD 69.0 245637 05TIFFIN C 69.0 1
END

5. (AEP - AEP) The 05MELMOR-05FOSTOR 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 113.35% to 137.97% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 42.33 MW to the thermal violation.

6. (AEP - AEP) The 05MELMOR-05HOWARD 138 kV line (from bus 243039 to bus 243024 ckt 1) loads from 116.57% to 135.74% (AC power flow) of its emergency rating (173 MVA) for the single line contingency outage of '1016_B3_05CHATFL 138-1_WOMOAB-A'. This project contributes approximately 36.24 MW to the thermal violation.

CONTINGENCY '1016_B3_05CHATFL 138-1_WOMOAB-A'
OPEN BRANCH FROM BUS 242953 TO BUS 243110 CKT 1 / 242953 05AIRCO8 138 243110 05STIFFI 138 1
OPEN BRANCH FROM BUS 242953 TO BUS 243137 CKT 1 / 242953 05AIRCO8 138 243137 05W.END 138 1
OPEN BRANCH FROM BUS 242984 TO BUS 932050 CKT 1 / 242984 05CHATFL 138 932050 AC2-015 TAP 138 1
OPEN BRANCH FROM BUS 242984 TO BUS 243039 CKT 1 / 932050 05CHATFL 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 242984 TO BUS 245656 CKT 1 / 242984 05CHATFL 138 245656 05CHATFIEL 69.0 1
OPEN BRANCH FROM BUS 243110 TO BUS 245630 CKT 1 / 243110 05STIFFI 138 245630 05S TIFFIN 69.0 1
OPEN BRANCH FROM BUS 247193 TO BUS 245655 CKT 1 / 247193 05BULLHDSS 69.0 245655 05CARROTHR 69.0 1
OPEN BRANCH FROM BUS 247193 TO BUS 245669 CKT 1 / 247193 05BULLHDSS 69.0 245669 05N WILLAR 69.0 1
OPEN BRANCH FROM BUS 245655 TO BUS 245656 CKT 1 / 245655 05CARROTHR 69.0 245656 05CHATFIEL 69.0 1
OPEN BRANCH FROM BUS 245655 TO BUS 245674 CKT 1 / 245655 05CARROTHR 69.0 245674 05ST.STEPHSS69.0 1
OPEN BRANCH FROM BUS 245656 TO BUS 247380 CKT 1 / 245656 05CHATFIEL 69.0 247380 05NEW WASHSS69.0 1
END

7. (AEP - AEP) The 05STIFFI-05AIRCO8 138 kV line (from bus 243110 to bus 242953 ckt 1) loads from 93.38% to 113.91% (AC power flow) of its emergency rating (167 MVA) for the single line contingency outage of 'AEP_P1-2_#7104'. This project contributes approximately 35.23 MW to the thermal violation.

© PJM Interconnection 2020. All rights reserved.

CONTINGENCY 'AEP_P1-2_#7104'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
END

8. (AEP - AEP) The AC2-015 TAP-05HOWARD 138 kV line (from bus 932050 to bus 243024 ckt 1) loads from 125.97% to 142.12% (AC power flow) of its emergency rating (167 MVA) for the single line contingency outage of 'AEP_P1-2_#7105'. This project contributes approximately 28.85 MW to the thermal violation.

CONTINGENCY 'AEP_P1-2_#7105'
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

9. (AEP - AEP) The AC2-015 TAP-05HOWARD 138 kV line (from bus 932050 to bus 243024 ckt 1) loads from 111.42% to 125.38% (AC power flow) of its normal rating (138 MVA) for non-contingency condition. This project contributes approximately 20.04 MW to the thermal violation.

# Light Load Analysis – 2021

## 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)*

| ID | FROM BUS# | FROM BUS | kV | FROM BUS AREA | TO BUS # | TO BUS | kV | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\| DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16354** | 243039 | 05MELMOR | 138.0 | AEP | 243024 | 05HOWARD | 138.0 | AEP | 1 | 1016_B3_05CHATFL 138-1_WOMOAB | single | 173.0 | 91.23 | 106.87 | AC | 29.0 |
| **16356** | 243039 | 05MELMOR | 138.0 | AEP | 243024 | 05HOWARD | 138.0 | AEP | 1 | 714_B3_05STIFFI 138-2_WOMOAB | single | 173.0 | 86.26 | 101.4 | AC | 28.13 |

**Table 1**

© PJM Interconnection 2020. All rights reserved.

## 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

## 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.

| ID | FROM BUS # | FROM BUS | kV | FROM BUS AREA | TO BUS # | TO BUS | kV | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\| DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16355** | 243039 | 05MELMOR | 138.0 | AEP | 243024 | 05HOWARD | 138.0 | AEP | 1 | 1016_B3_05CHATFL 138-1_WOMOAB | operation | 173.0 | 91.03 | 109.16 | AC | 34.12 |

**Table 2**

## Flow Gate Details

The following indices 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.

| ID | FROM BUS# | FROM BUS | FROM BUS AREA | TO BUS# | TO BUS | TO BUS AREA | CKT ID | CONT NAME | Type | Rating MVA | PRE PROJECT LOADING % | POST PROJECT LOADING % | AC\|DC | MW IMPACT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16354** | 243039 | 05MELMOR | AEP | 243024 | 05HOWARD | AEP | 1 | 1016_B3_05CHATFL 138-1_WOMOAB | single | 173.0 | 91.23 | 106.87 | AC | 29.0 |

| Bus # | Bus | MW Impact |
|---|---|---|
| **247551** | U4-028 C | 2.2178 |
| **247552** | U4-029 C | 2.2178 |
| **247940** | U4-028 E | 14.8422 |
| **247941** | U4-029 E | 14.8422 |
| **934461** | AD1-070 C O1 | 1.6917 |
| **934462** | AD1-070 E O1 | 7.9416 |
| **937021** | AD2-136 C O1 | 7.9841 |
| **937022** | AD2-136 E O1 | 53.4319 |
| **937381** | AD2-191 C | 3.7703 |
| **937382** | AD2-191 E | 25.2317 |

**Table 3**

© PJM Interconnection 2020. All rights reserved.

