PJM Generator Interconnection Request
Queue AB1-006
Olive-Dequine 345 kV
Feasibility Study Report

April 2016

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.

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General

The Interconnection Customer (IC) proposes to install a 200 MW (26 MW Capacity) wind generating facility on the American Electric Power (AEP) Transmission System. The proposed PJM Project #AB1-006 will connect to the existing Meadow Lake 345 kV substation. The proposed location of the generating facilities is located in White County, Indiana.

The requested in-service date is 12/15/2017.

The objective of this Feasibility Study is to determine budgetary cost estimates and approximate construction timelines for identified transmission facilities required to connect the proposed generating facilities to the AEP Transmission System. These reinforcements include the Attachment Facilities, Local Upgrades, and Network Upgrades required to maintain the reliability of the AEP Transmission System. Stability analysis is not included as part of this study.

Attachment Facilities

The one-line supplied shows creation of a four-terminal line, which is not acceptable to AEP.

Therefore, AEP recommends that AB1-006 interconnect utilizing one of several options:

- Add a new breaker facing the Meadow Lake station at the common connection point of the three projects; or,
- Provide a separate generator lead to connect to an open position at the Meadow Lake 345 kV substation.

Station Cost:

- No significant AEP work is required if a breaker facing Meadow Lake is installed at the customer end of the common generator lead.

Protection and Relay Cost:

- Feasibility Studies only include a very high level review of Protection and Control (P&C) requirements. A more thorough review will be conducted during the System Impact Study stage. However AEP Protection & Controls Engineering has indicated that a four-terminal line is not acceptable.

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Network Impacts

The Queue Project AB1-006 was evaluated as a 200.0 MW (Capacity 26.0 MW) injection at the Meadow Lake 345 kV substation in the AEP area. Project AB1-006 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB1-006 was studied with a commercial probability of 53%. Potential network impacts were as follows:

Summer Peak Analysis - 2019

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)

AB1-006 Multiple Facility Contingency – Table 1A

#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
1	LFFB	6189_C2_05HANG R 765-D1	AEP - OVEC	05JEFRSO-06CLIFTY 345 kV line	242865	248000	Z1	DC	89.41	90.74	ER	2354	27.28	1

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

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)

AB1-006 Contribution to Previously Identified Overloads – Table 2A

#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
1	LFFB	8648_C2_05JEFRSO 765-B1	AEP - MISO NIPS	05MEADOW-17REYNOLDS 345 kV line	243878	255205	1	DC	138.11	144.27	ER	1918	118.1	2
2	N-1	363_B2_TOR1682	AEP - MISO NIPS	05MEADOW-17REYNOLDS 345 kV line	243878	255205	1	DC	121.37	122.46	NR	1409	15.45	
3	LFFB	7444_C2_05DUMONT 765-A2	MISO NIPS - AEP	17HIPLE-05COLNGW 345 kV line	255105	243214	1	DC	103.25	103.3	ER	1409	16.16	3

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AB1-006 Contribution to Previously Identified Overloads – Table 2A															
#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.	FG App.
4	LFFB	2978_C2_05DUMONT 765-B_A	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	909144	243219	2	DC	111.51	112.22	ER	1409	22.27	4
5	LFFB	112-65-BT4-5__	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	909144	243219	2	DC	101.04	101.6	ER	1409	17.72	
6	LFFB	112-65-BT3-4__	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	909144	243219	2	DC	101.03	101.59	ER	1409	17.72	
7	N/A	'8808_B2'	AEP - MISO NIPS	05MEADOW-17REYNOLDS 345 kV line	243878	255205		DC	101.11	102.36	Norm	1409	17.64	

Affected System Analysis & Mitigation

To be determined in the System Impact Study

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.

AB1-006 Delivery of Energy Portion of Interconnection Request – Table 3A													
#	Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	PF	Loading Initial	Loading Final	Rating Type	Rating MVA	MW Con.
1	N-1	363_B2_TOR1682	AEP - MISO DEM	05EUGENE-08CAYSUB 345 kV line	243221	249504	1	DC	92.17	92.7	NR	1374	15.97
2	N-1	8695_B2	AEP - AEP	05MEADOW-05OLIVE 345 kV line	243878	243229	1	DC	118.78	125.49	NR	971	65.21
3	N-1	363_B2_TOR1682	AEP - MISO NIPS	05MEADOW-17REYNOLDS 345 kV line	243878	255205	1	DC	181.84	190.27	NR	1409	118.85
4	N-1	7442_B2_TOR200545	MISO NIPS - AEP	17HIPLE-05COLNGW 345 kV line	255105	243214	1	DC	102.08	102.12	NR	1409	15.81
5	N-1	695_B2	AEP - AEP	X2-052 TAP-05DUMONT 345 kV line	909144	243219	2	DC	100.88	101.45	NR	1409	17.72

