Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC2-087

Buckskin 69kV

December 2019

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: (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. 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 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 or merchant transmission upgrade, may also contribute to the need for the same network reinforcement.

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.

General

First Solar Development, LLC proposes to install PJM Project #AC2-087, an 85.0 MW (47.4 MW Capacity) solar generating facility in Ross County, Ohio (see Figure 2). The point of interconnection is a direct connection to AEP's Buckskin 69 kV substation (see Figure 1).

The requested in service date is May 31, 2019.

Attachment Facilities

Point of Interconnection (Buckskin 69kV substation)

To accommodate the interconnection at the Buckskin 69 kV substation, the substation will have to be expanded requiring the installation of two (2) new 69 kV circuit breakers (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 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.

Direct Connection at the Buckskin 69 kV Substation Work and Cost:

- Expand the substation requiring the installation of two (2) new 69 kV circuit breakers (see Figure 1). Installation of associated protection and control equipment, 69 kV line risers, SCADA, and 69 kV revenue metering will also be required.
- **Estimated Station Cost: $1,500,000**

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
69 kV Revenue Metering	**$200,000**
Upgrade line protection and controls at the Buckskin 69 kV substation.	**$200,000**
Total	**$400,000**

Table 1

Interconnection Customer Requirements

It is understood that First Solar Development is responsible for all costs associated with this interconnection. The cost of First Solar Development's generating plant and the costs for the line connecting the generating plant to the Buckskin 69 kV substation are not included in this report; these are assumed to be First Solar Development'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 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

Network Impacts

The Queue Project AC2-087 was evaluated as a 85.0 MW (Capacity 47.4 MW) injection into the Buckskin 69 kV substation in the AEP area. Project AC2-087 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-087 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis – 2020

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

1. (AEP - AEP) The 05BCKSKI-05PETERSB8 69 kV line (from bus 243598 to bus 243612 ckt 1) loads from 78.48% to 115.48% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 23.07 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

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

2. (AEP - AEP) The 05LATTAVL8-05BIERSRUN 69 kV line (from bus 243608 to bus 246893 ckt 1) loads from 91.26% to 121.51% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '6781_B3_05BIERSR 345-1'. This project contributes approximately 15.42 MW to the thermal violation.

CONTINGENCY '6781_B3_05BIERSR 345-1'
OPEN BRANCH FROM BUS 246888 TO BUS 246889 CKT 1 / 246888 05BIERSR 345 246889 05BIERSR 138 1
END

3. (AEP - AEP) The 05LATTAVL8-05BIERSRUN 69 kV line (from bus 243608 to bus 246893 ckt 1) loads from 98.11% to 136.83% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 24.33 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

Please refer to Appendix 3 for a table containing the generators having contribution to this flowgate.

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)

None

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

Instabilities were identified for the AC2-087 project connected at Buckskin 69 kV station for contingencies P4.05 and P4.07 due to the loss of the Buckskin – Petersburg – Highland and Buckskin – Lattaville – Biers Run 69 kV circuits, following two upgrades were made in the base case.

It was also observed that the AC2-087 plant is deficient in lagging power factor requirement by 15.27 MVAr. This may need to be addressed through reactive compensation.

The proposed upgrade to mitigate the instability is to add a second line (19.25 mile) from Buckskin to Highland 69 kV using 1033 ACSR conductor and AC2-087 is responsible for this upgrade. After applying the upgrade to the study case, all criteria were met for the contingencies tested.

Network Upgrade	Description	Cost Estimate
PJM Network Upgrade N6303	At Buckskin Substation install (2) 69kV CBs for a new line position with associated buswork. Construct the line exit for a new 69kV line to Highland.	$1.3M
PJM Network Upgrade N6304	At Highland Substation remove the existing 69-12 kV transformer #2 to free up space for the new line position. The transformer will be replaced with a new 138-12kV transformer served via the 138kV bus and install new 138kV circuit breaker for high-side protection. The DP&L Willmington line will need to be moved over to where the old 69-12kV Transformer #2 was. The Willmington Line will need a new 69kV breaker for its line termination. The new Buckskin Line #2 can be terminated where the Willmington line was (CB 64). There will be associated Protection & Control work.	$4.6M
PJM Network Upgrade N6305	Construct new 19.25-mile 69kV Buckskin–Highland #2 Line with steel H-frame construction using 1033 ACSR conductor.	$39M

Table 2

Short Circuit

(Summary of impacted circuit breakers)

New circuit breakers found to be over-duty:

None

TO Local Subtransmission System

Dayton identified the following constraints in which AC2-087 causes:

Thermal overloads and low voltages identified along the 69 kV path from Atlanta – Washington Courthouse – Texas Eastern Tap – Jeffersonville Tap for the loss of the Atlanta 345/69 kV transformer.

