Generation Interconnection
Feasibility Study Report
Queue Position AB2-177

The Interconnection Customer (IC) has proposed a 6.6 MW MFO (2.5 MWC) solar generating facility to be located in Snow Hill, Worcester County, Maryland. PJM studied AB2-177 as a 6.6 MW injection into the Delmarva Power and Light Company's (DPL) system at the Kenney 25 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 December 1, 2018. This date is not attainable due to additional required PJM studies and Transmission Owner construction schedules.

Point of Interconnection

The Interconnection Customer requested a distribution level interconnection. As a result, AB2-177 will interconnect with the Delmarva Power and Light distribution system as follows:

> The first 5.7 MWs will connect to the existing 25 kV feeder MD 2239 from the 69/25 kV T2 transformer at the Kenney Substation; the next 0.9 MW will connect to the 69/25 kV T2 transformer at the Kenney Substation via an express feeder.

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 work required to accommodate 5.7 MWs of generation on existing feeder MD2239 from Kenney Substation T2:

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. Transfer trip will be required. The cost included below is to install 48SM ADSS fiber optic cable in conduit from Kenney Substation to the POI, a total distance of approximately 3.5 miles. 69 kV potential transformers will need to be installed if none already in-service.
7. The feeder will need to be extended approximately 0.6 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			
Keeney Substation T2			
Fiber Installation	3.5	miles	$175,000
Feeder Extension	0.6	miles	$240,000
substation Relaying & 69kV PTs			$200,000
Recloser & Metering			$80,000
SCADA Integration into EMS			$10,000
Dynamic Study			$30,000
Various Departments Work			$60,000
Subtotal Cost			$795,000
Approximate Total Cost with 18% Contingency			$914,250

The estimated time to complete this work is **18-24 months** after receipt of a fully executed interconnection agreement.

TO work required to accommodate 0.9 MW of generation on an express feeder from Kenney Substation T2:

1. Design and construct one new 25 kV feeder with 477 aluminum conductor from Kenney Substation to the generation site – approximately 3.5 miles.
2. One new 25 kV feeder terminal position will be constructed.
3. A utility operated recloser equipped with the proper relaying and communications will be required.
4. Utility grade primary metering will be required for each feeder.
5. Generation telemetry and remote trip capability will be provided to the control center.
6. A detailed, time-based study may be performed during later study phases.
7. Protection, Planning, and other engineering departments will perform studies, design work, and prepare engineering estimates.
8. Transfer trip will be required. The cost included below is to install 48SM ADSS fiber optic cable in conduit from Kenney Substation to the POI, a total distance of approximately 3.5 miles. 69 kV potential transformers will need to be installed if none already in-service.
9. 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			
Keeney Substation T2			
477 AAC Express Feeder	3.5	Miles	$1,400,000
Fiber Installation			$175,000
New Feeder Terminal			$300,000
Substation Relayiong & 69kV PTs			$200,000
Recloser & Metering			$80,000
SCADA Integration into EMS			$10,000
Dynamic Study			$30,000
Various Departments Work			$90,000
Subtotal Cost			$2,285,000
Approximate Total Cost with 18% Contingency			$2,627,750

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.

The IC will purchase and install all metering instrument transformers as well as construct a metering structure per PHI's specifications. The secondary wiring connections at the instrument transformers will be completed by the interconnection customer's contractors and inspected by PHI, while the secondary wiring work at the metering enclosure will be completed by PHI's Meter technicians. The metering control cable and meter cabinets will be supplied by PHI and installed by the interconnection customer's contractors. PHI's meter technicians will program and install two solid state multi-function meters (Primary & Backup) for the new metering position. Each meter will be equipped with load profile, telemetry, and form-c pulse outputs. The ownership of metering equipment purchased or installed by the IC shall be transferred to the Transmission Owner at Commercial Operation, unless the IC asserts its right to install, own and operate the metering system.

Equipment Requirements

Any transformers on the IC'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 IC'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. 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 (DPL, ACE, Pepco) 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.

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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 PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 137.02% to 138.53% (DC power flow) of its emergency rating (143 MVA) for the line fault with failed breaker contingency outage of 'DP15'. This project contributes approximately 2.16 MW to the thermal violation.

   CONTINGENCY 'DP15' /*INDIAN RIVER BUS BREAKER TO PINEY GROVE
   DISCONNECT BRANCH FROM BUS 232007 TO BUS 232006 CKT 1/*PINEY GR INDRIV 4 230 230
   DISCONNECT BRANCH FROM BUS 232007 TO BUS 232128 CKT 1/*PINEY GR PINEY GR 230 138
   DISCONNECT BRANCH FROM BUS 232006 TO BUS 232004 CKT 1/*MILFORD INDIAN RIVER 230 230
   END

   Please refer to Appendix 1 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) PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) overload will require rebuilding of the Piney Grove – Mount Hermon 69 kV transmission line and substation reinforcements at Piney Grove Substation and Mount Hermon. The estimate to perform this work is **$9,688,000** and will take approximately **3 years** to complete.

Steady-State Voltage Requirements

To be determined in later study phases.

Short Circuit

Not required.

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.

