

Generation Interconnection Feasibility Study Report Queue Position AC1-228

The Interconnection Customer (IC) has proposed a 3 MW MFO (1.1 MWC) solar generating facility to be located in Hurlock, Maryland. PJM studied AC1-228 as a 3.0 MW injection into the Delmarva Power and Light Company's (DPL) system at the Todd 69 kV Substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2020. The planned in-service date, as requested by the IC during the project kick-off call, is March 31, 2018. This date may not be attainable due to additional PJM studies and the Transmission Owner's construction schedule.

Point of Interconnection

The Interconnection Customer requested a distribution level interconnection. As a result, AC1-228 will interconnect with the Delmarva Power and Light distribution system at a tap of the existing MD0439 12 kV feeder from the Todd Substation T3 transformer.

Direct Connection Requirements

Criteria Limits for Distributed Energy Resource (DER) Connections to the ACE, DPL and Pepco Distribution Systems (less than 69kV)

1. Single Phase Limit

Any DER with a capacity that exceeds 100kW shall be a balanced 3 phase system.

2. Voltage Limits

DER's are permitted to cause a voltage fluctuation of up to 2% at the Point of Interconnection, ½ the band width of any voltage regulator at its terminals, and ½ the net dead band of a switched capacitor bank at its connection point. When a DER is at maximum output, it shall not raise the feeder voltage above the ANSI C84.1 or state limit, whichever is more conservative.

3. Existing Distribution Circuit Capacity Limits

The aggregate limit of large (250 kW and over) generators running in parallel with a single, existing distribution circuit is 0.5 MWs on the 4kV, 3MWs on the 12 kV, 6 MWs on the 25 kV, and 10 MWs on the 34 kV.

4. Express Circuit Capacity Limits

Distributed generation installations which exceed the limit for an existing circuit require an express circuit.

The maximum generator size for express circuits shall be:

- 4 kV 0.5 MW
- 12 – 13.8 kV 10 MW
- 23 – 25 kV 10 MW
- 33.26 – 34.5 kV 15 MW

5. Distribution Power Transformer Limit

The aggregate limit of large (250 kW and over) generator injection to a single distribution transformer of 22.5 MVA nameplate or larger is 10 MWs. Transformers with nameplate ratings lower than 22.5 MVA will be given lower ratings on an individual basis. If the transformer rating is significantly greater than 40 MVA it may be possible to consider a greater generation capacity.

Adding a new transformer will be considered if there is no availability on any of the existing transformers and space is available in an existing substation. Any proposed transformers would be PHI's standard distribution transformer.

6. Express Circuit Length Limit

If there is no space for an additional transformer at the closest substation, the next closest substation will be considered. The length of an express circuit is limited to 5 miles, or for the sake of the feasibility study, 3.8 straight line miles to the substation. This simplification is used because the feasibility study phase does not allow for the time and resources to examine routes in detail (including existing pole lines, easements, ROW, and environmental issues etc.)

7. When a New Substation is Required

If a distribution express circuit can't be built from an existing substation for a project, it will be necessary to construct a new distribution substation with a standard ring bus design. It will be supplied by extending existing transmission lines. It is the developer's responsibility to verify eligibility of this configuration for solar renewable energy certificates.

All limits, given above in MWs, are subject to more detailed study to ensure feasibility.

Transmission Owner Scope of Work

TO scope of work required to accommodate 3 MW of generation on existing feeder MD0439 from Todd Substation T3:

1. A utility operated recloser equipped with the proper relaying and communications will be required.
2. Utility grade primary metering will be required.
3. Generation telemetry and remote trip capability will be provided to the control center.
4. A detailed, time-based study may be performed during later study phases.
5. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
6. Direct transfer trip will be required. Approximately 5.3 miles of 48SM ADSS fiber optic cable was estimated for this report to provide the communication channel from Price Substation to the PV site. 69 kV potential transformers will need to be installed if none already in-service.
7. The feeder will need to be extended approximately 1.3 miles.
8. If the voltage regulators in the substation are not properly equipped to handle the reverse power flow that the generator will cause, adjustments to their controllers will be required. If regulator cannot operate with controller, entire regulator will be upgraded.