Affected System Analysis & Mitigation

LGEE Impacts:

None

MISO Impacts:

None

Duke, Progress & TVA Impacts:

None

OVEC Impacts:

None

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. (AEP - AEP) The 05BCKSKI-05LATTAVL8 69 kV line (from bus 243598 to bus 243608 ckt 1) loads from 98.14% to 143.08% (AC power flow) of its emergency rating (100 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 43.63 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

2. (AEP - AEP) The 05BCKSKI-05PETERSB8 69 kV line (from bus 243598 to bus 243612 ckt 1) loads from 163.71% to 240.96% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 41.37 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

3. (AEP - AEP) The 05BCKSKI-05PETERSB8 69 kV line (from bus 243598 to bus 243612 ckt 1) loads from 103.04% to 149.82% (AC power flow) of its normal rating (50 MVA) for non-contingency condition. This project contributes approximately 27.3 MW to the thermal violation.

4. (AEP - AEP) The 05BCKSKI-AC2-020 TAP 69 kV line (from bus 243598 to bus 932130 ckt 1) loads from 113.63% to 172.41% (AC power flow) of its emergency rating (72 MVA) for the

single line contingency outage of '413_B2_TOR9317'. This project contributes approximately 42.31 MW to the thermal violation.

CONTINGENCY '413_B2_TOR9317'
OPEN BRANCH FROM BUS 243598 TO BUS 243612 CKT 1 / 243598 05BCKSKI 69.0 243612 05PETERSB8 69.0 1
OPEN BRANCH FROM BUS 243606 TO BUS 243612 CKT 1 / 243606 05HIGHLA 69.0 243612 05PETERSB8 69.0 1
END

5. (AEP - AEP) The 05BCKSKI-AC2-020 TAP 69 kV line (from bus 243598 to bus 932130 ckt 1) loads from 85.58% to 127.93% (AC power flow) of its normal rating (72 MVA) for non-contingency condition. This project contributes approximately 28.58 MW to the thermal violation.

6. (AEP - AEP) The 05LATTAVL8-05BIERSRUN 69 kV line (from bus 243608 to bus 246893 ckt 1) loads from 192.26% to 278.41% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 43.63 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

7. (AEP - AEP) The 05LATTAVL8-05BIERSRUN 69 kV line (from bus 243608 to bus 246893 ckt 1) loads from 127.34% to 177.34% (AC power flow) of its normal rating (50 MVA) for non-contingency condition. This project contributes approximately 29.13 MW to the thermal violation.

8. (AEP - AEP) The 05PETERSB8-05HIGHLA 69 kV line (from bus 243612 to bus 243606 ckt 1) loads from 153.53% to 220.77% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 41.37 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

9. (AEP - AEP) The 05PETERSB8-05HIGHLA 69 kV line (from bus 243612 to bus 243606 ckt 1) loads from 96.37% to 130.87% (AC power flow) of its normal rating (50 MVA) for non-contingency condition. This project contributes approximately 27.3 MW to the thermal violation.

10. (AEP - AEP) The 05BIERSRUN-05SLATE 69 kV line (from bus 246893 to bus 243617 ckt 1) loads from 106.46% to 118.38% (AC power flow) of its emergency rating (50 MVA) for the

single line contingency outage of '6786_B2'. This project contributes approximately 7.02 MW to the thermal violation.

CONTINGENCY '6786_B2'
OPEN BRANCH FROM BUS 246889 TO BUS 246890 CKT 1 / 246889 05BIERSR 138 246890 05HOPETN 138 1
END

11. (AEP - DAY) The AC2-020 TAP-09GRNFLD 69 kV line (from bus 932130 to bus 253030 ckt 1) loads from 128.06% to 186.82% (AC power flow) of its emergency rating (72 MVA) for the single line contingency outage of '413_B2_TOR9317'. This project contributes approximately 42.31 MW to the thermal violation.

CONTINGENCY '413_B2_TOR9317'
OPEN BRANCH FROM BUS 243598 TO BUS 243612 CKT 1 / 243598 05BCKSKI 69.0 243612 05PETERSB8 69.0 1
OPEN BRANCH FROM BUS 243606 TO BUS 243612 CKT 1 / 243606 05HIGHLA 69.0 243612 05PETERSB8 69.0 1
END

12. (AEP - DAY) The AC2-020 TAP-09GRNFLD 69 kV line (from bus 932130 to bus 253030 ckt 1) loads from 96.17% to 138.37% (AC power flow) of its normal rating (72 MVA) for non-contingency condition. This project contributes approximately 28.58 MW to the thermal violation.