# 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

The System Reinforcements listed below are not part of the Bulk Electric System (BES), but was identified by AEP and will be required for the interconnection of AD2-191. AEP will need to confirm the sub-transmission overloads and reinforcements identified in the table below in the Facilities Study.

| # | Overloaded Facility | Upgrade Description | Schedule | Estimated Cost |
|---|---|---|---|---|
| 1 | 05BERWICK-05SBERWICK 69 kV line | Replace Berwick switch.<br>Replace Berwick risers. | An approximate construction time would be 12 to 24 months after signing an interconnection agreement. | $350,000 |
| 2 | 05RIVERVIE-05BASCOM 69 kV line | COPPER ~ # 1 ~ 3 ~ - Conductor Section 1 will need to be rebuilt/ reconductored.<br>**Note:** PJM project S1486 will mitigate the constraint identified above. | The projected in service date for PJM project S1486 is 08/03/2018. | N/A |
| 3 | 05S TIFFIN-05SENECA SS 69 kV line | Replace S Tiffin risers.<br>Replace S Tiffin Switch. | An approximate construction time would be 12 to 24 months after signing an interconnection agreement | $600,000 |
| 4 | 05SENECA SS-05BERWICK 69 kV line | Replace Berwick Switch. | See item #1 above | See item #1 above |
| | | | **Total Network Upgrades** | **$950,000** |

**Table 4**

## 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. **The mitigation below will be required to alleviate the Ottawa – Lakeview 138 kV line overload:**

    - 2023 baseline upgrade B3033 - Reconductor the Ottawa – Lakeview 138 kV line and perform substation upgrades. The new SE rating is expected to be 516 MVA SE. Projected in-service date is 12/1/2023. FE needs 18 months to construct.

© PJM Interconnection 2020. All rights reserved.

AD2-191 customer would be responsibe to advance constrcution to an earlier date if requested and feasible. AD2-191 would need an interim study if coming into service prior to compeltion of B3033.

2. **The mitigation below will be required to alleviate the Lakeview - Greenfield 138 kV line overload:**

   - 2023 baseline upgrade B3034 - Reconductor the Lakeview-Greenfield 138 kV line and perform substation upgrades. The new expected SE rating is expected to be 385 MVA. Projected in-service date is 12/1/2023. FE needs 18 months to construct. AD2-191 customer would be responsibe to advance constrcution to an earlier date if requested and feasible. AD2-191 would need an interim study if coming into service prior to compeltion of B3034.

3. **The mitigation below will be required to alleviate the 05FREMCT-05FRMNT 138 kV line overloads:**

   - A sag study will be required on the 4.0 miles of ACSR ~ 795 ~ 45/7 ~ TERN - Conductor Section 1 to mitigate the overload. Depending on the sag study results, the cost for this upgrade is expected to be around $20,000 (no remediation required, just sag study) and $6 million (complete line reconductor/rebuild). New rating after sag study: S/N: 251 S/E: 335 MVA. Time Estimate: a) Sag Study: 6-12 months. b) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement. PJM Network Upgrade N6297.1.

     The cost allocation is as follows:

| Queue | *MW contribution | Summer/ Light Load | Percentage of cost | $ cost ($20 K) |
|---|---|---|---|---|
| AD2-136 | 143.7 | Summer | 67.91% | $13.582 |
| AD2-191 | 67.9 | Summer | 32.09% | $6.418 |

* MW contribution is the sum of MW contribution from each overloaded line.

4. **The mitigation below will be required to alleviate the following overloads: 05CHATFL-AC2-015 TAP 138 kV line, the AC2-015 Tap – Howard 138 kV line, 05STIFFI-05AIRCO8 138 kV line, 05AIRCO8-05W.END 138 kV line, 05MELMOR-05CHATFL 138 kV line, 05MELMOR-05STIFFI 138 kV line:**

   - Relocate either the Fostoria line or Howard line termination at Melmore 138 kV to the open breaker position in the AD2-136 breaker bay (or other available breaker bay positions if can be created such as the open AD2-191 breaker bay position) to eliminate the stuck breaker contingency involving the loss of the Fostoria and Howard lines at Melmore. Cost estimate is $4M. An approximate construction time would be 24 to 36 months after signing an interconnection agreement. PJM Network Upgrade N6295.2.

© PJM Interconnection 2020. All rights reserved.

The cost allocation is as follows:

| Queue | *MW contribution | Summer/ Light Load | Percentage of cost | $ cost ($4) M |
|---|---|---|---|---|
| AD2-136 | 156.5 | Summer | 39.67% | $1.587 |
| AD2-191 | 238.0 | Summer | 60.33% | $2.413 |

* MW contribution is the sum of MW contribution from each overloaded line.

- The upgrade above, N6295.2 should be re-confirmed during the Facilities Study phase that it is feasible. If not, the upgrades to increase the line ratings on the 6 individual lines which are overloaded will need to be determined and confirmed per the below details, which will be larger in scope and cost compared to network upgrade N6295.2, such as:

1. **The mitigation below will be required to alleviate the overload on the 05CHATFL-AC2-015 TAP 138 kV line:**

    - A Sag Study will be required on the 4.9 mile section of ACSR ~ 397.5 ~ 30/7 ~ LARK- Conductor section 1 line to mitigate the overload. New Ratings after the sag study S/N : 167 MVA S/E: 245 MVA. Depending on the sag study results, cost for this upgrade is expected to be between $19,600 (no remediations required just sag study) and $7.35million (complete line reconductor/rebuild required).
    - Replace Chatfield Switch (Estimated Cost: $200K)
    - An approximate construction time will be 24 to 36 months after signing of an interconnection agreement.
    - New expected Summer emergency rating: 245 MVA
    - Total Cost estimate: $219,600

2. **The mitigation below will be required to alleviate the overload on the AC2-015 Tap – Howard 138 kV line:**

    - Sag study ($44,400) with potential of Rebuild 11.5 mile double circuit line between AC2-015 TAP and Howard with 1590 ACSR (replacing ACSR ~ 397.5 ~ 30/7 ~ LARK conductor). Estimated cost: $34.5 Million. 24-36 months time estimate. New SE rating expected to be 245 MVA.
    - Howard Line risers Sub cond 300 MCM CU 37 Str need to be replaced, Estimated cost: $100k. 12-18 months time estimate. New SE rating expected to be 179 MVA.
    - Upgrade CT Thermal Limit 749 Amps & Relay Thermal Limit 749 Amps at Howard. An engineering study will need to be conducted to determine if the thermal limits settings can be adjusted to mitigate the overload, Estimated Cost $25,000. New relay packages will be

© PJM Interconnection 2020. All rights reserved.

required if the settings cannot be adjusted, Estimated Cost: $600,000. 12-18 months time estimate. New SE rating expected to be 180 MVA.

