Generation Interconnection

Impact Study Report

for

Queue Project AE1-217

DESOTO-GASTON 138 KV

84 MW Capacity / 200 MW Energy

November, 2019

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Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

An Interconnection Customer 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.

General

Invenergy Solar Development North America has proposed a Solar generating facility located in Delaware County, Indiana. The installed facilities will have a total capability of 200 MW with 84 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is December 2022. This study does not imply a TO commitment to this in-service date.

Queue Number	**AE1-217**
Project Name	DESOTO-GASTON 138 KV
Interconnection Customer	Invenergy Solar Development North America LLC
State	Indiana
County	Delaware
Transmission Owner	AEP
MFO	200
MWE	200
MWC	84
Fuel	Solar
Basecase Study Year	2022

Primary Point of Interconnection

AE1-217 will interconnect with the AEP transmission system via a new station cut into the Gaston to Desoto 138 kV section of the Deer Creek to Desoto 138kV Circuit.

To accommodate the interconnection on the Desoto –Gaston 138kV section of the Desoto – Deer Creek 138kV Circuit, a new three (3) circuit breaker 138kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus will be constructed (see Figure 1). Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required. AEP reserves the right to specify the final acceptable configuration considering design practices, future expansion, and compliance requirements.

Cost Summary

The AE1-217 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 250,000
Direct Connection Network Upgrade	$ 6,000,000
Non Direct Connection Network Upgrades	$ 1,500,000
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 74,905
Total Costs	$ 7,824,905

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements.

Transmission Owner Scope of Work

Attachment Facilities

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

Description	Total Cost
138kV Revenue Metering	$ 250,000
Total Attachment Facility Costs	$ 250,000

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	Total Cost
Construct a new three (3) circuit breaker 138 kV switching station physically configured in a breaker and half bus arrangement but operated as a ring-bus (See Figure 1). Installation of associated protection and control equipment, 138 kV line risers and SCADA will also be required.	$ 6,000,000
Total Direct Connection Facility Costs	$ 6,000,000

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	Total Cost
Desoto – Gaston 138kV T- Line Cut In	$ 1,000,000
Upgrade line protections & Controls at the Deer Creek 138kV Substation	$ 250,000
Upgrade line protections & Controls at the Desoto 138kV Substation	$ 250,000
Total Non-Direct Connection Facility Costs	$ 1,500,000

Incremental Capacity Transfer Rights (ICTRs)

Will be determined at a later study phase

Schedule

It is anticipated that the time between receipt of executed Agreements and Commercial Operation may range from 12 to 18 months if no line work is required. If line work is required, construction time would generally be between 24 to 36 months after Agreement execution.

Transmission Owner Analysis

Note: An AEP supplemental project will install the Gaston 138kV Breaker shown in Figure 1, and rebuild the Deer Creek – Desoto 138kV line. The projected ISD is 10/8/2021. PJM has not assigned the S number yet.

Interconnection Customer Requirements

It is understood that Invenergy Solar Development North America is responsible for all costs associated with this interconnection. The costs above are reimbursable to AEP. The cost of Invenergy Solar Development North America's generating plant and the costs for the line connecting the generating plant to the Desoto – Gaston 138kV section of the Desoto – Deer Creek 138kV Circuit are not included in this report; these are assumed to be Invenergy Solar Development North America's responsibility.

The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Requirement from the PJM Open Access Transmission Tariff:

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.

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 Section 8 of Attachment O.

AEP Requirements

The Interconnection Customer will be required to comply with all AEP Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-aep/aep-interconnection-requirements.ashx

Network Impacts

The Queue Project AE1-217 was evaluated as a 200.0 MW (Capacity 84.0 MW) injection into a tap of the Desoto – Gaston 138 kV kV line in the AEP area. Project AE1-217 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-217 was studied with a commercial probability of 1.00. Potential network impacts were as follows:

Summer Peak Load Flow

Generation 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
569443	243278	05DESOTO	AEP	243319	05JAY	AEP	1	AEP_P7-1_#11087	tower	393.0	98.33	101.61	AC	14.8

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
569442	243278	05DESOTO	AEP	243319	05JAY	AEP	1	AEP_P7-1_#11019	tower	393.0	103.39	106.67	AC	14.8
882372	248001	06DEARB1	OVEC	248013	06PIERCE	OVEC	1	.345.DEO&K-AEP.C5 4504MFTANNERS4512EBTANNERS	tower	972.0	106.75	108.43	AC	18.8