Estimated Costs			
Todd Substation T3			
477 AAC Feeder extension	1.3	Miles	\$520,000
Fiber Installation	5.3	Miles	\$265,000
Substation Relaying & 69kV PTs			\$200,000
Substation Regulator & Controller			\$100,000
Recloser & Metering			\$80,000
SCADA Integration into EMS			\$10,000
Dynamic Study			\$50,000
Various Departments Work			\$90,000
Subtotal Cost			\$1,315,000
Approximate Total Cost with 18% Contingency			\$1,512,250

The estimated time to complete this work is **36-48 months** after receipt of a fully executed interconnection agreement.

Interconnection Customer Scope of Work

The Interconnection Customer (IC) is responsible for all design and construction related to activities on their side of the point of Interconnection. Site preparation, including grading and an access road, as necessary, is assumed to be by the IC. Route selection, line design, and right-of-way acquisition of the direct connect facilities is not included in this report, and is the responsibility of the IC.

Protective relaying and metering design and installation must comply with PHI’s applicable standards. The IC is also required to provide revenue metering and real-time telemetering data to PJM in conformance with the requirements contained in PJM Manuals M-01 and M-14 and the PJM Tariff.

Equipment Requirements

Any transformers on the customer's side must be Wye grounded on the utility side or alternatively 3 phase potential transformers and a relay capable of detecting over/under voltage shall be installed to detect an undesirable condition on the high side of the customer's transformer.

The inverter at the DG location shall have the following capabilities:

- Voltage flicker reduction through dynamic VAR or fixed PF response
- Ramp rate control
- SCADA communications
- Curtailment or other mitigation ability if high voltage were to occur
- Low voltage and system disturbance ride through
- Ability to receive and respond to a transfer trip signal
- Ability to adjust PF or VARs based on utility signal
- Ability to Adjust Real Power Output based on utility signal

The inverter shall operate in accordance with the IEEE 1547 series of standards that have been approved. While inverters should be capable of voltage stabilization thru dynamic VAR response and capable of low voltage and system disturbance ride through, neither of these capabilities shall be implemented until such time that the IEEE 1547 series of standards are revised and approved to include standards for these capabilities. At such time as these revised standards become available, the PV owner/operator shall cooperate with the Company (the 'Company' referring to ACE, DPL, or PEPCO) to implement these capabilities with settings acceptable to the Company. Until then, the following will be required:

1. *Operate inverters at a leading power factor ("PF") of (0.99), absorbing Volt-amps-reactive ("VARs").*

It is the responsibility of the owner to secure the inverter from any unauthorized access (including physical and remote access) which could alter settings or adversely affect the inverter's ability to operate as required. Security measures should include utilizing secure password settings and/or physical locks on cabinet doors.

Additional Operating Requirements

1. The Company (Pepco, ACE, DPL) will require the capability to remotely disconnect the generator from the grid by communication from its System Operations facility. This will be accomplished with a line recloser.
2. It is the Interconnection Customer's responsibility to send the data that PJM and the Company requires directly to PJM. The Interconnection Customer will grant permission for PJM to send the Company the following telemetry that the Interconnection Customer sends to PJM: real time MW, MVAR, volts, amperes, generator breaker status or inverter status, and interval MWH and MVARH.
3. The Interconnection Customer will be required to make provisions for a voice quality phone line within approximately 3 feet of each Company metering position to facilitate remote interrogation and data collection.
4. A mutually acceptable means of interrupting and disconnecting the generator with a visible break, able to be tagged and locked out, shall be worked out with Company Distribution Engineering.
5. Company reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering and telecommunications facilities, owned by Company.
6. Study was performed with the generator on the transformer that it will be served from during normal conditions. Customer will not be allowed to generate when the feeder is served by an alternate transformer.

High Voltage Warning

Voltage received at the meter from the utility can be 104% or 105% of nominal. Normal operating procedures dictate that voltage at the substation be raised to the higher end of an acceptable bandwidth in order to provide adequate supply to distant customers. Transformers with no load taps should be used to reduce the voltage by 2.5% to avoid the possibility of inverter trips. Failure to account for this may result in lost energy production.

Summer Peak Analysis - 2020

Transmission Network Impacts

Potential transmission network impacts are 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. (DP&L - DP&L) The PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) loads from 150.01% to 151.26% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.16 MW to the thermal violation.

