Generation Interconnection Feasibility Study Report Queue Position AD2-151

Interconnection Customer has proposed a 100 MW solar generating facility to be built in Muskingum County, Ohio. PJM recognizes 42 MW as Capacity Interconnection Rights for this project. The proposed in-service date is August 31, 2020. **This study does not imply a Duke Energy Ohio Kentucky ("Transmission Owner" or "Duke Energy") commitment to this in-service date.**

Point of Interconnection ("POI")

The AD2-151 will interconnect with the Duke Energy transmission system by one of the following two options:

- Option 1 or Primary POI will be direct injection into Hillcrest 345 kV substation. Gen-tie is 80 miles long; Duke Energy will construct a terminal inside the substation where the POI will be located. The project will be modeled at line segment bus #249578 (Hillcrest Substation).
- Option 2 or Secondary POI is direct injection into Eastwood 138 kV substation. Gen-tie is 90 miles long; the POI will be located inside the substation. The project will be modeled at the line segment of bus #250021 (Eastwood Substation). There are no costs listed in this report for the secondary POI.

Revenue Metering and SCADA Requirements

Network Impacts

OPTION 1 POI

The Queue Project AD2-151 was evaluated as a 100.0 MW (Capacity 42.0 MW) injection at the Hillcrest 345kV substation in the DEOK area. Project AD2-151 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-151 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak 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)

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. (DAY - AEP) The 09KILLEN-05MARQUI 345 kV line (from bus 253038 to bus 242938 ckt 1) loads from 104.11% to 104.7% (**DC power flow**) of its emergency rating (1372 MVA) for the tower line contingency outage of 'AEP_P7-1_#8123'. This project contributes approximately 17.91 MW to the thermal violation.

```
CONTINGENCY 'AEP_P7-1_#8123'
  OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1              / 243453
05BEATTY 345 253110 09ADKINS 345 1
  OPEN BRANCH FROM BUS 243453 TO BUS 253248 CKT 1              / 243453
05BEATTY 345 253248 09SCHARL 345 1
  OPEN BRANCH FROM BUS 243453 TO BUS 243469 CKT 3              / 243453
05BEATTY 345 243469 05BEATTY 138 3
  END
```

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

Steady-State Voltage Requirements

To be determined at the system impact study stage.

Short Circuit

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.

1. (OVEC - AEP) The 06KYGER-05SPORN 345 kV line (from bus 248005 to bus 242528 ckt 2) loads from 140.17% to 140.6% (**DC power flow**) of its normal rating (971 MVA) for the single line contingency outage of 'AEP_P1-2_#349'. This project contributes approximately 11.35 MW to the thermal violation.

CONTINGENCY 'AEP_P1-2_#349'
OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1 / 242528 05SPORN 345 248005 06KYGER 345 1
END

2. (DAY - AEP) The 09ADKINS-05BEATTY 345 kV line (from bus 253110 to bus 243453 ckt 1) loads from 112.5% to 113.29% (**DC power flow**) of its normal rating (1256 MVA) for the single line contingency outage of 'DEO&K P1-* P2-1 FOSTER-HILLCREST 34569'. This project contributes approximately 13.48 MW to the thermal violation.

CONTINGENCY 'DEO&K P1-* P2-1 FOSTER-HILLCREST 34569'
OPEN BRANCH FROM BUS 249566 TO BUS 249578 CKT 1
END

Light Load Analysis - 2021

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

System Reinforcements

Short Circuit

None

Stability and Reactive Power Requirement

To be determined at the system impact study stage.

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)

1. (DAY - AEP) The 09KILLEN-05MARQUI 345 kV line (from bus 253038 to bus 242938 ckt 1) loads from 104.11% to 104.7% (**DC power flow**) of its emergency rating (1372 MVA) for the tower line contingency outage of 'AEP_P7-1_#8123'. This project contributes approximately 17.91 MW to the thermal violation.