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
568587	243343	05MISSIS	AEP	243274	05DEERCR	AEP	1	AEP_P1-2_#5535-A	operation	233.0	69.27	134.29	AC	200.0
568481	939760	AE1-207 TAP	AEP	243343	05MISSIS	AEP	1	AEP_P1-2_#5535-A	operation	233.0	67.24	148.14	AC	200.0

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
568482	939760	AE1-207 TAP	AEP	243343	05MISSIS	AEP	1	Base Case	operation	167.0	61.72	109.39	AC	82.26
568483	939810	AE1-217 TAP	AEP	243278	05DESOTO	AEP	1	AEP_P1-2_#5535-C	operation	233.0	67.08	147.78	AC	200.0
568485	939810	AE1-217 TAP	AEP	243278	05DESOTO	AEP	1	Base Case	operation	167.0	61.21	113.88	AC	117.74

System Reinforcements

<table>
<tr><th>ID</th><th>Index</th><th>Facility</th><th>Upgrade Description</th><th>Cost</th><th>Cost Allocated to AE1-217</th><th>NUN</th></tr>
<tr><td></td><td></td><td>Desoto – Jay 138 kV line</td><td>Replace 2 risers at Jay 138 kV substation. Time estimate 24-36 months. New expected ratings 383/409 MVA SN/SE.

The cost allocation is as follows:

<table>
<tr><th>Queue</th><th>MW contribution</th><th>Percentage of Cost</th><th>$ cost (70 K)</th></tr>
<tr><td>AE1-207</td><td>9.6</td><td>22.97%</td><td>16.077</td></tr>
<tr><td>AE1-209</td><td>8.7</td><td>20.81%</td><td>14.569</td></tr>
<tr><td>AE1-210</td><td>8.7</td><td>20.81%</td><td>14.569</td></tr>
<tr><td>AE1-217</td><td>14.8</td><td>35.41%</td><td>24.785</td></tr>
</table>

Note: There is a supplemental project, S2015.3, which may increase the SE rating to 409 MVA. Need AEP to confirm this during the Facilities Study.</td><td>$70 K</td><td>$24.785 K</td><td>N6279.1</td></tr>
<tr><td></td><td></td><td>Desoto – Jay 138 kV line</td><td>A Sag Study will be required on the 12.53 miles of ACSR ~ 556.5 ~ 26/7 ~ DOVE - Conductor section 1 to mitigate the overload. The new ratings after sag study will be: S/N: 409 MVA, S/E: 620 MVA, Depending on the sag study results, the cost for this upgrade is expected to be between $50,120(no remediation required, just sag study) and $18.8 million (complete line Reconductor/rebuild). Time Estimate: a) Sag Study: 6-12 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.</td><td>$50.120 K</td><td>$50.120 K</td><td>N6279.2</td></tr>
</table>

<table>
<tr><th>ID</th><th>Index</th><th>Facility</th><th>Upgrade Description</th><th>Cost</th><th>Cost Allocated to AE1-217</th><th>NUN</th></tr>
<tr><td></td><td></td><td>Dearborn – Pierce 345 kV line</td><td>Perform a sag study.

Queue Project AE1-217 presently does not receive cost allocation for this upgrade.

Note 1: as changes to the interconnection process occur, such as prior queued projects withdrawing from the queue, reducing in size, etc, Queue Project AE1-217 could receive cost allocation.

The potential cost responsibility is as follows:

<table><tr><th>Queue</th><th>MW contribution</th><th>Percentage of Cost</th><th>$ cost (125 K)</th></tr><tr><td>AE1-207</td><td>14.2</td><td>20.23%</td><td>25.285</td></tr><tr><td>AE1-208</td><td>12.4</td><td>17.66%</td><td>22.080</td></tr><tr><td>AE1-209</td><td>12.4</td><td>17.66%</td><td>22.080</td></tr><tr><td>AE1-210</td><td>12.4</td><td>17.66%</td><td>22.080</td></tr><tr><td>AE1-217</td><td>18.8</td><td>26.78%</td><td>33.476</td></tr></table>
Note 2: Although Queue Project AE1-217 may not have cost responsibility for this upgrade, Queue Project AE1-217 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AE1-217 comes into service prior to completion of the upgrade, Queue Project AE1-217 will need an interim study.</td><td>$125 K</td><td>$0</td><td>N/A</td></tr>
<tr><td></td><td></td><td></td><td>TOTAL COST</td><td></td><td>$74,905</td><td></td></tr>
</table>

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
569442	243278	05DESOTO	AEP	243319	05JAY	AEP	1	AEP_P7-1_#11019	tower	393.0	103.39	106.67	AC	15.17

