Generation Interconnection
Revised Feasibility Study Report
Queue Position AE2-301

The Interconnection Customer (IC) has proposed a 10.0 MW Energy (4.0 MW Capacity) energy storage generating facility to be located in Somerset County, Maryland at coordinates: Latitude 37.0047250, Longitude -75.8349890. AE2-301 was studied with a commercial probability of 53%. The in-service date, as requested by the IC during the project kick-off call, is September 22, 2021. This date may not be attainable due to required PJM studies and the Transmission Owner's construction schedule.

Point(s) of Interconnection

The Interconnection Customer requested a Primary and Secondary Point of Interconnection (POI) be evaluated for the AE2-301 project.

Primary Point of Interconnection

The IC requested a distribution level Point of Interconnection at the Crisfield 25 kV Substation. PJM studied the AE2-301 project as an injection into the Delmarva Power & Light Company system at the Crisfield 69 kV Substation (PSSE bus #232279) and evaluated it for compliance with reliability criteria for summer peak conditions in 2022.

The AE2-301 project will connect to the DPL distribution system at the Crisfield 69/25kV Substation as follows:

- The first 5.5 MWs will connect to existing feeder MD2212 from the Crisfield Substation T3 Transformer.

- The next 4.5 MWs will connect to the Crisfield 69/25kV Substation T3 transformer via a new express feeder

Direct Connection Requirements

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

1. Single Phase Limit

Any DER with a capacity that exceeds 100 kW shall be a balanced three-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 MW on the 4 kV, 3 MW on the 12 kV, 6 MW on the 25 kV, and 10 MW on the 34 kV.

4. Express Circuit Capacity Limits
Distributed generation installations which exceed the criteria limit for an existing circuit require an express circuit.

The maximum generator size for express circuits, depending on transformer capacity, 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 MW. 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 DPL'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 MW, are subject to more detailed study to ensure feasibility.

Transmission Owner Work Scope for Direct Connect and Attachment Facilities

TO work required to accommodate 5.5 MW of energy storage to existing feeder MD2212 from the Crisfield Substation T3 transformer:

1. A utility operated recloser equipped with the proper relaying and communications will be required.

2. Utility grade primary metering will be required
3. 25 kV (3) 3.3 MW voltage regulator is required.
4. An approximately 0.104 miles of 477 KCM 25kV conductor extension off the existing feeder MD 2212 to the point of interconnection along Crisfield Rd will be required.
5. Generation DTT (Direct Transfer Trip) with fiber installation will be provided to the control center.

Estimated Costs	
Interconnection to Crisfield substation	
25kV (3) voltage regulators	$252,204
Express feeder (0.104 miles)	$79,000
Automatic Circuit Recloser	$85,634
Fiber (0.44 miles)	$53,131
Engineering Overhead	$89,313
Telecommunications	$150,019
Subtotal Cost	**$709,301**
Total cost with 30% Contingency	**$922,092**

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

TO work required to accommodate 4.5 MW of energy storage via a new express feeder from the Crisfield Substation T3 transformer:

1. A 25 kV breaker terminal with the proper relaying and communications will be required.
2. A utility operated recloser equipped with the proper relaying and communications will be required.
3. 25 kV (3) 3.3 MW voltage regulator is required.
4. The 25 kV feeder will require a three-phase extension of approximately 0.14 miles of 1000 kcmil from Crisfield substation to the first getaway pole then approximately 0.3 mile of 477 KCM 25 kV feeder from getaway pole to the storage site point of interconnection along Crisfield Rd.
5. Generation DTT (Direct Transfer Trip) with fiber installation will be provided to the control center.
6. Primary metering will be required.

Estimated Costs	
Interconnection to Crisfield substation	
25kV breaker terminal	$304,000
25kV (3) voltage regulators	$252,204
Express feeder (0.44 miles)	$1,330,425
Automatic Circuit Recloser	$85,634
Fiber (0.44 miles)	$53,131

Engineering Overhead	$89,313
Telecommunications	$150,019
Subtotal Cost	**$2,264,725**
Total cost with 30% Contingency	**$2,944,143**

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

Interconnection Customer Scope of Work

The 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 DPL'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 be required to make provisions for a voice quality phone ("plain old telephone" or "POT") line within approximately 3 feet of each DPL metering position to facilitate remote interrogation and data collection.