AEP:

1. **Sag Study will be required on the 6.97 miles of conductor to mitigate the overload. Depending on the sag study results. The cost for this upgrade is expected to be between $27,880 (no remediations required, just sag study) and $10.455 million (complete line reconductor/rebuild).**

(A) Sag Study: 6 to 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.

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)

None

OPTION 2 POI

The Queue Project AD2-151 was evaluated as a 100.0 MW (Capacity 42.0 MW) injection at the Eastwood 138kV substation in the DEOK area. Project AD2-151 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD2-151 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak 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)

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. (DAY - AEP) The 09KILLEN-05MARQUI 345 kV line (from bus 253038 to bus 242938 ckt 1) loads from 104.57% to 105.13% (**DC power flow**) of its emergency rating (1372 MVA) for the tower line contingency outage of 'AEP_P7-1_#8123'. This project contributes approximately 17.15 MW to the thermal violation.

```
CONTINGENCY 'AEP_P7-1_#8123'
  OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1              / 243453 05BEATTY 345 253110
09ADKINS 345 1
  OPEN BRANCH FROM BUS 243453 TO BUS 253248 CKT 1              / 243453 05BEATTY 345 253248
09SCHARL 345 1
  OPEN BRANCH FROM BUS 243453 TO BUS 243469 CKT 3              / 243453 05BEATTY 345 243469
05BEATTY 138 3
  END
```

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

Steady-State Voltage Requirements

To be determined at the system impact study stage.

Short Circuit

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.

1. (OVEC - AEP) The 06KYGER-05SPORN 345 kV line (from bus 248005 to bus 242528 ckt 2) loads from 140.59% to 141.02% (**DC power flow**) of its normal rating (971 MVA) for the single line contingency outage of 'AEP_P1-2_#349'. This project contributes approximately 11.32 MW to the thermal violation.

```
CONTINGENCY 'AEP_P1-2_#349'
  OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1                / 242528 05SPORN 345 248005
06KYGER 345 1
  END
```

Light Load Analysis - 2021

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

System Reinforcements

Short Circuit

None

Stability and Reactive Power Requirement

To be determined at the system impact study stage.

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)

None

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

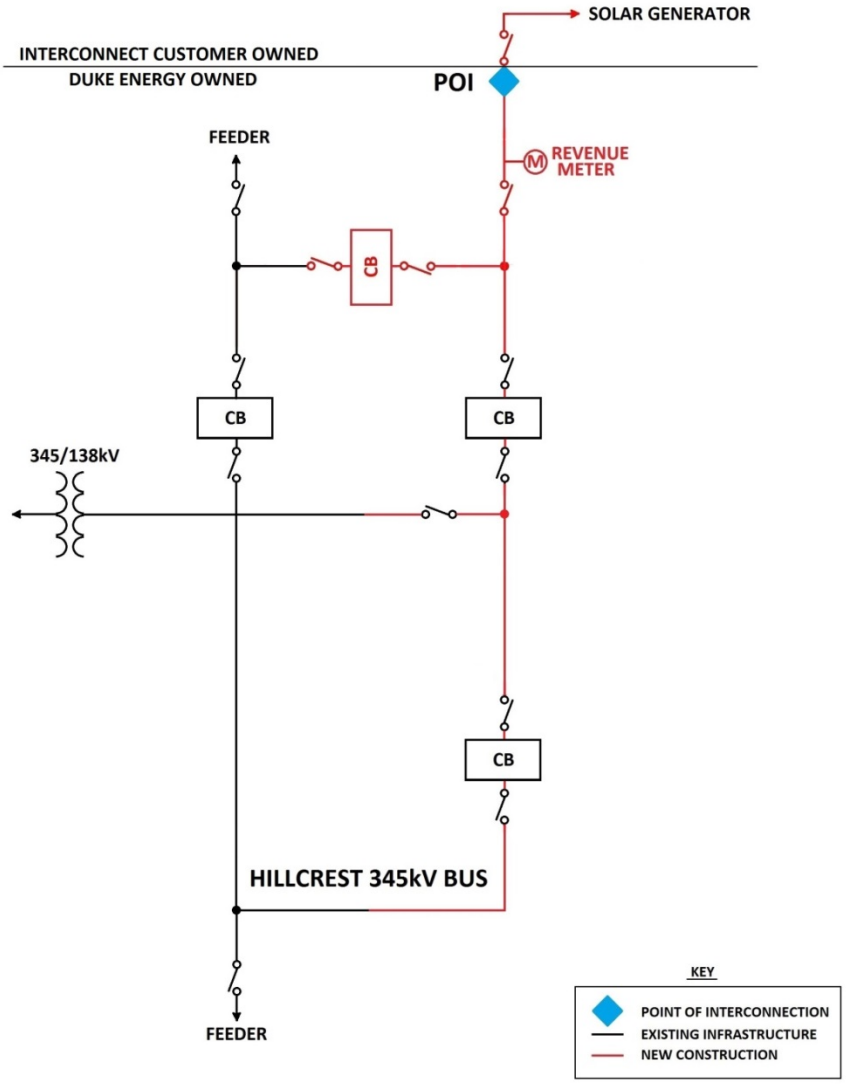
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None