- Replace Sub cond 397.5 ACSR 26/7 at Howard, estimated cost: $100k. 12-18 months time estimate. New SE rating expected to be 233 MVA.
- Upgrade Relay Compliance Trip Limit 975 Amps at Howard. Estimated cost: $25k. 12-18 months time estimate. New SE rating expected to be 255 MVA.
- Replace five Sub cond 795 AAC 37 Str at Howard. Estimated cost: $500k. 12-18 months time estimate. New SE rating is 330 MVA.
- Total Cost Estimate: $269,400

**3. The mitigation below will be required to alleviate the overload on the 05STIFFI-05AIRCO8 138 kV line:**

- A Sag Study will be required on the 11.6-mile section of ACSR~397.5~30/7~LARK Conductor section 1 line to mitigate the overload. New Ratings after the sag study S/N : 167 MVA S/E: 245 MVA. Depending on the sag study results, cost for this upgrade is expected to be between $46,400 (no remediations required just sag study) and $17.4million (complete line reconductor/rebuild required)
- An Engineering study need to be conducted to determine if the W.End relay thermal limits settings can be adjusted to mitigate the overload, Estimated Cost: $25,000. New relay packages will be required if the settings cannot be adjusted, Estimated Cost for relay package: $600,000.
- An Engineering study need to be conducted to determine if the W.End CT Thermal Limit settings can be adjusted to mitigate the overload, Estimated Cost: $25,000. New relay packages will be required if the settings cannot be adjusted, Estimated Cost for relay package: $600,000.
- Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.
- New expected summer emergency rating: 233 MVA
- Total Cost estimate is $96,400

**4. The mitigation below will be required to alleviate the overload on the 05AIRCO8-05W.END 138 kV line:**

- A Sag Study will be required on the 11.6-mile section of ACSR~397.5~30/7~LARK Conductor section 1 line to mitigate the overload. New Ratings after the sag study S/N : 167 MVA S/E: 245 MVA. Depending on the sag study results, cost for this upgrade is expected to be between $46,400 (no remediations required just sag study) and $17.4million (complete line reconductor/rebuild required)

© PJM Interconnection 2020. All rights reserved.

- An Engineering study need to be conducted to determine if the W.End relay thermal limits settings can be adjusted to mitigate the overload, Estimated Cost: $25,000. New relay packages will be required if the settings cannot be adjusted, Estimated Cost for relay package: $600,000.
- An Engineering study need to be conducted to determine if the W.End CT Thermal Limit settings can be adjusted to mitigate the overload, Estimated Cost: $25,000. New relay packages will be required if the settings cannot be adjusted, Estimated Cost for relay package: $600,000.
- Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.
- New expected summer emergency rating: 233 MVA
- Total Cost estimate is $96,400

**5. The mitigation below will be required to alleviate the overload on the 05MELMOR-05CHATFL 138 kV line:**

- Current AEP Ratings are S/N : 164 MVA S/E: 167 MVA
- A Sag Study will be required on the 11.3 mile section of ACSR ~ 397.5 ~ 30/7 ~ LARK- Conductor section 1 line to mitigate the overload.
- New Ratings after the sag study S/N : 167 MVA S/E: 245 MVA. Depending on the sag study results, cost for this upgrade is expected to be between $45,200 (no remediations required just sag study) and $16.95million (complete line reconductor/rebuild required)
- Replace Chatfield switch (estimated cost : $200k)
- An approximate construction time would be 24 to 36 months after signing an interconnection agreement.
- New expected summer emergency rating: 245 MVA
- Total Cost Estimate: $245,200
- Additional upgrades may be needed to obtain a minimum SE rating of 253 MVA.

**6. The mitigation below will be required to alleviate the overload on the 05MELMOR-05STIFFI 138 kV line:**

- Current AEP Ratings are S/N: 167 MVA S/E: 167 MVA
- A Sag Study will be required on the 6.1 mile section of ACSR ~ 397.5 ~ 30/7 ~ LARK- Conductor section 1 line to mitigate the overload. New Ratings after the sag study S/N : 167 MVA S/E: 245 MVA. Depending on the sag study results, cost for this upgrade is expected to be between $24,400 (no remediations required just sag study) and $9.15million (complete line reconductor/rebuild required)
- Replace four (4) South Tiffin Sub cond 500 MCM CU 37 Str Risers; Est Cost : $ 400k

© PJM Interconnection 2020. All rights reserved.

- New expected Summer emergency MVA rating: 245 MVA
- Total Cost Estimate: $424,400
- Additional upgrades may be needed to obtain a minimum SE rating of 248 MVA.

© PJM Interconnection 2020. All rights reserved.

The System Reinforcements listed below are not part of the Bulk Electric System (BES), but was identified by AEP and will be required for the interconnection of AD2-191. AEP will need to confirm the sub-transmission overloads and reinforcements identified in the table below in the Facilities Study.

| Violation # | Overloaded Facility | Upgrade Description | Schedule | Estimated Cost |
|---|---|---|---|---|
| 1 | 05STIFFI 138/69 kV transformer | Replace Transformer.<br>Replace Switch. | An approximate construction time would be 24 to 36 months after signing an interconnection agreement. | $2,000,000 |
| 2 | 05TIFFIN C-05MAULE RD 69 kV line | Replace Tifffin Center risers.<br>3.28 miles of ACSR ~ 556.5 ~ 18/1 ~ OSPRE conductor will need to be rebuilt/reconductored.<br>Replace Tiffin Center CB A. | An approximate construction time would be 24 to 36 months after signing an interconnection agreement. | $4,536,000 |
| 3 | 05TIFFIN T-05RIVERVIE 69 kV line | 1.03 miles of ACSR ~ 336.4 ~ 18/1 ~ MERLIN conductor need to be rebuilt/ reconductored.<br>Replace Reverview risers.<br>Replace Tiffin Tapoff MOAB Switch W.<br>Replace Riverview Switch.<br>Replace Riverview Switch. | An approximate construction time would be 24 to 36 months after signing an interconnection agreement. | $2,086,000 |
| 4 | 05MAULE RD-05DAVIS STSS 69 kV line | 1.75 miles of ACSR ~ 336.4 ~ 18/1 ~ MERLIN conductor need to be rebuilt/reconductored. Estimated cost.<br>Replace Davis St Switch. Estimated cost. | An approximate construction time would be 24 to 36 months after signing an interconnection agreement. | $2,350,000 |
| 5 | 05ST.STEPHSS-05CARROTHR 69 kV line | 2.6 miles of COPPER ~ # 1 ~ 3 ~ - Conductor Section 1 need to be rebuilt/reconductored. Estimated cost: $3.12 million.<br>**Note:** The upgrade costs are presently the responsibilities of the Transmission Owner under PJM project B2791 which is scheduled to be put in service by 06/01/2021. Any cost to advance the in service date would be determined in the facility study. | The projected in service date for project B2791 is 06/01/2021. | N/A |
| 6 | 05DAVIS STSS-05TIFFIN T 69 kV line | 0.26 mile of conductor needs to be rebuilt/ reconductored.<br>Replace Davis St Switch. Estimated cost.<br>Replace Tiffin Tapoff MOAB "Y". | An approximate construction time would be 24 to 36 months after signing an interconnection agreement. | $1,162,000 |
| | | | **Total New Network Upgrades** | **$12,134,000** |