CONTINGENCY 'DP11'/*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1/*MILFORD STEELE
230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1/*STEELE VIENNA
230 230
END

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

2. (DP&L - DP&L) The TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) loads from 156.04% to 157.28% (DC power flow) of its emergency rating (93 MVA) for the line fault

with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.16 MW to the thermal violation.

CONTINGENCY 'DP11'/*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1/*MILFORD STEELE
230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1/*STEELE VIENNA
230 230
END

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

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. To mitigate the (DP&L) PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) overload will require replacement of a disconnect switch at Preston Substation. The estimate to perform this work is **\$36,000** and will take approximately **1 year** to complete.
2. To mitigate the (DP&L) TODD-PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) overload will require substation reinforcements at Preston Substation and Todd Substation. The estimate to perform this work is **\$67,000** and will take approximately **1 year** to complete.

Steady-State Voltage Requirements

To be determined in later study phases.

Short Circuit

No issue identified.

Stability and Reactive Power Requirement

To be performed in later study phases if required.

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.

None

Light Load Analysis - 2020

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

Facilities Study Estimate

The estimated time for PJM to issue a Facilities Study Report is 7 months. The deposit required for project will be \$50,000.

Appendices

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

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

Appendix 1

(DP&L - DP&L) The PRESTON-TANYARD 69 kV line (from bus 232233 to bus 232821 ckt 1) loads from 150.01% to 151.26% (DC power flow) of its emergency rating (93 MVA) for the line fault with failed breaker contingency outage of 'DP11'. This project contributes approximately 1.16 MW to the thermal violation.