Bus #	Bus	MW Impact
247935	V3-007 E	13.23
247963	05HDWTR1G E	4.76
923881	AB2-028 C	1.66
923882	AB2-028 E	11.08
926881	AC1-175 C	5.78
926882	AC1-175 E	9.43
927182	AC1-212 E	1.35
932681	AC2-090 C	2.89
932682	AC2-090 E	4.71
933601	AC2-177 C O1	1.98
933602	AC2-177 E O1	13.23
939761	AE1-207 C	4.01
939762	AE1-207 E	5.54
939781	AE1-209 C	1.13
939782	AE1-209 E	7.54
939791	AE1-210 C O1	1.13
939792	AE1-210 E O1	7.54
939811	AE1-217 C O1	6.22
939812	AE1-217 E O1	8.59
CARR	CARR	0.04
CBM-S1	CBM-S1	2.29
CBM-S2	CBM-S2	0.46
CBM-W2	CBM-W2	20.35
CIN	CIN	4.38
CPLE	CPLE	0.14
G-007	G-007	0.09
IPL	IPL	3.78
LGEE	LGEE	0.81
MEC	MEC	1.66
O-066	O-066	0.59
RENSSELAER	RENSSELAER	0.03
WEC	WEC	0.06

Index 2

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
882372	248001	06DEARB1	OVEC	248013	06PIERCE	OVEC	1	.345.DEO&K-AEP.C5 4504MFTANNERS4512EBTANNERS	tower	972.0	106.75	108.43	AC	18.8

Bus #	Bus	MW Impact
243795	05HDWTR1G C	0.56
247264	05LAWG1A	7.01
247265	05LAWG1B	7.01
247266	05LAWG1S	11.19
247267	05LAWG2A	7.01
247268	05LAWG2B	7.01
247269	05LAWG2S	11.19
247543	V3-007 C	0.56
247914	05WLD G1 E	8.0
247929	S-071 E	8.56
247935	V3-007 E	26.83
247958	05WLD G2 E	8.39
247963	05HDWTR1G E	9.66
247968	Z2-115 E	0.16
915662	Y3-099 E	0.2
915672	Y3-100 E	0.2
916182	Z1-065 E	0.38
920501	AA2-148 C O1	3.54
920502	AA2-148 E O1	23.67
923881	AB2-028 C	2.91
923882	AB2-028 E	19.45
925242	AB2-178 E	1.98
926691	AC1-152	2.2
926851	AC1-172	2.2
926881	AC1-175 C	11.72
926882	AC1-175 E	19.12
932681	AC2-090 C	5.86
932682	AC2-090 E	9.56
932841	AC2-111 C O1	2.77
932842	AC2-111 E O1	4.52
933591	AC2-176 C O1	1.52
933592	AC2-176 E O1	10.14
933601	AC2-177 C O1	4.01
933602	AC2-177 E O1	26.83
934161	AD1-043 C O1	4.47
934162	AD1-043 E O1	7.29
934961	AD1-128 C O1	5.62
934962	AD1-128 E O1	9.17
936561	AD2-071 C	5.94
936562	AD2-071 E	2.92
936681	AD2-087 C O1	3.17

Bus #	Bus	MW Impact
936682	AD2-087 E O1	14.83
938061	AE1-008 C	0.69
938062	AE1-008 E	1.13
939761	AE1-207 C	5.95
939762	AE1-207 E	8.22
939771	AE1-208 C	5.24
939772	AE1-208 E	7.14
939781	AE1-209 C O1	1.61
939782	AE1-209 E O1	10.75
939791	AE1-210 C O1	1.61
939792	AE1-210 E O1	10.76
939811	AE1-217 C O1	7.89
939812	AE1-217 E O1	10.89
950161	J401	1.31
CARR	CARR	0.32
CATAWBA	CATAWBA	0.09
CBM-S1	CBM-S1	4.29
CBM-W1	CBM-W1	17.06
CBM-W2	CBM-W2	71.94
CIN	CIN	13.65
G-007	G-007	0.94
HAMLET	HAMLET	0.19
IPL	IPL	12.54
LGEE	LGEE	1.08
MEC	MEC	15.37
MECS	MECS	7.22
O-066	O-066	6.05
RENSSELAER	RENSSELAER	0.26
WEC	WEC	2.42
Z1-043	Z1-043	9.74

Affected Systems

Affected Systems

LG&E

None

MISO

MISO Impacts to be determined during later study phases (as applicable).