**Table 5**

## Light Load Analysis Reinforcements

| ID | Index | Facility | Upgrade Description | Cost | Cost Allocated to AD2-191 | Upgrade Number |
|---|---|---|---|---|---|---|
| 16356,16354 | 1 | **05MELMOR 138.0 kV - 05HOWARD 138.0 kV Ckt 1** | Description :<br><br>1) A Sag Study will be required on the 26.5 miles of ACSR ~ 397.5 ~ 30/7 ~ LARK - Conductor Section 1 to mitigate the overload. Depending on the sag study results, the cost for this upgrade is expected to be between $106,000 (no remediations required, just sag study) and $39.75 million (complete line reconductor/rebuild). New rating after sag study: S/N:167 S/E: 245. Time Estimate: a) Sag Study: 6-12 months b) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 24 to 36 months after signing an interconnection agreement.<br><br>2) Replace two Howard Line risers. Estimated cost: $100,000.<br><br>**The need for rebuild will be assessed in the Facility Study Phase. Line Rebuild cost is $39.75 Million and the customer may be responsible for the cost if there exists a need for rebuilt in the facility study phase.** | $206, 000 | $206, 000 | N6298.1<br>N6298.2 |
| | | | **TOTAL COST** | $206, 000 | $206, 000 | |

**Table 6**

© PJM Interconnection 2020. All rights reserved.

## Schedule

It is anticipated that the time between receipt of executed agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would be between 24 to 36 months after signing an interconnection agreement.

## Conclusion

Based upon the results of this System Impact Study, the construction of the 170.0 MW (22.1 MW Capacity) Wind generating facility of Seneca Wind, LLC (PJM Project #AD2-191) will require the following additional interconnection charges. This plan of service will interconnect the proposed generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the Seneca Wind generating facility.

| Cost Breakdown for Point of Interconnection (Melmore 138 kV) | | |
|---|---|---|
| **Attachment Cost** | PJM Project U4-028 and U4-029 will pay for the necessary direct connection work required. Project U4-028, U4-029 and AD2-191 will share the same Generator lead to the Melmore 138kV station. | PJM Project #U4-028 and U4-029 to pay for Attachment Facilities |
| **Non-Direct Connection Cost Estimate** | Load Flow - New System Reinforcements | $0 |
| | Load Flow - Contribution to Previously Identified System Reinforcements | $2,149,418 |
| | Load Flow - New System Reinforcements-Not part of the BES | $950,000 |
| | Load Flow - Contribution to Previously Identified System Reinforcements-Not part of the BES | $12,134,000 |
| | Light Load – New System Reinforcements | $206,000 |
| | **Total Estimated Cost for Project AD2-191** | **$15,439,418** |

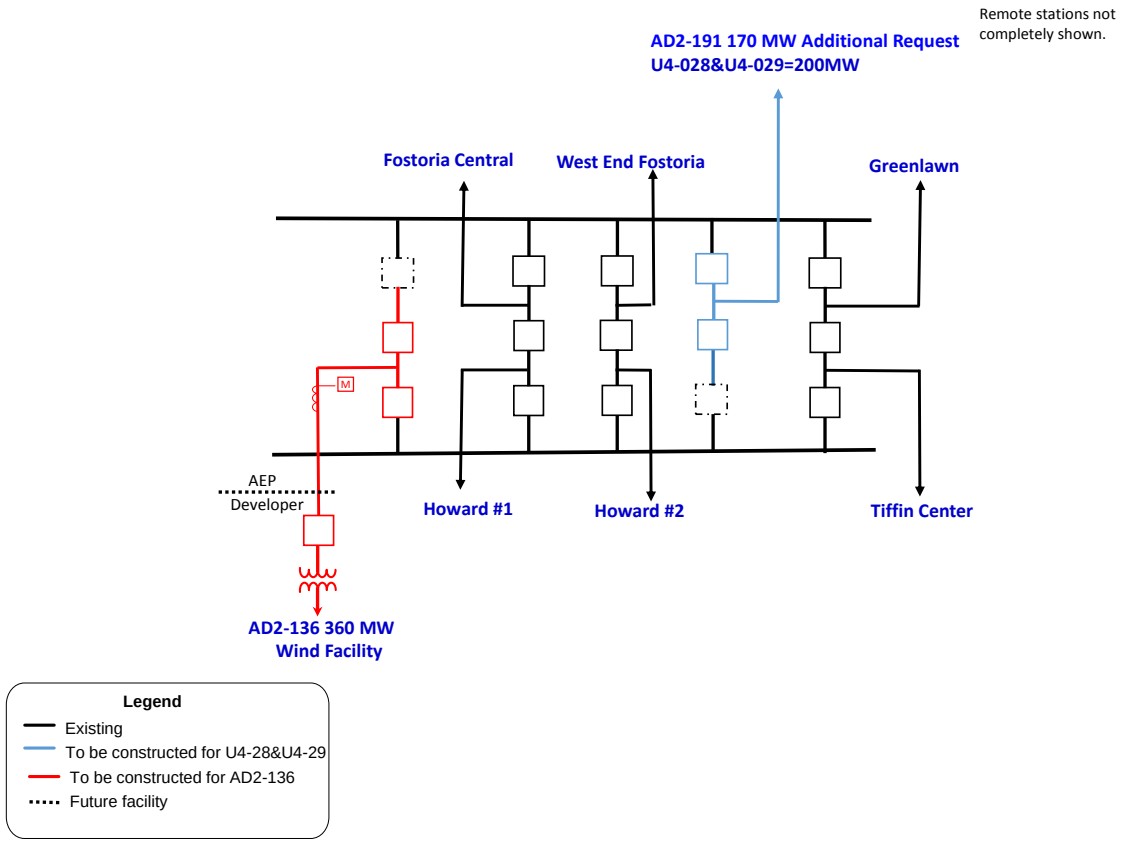
**Table 7**

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.

© PJM Interconnection 2020. All rights reserved.

