Generation Interconnection Feasibility Study Report

For

PJM Generation Interconnection Request Queue Position AC2-059

Biers Run - Circleville 138kV

September 2017

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, 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 impact study is performed.

The Feasibility 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.

General

The Interconnection Customer (IC) proposes to install PJM Project #AC2-059, a 127.00 MW (62.5 MW Capacity) solar generating facility in Ross County, Ohio (see Figure 3). The primary point of interconnection is to AEP's Biers Run – Circleville 138 kV circuit (see Figure 1). The secondary point of interconnection is to AEP's Biers Run – Delano 138 kV circuit (see Figure 2).

The requested in service date is December 31, 2019.

Attachment Facilities

Primary Point of Interconnection (Biers Run - Circleville 138 kV substation)

To accommodate the interconnection on the Biers Run – Circleville 138 kV circuit, 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 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.

<u>New Switching Station Work:</u>

- 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. Installation of associated protection and control equipment, 138 kV line risers, SCADA, and 138 kV revenue metering will also be required (see Figure 1).
    - **Estimated Station Cost: $6,300,000**

Direct Connection Cost Estimate

The total preliminary cost estimate for Direct Connection work is given in the following tables below.

For AEP building Direct Connection cost estimates:

Description	Total Cost
Biers Run – Circleville 138 kV T-Line Cut In	**$1,500,000**
Total	**$1,500,000**

Table 1

Non-Direct Connection Cost Estimate

The total preliminary cost estimate for Non-Direct Connection work is given in the following table below:

For AEP building Non-Direct Connection cost estimates:

Description	Estimated Cost
138 kV Revenue Metering	**$250,000**
Upgrade line protection and controls at the Biers Run 138 kV substation.	**$250,000**
Upgrade line protection and controls at the Circleville 138 kV substation.	**$250,000**
Total	**$750,000**

Table 2

Secondary Point of Interconnection (Biers Run – Delano 138kV)

To accommodate the interconnection on the Biers Run – Circleville 138 kV circuit, 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 will be constructed (see Figure 2). 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.

It is understood that the IC is responsible for all costs associated with this interconnection. The cost of The IC's generating plant and the costs for the line connecting the generating plant to the new proposed 138 kV switching station are not included in this report; these are assumed to be the IC'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.

Interconnection Customer Requirements

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 the IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

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

Option 1

Network Impacts

The Queue Project AC2-059 was evaluated as a 127.0 MW (Capacity 62.5 MW) injection tapping the Biers Run – Circleville 138 kV line in the AEP area. Project AC2-059 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-059 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

Contingency Descriptions

The following contingencies resulted in overloads:

Option 1	
Contingency Name	**Description**
6783	CONTINGENCY '6783' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1 END
8094_C2_05BIXBY 345-303C	CONTINGENCY '8094_C2_05BIXBY 345-303C' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1 END
8126_B	CONTINGENCY '8126_B' OPEN BRANCH FROM BUS 931410 TO BUS 243483 CKT 1 / 931410 AC2-059 TAP 138 243483 05CRCLVS 138 1 OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1 END

Table 3

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)

AC2-059 Multiple Facility Contingency															
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	LFFB	8094_C2_05BIXBY 345-303C	AEP - AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	96.6	106.66	ER	179	18	1
2	DCTL	6783	AEP - AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	96.6	106.66	ER	179	18	

Table 4

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)

The contributions to previously identified overload listed below is not part of the Bulk Electric System (BES), but was identified by AEP as a criteria violation.

AC2-059 Contribution to Previously Identified Overloads															
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
3	DCTL	8126_B	AEP - AEP	05BIERSRUN-05SLATE 69 kV line	246893	243617	1	DC	117.81	125.28	ER	50	8.3	2

Table 5

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Affected System Analysis & Mitigation

LGEE Impacts:

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

MISO Impacts:

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

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

OVEC Impacts:

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

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

New System Reinforcements

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

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
#1	05HARRIS-05OBETZ 138 kV line	Upgrade the Harrison 138 kV substation bus work.	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$200,000**
			Total New Network Upgrade	**$200,000**

Table 6

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

The System Reinforcement listed below is not part of the Bulk Electric System (BES), but was identified by AEP and will be required for interconnection of AC2-059.