TVA

None

Duke Energy Progress

None

NYISO

None

Contingency Descriptions

Contingency Name	Contingency Definition
.345.DEO&K-AEP.C5 4504MFTANNERS4512EBTANNERS	CONTINGENCY '.345.DEO&K-AEP.C5 4504MFTANNERS4512EBTANNERS' OPEN BRANCH FROM BUS 243233 TO BUS 249567 CKT 1 OPEN BRANCH FROM BUS 243233 TO BUS 249565 CKT 1 END
AEP_P1-2_#5535-C	CONTINGENCY 'AEP_P1-2_#5535-C' OPEN BRANCH FROM BUS 243274 TO BUS 243343 CKT 1 / 243274 05DEERCR 138 243343 05MISSIS 138 1 OPEN BRANCH FROM BUS 939760 TO BUS 243343 CKT 1 / 939760 AE1-207 TAP 138 243343 05MISSIS 138 1 END
AEP_P1-2_#5535-A	CONTINGENCY 'AEP_P1-2_#5535-A' OPEN BRANCH FROM BUS 243278 TO BUS 939810 CKT 1 / 243278 05DESOTO 138 939810 AE1-217 TAP 138 1 END
Base Case	
AEP_P7-1_#11019	CONTINGENCY 'AEP_P7-1_#11019' OPEN BRANCH FROM BUS 243218 TO BUS 243232 CKT 2 / 243218 05DESOTO 345 243232 05SORENS 345 2 OPEN BRANCH FROM BUS 243225 TO BUS 243232 CKT 1 / 243225 05KEYSTN 345 243232 05SORENS 345 1 END
AEP_P7-1_#11087	CONTINGENCY 'AEP_P7-1_#11087' OPEN BRANCH FROM BUS 243218 TO BUS 243225 CKT 1 / 243218 05DESOTO 345 243225 05KEYSTN 345 1 OPEN BRANCH FROM BUS 243218 TO BUS 243232 CKT 2 / 243218 05DESOTO 345 243232 05SORENS 345 2 END

Short Circuit

Short Circuit

The following Breakers are over duty

None

Figure 1 : AE1-217 Desoto – Gaston 138kV One Line Diagram

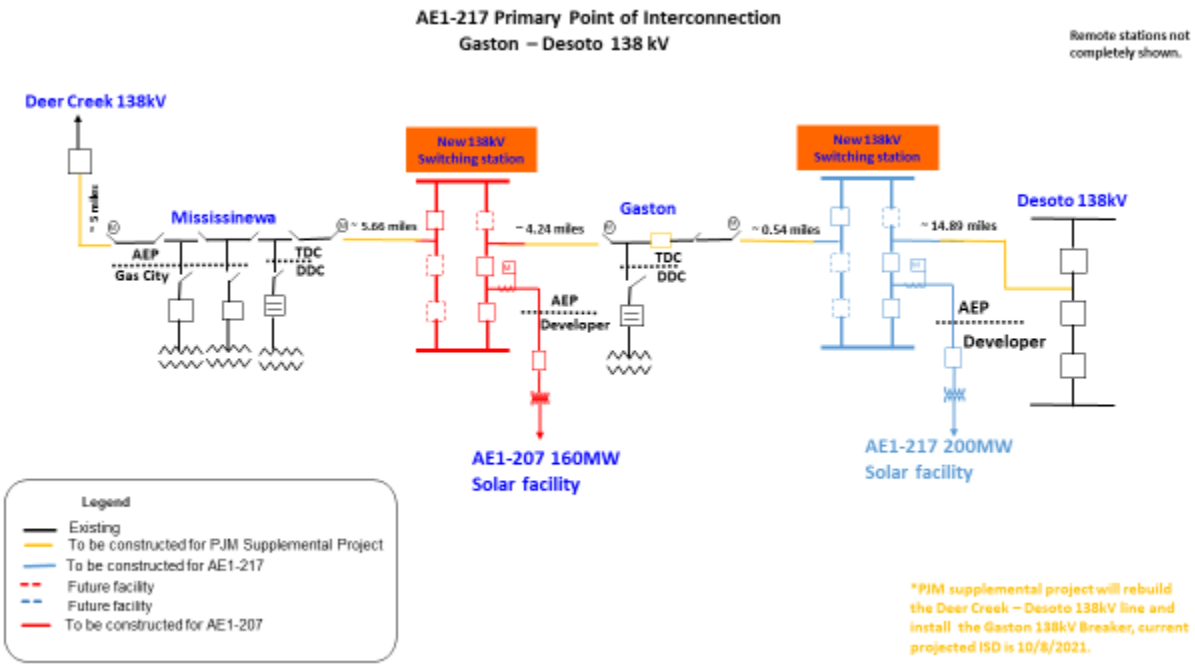

Figure2: AE1-217 Point of Interconnection (Desoto – Gaston 138kV)