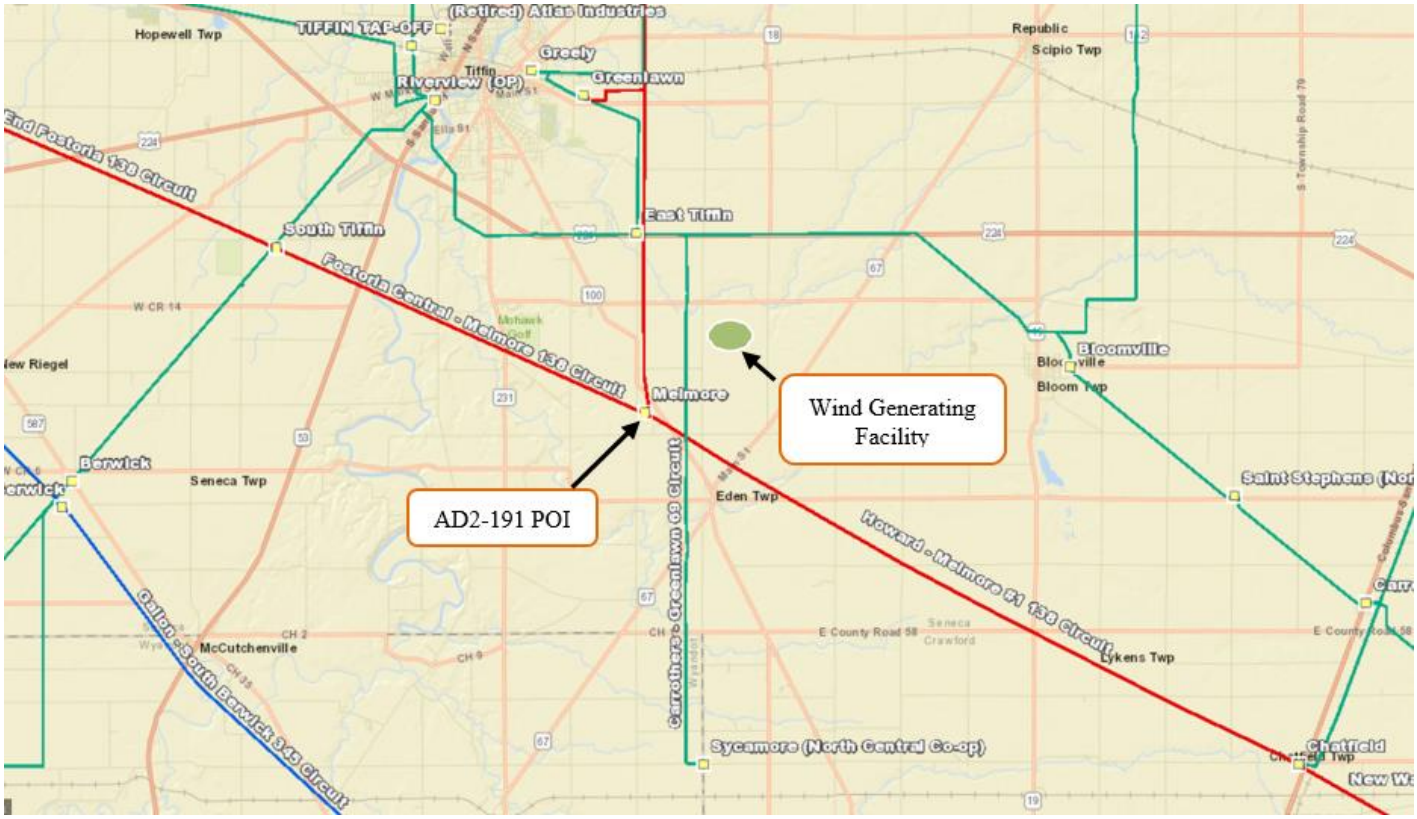
## Figure 1: Point of Interconnection (Melmore 138 kV)

## One-Line Diagram




© PJM Interconnection 2020. All rights reserved.

**Figure 2: AD2-191 Point of Interconnection (Melmore 138 kV)**



# 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. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the Appendices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the Appendices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators.

It should be noted the project/generator MW contributions presented in the body of the report and appendices sections are full contributions, whereas the loading percentages reported in the body of the report, take into consideration the commercial probability of each project as well as the ramping impact of "Adder" contributions.

© PJM Interconnection 2020. All rights reserved.

# Appendix 1

(AEP - AEP) The 05AIRCO8-05W.END 138 kV line (from bus 242953 to bus 243137 ckt 1) loads from 96.94% to 119.61% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 39.04 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *932051* | *AC2-015 C* | *7.67* |
| *932052* | *AC2-015 E* | *8.95* |
| *937021* | *AD2-136 C O1* | *10.75* |
| *937022* | *AD2-136 E O1* | *71.93* |
| *937381* | *AD2-191 C* | *5.08* |
| *937382* | *AD2-191 E* | *33.97* |
| *LTF* | *AMIL* | *0.09* |
| *LTF* | *BAYOU* | *0.22* |
| *LTF* | *BIG_CAJUN1* | *0.33* |
| *LTF* | *BIG_CAJUN2* | *0.67* |
| *LTF* | *BLUEG* | *0.46* |
| *LTF* | *CALDERWOOD* | *0.08* |
| *LTF* | *CANNELTON* | *0.08* |
| *LTF* | *CATAWBA* | *0.03* |
| *LTF* | *CBM-N* | *0.04* |
| *LTF* | *CHEOAH* | *0.08* |
| *LTF* | *CHILHOWEE* | *0.03* |
| *LTF* | *CHOCTAW* | *0.21* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *CLIFTY* | *1.31* |
| *LTF* | *COTTONWOOD* | *0.9* |
| *LTF* | *DEARBORN* | *0.49* |
| *LTF* | *EDWARDS* | *0.18* |
| *LTF* | *ELMERSMITH* | *0.23* |
| *LTF* | *FARMERCITY* | *0.11* |
| *LTF* | *G-007A* | *0.28* |
| *LTF* | *GIBSON* | *0.18* |
| *LTF* | *HAMLET* | *0.09* |
| *LTF* | *MORGAN* | *0.34* |
| *LTF* | *NEWTON* | *0.4* |
| *LTF* | *NYISO* | *0.61* |
| *LTF* | *PRAIRIE* | *0.74* |
| *LTF* | *SANTEETLA* | *0.02* |
| *LTF* | *SMITHLAND* | *0.05* |
| *LTF* | *TATANKA* | *0.2* |
| *LTF* | *TILTON* | *0.21* |
| *LTF* | *TRIMBLE* | *0.09* |
| *LTF* | *TVA* | *0.15* |
| *247551* | *U4-028 C* | *2.99* |
| *247940* | *U4-028 E* | *19.98* |
| *247552* | *U4-029 C* | *2.99* |
| *247941* | *U4-029 E* | *19.98* |
| *LTF* | *UNIONPOWER* | *0.12* |
| *247548* | *V4-010 C* | *4.85* |
| *247947* | *V4-010 E* | *32.46* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *VFT* | *0.74* |
| *925751* | *AC1-051 C* | *0.97* |
| *925752* | *AC1-051 E* | *6.5* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 2