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
N/A	05BIERSRUN-05SLATE 69 kV line	The following work will be required to relieve the Biers Run – Slate 69 kV line overload: 5.0 mile section of the ACSR 211.6 6/1 Penguin (4/0) conductor section 1 will need to be rebuilt.	An approximate construction time would be 24 to 36 months after signing an interconnection agreement.	**$6.0 Million**

#	Overloaded Facility	Upgrade Description	Schedule	Estimated Cost
			Total New Network Upgrade	$6.0 Million

Table 7

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 be between 24 to 36 months after signing an interconnection agreement.

Note: The time provided between anticipated normal completion of System Impact, Facilities Studies, subsequent execution of ISA and ICSA documents, and the proposed In-Service Date is shorter than usual and may be difficult to achieve.

Conclusion

Based upon the results of this Feasibility Study, the construction of the IC's 127.00 MW (62.5 MW Capacity) solar generating facility (PJM Project #AC2-059) will require the following additional interconnection charges. This plan of service will interconnect the proposed generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the IC's Development generating facility.

Cost Breakdown for Primary Point of Interconnection (Biers Run – Circleville 138 kV)		
Attachment Cost	New 138 kV Switching Station	**$6,300,000**
Direct Connection Cost Estimate	Biers Run - Circleville 138 kV T-Line Cut In	**$1,500,000**
Non-Direct Connection Cost Estimate	138 kV Revenue Metering	**$250,000**
	Upgrade line protection and controls at the Biers Run 138 kV substation.	**$250,000**
	Upgrade line protection and controls at the Circleville 138 kV substation.	**$250,000**
	Upgrade the Harrison 138 kV substation bus work.	**$200,000**
	5.0 mile section of the ACSR 211.6 6/1 Penguin (4/0) conductor section 1 will need to be rebuilt.	**$6,000,000**
	Total Estimated Cost for Project AC2-059	**$14,750,000**

Table 8

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.

Option 2

Network Impacts

The Queue Project AC2-059 was evaluated as a 127.0 MW (Capacity 62.5 MW) injection tapping the Biers Run – Hopetown 138 kV line in the AEP area. Project AC2-059 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-059 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

Contingency Descriptions

The following contingencies resulted in overloads:

Option 2	
Contingency Name	**Description**
6783	CONTINGENCY '6783' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1 END
6190_B3_05SPORN 345-4_WOMOAB	CONTINGENCY '6190_B3_05SPORN 345-4_WOMOAB' OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 1 / 242528 05SPORN 345 248005 06KYGER 345 1 OPEN BRANCH FROM BUS 242528 TO BUS 242808 CKT 4 / 242528 05SPORN 345 242808 05SPORNS 138 4 END
8094_C2_05BIXBY 345-303C	CONTINGENCY '8094_C2_05BIXBY 345-303C' OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1 OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1 END
8126_B	CONTINGENCY '8126_B' OPEN BRANCH FROM BUS 246889 TO BUS 243483 CKT 1 / 246889 05BIERSR 138 243483 05CRCLVS 138 1 OPEN BRANCH FROM BUS 931410 TO BUS 246890 CKT 1 / 931410 AC2-059 TAP 138 246890 05HOPETN 138 1 END
8468_B2	CONTINGENCY '8468_B2' OPEN BRANCH FROM BUS 242528 TO BUS 248005 CKT 2 / 242528 05SPORN 345 248005 06KYGER 345 2 END

Table 9

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)

AC2-059 Multiple Facility Contingency														
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	LFFB	8094_C2_05BIXBY 345-303C	AEP - AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	96.6	99.39	ER	179	11.09	1
2	DCTL	6783	AEP - AEP	05HARRIS-05OBETZ 138 kV line	243522	243550	1	DC	96.6	99.39	ER	179	11.09	

Table 10

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)

The contributions to previously identified overload listed below is not part of the Bulk Electric System (BES), but was identified by AEP as a criteria violation.

AC2-059 Contribution to Previously Identified Overloads														
	Contingency		Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	DCTL	8126_B	AEP - AEP	05BIERSRUN-05SLATE 69 kV line	246893	243617	1	DC	118.29	125.77	ER	50	8.3	2

Table 11

Steady-State Voltage Requirements

None

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

Affected System Analysis & Mitigation

LGEE Impacts:

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

MISO Impacts:

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

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

OVEC Impacts:

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

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.