1. (DP&L - DP&L) The PINEY138-LORETTO 138 kV line (from bus 232128 to bus 232127 ckt 1) loads from 124.58% to 125.71% (DC power flow) of its emergency rating (159 MVA) for the single line contingency outage of 'CKT 13713'. This project contributes approximately 1.8 MW to the thermal violation.

   CONTINGENCY 'CKT 13713'

OPEN LINE FROM BUS 232129 TO BUS 232127 CIRCUIT 1/KINGS CREEK - LORETTO 138
END

2. (DP&L - DP&L) The PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 136.65% to 138.17% (DC power flow) of its emergency rating (143 MVA) for the single line contingency outage of 'CKT 23002'. This project contributes approximately 2.17 MW to the thermal violation.

   CONTINGENCY 'CKT 23002'
   DISCONNECT BUS 232007/INDIAN RIVER - PINEY GROVE 230 & PNY GRV AT-20 XFMER
   END

3. (DP&L - DP&L) The SHORT 1-LAUREL 69 kV line (from bus 232828 to bus 232249 ckt 1) loads from 102.94% to 104.21% (DC power flow) of its emergency rating (57 MVA) for the single line contingency outage of 'CKT 23002'. This project contributes approximately 0.73 MW to the thermal violation.

   CONTINGENCY 'CKT 23002'
   DISCONNECT BUS 232007/INDIAN RIVER - PINEY GROVE 230 & PNY GRV AT-20 XFMER
   END

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 PINEY_69-M HERMON 69 kV line (from bus 232274 to bus 232272 ckt 1) loads from 137.02% to 138.53% (DC power flow) of its emergency rating (143 MVA) for the line fault with failed breaker contingency outage of 'DP15'. This project contributes approximately 2.16 MW to the thermal violation.

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CONTINGENCY 'DP15'                                  /*INDIAN RIVER BUS BREAKER TO
PINEY GROVE
  DISCONNECT BRANCH FROM BUS 232007 TO BUS 232006 CKT 1          /*PINEY GR
INDRIV 4 230 230
  DISCONNECT BRANCH FROM BUS 232007 TO BUS 232128 CKT 1          /*PINEY GR
PINEY GR 230 138
  DISCONNECT BRANCH FROM BUS 232006 TO BUS 232004 CKT 1          /*MILFORD
INDIAN RIVER 230 230
  END
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Bus Number	*Bus Name*	*Full Contribution*
232905	*BAYVIEW1*	*0.59*
232926	*CRISFLD1*	*0.36*
232912	*OH NUG1*	*2.1*
232913	*OH NUG2*	*2.07*
232914	*OH NUG3*	*2.1*
232915	*OH NUG4*	*2.1*
232916	*OH NUG5*	*2.1*
232917	*OH NUG6*	*2.09*
232918	*OH NUG7*	*2.09*
232921	*TASLEY2G*	*1.46*
904210	*V4-022C*	*0.09*
904212	*V4-022E*	*0.75*
901003	*W1-003 C*	*0.15*
901004	*W1-003 E*	*1.07*
901013	*W1-004 C*	*0.15*
901014	*W1-004 E*	*1.07*
901023	*W1-005 C*	*0.15*
901024	*W1-005 E*	*1.07*
901033	*W1-006 C*	*< 0.01*
901034	*W1-006 E*	*1.07*
907052	*X1-032 E*	*0.82*
907323	*X1-096 C*	*0.71*
907324	*X1-096 E*	*17.31*
920582	*Z1-076 C*	*1.54*
920583	*Z1-076 E*	*2.52*
920592	*Z1-077 C*	*1.1*
920593	*Z1-077 E*	*1.8*
916441	*Z1-100*	*0.19*
916451	*Z1-101*	*0.19*

916461	*Z1-102*	*0.19*
920602	*Z1-103*	*0.19*
917081	*Z2-012 C*	*0.36*
917082	*Z2-012 E*	*2.99*
920952	*AA1-025*	*0.17*
920962	*AA1-026*	*0.17*
920972	*AA1-027*	*0.17*
920982	*AA1-028*	*0.17*
921122	*AA1-059 C*	*0.8*
921123	*AA1-059 E*	*0.32*
918831	*AA1-102*	*1.37*
921602	*AA1-141 C*	*1.86*
921603	*AA1-141 E*	*3.04*
922213	*AA2-129 E*	*4.76*
922222	*AA2-130*	*0.37*
923902	*AB2-030 E*	*0.97*
923931	*AB2-033 C*	*1.73*
923932	*AB2-033 E*	*0.68*
924361	*AB2-084 C*	*0.78*
924362	*AB2-084 E*	*1.27*
924681	*AB2-120 C OP*	*9.21*
924682	*AB2-120 E OP*	*15.02*
925071	*AB2-164 C OP*	*1.83*
925072	*AB2-164 E OP*	*2.99*
925081	*AB2-165 C OP*	*1.83*
925082	*AB2-165 E OP*	*2.99*
925101	*AB2-167 C*	*1.54*
925102	*AB2-167 E*	*2.53*
925231	*AB2-17 C*	*0.82*
925232	*AB2-177 E*	*1.34*
925311	*AB2-192 C OP*	*1.83*
925312	*AB2-192 E OP*	*2.99*