(AEP - AEP) The 05MELMOR-05CHATFL 138 kV line (from bus 243039 to bus 242984 ckt 1) loads from 86.72% to 102.08% (AC power flow) of its emergency rating (245 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 41.31 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *934251* | *AD1-052 C1* | *0.34* |
| *934261* | *AD1-052 C2* | *0.34* |
| *937021* | *AD2-136 C O1* | *11.37* |
| *937022* | *AD2-136 E O1* | *76.11* |
| *937381* | *AD2-191 C* | *5.37* |
| *937382* | *AD2-191 E* | *35.94* |
| *LTF* | *CALDERWOOD* | *0.01* |
| *LTF* | *CARR* | *0.02* |
| *LTF* | *CATAWBA* | *0.03* |
| *LTF* | *CBM-S1* | *0.12* |
| *LTF* | *CBM-W1* | *7.01* |
| *LTF* | *CBM-W2* | *2.16* |
| *LTF* | *CHEOAH* | *0.01* |
| *LTF* | *CHILHOWEE* | *< 0.01* |
| *LTF* | *CIN* | *0.4* |
| *LTF* | *CLIFTY* | *0.44* |
| *LTF* | *G-007* | *0.14* |
| *LTF* | *HAMLET* | *0.1* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *IPL* | *0.26* |
| *LTF* | *LGEE* | *0.03* |
| *LTF* | *MEC* | *1.1* |
| *LTF* | *MECS* | *5.04* |
| *LTF* | *O-066* | *0.91* |
| *LTF* | *RENSSELAER* | *0.02* |
| *LTF* | *SANTEETLA* | *< 0.01* |
| *247551* | *U4-028 C* | *3.16* |
| *247940* | *U4-028 E* | *21.14* |
| *247552* | *U4-029 C* | *3.16* |
| *247941* | *U4-029 E* | *21.14* |
| *247548* | *V4-010 C* | *4.85* |
| *247947* | *V4-010 E* | *32.46* |
| *LTF* | *WEC* | *0.21* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 3

(AEP - AEP) The 05MELMOR-05STIFFI 138 kV line (from bus 243039 to bus 243110 ckt 1) loads from 82.79% to 100.39% (AC power flow) of its emergency rating (245 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 44.75 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *932051* | *AC2-015 C* | *8.39* |
| *932052* | *AC2-015 E* | *9.79* |
| *937021* | *AD2-136 C O1* | *12.32* |
| *937022* | *AD2-136 E O1* | *82.45* |
| *937381* | *AD2-191 C* | *5.82* |
| *937382* | *AD2-191 E* | *38.94* |
| *LTF* | *AMIL* | *0.08* |
| *LTF* | *BAYOU* | *0.22* |
| *LTF* | *BIG_CAJUN1* | *0.32* |
| *LTF* | *BIG_CAJUN2* | *0.65* |
| *LTF* | *BLUEG* | *0.45* |
| *LTF* | *CALDERWOOD* | *0.08* |
| *LTF* | *CANNELTON* | *0.08* |
| *LTF* | *CATAWBA* | *0.03* |
| *LTF* | *CBM-N* | *0.04* |
| *LTF* | *CHEOAH* | *0.08* |
| *LTF* | *CHILHOWEE* | *0.03* |
| *LTF* | *CHOCTAW* | *0.21* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *CLIFTY* | *1.32* |
| *LTF* | *COTTONWOOD* | *0.86* |
| *LTF* | *DEARBORN* | *0.41* |
| *LTF* | *EDWARDS* | *0.17* |
| *LTF* | *ELMERSMITH* | *0.22* |
| *LTF* | *FARMERCITY* | *0.1* |
| *LTF* | *G-007A* | *0.25* |
| *LTF* | *GIBSON* | *0.17* |
| *LTF* | *HAMLET* | *0.09* |
| *LTF* | *MORGAN* | *0.33* |
| *LTF* | *NEWTON* | *0.38* |
| *LTF* | *NYISO* | *0.6* |
| *LTF* | *PRAIRIE* | *0.69* |
| *LTF* | *SANTEETLA* | *0.02* |
| *LTF* | *SMITHLAND* | *0.05* |
| *LTF* | *TATANKA* | *0.19* |
| *LTF* | *TILTON* | *0.19* |
| *LTF* | *TRIMBLE* | *0.09* |
| *LTF* | *TVA* | *0.15* |
| *247551* | *U4-028 C* | *3.42* |
| *247940* | *U4-028 E* | *22.9* |
| *247552* | *U4-029 C* | *3.42* |
| *247941* | *U4-029 E* | *22.9* |
| *LTF* | *UNIONPOWER* | *0.12* |
| *247548* | *V4-010 C* | *5.19* |
| *247947* | *V4-010 E* | *34.74* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *VFT* | *0.68* |
| *925751* | *AC1-051 C* | *0.96* |
| *925752* | *AC1-051 E* | *6.45* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 4

(FE - FE) The 02LAKVEW-02GRNFLD 138 kV line (from bus 238874 to bus 238768 ckt 1) loads from 110.09% to 112.86% (AC power flow) of its emergency rating (316 MVA) for the tower line contingency outage of 'ADD202'. This project contributes approximately 9.5 MW to the thermal violation.

CONTINGENCY 'ADD202'
 DISCONNECT BRANCH FROM BUS 238654 TO BUS 239289 CKT 1 /* 02DAVIS BESSE 345 02HAYES 345
 DISCONNECT BRANCH FROM BUS 238654 TO BUS 907060 CKT 1 /* 02DAVIS BESSE 345 X1-027A TAP 345
 END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *238601* | *02FRMENG 1* | *3.7* |
| *238602* | *02FRMENG 2* | *3.7* |
| *238603* | *02FRMENG 3* | *6.68* |
| *238979* | *02NAPMUN* | *2.36* |
| *934251* | *AD1-052 C1* | *0.54* |
| *934261* | *AD1-052 C2* | *0.54* |
| *934461* | *AD1-070 C O1* | *1.86* |
| *934462* | *AD1-070 E O1* | *8.72* |
| *934891* | *AD1-118* | *4.36* |
| *937021* | *AD2-136 C O1* | *2.62* |
| *937022* | *AD2-136 E O1* | *17.5* |
| *937381* | *AD2-191 C* | *1.24* |
| *937382* | *AD2-191 E* | *8.27* |
| *LTF* | *CARR* | *0.61* |
| *LTF* | *CBM-S1* | *3.28* |
| *LTF* | *CBM-S2* | *1.2* |
| *LTF* | *CBM-W1* | *30.21* |
| *LTF* | *CBM-W2* | *23.79* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *CIN* | *3.86* |
| *LTF* | *CPLE* | *0.2* |
| *LTF* | *G-007* | *0.97* |
| *LTF* | *IPL* | *2.49* |
| *LTF* | *LGEE* | *0.68* |
| *LTF* | *MEC* | *7.79* |
| *LTF* | *MECS* | *16.68* |
| *LTF* | *O-066* | *6.27* |
| *LTF* | *RENSSELAER* | *0.48* |
| *247551* | *U4-028 C* | *0.73* |
| *247940* | *U4-028 E* | *4.86* |
| *247552* | *U4-029 C* | *0.73* |
| *247941* | *U4-029 E* | *4.86* |
| *247548* | *V4-010 C* | *1.7* |
| *247947* | *V4-010 E* | *11.34* |
| *LTF* | *WEC* | *1.27* |
| *LTF* | *Y3-032* | *14.06* |
| *931951* | *AB1-107 1* | *24.25* |
| *931961* | *AB1-107 2* | *39.76* |
| *926941* | *AC1-181* | *0.25* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 5

(FE - FE) The 02OTTAWA-02LAKVEW 138 kV line (from bus 239030 to bus 238874 ckt 1) loads from 108.87% to 111.18% (AC power flow) of its emergency rating (380 MVA) for the tower line contingency outage of 'ADD202'. This project contributes approximately 9.5 MW to the thermal violation.