Appendix 1
Facility Location
PJM Queue Position: AD2-151

Appendix 2

Interconnection One-Line Diagram
PJM Queue Position: AD2-151



Appendix 3

Flowgate Information: Contingency – 09KILLEN-05MARQUI 345 kV line
PJM Queue Position: AD2-151

OPTION 1 POI

This appendix contains additional information about the flowgate presented in the body of the report. The intent of this 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.

(DAY - AEP) The 09KILLEN-05MARQUI 345 kV line (from bus 253038 to bus 242938 ckt 1) loads from 104.11% to 104.7% (**DC power flow**) of its emergency rating (1372 MVA) for the tower line contingency outage of 'AEP_P7-1_#8123'. This project contributes approximately 17.91 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#8123'
OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1
OPEN BRANCH FROM BUS 243453 TO BUS 253248 CKT 1 / 243453 05BEATTY 345 253248 09SCHARL 345 1
OPEN BRANCH FROM BUS 243453 TO BUS 243469 CKT 3 / 243453 05BEATTY 345 243469 05BEATTY 138 3
END

Appendix 3 – Continued from previous page

Flowgate Information: Contingency – 09KILLEN-05MARQUI 345 kV line
PJM Queue Position: AD2-151

OPTION 1 POI

Bus Number	Gen. Bus Name	Full Contribution
LTF	CARR	0.44
LTF	CATAWBA	0.07
LTF	CBM-S1	7.96
LTF	CBM-W1	20.5
LTF	CBM-W2	43
LTF	CELEVELAND	0.13
LTF	CIN	9.8
LTF	G-007	1.33
LTF	HAMLET	0.41
LTF	IPL	6.13
LTF	LGEE	2.96
LTF	MEC	10.19
LTF	MECS	4.14
LTF	O-066	8.51
LTF	RENSSELAER	0.35
LTF	ROSETON	2.53
LTF	ROWAN	0.27
LTF	WEC	1.41
937152	AD2-151 E O1	10.39
937151	AD2-151 C O1	7.52
937112	AD2-147 E O1	6.45
937111	AD2-147 C O1	4.67
936572	AD2-072 E O1	2.56
936571	AD2-072 C O1	5.22
936382	AD2-048 E	2.87
936381	AD2-048 C	5.75
936282	AD2-036 E	2.54
936281	AD2-036 C	5.08
936252	AD2-031 E O1	3.78
936251	AD2-031 C O1	2.31
936092	AD2-012 E	8.78
936091	AD2-012 C	13.17
935044	AD1-140 E2	1.47
935043	AD1-140 C2	0.48
935042	AD1-140 E1	6.17
935041	AD1-140 C1	7.47
935032	AD1-136 E	0.9
935031	AD1-136 C	1.06
935011	AD1-134	7.97
934492	AD1-073 E	0.42
934491	AD1-073 C	0.81
932842	AC2-111 E	3.36
932841	AC2-111 C	2.06
932662	AC2-088 E	6.21
932661	AC2-088 C	7.54
932652	AC2-087 E	2.3
932651	AC2-087 C	2.9
932642	AC2-085 E	1.58
932641	AC2-085 C	1.85
932552	AC2-075 E	0.84