New System Reinforcements

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

1. To relieve the 05BCKSKI-05PETERSB8 69 kV line overload:

   8.5 miles of conductor will need to be rebuilt/reconductored, estimated cost $10.2 million. PJM Network Upgrade N5585.

   AC2-087 is responsible for this cost.

2. To relieve the 05LATTAVL8-05BIERSRUN 69 kV line overload: 12.2 miles of conductor will need to be rebuilt/reconductored, estimated cost $14.4 million. PJM Network Upgrade N5566.

   AC2-087 is responsible for this cost.

3. To relieve the Dayton identified thermal overloads and low voltages identified along the 69 kV path from Atlanta – Washington Courthouse – Texas Eastern Tap – Jeffersonville Tap:

   Washington Courthouse- Texas Eastern Tap 69kV: DP&L will reconductor the existing 69kV line using 1351 AAC conductor which will increase the line rating to 151/165 MVA. The estimated cost is $3,000,000. PJM Network Upgrade N6301.

Jeffersonville Tap- Texas Eastern Tap 69kV : DP&L will reconductor the existing 69kV line using 1351 AAC conductor and replace the existing 600A switch with a 1200A switch which will increase the line rating to 151/187 MVA. The estimated cost is $5,400,000. PJM Network Upgrade N6302.

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)

None

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 System Impact Study, the construction of the 85.0 MW (47.4 MW Capacity) solar generating facility of First Solar Development (PJM Project #AC2-087) will require the following additional interconnection charges shown in table 3 below. 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 First Solar Development generating facility.

Cost Breakdown for the Point of Interconnection (Buckskin 69 kV Substation)		
Attachment Cost	Expand Buckskin 69 kV Substation	**$1,500,000**
Non-Direct Connection Cost Estimate	69 kV Revenue Metering	**$200,000**
	Upgrade line protection and controls at the Buckskin 69 kV substation.	**$200,000**
	Construct new 19.25-mile 69kV Buckskin–Highland #2 Line with steel H-frame construction using 1033 ACSR conductor. PJM Network Upgrade N6305.	**$39,000,000**
	At Buckskin Substation install (2) 69kV CBs for a new line position with associated buswork. Construct the line exit for a new 69kV line to Highland. PJM Network Upgrade N6303.	**$1,300,000**
	At Highland Substation remove the existing 69-12 kV transformer #2 to free up space for the new line position. The transformer will be replaced with a new 138-12kV transformer served via the 138kV bus and install new 138kV circuit breaker for high-side protection. The DP&L Willmington line will need to be moved over to where the old 69-12kV Transformer #2 was. The Willmington Line will need a new 69kV breaker for its line termination. The new Buckskin Line #2 can be terminated where the Willmington line was (CB 64). There will be associated Protection & Control work. PJM Network Upgrade N6304.	**$4,600,000**
	8.5 miles of conductor will need to be rebuilt/reconductored, estimated cost $10.2 million. PJM Network Upgrade N5585.	**$10,200,000**
	To relieve the 05LATTAVL8-05BIERSRUN 69 kV line overload: 12.2 miles of conductor will need to be rebuilt/reconductored, estimated cost $14.4 million. PJM Network Upgrade N5566.	**$14,400,000**
	Washington Courthouse- Texas Eastern Tap 69kV: DP&L will reconductor the existing 69kV line using 1351 AAC conductor which will increase the line rating to 151/165 MVA. The estimated cost is $3,000,000. PJM Network Upgrade N6301.	**$3,000,000**
	Jeffersonville Tap- Texas Eastern Tap 69kV : DP&L will reconductor the existing 69kV line using 1351 AAC conductor and replace the existing 600A switch with a 1200A switch which will increase the line rating to 151/187 MVA. The estimated cost is $5,400,000. PJM Network Upgrade N6302.	**$5,400,000**
	Total Estimated Cost for Project AC2-087	**$79,800,000**

Table 3

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.

