Generation Interconnection

Feasibility Study Report

Queue Position AB1-149

Interconnection Customer (IC) has proposed a wind generating facility located in Hardy County, West Virginia. The installed facilities will have a total capability of 121.60 MW with 15.80 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 31, 2018. **This study does not imply a Potomac Edison commitment to this in-service date.**

Point of Interconnection

AB1-149 will interconnect with Potomac Edison transmission system at one of the following points of interconnection: Option 1 will be a direct interconnection to existing 138kV bus at Baker substation; and Option 2 will be a direct interconnection to 138kV bus at Hardy substation.

Cost Summary

The AB1-149 project will be responsible for the following costs:

Description	Amount
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 2,723,000
Non-Direct Connection Network Upgrades	$ 547,500
Totals	**$ 3,270,500**

In addition, the AB1-149 project may be responsible for a contribution to the following costs:

Description	Amount
New System Upgrades	$ 0
Previously Identified Upgrades	$ 41,673,300
Totals	**$ 41,673,300**

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

Attachment Facilities

As defined by the Interconnection Customer, the proposed Interconnection Customer site will be located approximately 1 mile from the existing 138 kV Baker substation. Attachment 1 shows a conceptual one-line diagram of the proposed primary direct connection of AB1-149 to the Potomac Edison transmission system. For their secondary point of interconnection ("POI"), the Interconnection Customer site will be connected to the 138 kV bus at Hardy substation. The Interconnection Customer will be responsible for constructing all of the facilities on its side of the POI including the attachment line. The Interconnection Customer may not install above ground equipment within any PE right-of-way unless permission to do so is expressly granted by PE.

There is no Attachment Facilities work required for this project.

Direct Connection Cost Estimate

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

Description	Amount
Baker SS - Construct a 138kV ring bus	$ 2,539,500
Hardy SS - Install 1-2000A 138kV wave trap, 1-138kV CVT, structures and foundations, tuner, transfer trip transmitter and associated facilities. Revise relay settings as required	$ 183,500
Totals	**$ 2,723,000**

Non-Direct Connection Cost Estimate

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

Description	Amount
Baker-Hardy 138kV loop to Short Mountain. Loop the existing Baker-Hardy 138kV circuit into the new Short Mountain Substation. Existing horizontal circuit to be maintained on single-circuit structures.	$ 547,500
Totals	**$ 547,500**

Interconnection Customer Requirements

In addition to the Potomac Edison and First Energy affiliated facilities, the Interconnection Customer will also be responsible for meeting all criteria as specified in the applicable sections of the First Energy "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated 138 kV circuit breaker on the high side of the AB1-149 step-up transformer.

2. The purchase and installation of the minimum required First Energy generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the First Energy Transmission System Control Center.

4. The establishment of dedicated communication circuits for SCADA to the First Energy Transmission System Control Center.

5. A compliance with the First Energy and PJM generator power factor and voltage control requirements.

6. The execution of a back-up service agreement to serve the customer load supplied from the AB1-149 generation project interconnection point when the units are out-of-service. This assumes the intent of the Interconnection Customer is to net the generation with the load.

The above requirements are in addition to any metering or other requirements imposed by PJM.

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.

Transmission Owner Requirements

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

http://www.firstenergycorp.com/feconnect
http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx

Network Impacts

The Queue Project AB1-149 was evaluated as a 121.6 MW (Capacity 15.8 MW) injection at the Baker 138kV substation in the APS area. Project AB1-149 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). The Study is based on Summer Peak Analysis – 2019. Project AB1-149 was studied with a commercial probability of 53%. Potential network impacts were as follows:

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)

1. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 145.72% to 162.11% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

CONTINGENCY 'AP_SB_411' / ALBRIGHT BREAKER FAILURE - TIE BREAKER
OPEN BUS 235120
OPEN BUS 235564
OPEN BUS 235565
OPEN BUS 235566
END

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

2. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 137.6% to 151.48% (**DC power flow**) of its emergency rating (179 MVA) for the bus fault outage of 'AP_C1_73'. This project contributes approximately 24.85 MW to the thermal violation.

CONTINGENCY 'AP_C1_73' / ALBRIGHT_138_NORTH
OPEN BRANCH FROM BUS 235120 TO BUS 235566 CKT 1

OPEN BRANCH FROM BUS 235120 TO BUS 235356 CKT 1
OPEN BRANCH FROM BUS 235120 TO BUS 235398 CKT 1
OPEN BRANCH FROM BUS 235120 TO BUS 235304 CKT 1
OPEN BRANCH FROM BUS 235120 TO BUS 235485 CKT 1F
END

3. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 125.45% to 139.33% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_13'. This project contributes approximately 24.85 MW to the thermal violation.