AC2-059 Delivery of Energy Portion of Interconnection Request															
		Contingency	Affected		Bus				Loading		Rating		MW	FG
#	Type	Name	Area	Facility Description	From	To	Cir.	PF	Initial	Final	Type	MVA	Con.	App.
1	N-1	8468_B2	OVEC - AEP	06KYGER-05SPORN 345 kV line	248005	242528	1	DC	119.43	119.91	NR	1017	10.64	
2	N-1	6190_B3_05SPORN 345-4_WOMOAB	OVEC - AEP	06KYGER-05SPORN 345 kV line	248005	242528	2	DC	125.49	125.99	NR	971	10.73	

Table 12

New System Reinforcements

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

None

Figure 1: Primary Point of Interconnection (Biers Run – Circleville 138kV)

Single Line Diagram

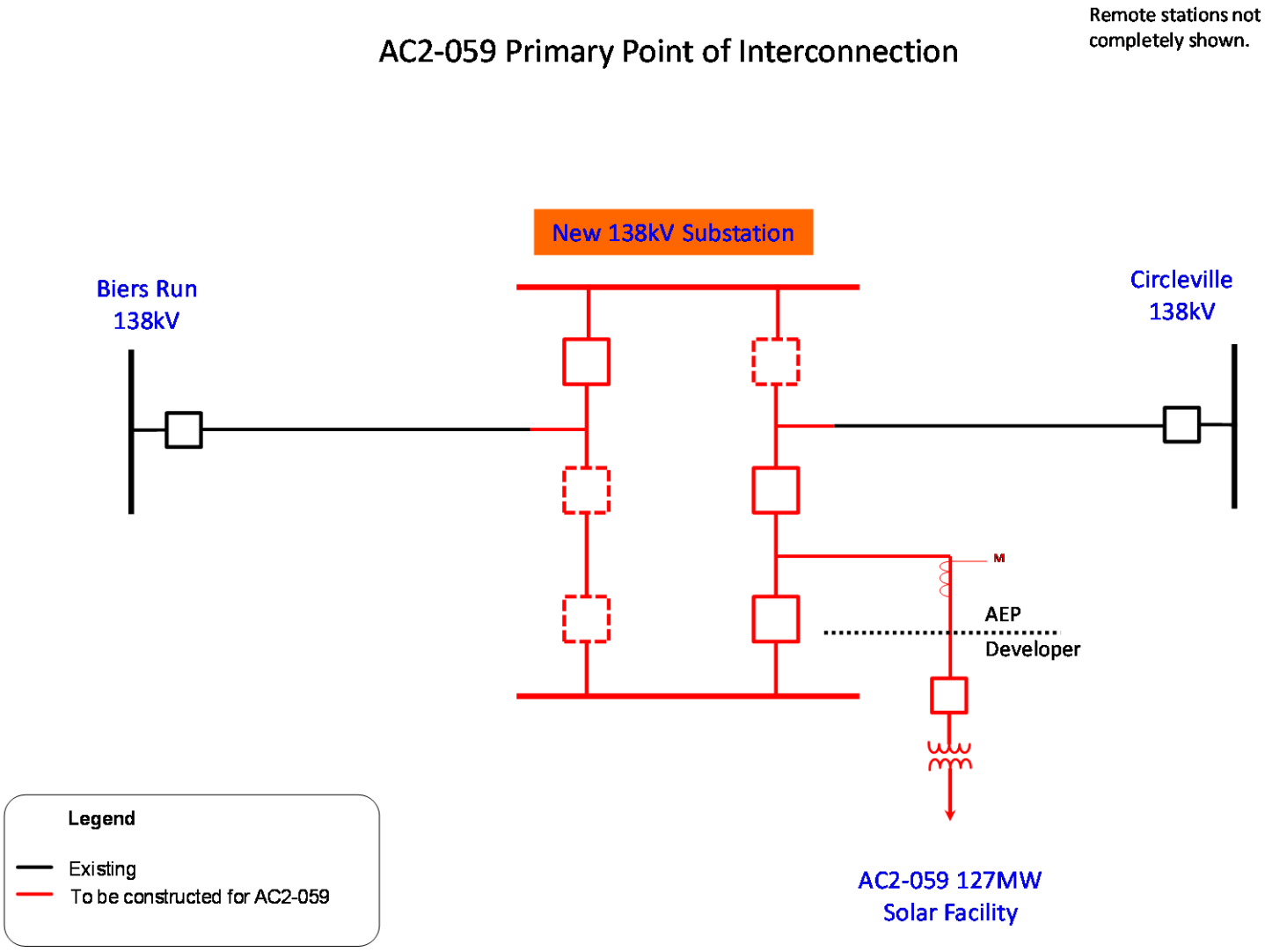


Figure 2: Secondary Point of Interconnection (Biers Run – Delano 138kV)