Figure 1: Point of Interconnection (Buckskin 69 kV Substation)

Single Line Diagram

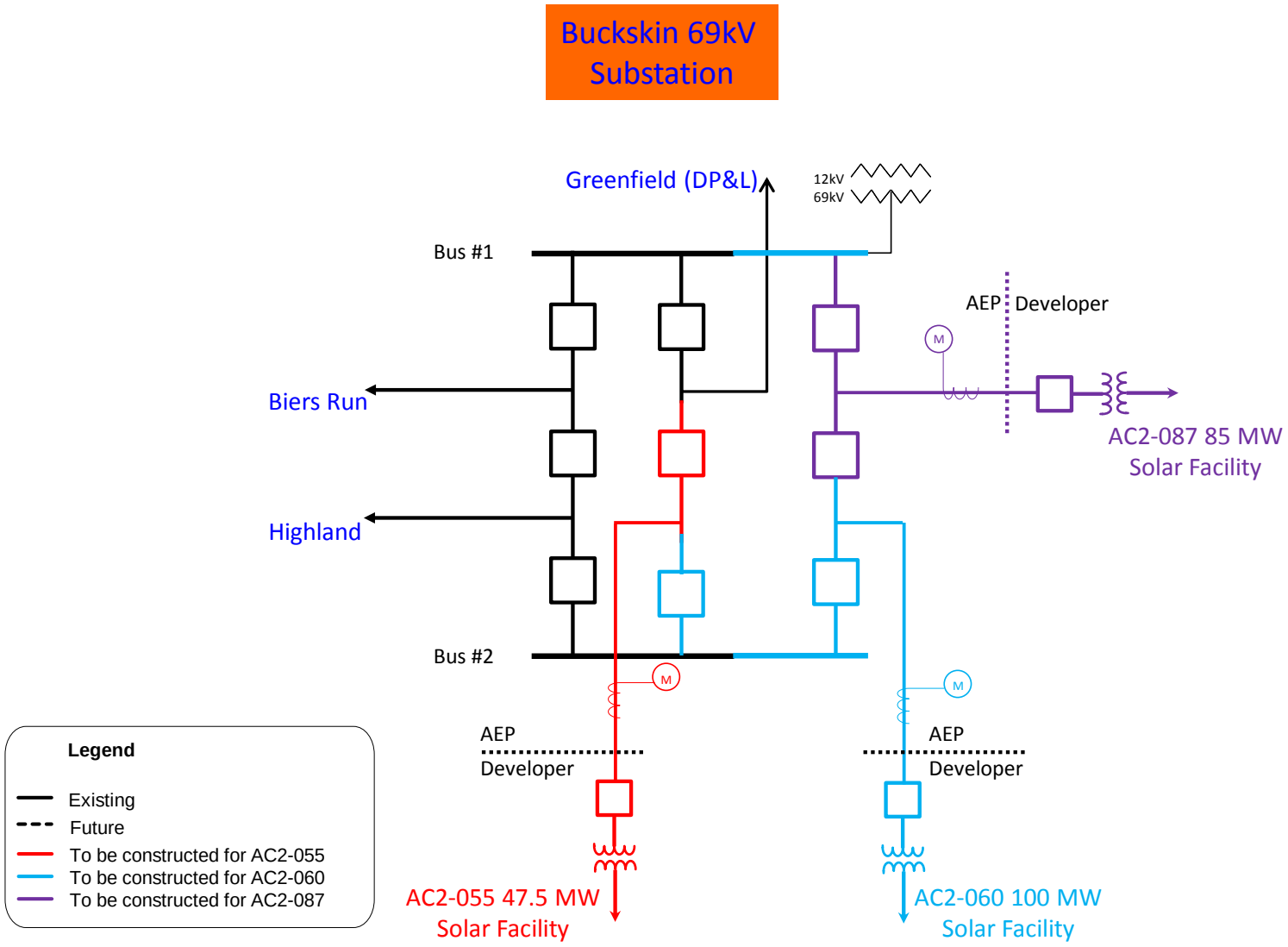
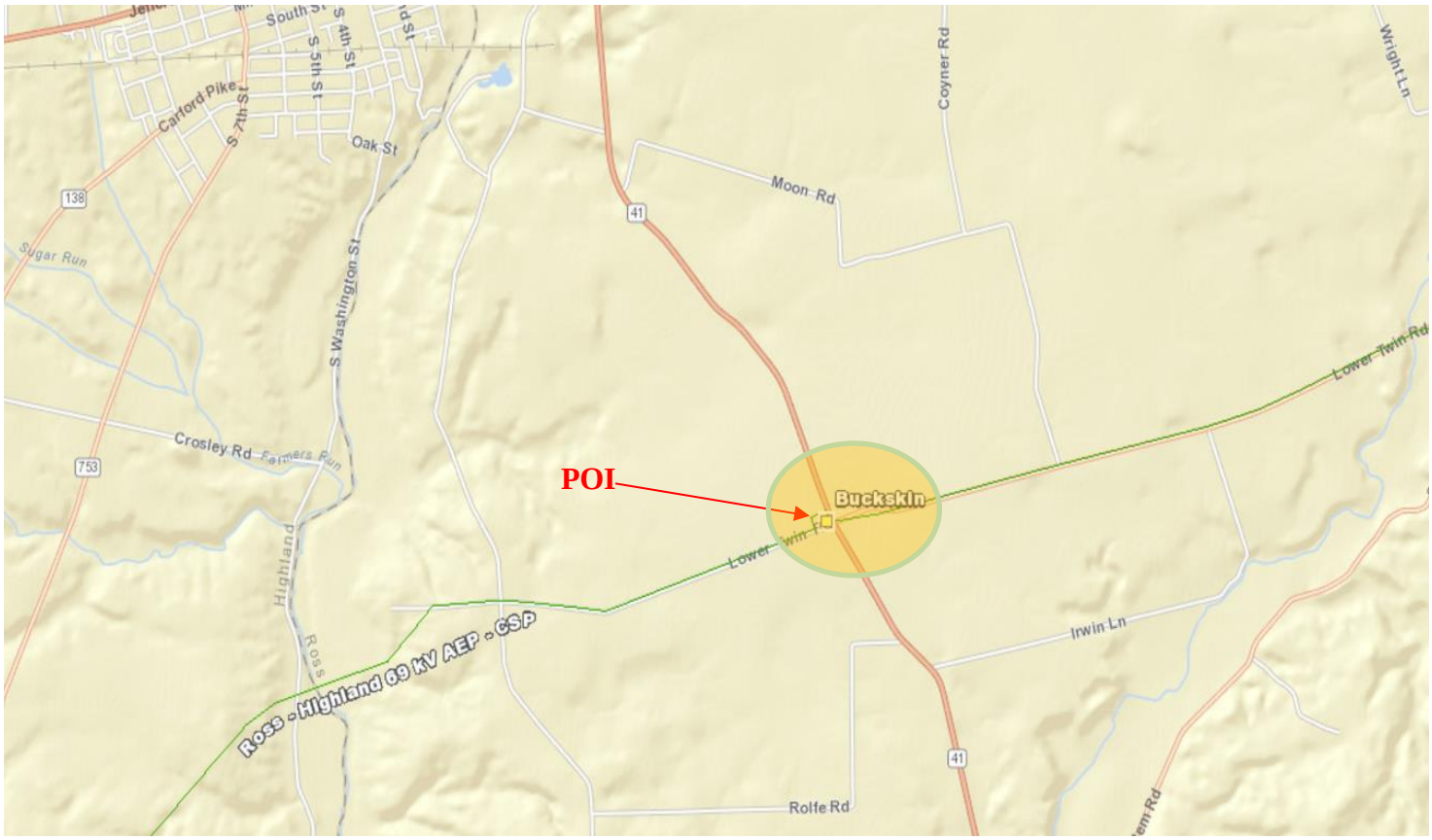