CONTINGENCY 'AP_SB_13' / ALBRIGHT-METTIKI STK BKR AT ALBRIGHT
OPEN BRANCH FROM BUS 235120 TO BUS 235398 CKT 1
OPEN BRANCH FROM BUS 235120 TO BUS 235304 CKT 1
OPEN BRANCH FROM BUS 235120 TO BUS 235356 CKT 1
OPEN BUS 235566
OPEN BUS 235485
END

4. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 123.75% to 137.29% (**DC power flow**) of its emergency rating (179 MVA) for the tower line contingency outage of 'AP_C5_30'. This project contributes approximately 24.24 MW to the thermal violation.

CONTINGENCY 'AP_C5_30' /AT-GFT_AT-WM
OPEN BUS 235320
OPEN BUS 235485
OPEN BUS 235810
END

5. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 150.13% to 166.52% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

CONTINGENCY 'AP_SB_411' / ALBRIGHT BREAKER FAILURE - TIE BREAKER
OPEN BUS 235120
OPEN BUS 235564
OPEN BUS 235565
OPEN BUS 235566
END

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

6. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 142.07% to 155.95% (**DC power flow**) of its emergency rating (179 MVA) for the bus fault outage of 'AP_C1_73'. This project contributes approximately 24.85 MW to the thermal violation.

```
CONTINGENCY 'AP_C1_73'                          / ALBRIGHT_138_NORTH
  OPEN BRANCH FROM BUS 235120 TO BUS 235566 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235356 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235398 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235304 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235485 CKT 1F
  END
```

7. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 129.86% to 143.74% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_7A'. This project contributes approximately 24.85 MW to the thermal violation.

```
CONTINGENCY 'AP_SB_7A'                          / ALBRIGHT-RUTHBELLE STK
BKR AT ALBRIGHT
  OPEN BRANCH FROM BUS 235120 TO BUS 235304 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235356 CKT 1
  OPEN BRANCH FROM BUS 235120 TO BUS 235485 CKT 1F          /* ALBRIGHT-
METIKI
  OPEN BRANCH FROM BUS 235485 TO BUS 235427 CKT 1           /* METIKI-
WILLIAM .
  OPEN BUS 235566
  OPEN BRANCH FROM BUS 235120 TO BUS 235398 CKT 1
  END
```

8. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 128.22% to 141.76% (**DC power flow**) of its emergency rating (179 MVA) for the tower line contingency outage of 'AP_C5_30'. This project contributes approximately 24.24 MW to the thermal violation.

```
CONTINGENCY 'AP_C5_30'                          /AT-GFT_AT-WM
  OPEN BUS 235320
  OPEN BUS 235485
  OPEN BUS 235810
  END
```

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

To be determined

Short Circuit
(Summary of impacted circuit breakers)

AB1-149 did not cause any breakers to become newly over duty and did not have a > 3% contribution to any existing over duty breakers.

The following is First Energy results when conducting their Short Circuit analysis:

In accordance with the RTEP process, a short circuit analysis was conducted by PJM and confirmed by the FE Protection staff. The analysis determined that no transmission FE circuit breaker will exceed its interrupting capability with the interconnection of the Baker 138 kV (AB1-149) Generation Project. Therefore, no circuit breaker reinforcements will be required.

In accordance with the RTEP Impact Study process, PJM is responsible for the performance of a dynamic analysis for the Baker 138 kV (AB1-149) Generation Project. The results of these studies will be included in the System Impact Study stage of the RTEP process.

Affected System Analysis & Mitigation

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. (AP - AP) The 01LKLYNN-01LARDIN 138 kV line (from bus 235122 to bus 235207 ckt 1F) loads from 98.58% to 99.56% (**DC power flow**) of its emergency rating (302 MVA) for the single line contingency outage of '01HATFLD _01RONCO _059'. This project contributes approximately 6.54 MW to the thermal violation.

CONTINGENCY '01HATFLD _01RONCO _059'
DISCONNECT BRANCH FROM BUS 235108 TO BUS 235774 CKT 1 /* 500/500KV, AREA 201/201.
END

2. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 122.09% to 135.43% (**DC power flow**) of its emergency rating (179 MVA) for the single line contingency outage of 'AP_B2_498'. This project contributes approximately 23.87 MW to the thermal violation.

CONTINGENCY 'AP_B2_498' / ALBRIGHT-WILLIAM
OPEN BUS 235485
END

3. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 126.5% to 139.84% (**DC power flow**) of its emergency rating (179 MVA) for the single line contingency outage of 'AP_B2_498'. This project contributes approximately 23.87 MW to the thermal violation.

CONTINGENCY 'AP_B2_498' / ALBRIGHT-WILLIAM
OPEN BUS 235485
END

4. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 91.66% to 101.52% (**DC power flow**) of its normal rating (152 MVA) for non-contingency condition. This project contributes approximately 14.99 MW to the thermal violation.

5. (AP - AP) The 01BLACKO 500/138 kV transformer (from bus 235446 to bus 235103 ckt 3) loads from 99.11% to 106.83% (**DC power flow**) of its emergency rating (549 MVA) for the single line contingency outage of '01HATFLD _01BLACKO _058'. This project contributes approximately 42.36 MW to the thermal violation.