The IC shall provide a protection and interrupting device deemed acceptable by DPL to protect the Facility. The protection and interrupting device shall be located at a mutually agreeable location on the Interconnection Customer side of the Point of Interconnection.

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 DPL Distribution Engineering.

Power Factor Requirement

The generators used for this project shall be capable of operating at a power factor (or schedule) specified by DPL in the range of 0.95 leading to 0.95 lagging. It is the responsibility of the developer/customer to obtain equipment that can operate with these requirements while also meeting all applicable requirements of IEEE and UL standards such as, but not limited to, IEEE 1547 and UL 1741.

For this project, operate inverters at a lagging power factor of (**0.99**) absorbing volt-ampere reactive ("VAR") continuously.

Inverter Requirements (if applicable):

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

- Voltage flicker reduction through dynamic VAR or fixed power factor response
- Ramp rate control

- SCADA communications
- Curtailment or other mitigation ability if high voltage were to occur
- Disturbance Ride through for both Voltage and Frequency
- Ability to receive and respond to a transfer trip signal
- Ability to adjust power factor or VAR based on utility signal
- Ability to Adjust Real Power Output based on utility signal
- Ability to operate on a Volt/VAR schedule
- Ability to maintain a voltage schedule

The inverter(s) shall operate in accordance with both the IEEE 1547 and UL 1741 series of standards that have been approved and use default settings except when specified otherwise by DPL. While inverters should be capable of voltage stabilization through dynamic VAR response and capable of low voltage and system disturbance ride through, neither of these capabilities will 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 generation owner/operator shall cooperate with DPL to implement these capabilities with settings acceptable to DPL. Until such time, the inverters shall operate with a fixed power factor value between 0.95 lead and 0.95 lag as specified by DPL.

Security Requirements

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

High Voltage Warning

Typically, voltage received at the meter from the utility can be up to 105% of nominal (without generation on). 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. It is recommended that transformers with no load taps should be used to adjust secondary voltage to avoid the possibility of inverter trips. Failure to account for this may result in lost energy production.

Additional Operating Requirements

1. 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 IC's responsibility to send the data that PJM and DPL requires directly to PJM (or in some cases to DPL directly). The IC will grant permission for PJM to send DPL the following telemetry that the IC sends to PJM: real time MW, MVAR, volts, amperes, generator/status, and interval MWh and MVARh.

3. DPL reserves the right to charge the IC operation and maintenance expenses to maintain the IC attachment facilities, including metering and telecommunications facilities, owned by DPL.

Summer Peak Analysis - 2022

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)

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
7728303	232128	PINEY138	DP&L	232127	LORETTO	DP&L	1	ACE_P4-2_DP58	breaker	158.0	98.08	100.93	DC	4.51

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)

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
7727770	232234	TODD	DP&L	232233	PRESTON	DP&L	1	ACE_P4-2_DP11	breaker	93.0	162.35	163.59	DC	1.17

Summer Peak Load Flow Analysis Reinforcements

System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

ID	Index	Facility	Upgrade Description	Cost
7728303	1	**PINEY138 138.0 kV - LORETTO 138.0 kV Ckt 1**	**dt13777r0001 (99) : Reconductor Line** **Project Type : FAC** **Cost : $17,300,000** **Time Estimate : 32-48 Months**	$17,300,000
7727770	3	**TODD 69.0 kV - PRESTON 69.0 kV Ckt 1**	**ds6716r0001 (101) : Previously identified in AB2-172, To mitigate the (DP&L) TODD to PRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) overload will require substation reinforcements at Preston Substation and Todd Substation.**	$106,000

			Replace 600A Disconnect Switch at each substation. **Project Type : FAC** **Cost : $67,000** **Time Estimate : 12.0 Months** **ds6716r0002 (102) : Previously identified in AE1-188, To mitigate the (DP&L) TODD toPRESTON 69 kV line (from bus 232234 to bus 232233 ckt 1) overload will require substation reinforcements at Preston Substation and Todd Substation.** **Project Type : FAC** **Cost : $39,000** **Time Estimate : 12.0 Months**	
			TOTAL COST	**$17,406,000**

Short Circuit

No issues identified.