Bus Number	Gen. Bus Name	Full Contribution
932551	AC2-075 C	1.7
932482	AC2-068 E	3.9
932481	AC2-068 C	2.38
932462	AC2-066 E	8.16
932461	AC2-066 C	5
932432	AC2-061 E	3.91
932431	AC2-061 C	3.86
932422	AC2-060 E	2.2
932421	AC2-060 C	3.91
932382	AC2-055 E	1.8
932381	AC2-055 C	1.1
932132	AC2-020 E	0.82
932131	AC2-020 C	0.51
931181	AB1-169	299.22
930062	AB1-014 E	13.6
926951	AC1-182	2.8
926851	AC1-172	3.37
926802	AC1-166 E	3.77
926801	AC1-166 C	7.78
926792	AC1-165 E	3.77
926791	AC1-165 C	7.78
926691	AC1-152	3.37
926632	AC1-144 E	1.75
926631	AC1-144 C	3.6
926102	AC1-089 E	7.58
926101	AC1-089 C	4.65
926062	AC1-085 E	56.1
926061	AC1-085 C	34.38
925982	AC1-074 E	3.05
925981	AC1-074 C	7.11
925932	AC1-069 E	3.68
925931	AC1-069 C	7.87
925922	AC1-068 E	3.68
925921	AC1-068 C	7.87
925242	AB2-178 E	1.57
918802	AA1-099 E	0.32
916272	Z1-080 E	0.48
916182	Z1-065 E	0.54
915672	Y3-100 E	0.16
915662	Y3-099 E	0.16
915582	Y3-080 E	0.76
914372	Y2-111 E	1.13
913222	Y1-054 E	1.79
910512	X3-002 E	0.16
904722	V4-073E	0.15
902532	W2-040E	1.15
902531	W2-040C	0.7
253077	09STUART	633.04
253038	09KILLEN	297.64

Appendix 4

Flowgate Information: Contingency – 09KILLEN-05MARQUI 345 kV line
PJM Queue Position: AD2-151

OPTION 2 POI

This appendix contains additional information about the flowgate presented in the body of the report. The intent of this 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.

(DAY - AEP) The 09KILLEN-05MARQUI 345 kV line (from bus 253038 to bus 242938 ckt 1) loads from 104.57% to 105.13% (**DC power flow**) of its emergency rating (1372 MVA) for the tower line contingency outage of 'AEP_P7-1_#8123'. This project contributes approximately 17.15 MW to the thermal violation.

CONTINGENCY 'AEP_P7-1_#8123'
OPEN BRANCH FROM BUS 243453 TO BUS 253110 CKT 1 / 243453 05BEATTY 345 253110 09ADKINS 345 1
OPEN BRANCH FROM BUS 243453 TO BUS 253248 CKT 1 / 243453 05BEATTY 345 253248 09SCHARL 345 1
OPEN BRANCH FROM BUS 243453 TO BUS 243469 CKT 3 / 243453 05BEATTY 345 243469 05BEATTY 138 3
END

Appendix 4 – Continued from previous page

Flowgate Information: Contingency – 09KILLEN-05MARQUI 345 kV line
PJM Queue Position: AD2-151 OPTION 2 POI