CONTINGENCY '01HATFLD _01BLACKO _058'
DISCONNECT BRANCH FROM BUS 235108 TO BUS 235103 CKT 1 /* 500/500KV, AREA 201/201.
END

Light Load Analysis - 2019

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

System Reinforcements

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

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

To be determined

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)

Contribution to Previously Identified Overloads

1. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 145.72% to 162.11% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

Reinforcement: Loughs Lane SS. On the William 138kV line, replace the 800A trap with a 2000A unit, replace the electromechanical line relays with new microprocessor relays and replace the 336AA line risers with 954 ACSR & rebuild 34.1 miles of Loughs Lane-William 138kV circuit, replacing existing 336.5 kcmil ACSR conductor with 795 ACSR Conductor
Cost: $41,673,300
Time: 20 months

2. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 137.6% to 151.48% (**DC power flow**) of its emergency rating (179 MVA) for the bus fault outage of 'AP_C1_73'. This project contributes approximately 24.85 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #1

3. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 125.45% to 139.33% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_13'. This project contributes approximately 24.85 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #1

4. (AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 123.75% to 137.29% (**DC power flow**) of its emergency rating (179 MVA) for the tower line contingency outage of 'AP_C5_30'. This project contributes approximately 24.24 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #1

5. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 150.13% to 166.52% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

Reinforcement: William SS. On the Loughs Lane 138kV line, replace the 800A trap with a 2000A unit, replace the electromechanical line relays with new microprocessor relays and replace the 336AA line risers with 954 ACSR.& rebuild 34.1 miles of Loughs Lane-William 138kV circuit, replacing existing 336.5 kcmil ACSR conductor with 795 ACSR Conductor
Cost: $41,673,300
Time: 20 months

6. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 142.07% to 155.95% (**DC power flow**) of its emergency rating (179 MVA) for the bus fault outage of 'AP_C1_73'. This project contributes approximately 24.85 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #5

7. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 129.86% to 143.74% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_7A'. This project contributes approximately 24.85 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #5

8. (AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 128.22% to 141.76% (**DC power flow**) of its emergency rating (179 MVA) for the tower line contingency outage of 'AP_C5_30'. This project contributes approximately 24.24 MW to the thermal violation.

Same as Contribution of Previously Identified Overloads #5

Light Load 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)

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Additional Interconnection Customer Responsibilities:

1. An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.

Note to Attachments 3 and 4

FLOWGATE DETAILS

Attachments 3 and 4 contain additional information about each flowgate presented in the body of the Network Impacts report. For each attachment, a description of the flowgate and its contingency was included for convenience. However, the intent of the attachment 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 attachment sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Attachment 3

Flowgate Details

(AP - AP) The 01PARSNS-01LOUGHL 138 kV line (from bus 235385 to bus 235362 ckt 1F) loads from 145.72% to 162.11% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

CONTINGENCY 'AP_SB_411' / ALBRIGHT BREAKER
FAILURE - TIE BREAKER
OPEN BUS 235120
OPEN BUS 235564
OPEN BUS 235565
OPEN BUS 235566
END

Bus Number	*Bus Name*	*Full Contribution*
235625	*01BACKB*	*31.51*
237503	*01HENRY M23*	*1.52*
237512	*01ROTHROCK*	*0.33*
292310	*K-019*	*0.67*
292400	*K-028 C*	*0.31*
292401	*K-028 E*	*14.66*
237508	*M-023 E*	*71.61*
885641	*T-016 C*	*0.09*
885642	*T-016 E*	*4.39*
237519	*U2-061 E*	*25.96*
918471	*AA1-062 C*	*17.31*
918472	*AA1-062 E*	*116.36*
920072	*AA2-103 E*	*11.93*
931001	*AB1-149 C OP*	*3.81*
931002	*AB1-149 E OP*	*25.53*

Attachment 4

Flowgate Details

(AP - AP) The 01WILLIM-01PARSNS 138 kV line (from bus 235427 to bus 235385 ckt 1F) loads from 150.13% to 166.52% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of 'AP_SB_411'. This project contributes approximately 29.34 MW to the thermal violation.

CONTINGENCY 'AP_SB_411' / ALBRIGHT BREAKER
FAILURE - TIE BREAKER
OPEN BUS 235120
OPEN BUS 235564
OPEN BUS 235565
OPEN BUS 235566
END

Bus Number	*Bus Name*	*Full Contribution*
235625	*01BACKB*	*31.51*
237503	*01HENRY M23*	*1.52*
237512	*01ROTHROCK*	*0.33*
292310	*K-019*	*0.67*
292400	*K-028 C*	*0.31*
292401	*K-028 E*	*14.66*
237508	*M-023 E*	*71.61*
885641	*T-016 C*	*0.09*
885642	*T-016 E*	*4.39*
237519	*U2-061 E*	*25.96*
918471	*AA1-062 C*	*17.31*
918472	*AA1-062 E*	*116.36*
920072	*AA2-103 E*	*11.93*
931001	*AB1-149 C OP*	*3.81*
931002	*AB1-149 E OP*	*25.53*