CONTINGENCY 'ADD202'
 DISCONNECT BRANCH FROM BUS 238654 TO BUS 239289 CKT 1 /* 02DAVIS BESSE 345 02HAYES 345
 DISCONNECT BRANCH FROM BUS 238654 TO BUS 907060 CKT 1 /* 02DAVIS BESSE 345 X1-027A TAP 345
 END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *238601* | *02FRMENG 1* | *3.7* |
| *238602* | *02FRMENG 2* | *3.7* |
| *238603* | *02FRMENG 3* | *6.68* |
| *238979* | *02NAPMUN* | *2.36* |
| *934251* | *AD1-052 C1* | *0.54* |
| *934261* | *AD1-052 C2* | *0.54* |
| *934461* | *AD1-070 C O1* | *1.86* |
| *934462* | *AD1-070 E O1* | *8.72* |
| *934891* | *AD1-118* | *4.36* |
| *937021* | *AD2-136 C O1* | *2.62* |
| *937022* | *AD2-136 E O1* | *17.5* |
| *937381* | *AD2-191 C* | *1.24* |
| *937382* | *AD2-191 E* | *8.27* |
| *LTF* | *CARR* | *0.61* |
| *LTF* | *CBM-S1* | *3.28* |
| *LTF* | *CBM-S2* | *1.2* |
| *LTF* | *CBM-W1* | *30.21* |
| *LTF* | *CBM-W2* | *23.79* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *CIN* | *3.86* |
| *LTF* | *CPLE* | *0.2* |
| *LTF* | *G-007* | *0.97* |
| *LTF* | *IPL* | *2.49* |
| *LTF* | *LGEE* | *0.68* |
| *LTF* | *MEC* | *7.79* |
| *LTF* | *MECS* | *16.68* |
| *LTF* | *O-066* | *6.27* |
| *LTF* | *RENSSELAER* | *0.48* |
| *247551* | *U4-028 C* | *0.73* |
| *247940* | *U4-028 E* | *4.86* |
| *247552* | *U4-029 C* | *0.73* |
| *247941* | *U4-029 E* | *4.86* |
| *247548* | *V4-010 C* | *1.7* |
| *247947* | *V4-010 E* | *11.34* |
| *LTF* | *WEC* | *1.27* |
| *LTF* | *Y3-032* | *14.06* |
| *931951* | *AB1-107 1* | *24.25* |
| *931961* | *AB1-107 2* | *39.76* |
| *926941* | *AC1-181* | *0.25* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 6

(AEP - AEP) The 05CHATFL-AC2-015 TAP 138 kV line (from bus 242984 to bus 932050 ckt 1) loads from 101.82% to 122.13% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 36.95 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *934251* | *AD1-052 C1* | *0.33* |
| *934261* | *AD1-052 C2* | *0.33* |
| *937021* | *AD2-136 C O1* | *10.17* |
| *937022* | *AD2-136 E O1* | *68.07* |
| *937381* | *AD2-191 C* | *4.8* |
| *937382* | *AD2-191 E* | *32.15* |
| *LTF* | *CALDERWOOD* | *< 0.01* |
| *LTF* | *CARR* | *0.02* |
| *LTF* | *CATAWBA* | *0.02* |
| *LTF* | *CBM-S1* | *0.14* |
| *LTF* | *CBM-W1* | *6.92* |
| *LTF* | *CBM-W2* | *2.22* |
| *LTF* | *CHEOAH* | *< 0.01* |
| *LTF* | *CHILHOWEE* | *< 0.01* |
| *LTF* | *CIN* | *0.41* |
| *LTF* | *CLIFTY* | *0.39* |
| *LTF* | *G-007* | *0.14* |
| *LTF* | *HAMLET* | *0.09* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *IPL* | *0.27* |
| *LTF* | *LGEE* | *0.03* |
| *LTF* | *MEC* | *1.11* |
| *LTF* | *MECS* | *4.94* |
| *LTF* | *O-066* | *0.91* |
| *LTF* | *RENSSELAER* | *0.02* |
| *LTF* | *SANTEETLA* | *< 0.01* |
| *247551* | *U4-028 C* | *2.83* |
| *247940* | *U4-028 E* | *18.91* |
| *247552* | *U4-029 C* | *2.83* |
| *247941* | *U4-029 E* | *18.91* |
| *247548* | *V4-010 C* | *4.61* |
| *247947* | *V4-010 E* | *30.87* |
| *LTF* | *WEC* | *0.21* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 7

(AEP - AEP) The 05FREMCT-05FRMNT 138 kV line (from bus 243008 to bus 243009 ckt 1) loads from 105.02% to 131.08% (AC power flow) of its emergency rating (251 MVA) for the tower line contingency outage of 'AEP_P7-1_#7114'. This project contributes approximately 67.86 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#7114'
OPEN BRANCH FROM BUS 242953 TO BUS 243110 CKT 1 / 242953 05AIRCO8 138 243110 05STIFFI 138 1
OPEN BRANCH FROM BUS 242953 TO BUS 243137 CKT 1 / 242953 05AIRCO8 138 243137 05W.END 138 1
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243039 TO BUS 243110 CKT 1 / 243039 05MELMOR 138 243110 05STIFFI 138 1
OPEN BRANCH FROM BUS 243110 TO BUS 245630 CKT 1 / 243110 05STIFFI 138 245630 05S TIFFIN 69.0 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *932051* | *AC2-015 C* | *15.31* |
| *932052* | *AC2-015 E* | *17.86* |
| *937021* | *AD2-136 C O1* | *18.68* |
| *937022* | *AD2-136 E O1* | *125.02* |
| *937381* | *AD2-191 C* | *8.82* |
| *937382* | *AD2-191 E* | *59.04* |
| *LTF* | *CARR* | *0.03* |
| *LTF* | *CBM-S1* | *0.41* |
| *LTF* | *CBM-S2* | *0.49* |
| *LTF* | *CBM-W2* | *1.25* |
| *LTF* | *CIN* | *0.15* |
| *LTF* | *CPLE* | *0.12* |
| *LTF* | *DEARBORN* | *1.63* |
| *LTF* | *EDWARDS* | *0.04* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *FARMERCITY* | *< 0.01* |
| *LTF* | *G-007A* | *0.18* |
| *LTF* | *IPL* | *0.1* |
| *LTF* | *LGEE* | *0.08* |
| *LTF* | *RENSSELAER* | *0.03* |
| *LTF* | *TATANKA* | *0.03* |
| *LTF* | *TILTON* | *0.01* |
| *247551* | *U4-028 C* | *5.19* |
| *247940* | *U4-028 E* | *34.73* |
| *247552* | *U4-029 C* | *5.19* |
| *247941* | *U4-029 E* | *34.73* |
| *247548* | *V4-010 C* | *11.91* |
| *247947* | *V4-010 E* | *79.71* |
| *LTF* | *VFT* | *0.48* |
| *925751* | *AC1-051 C* | *2.03* |
| *925752* | *AC1-051 E* | *13.57* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 8