Single Line Diagram

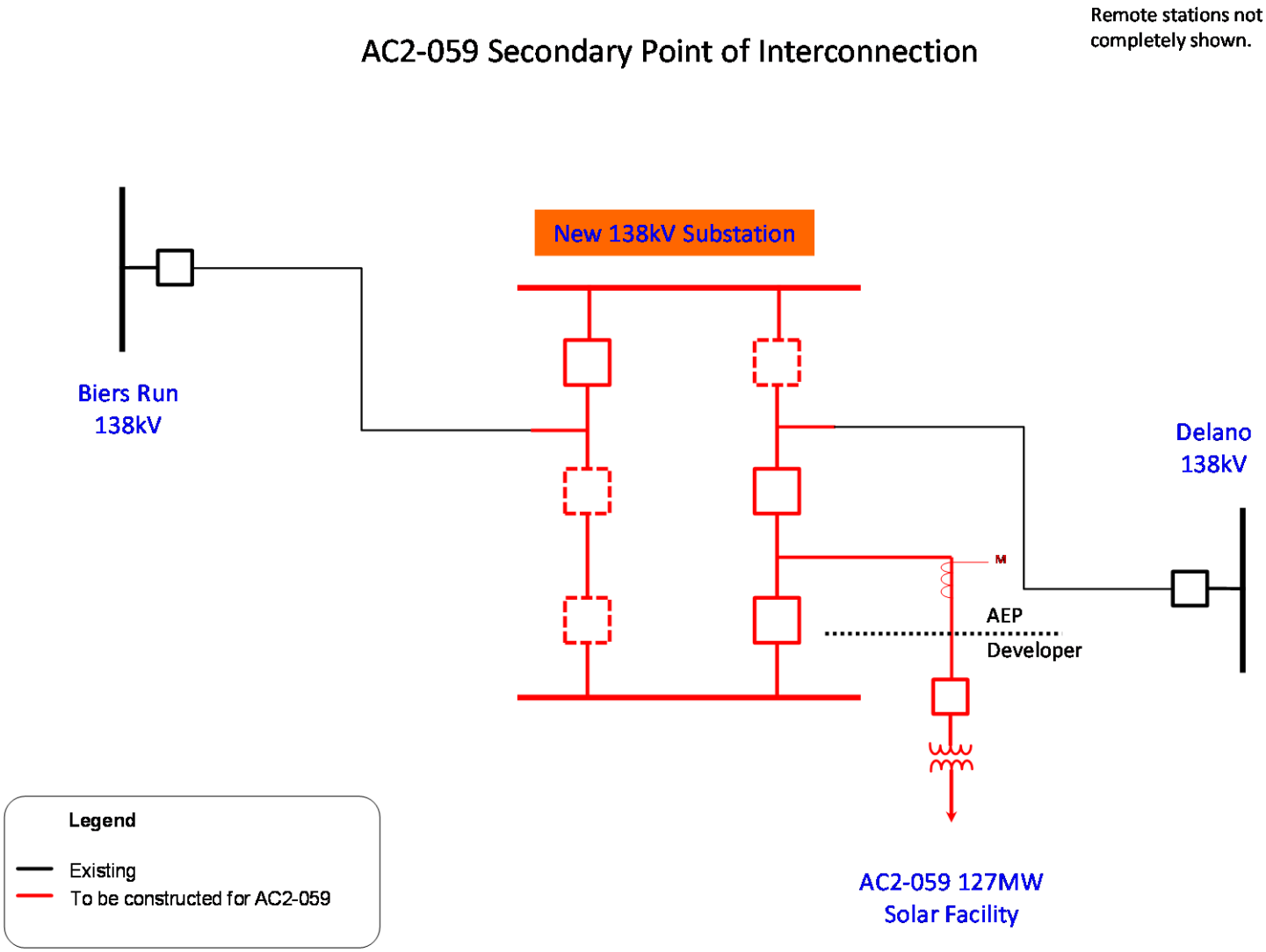
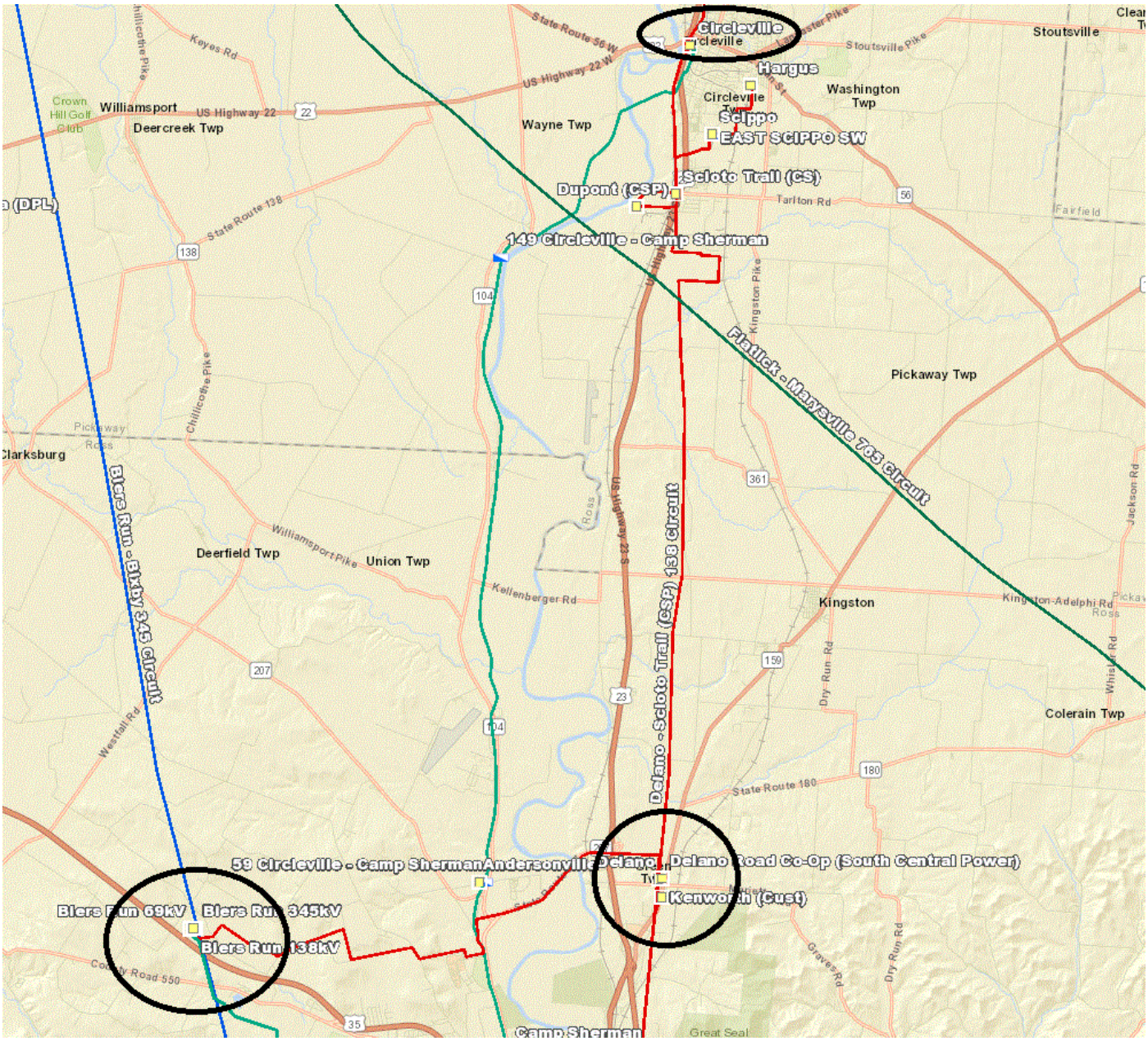


Figure 3: Primary and Secondary Point of Interconnection Map



Appendices – Primary POI

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

(AEP - AEP) The 05HARRIS-05OBETZ 138 kV line (from bus 243522 to bus 243550 ckt 1) loads from 96.6% to 106.66% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of '8094_C2_05BIXBY 345-303C'. This project contributes approximately 18.0 MW to the thermal violation.