Bus Number	Gen. Bus Name	Full Contribution
LTF	CARR	0.44
LTF	CATAWBA	0.07
LTF	CBM-S1	7.96
LTF	CBM-W1	20.5
LTF	CBM-W2	43
LTF	CELEVELAND	0.13
LTF	CIN	9.8
LTF	G-007	1.33
LTF	HAMLET	0.41
LTF	IPL	6.13
LTF	LGEE	2.96
LTF	MEC	10.19
LTF	MECS	4.14
LTF	O-066	8.51
LTF	RENSSELAER	0.35
LTF	ROSETON	2.53
LTF	ROWAN	0.27
LTF	WEC	1.41
937152	AD2-151 E O2	9.95
937151	AD2-151 C O2	7.2
937112	AD2-147 E O2	5.33
937111	AD2-147 C O2	3.86
936682	AD2-087 E O2	4.99
936681	AD2-087 C O2	11.1
936572	AD2-072 E O2	2.56
936571	AD2-072 C O2	5.23
936382	AD2-048 E	2.87
936381	AD2-048 C	5.75
936282	AD2-036 E	2.54
936281	AD2-036 C	5.08
936252	AD2-031 E O2	3.64
936251	AD2-031 C O2	2.23
936092	AD2-012 E	8.78
936091	AD2-012 C	13.17
935044	AD1-140 E2	1.47
935043	AD1-140 C2	0.48
935042	AD1-140 E1	6.17
935041	AD1-140 C1	7.47
935032	AD1-136 E	0.9
935031	AD1-136 C	1.06
935011	AD1-134	7.97
934492	AD1-073 E	0.42
934491	AD1-073 C	0.81
932842	AC2-111 E	3.36
932841	AC2-111 C	2.06
932662	AC2-088 E	6.21
932661	AC2-088 C	7.54
932652	AC2-087 E	2.3
932651	AC2-087 C	2.9
932642	AC2-085 E	1.58
932641	AC2-085 C	1.85
LTF	CARR	0.44

Bus Number	Gen. Bus Name	Full Contribution
932552	AC2-075 E	0.84
932551	AC2-075 C	1.7
932482	AC2-068 E	3.9
932481	AC2-068 C	2.38
932462	AC2-066 E	8.16
932461	AC2-066 C	5
932432	AC2-061 E	3.91
932431	AC2-061 C	3.86
932422	AC2-060 E	2.2
932421	AC2-060 C	3.91
932382	AC2-055 E	1.8
932381	AC2-055 C	1.1
932132	AC2-020 E	0.82
932131	AC2-020 C	0.51
931181	AB1-169	299.22
930062	AB1-014 E	13.6
926951	AC1-182	2.8
926851	AC1-172	3.37
926802	AC1-166 E	3.77
926801	AC1-166 C	7.78
926792	AC1-165 E	3.77
926791	AC1-165 C	7.78
926691	AC1-152	3.37
926632	AC1-144 E	1.75
926631	AC1-144 C	3.6
926102	AC1-089 E	7.58
926101	AC1-089 C	4.65
926062	AC1-085 E	56.1
926061	AC1-085 C	34.38
925982	AC1-074 E	3.05
925981	AC1-074 C	7.11
925932	AC1-069 E	3.68
925931	AC1-069 C	7.87
925922	AC1-068 E	3.68
925921	AC1-068 C	7.87
925242	AB2-178 E	1.57
918802	AA1-099 E	0.32
916272	Z1-080 E	0.48
916182	Z1-065 E	0.54
915672	Y3-100 E	0.16
915662	Y3-099 E	0.16
915582	Y3-080 E	0.76
914372	Y2-111 E	1.13
913222	Y1-054 E	1.79
910512	X3-002 E	0.16
904722	V4-073E	0.15
902532	W2-040E	1.15
902531	W2-040C	0.7
253077	09STUART	633.04
253038	09KILLEN	297.64
932552	AC2-075 E	0.84

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