Stability and Reactive Power Requirement

To be performed during later study phases if required.

Light Load Analysis - 2022

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

Potential Congestion due to Local Energy Deliverability

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.

Note: Only the most severely overloaded conditions are listed below. 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 shall study all overload conditions associated with the overloaded element(s) identified.

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
8106292	232128	PINEY138	DP&L	232127	LORETTO	DP&L	1	ACE_P1_2_CKT 13787	operation	158.0	98.01	100.86	DC	4.51
8106072	232276	KINGS_69	DP&L	232842	WESTOVER	DP&L	1	ACE_P1_1_232926 CRISFLD1 12.5	operation	23.0	76.98	120.46	DC	10.0
8105640	232280	OAKHL_69	DP&L	232281	WATTSVIL	DP&L	1	ACE_P1_2_CKT 13789	operation	88.0	152.79	153.28	DC	0.96

Secondary Point of Interconnection

The IC requested a transmission level Point of Interconnection at the Crisfield 69 kV Substation.
PJM studied the AE2-301 project as an injection into the Delmarva Power & Light Company system

at the Crisfield 69 kV Substation (PSSE bus #232279) and evaluated it for compliance with reliability criteria for summer peak conditions in 2022.

Summer Peak Analysis - 2022

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)

Same as Primary Point of Interconnection results.

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

Same as Primary Point of Interconnection results.

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)

Same as Primary Point of Interconnection results.

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.

Same as Primary Point of Interconnection results.

Flow Gate Details

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.

Index 1

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
7728303	232128	PINEY138	DP&L	232127	LORETTO	DP&L	1	DPL_P4-2_DP58	breaker	158.0	98.08	100.93	DC	4.51

Bus #	Bus	MW Impact
232912	OH NUG1	1.07
232914	OH NUG3	1.07
232915	OH NUG4	1.07
232916	OH NUG5	1.07
232917	OH NUG6	1.07
232918	OH NUG7	1.06
901004	W1-003 E	1.44
901014	W1-004 E	1.44
901024	W1-005 E	1.44
901034	W1-006 E	1.44
917082	Z2-012 E	3.9
924681	AB2-120 C	12.06
924682	AB2-120 E	19.68
939151	AE1-145 C1	3.75
939152	AE1-145 C2	2.5
939153	AE1-145 E	0.06
939361	AE1-167 C O1	1.87
939362	AE1-167 E O1	1.56
939621	AE1-192 C O1	14.79
939622	AE1-192 E O1	7.24
942823	AE2-301 BAT	4.51
BLUEG	BLUEG	0.37
CALDERWOOD	CALDERWOOD	0.04
CANNELTON	CANNELTON	0.02
CARR	CARR	0.02
CATAWBA	CATAWBA	0.03
CHEOAH	CHEOAH	0.04
CHILHOWEE	CHILHOWEE	0.01
COFFEEN	COFFEEN	0.04
COTTONWOOD	COTTONWOOD	0.16
DUCKCREEK	DUCKCREEK	0.09
EDWARDS	EDWARDS	0.04
ELMERSMITH	ELMERSMITH	0.04
FARMERCITY	FARMERCITY	0.03
G-007	G-007	0.06
GIBSON	GIBSON	0.02

HAMLET	HAMLET	0.04
NEWTON	NEWTON	0.1
O-066	O-066	0.42
PRAIRIE	PRAIRIE	0.19
RENSSELAER	RENSSELAER	0.02
SANTEETLA	SANTEETLA	0.01
SMITHLAND	SMITHLAND	0.02
TATANKA	TATANKA	0.05
TILTON	TILTON	0.05
TRIMBLE	TRIMBLE	0.04
TVA	TVA	0.13
UNIONPOWER	UNIONPOWER	0.06

Index 3

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
7727770	232234	TODD	DP&L	232233	PRESTON	DP&L	1	DPL_P4-2_DP11	breaker	93.0	162.35	163.59	DC	1.17