Figure 2: Point of Interconnection (Buckskin 69 kV Substation)



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

(AEP - AEP) The 05BCKSKI-05PETERSB8 69 kV line (from bus 243598 to bus 243612 ckt 1) loads from 78.48% to 115.48% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 23.07 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

Bus Number	*Bus Name*	*Full Contribution*
~~*932131*~~	~~*AC2-020 C*~~	~~*3.7*~~
932381	*AC2-055 C O1*	*8.78*
932421	*AC2-060 C*	*31.15*
932651	*AC2-087 C O1*	*23.07*

Appendix 3

(AEP - AEP) The 05LATTAVL8-05BIERSRUN 69 kV line (from bus 243608 to bus 246893 ckt 1) loads from 98.11% to 136.83% (AC power flow) of its emergency rating (50 MVA) for the single line contingency outage of '412_B2_TOR13998_WOMOAB_B'. This project contributes approximately 24.33 MW to the thermal violation.

CONTINGENCY '412_B2_TOR13998_WOMOAB_B'
OPEN BRANCH FROM BUS 253030 TO BUS 932130 CKT 1 / 932130 AC2-020 TAP 69.0 253030 09GRNFLD 69.0 1
END

Bus Number	*Bus Name*	*Full Contribution*
~~*932131*~~	~~*AC2-020 C*~~	~~*3.9*~~
932381	*AC2-055 C O1*	*9.27*
932421	*AC2-060 C*	*32.85*
932651	*AC2-087 C O1*	*24.33*