CONTINGENCY '8094_C2_05BIXBY 345-303C'
OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1
OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1
END

Bus Number	*Bus Name*	*Full Contribution*
931201	*AC2-029 C*	*5.37*
931202	*AC2-029 E*	*8.76*
931411	*AC2-059 C*	*8.86*
931412	*AC2-059 E*	*9.14*
931811	*AC2-106 C OP*	*5.59*
931812	*AC2-106 E OP*	*2.58*
924351	*AB2-083 C OP*	*2.83*
924352	*AB2-083 E OP*	*1.33*
925341	*AC1-001 C*	*5.65*
925342	*AC1-001 E*	*2.66*
927161	*AC1-210 C OP*	*8.9*
927162	*AC1-210 E OP*	*4.02*

Appendices Secondary POI

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

(AEP - AEP) The 05HARRIS-05OBETZ 138 kV line (from bus 243522 to bus 243550 ckt 1) loads from 96.6% to 99.39% (**DC power flow**) of its emergency rating (179 MVA) for the line fault with failed breaker contingency outage of '8094_C2_05BIXBY 345-303C'. This project contributes approximately 11.09 MW to the thermal violation.

CONTINGENCY '8094_C2_05BIXBY 345-303C'
OPEN BRANCH FROM BUS 243453 TO BUS 243454 CKT 1 / 243453 05BEATTY 345 243454 05BIXBY 345 1
OPEN BRANCH FROM BUS 246888 TO BUS 243454 CKT 1 / 246888 05BIERSR 345 243454 05BIXBY 345 1
END

Bus Number	*Bus Name*	*Full Contribution*
931201	*AC2-029 C*	*5.37*
931202	*AC2-029 E*	*8.76*
931411	*AC2-059 C OP*	*5.46*
931412	*AC2-059 E OP*	*5.63*
931811	*AC2-106 C OP*	*5.22*
931812	*AC2-106 E OP*	*2.41*
924351	*AB2-083 C OP*	*2.83*
924352	*AB2-083 E OP*	*1.33*
925341	*AC1-001 C*	*5.65*
925342	*AC1-001 E*	*2.66*
927161	*AC1-210 C OP*	*8.9*
927162	*AC1-210 E OP*	*4.02*

Appendix 2

(AEP - AEP) The 05BIERSRUN-05SLATE 69 kV line (from bus 246893 to bus 243617 ckt 1) loads from 118.29% to 125.77% (**DC power flow**) of its emergency rating (50 MVA) for the tower line contingency outage of '8126_B'. This project contributes approximately 8.3 MW to the thermal violation.

CONTINGENCY '8126_B'
OPEN BRANCH FROM BUS 246889 TO BUS 243483 CKT 1 / 246889 05BIERSR 138 243483 05CRCLVS 138 1
OPEN BRANCH FROM BUS 931410 TO BUS 246890 CKT 1 / 931410 AC2-059 TAP 138 246890 05HOPETN 138 1
END

Bus Number	*Bus Name*	*Full Contribution*
931131	*AC2-020 C OP*	*0.66*
931132	*AC2-020 E OP*	*1.73*
931381	*AC2-055 C OP*	*1.56*
931382	*AC2-055 E OP*	*2.55*
931411	*AC2-059 C OP*	*4.08*
931412	*AC2-059 E OP*	*4.21*
931421	*AC2-060 C*	*5.53*
931422	*AC2-060 E*	*3.11*
931651	*AC2-087 C OP*	*4.05*
931652	*AC2-087 E OP*	*3.21*
931811	*AC2-106 C OP*	*15.57*
931812	*AC2-106 E OP*	*7.19*
247592	*W4-036*	*1.04*