Bus #	Bus	MW Impact
232905	BAYVIEW1	0.17
232907	VN8	2.68
232914	OH NUG3	0.37
232915	OH NUG4	0.37
232916	OH NUG5	0.37
232919	VN10	0.22
232921	TASLEY2G	0.25
232926	CRISFLD1	0.14
292089	T-011	0.06
293670	O-025 C	0.09
901003	W1-003 C	0.21
901004	W1-003 E	0.5
901013	W1-004 C	0.21
901014	W1-004 E	0.5
901023	W1-005 C	0.21
901024	W1-005 E	0.5
901033	W1-006 C	0.21
901034	W1-006 E	0.5
907052	X1-032 E	0.46
910571	X3-008 C	0.35
910572	X3-008 E	4.67
913411	Y1-080 C	0.04
913412	Y1-080 E	0.55
915541	Y3-058 C	0.1
915542	Y3-058 E	1.38
917081	Z2-012 C	0.1
917082	Z2-012 E	1.36
917432	Z2-076 E	0.18
917442	Z2-077 E	0.18
918831	AA1-102	0.53

920321	AA2-130	0.03
924681	AB2-120 C	4.15
924682	AB2-120 E	6.77
924781	AB2-130 C O1	4.04
924782	AB2-130 E O1	6.59
924831	AB2-136 C	7.56
924832	AB2-136 E	8.02
925151	AB2-172 C	7.15
925152	AB2-172 E	11.67
925261	AB2-180 C	2.08
925262	AB2-180 E	0.89
926911	AC1-177	0.46
927031	AC1-190 C	12.58
927032	AC1-190 E	5.39
927191	AC1-213 C	0.41
927192	AC1-213 E	0.27
930202	AB1-056 E O1	13.59
930881	AB1-137 C	0.33
930882	AB1-137 E	0.14
932161	AC2-023 C	4.29
932162	AC2-023 E	3.13
936691	AD2-088 C O1	2.27
936692	AD2-088 E O1	1.51
938651	AE1-087 C	6.02
938652	AE1-087 E	1.51
938891	AE1-117 C O1	3.83
938892	AE1-117 E O1	10.21
938901	AE1-118 C O1	3.85
938902	AE1-118 E O1	10.25
939151	AE1-145 C1	1.31
939152	AE1-145 C2	0.88
939153	AE1-145 E	0.02
939361	AE1-167 C O1	0.66
939362	AE1-167 E O1	0.55
939621	AE1-192 C O1	5.15
939622	AE1-192 E O1	2.52
941971	AE2-209 C	8.71
941972	AE2-209 E	6.07
942441	AE2-257 C O1	2.61
942442	AE2-257 E O1	6.88
942701	AE2-286 C	1.98
942702	AE2-286 E	2.88
942821	AE2-301 C	0.46
942822	AE2-301 E	0.71
BLUEG	BLUEG	0.38
CALDERWOOD	CALDERWOOD	0.04
CANNELTON	CANNELTON	0.02
CARR	CARR	0.02
CATAWBA	CATAWBA	0.03
CHEOAH	CHEOAH	0.04
CHILHOWEE	CHILHOWEE	0.01
COFFEEN	COFFEEN	0.04
COTTONWOOD	COTTONWOOD	0.16

DUCKCREEK	DUCKCREEK	0.09
EDWARDS	EDWARDS	0.04
ELMERSMITH	ELMERSMITH	0.04
FARMERCITY	FARMERCITY	0.03
G-007	G-007	0.04
GIBSON	GIBSON	0.02
HAMLET	HAMLET	0.04
NEWTON	NEWTON	0.1
O-066	O-066	0.32
PRAIRIE	PRAIRIE	0.19
RENSSELAER	RENSSELAER	0.02
SANTEETLA	SANTEETLA	0.01
SMITHLAND	SMITHLAND	0.02
TATANKA	TATANKA	0.05
TILTON	TILTON	0.05
TRIMBLE	TRIMBLE	0.04
TVA	TVA	0.13
UNIONPOWER	UNIONPOWER	0.06

Contingency Name	**Contingency Definition**
DPL_P4-2_DP11	CONTINGENCY 'DPL_P4-2_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
DPL_P4-2_DP58	CONTINGENCY 'DPL_P4-2_DP58' /*OAK HALL BUS BREAKER DISCONNECT BRANCH FROM BUS 232132 TO BUS 232130 CKT 1 /*OAK HALL POCOMOKE 138 138 DISCONNECT BRANCH FROM BUS 232132 TO BUS 232131 CKT 1 /*OAK HALL NEW CHURCH 138 138 END