(AEP - AEP) The 05STIFFI-05AIRCO8 138 kV line (from bus 243110 to bus 242953 ckt 1) loads from 96.94% to 119.61% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 39.04 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *932051* | *AC2-015 C* | *7.67* |
| *932052* | *AC2-015 E* | *8.95* |
| *937021* | *AD2-136 C O1* | *10.75* |
| *937022* | *AD2-136 E O1* | *71.93* |
| *937381* | *AD2-191 C* | *5.08* |
| *937382* | *AD2-191 E* | *33.97* |
| *LTF* | *AMIL* | *0.09* |
| *LTF* | *BAYOU* | *0.22* |
| *LTF* | *BIG_CAJUN1* | *0.33* |
| *LTF* | *BIG_CAJUN2* | *0.67* |
| *LTF* | *BLUEG* | *0.46* |
| *LTF* | *CALDERWOOD* | *0.08* |
| *LTF* | *CANNELTON* | *0.08* |
| *LTF* | *CATAWBA* | *0.03* |
| *LTF* | *CBM-N* | *0.04* |
| *LTF* | *CHEOAH* | *0.08* |
| *LTF* | *CHILHOWEE* | *0.03* |
| *LTF* | *CHOCTAW* | *0.21* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *CLIFTY* | *1.31* |
| *LTF* | *COTTONWOOD* | *0.9* |
| *LTF* | *DEARBORN* | *0.49* |
| *LTF* | *EDWARDS* | *0.18* |
| *LTF* | *ELMERSMITH* | *0.23* |
| *LTF* | *FARMERCITY* | *0.11* |
| *LTF* | *G-007A* | *0.28* |
| *LTF* | *GIBSON* | *0.18* |
| *LTF* | *HAMLET* | *0.09* |
| *LTF* | *MORGAN* | *0.34* |
| *LTF* | *NEWTON* | *0.4* |
| *LTF* | *NYISO* | *0.61* |
| *LTF* | *PRAIRIE* | *0.74* |
| *LTF* | *SANTEETLA* | *0.02* |
| *LTF* | *SMITHLAND* | *0.05* |
| *LTF* | *TATANKA* | *0.2* |
| *LTF* | *TILTON* | *0.21* |
| *LTF* | *TRIMBLE* | *0.09* |
| *LTF* | *TVA* | *0.15* |
| *247551* | *U4-028 C* | *2.99* |
| *247940* | *U4-028 E* | *19.98* |
| *247552* | *U4-029 C* | *2.99* |
| *247941* | *U4-029 E* | *19.98* |
| *LTF* | *UNIONPOWER* | *0.12* |
| *247548* | *V4-010 C* | *4.85* |
| *247947* | *V4-010 E* | *32.46* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *VFT* | *0.74* |
| *925751* | *AC1-051 C* | *0.97* |
| *925752* | *AC1-051 E* | *6.5* |

© PJM Interconnection 2020. All rights reserved.

# Appendix 9

(AEP - AEP) The AC2-015 TAP-05HOWARD 138 kV line (from bus 932050 to bus 243024 ckt 1) loads from 137.16% to 157.85% (AC power flow) of its emergency rating (167 MVA) for the line fault with failed breaker contingency outage of 'AEP_P4_#7111_05MELMOR 138'. This project contributes approximately 36.95 MW to the thermal violation.

CONTINGENCY 'AEP_P4_#7111_05MELMOR 138'
OPEN BRANCH FROM BUS 243006 TO BUS 243039 CKT 1 / 243006 05FOSTOR 138 243039 05MELMOR 138 1
OPEN BRANCH FROM BUS 243024 TO BUS 243039 CKT 1 / 243024 05HOWARD 138 243039 05MELMOR 138 1
END

| *Bus Number* | *Bus Name* | *Full Contribution* |
|---|---|---|
| *932051* | *AC2-015 C* | *27.82* |
| *932052* | *AC2-015 E* | *32.45* |
| *934251* | *AD1-052 C1* | *0.33* |
| *934261* | *AD1-052 C2* | *0.33* |
| *937021* | *AD2-136 C O1* | *10.17* |
| *937022* | *AD2-136 E O1* | *68.07* |
| *937381* | *AD2-191 C* | *4.8* |
| *937382* | *AD2-191 E* | *32.15* |
| *LTF* | *CALDERWOOD* | *< 0.01* |
| *LTF* | *CARR* | *0.02* |
| *LTF* | *CATAWBA* | *0.02* |
| *LTF* | *CBM-S1* | *0.14* |
| *LTF* | *CBM-W1* | *6.92* |
| *LTF* | *CBM-W2* | *2.22* |
| *LTF* | *CHEOAH* | *< 0.01* |
| *LTF* | *CHILHOWEE* | *< 0.01* |
| *LTF* | *CIN* | *0.41* |
| *LTF* | *CLIFTY* | *0.39* |

© PJM Interconnection 2020. All rights reserved.

| | | |
|---|---|---|
| *LTF* | *G-007* | *0.14* |
| *LTF* | *HAMLET* | *0.09* |
| *LTF* | *IPL* | *0.27* |
| *LTF* | *LGEE* | *0.03* |
| *LTF* | *MEC* | *1.11* |
| *LTF* | *MECS* | *4.94* |
| *LTF* | *O-066* | *0.91* |
| *LTF* | *RENSSELAER* | *0.02* |
| *LTF* | *SANTEETLA* | *< 0.01* |
| *247551* | *U4-028 C* | *2.83* |
| *247940* | *U4-028 E* | *18.91* |
| *247552* | *U4-029 C* | *2.83* |
| *247941* | *U4-029 E* | *18.91* |
| *247548* | *V4-010 C* | *4.61* |
| *247947* | *V4-010 E* | *30.87* |
| *LTF* | *WEC* | *0.21* |

© PJM Interconnection 2020. All rights reserved.