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CONTINGENCY 'DP11'                                /*STEELE BUS BREAKER TO MILFORD
DISCONNECT BRANCH FROM BUS 232004 TO BUS 232000 CKT 1    /*MILFORD
STEELE 230 230
DISCONNECT BRANCH FROM BUS 232000 TO BUS 232005 CKT 1    /*STEELE
VIENNA 230 230
END
```

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
232926	CRISFLD1	0.23
293670	O-025 C	0.15
297076	V2-028 C	0.09
297077	V2-028 E	0.81
904212	V4-022E	0.36
232919	VN10	0.59
232907	VN8	4.3
901003	W1-003 C	0.07
901004	W1-003 E	0.52
901013	W1-004 C	0.07
901014	W1-004 E	0.52
901023	W1-005 C	0.07
901024	W1-005 E	0.52
901033	W1-006 C	< 0.01
901034	W1-006 E	0.52
907052	X1-032 E	0.47
907323	X1-096 C	0.44
907324	X1-096 E	11.19
910571	X3-008 C	0.56
910572	X3-008 E	4.78
910591	X3-015 C	0.4
910592	X3-015 E	3.43
913411	Y1-080 C	0.06
913412	Y1-080 E	0.56
915541	Y3-058 C	0.17
915542	Y3-058 E	1.43
920582	Z1-076 C	0.61
920583	Z1-076 E	1.
920592	Z1-077 C	0.44
920593	Z1-077 E	0.71
916441	Z1-100	0.09
916451	Z1-101	0.09
916461	Z1-102	0.09
920602	Z1-103	0.09
917082	Z2-012 E	1.42
920763	Z2-076 E	0.18
920773	Z2-077 E	0.18
920952	AA1-025	0.08
920962	AA1-026	0.08
920972	AA1-027	0.08
920982	AA1-028	0.08
921122	AA1-059 C	0.52
921123	AA1-059 E	0.2

921142	AA1-061 C	4.87
921143	AA1-061 E	2.4
918831	AA1-102	0.86
921592	AA1-140 C	0.67
921593	AA1-140 E	1.1
921602	AA1-141 C	0.65
921603	AA1-141 E	1.07
922213	AA2-129 E	2.29
922222	AA2-130	0.24
922752	AB1-056 C OP	4.91
922753	AB1-056 E OP	13.99
922762	AB1-057 C	4.99
922763	AB1-057 E	14.22
923282	AB1-137 C	1.14
923283	AB1-137 E	0.49
923902	AB2-030 E	0.46
923931	AB2-033 C	0.82
923932	AB2-033 E	0.33
924361	AB2-084 C	0.45
924362	AB2-084 E	0.73
924681	AB2-120 C OP	4.32
924682	AB2-120 E OP	7.05
924781	AB2-130 C OP	4.57
924782	AB2-130 E OP	7.45
924831	AB2-136 C OP	7.47
924832	AB2-136 E OP	10.6
925091	AB2-166 C	0.26
925092	AB2-166 E	0.45
925101	AB2-167 C	0.61
925102	AB2-167 E	1.
925151	AB2-172 C OP	7.33
925152	AB2-172 E OP	11.95
925231	AB2-177 C	0.29
925232	AB2-177 E	0.47
925261	AB2-180 C	2.15
925262	AB2-180 E	0.92
925381	AC1-009 C	0.87
925382	AC1-009 E	1.42
925531	AC1-028	0.51
925651	AC1-041 C	0.22
925652	AC1-041 E	0.36
925731	AC1-049 C	0.13
925732	AC1-049 E	0.22
925741	AC1-050 C	0.35
925742	AC1-050 E	0.58

907324	X1-096 E	11.19
910571	X3-008 C	0.56
910572	X3-008 E	4.78
910591	X3-015 C	0.4
910592	X3-015 E	3.43
913411	Y1-080 C	0.06
913412	Y1-080 E	0.56
915541	Y3-058 C	0.17
915542	Y3-058 E	1.43
920582	Z1-076 C	0.61
920583	Z1-076 E	1.
920592	Z1-077 C	0.44
920593	Z1-077 E	0.71
916441	Z1-100	0.09
916451	Z1-101	0.09
916461	Z1-102	0.09
920602	Z1-103	0.09
917082	Z2-012 E	1.42
920763	Z2-076 E	0.18
920773	Z2-077 E	0.18
920952	AA1-025	0.08
920962	AA1-026	0.08
920972	AA1-027	0.08
920982	AA1-028	0.08
921122	AA1-059 C	0.52
921123	AA1-059 E	0.2
921142	AA1-061 C	4.87
921143	AA1-061 E	2.4
918831	AA1-102	0.86
921592	AA1-140 C	0.67
921593	AA1-140 E	1.1
921602	AA1-141 C	0.65
921603	AA1-141 E	1.07
922213	AA2-129 E	2.29
922222	AA2-130	0.24
922752	AB1-056 C OP	4.91
922753	AB1-056 E OP	13.99
922762	AB1-057 C	4.99
922763	AB1-057 E	14.22
923282	AB1-137 C	1.14
923283	AB1-137 E	0.49
923902	AB2-030 E	0.46
923931	AB2-033 C	0.82
923932	AB2-033 E	0.33
924361	AB2-084 C	0.45

924362	AB2-084 E	0.73
924681	AB2-120 C OP	4.32
924682	AB2-120 E OP	7.05
924781	AB2-130 C OP	4.57
924782	AB2-130 E OP	7.45
924831	AB2-136 C OP	7.47
924832	AB2-136 E OP	10.6
925091	AB2-166 C	0.26
925092	AB2-166 E	0.45
925101	AB2-167 C	0.61
925102	AB2-167 E	1.
925151	AB2-172 C OP	7.33
925152	AB2-172 E OP	11.95
925231	AB2-177 C	0.29
925232	AB2-177 E	0.47
925261	AB2-180 C	2.15
925262	AB2-180 E	0.92
925381	AC1-009 C	0.87
925382	AC1-009 E	1.42
925531	AC1-028	0.51
925651	AC1-041 C	0.22
925652	AC1-041 E	0.36
925731	AC1-049 C	0.13
925732	AC1-049 E	0.22
925741	AC1-050 C	0.35
925742	AC1-050 E	0.58
925761	AC1-052 C	1.15
925762	AC1-052 E	0.46
926911	AC1-177	0.48
926931	AC1-180	0.72
927031	AC1-190 C	12.97
927032	AC1-190 E	5.56
927191	AC1-213 C	0.47
927192	AC1-213 E	0.24
927311	AC1-228 C	0.42
927312	AC1-228 E	0.73
927321	AC1-229 C	0.31
927322	AC1-229 E	0.5