Light Load Analysis - 2019

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

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System Reinforcements

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

None

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined

New System Reinforcements

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

#	Contingency Name	Contingency Description	Facility Description	Limiting element	Mitigation and Cost	Schedule
1	LFFB	6189_C2_05HANG R 765-D1	05JEFRSO-06CLIFTY 345 kV line	To Be determined	Reinforcement: A Sag Study will be required on the 0.75 mile section of line to mitigate the overload on the Jefferson - Clifty Creek 345 kV line. Depending on the sag study results, cost for this upgrade is expected to be between $4,000 (no remediation required just sag study) and $2.0 million (complete line rebuild required). This is an AEP-OVEC tie line therefore; PJM is going to have to coordinate this upgrade with OVEC as well to make sure that their equipment will not set a limit lower than what is specified here.	Depending on the sag study results, cost for this upgrade is expected to be between $4,000 (no remediation required just sag study) and $2.0 million (complete line rebuild required).

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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)

#	Contingency Name	Contingency Description	Facility Description	Limiting element	Mitigation and Cost	Schedule
1	CONTINGENCY '8648_C2_05JEFRSO 765-B'	OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1 OPEN BRANCH FROM BUS 243208 TO BUS 242865 CKT 1 / 243208 05JEFRSO 765 242865 05JEFRSO 345 1 OPEN BRANCH FROM BUS 242865 TO BUS 248000 CKT Z1 / 242865 05JEFRSO 345 248000 06CLIFTY 345 Z1 END	(AEP - MISO NIPS) The 05MEADOW-17REYNOLDS 345 kV line (from bus 243878 to bus 255205 ckt 1) loads from 138.11% to 144.27% (DC power flow) of its emergency rating (1918 MVA) for the line fault with failed breaker contingency outage of '8648_C2_05JEFRSO 765-B1'. This project contributes approximately 118.1 MW to the thermal violation.	Based on our current record, limiting element is: Three-954 ACSR Cardinal conductor	AEP is in the process of rebuilding the Meadow Lake – Reynolds 345 kV line. The rebuild is expected to be completed by mid-2018 provided there are no outage cancelations.	Provided there are no outage cancelations, the rebuild is expected to be completed by mid-2018. The rebuild cannot be advanced.
2	'363_B2_TOR1682'	CONTINGENCY '363_B2_TOR1682' OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1 END	(AEP - MISO NIPS) The 05MEADOW-17REYNOLDS 345 kV line (from bus 243878 to bus 255205 ckt 1) loads from 121.37% to 122.46% (DC power flow) of its normal rating (1409 MVA) for the single line contingency outage of '363_B2_TOR1682'. This project contributes approximately 15.45 MW to the thermal violation.	Based on our current record, limiting element is: Meadow Lake Wavetrap (3000A).	AEP is in the process of rebuilding the Meadow Lake – Reynolds 345 kV line. The rebuild is expected to be completed by mid-2018 provided there are no outage cancelations.	Provided there are no outage cancelations, the rebuild is expected to be completed by mid-2018. The rebuild cannot be advanced.
3	'7444_C2_05DUMONT 765-A2'	CONTINGENCY '7444_C2_05DUMONT 765-A2' OPEN BRANCH FROM BUS 243206 TO BUS 246999 CKT 1 / 243206 05DUMONT 765 246999 05SORENS 765 1 OPEN BRANCH FROM BUS 243206 TO BUS 243219 CKT 2 / 243206 05DUMONT 765 243219 05DUMONT 345 2 OPEN BRANCH FROM BUS 243219 TO BUS 909144 CKT 2 / 243219 05DUMONT 345 909144 X2-052 TAP 345 2 END	(MISO NIPS - AEP) The 17HIPLE-05COLNGW 345 kV line (from bus 255105 to bus 243214 ckt 1) loads from 103.25% to 103.3% (DC power flow) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '7444_C2_05DUMONT 765-A2'. This project contributes approximately 16.17 MW to the thermal violation.	ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1	A Sag Study will be required on the 33.46 mile section of line to mitigate the overload on the Collingwood - Hiple 345 kV line. Depending on the sag study results, cost for this upgrade is expected to be between $133,840 (no remediation required just sag study) and $67 million (complete line rebuild required). This is an AEP-NIPSCO tie line therefore, PJM is going to have to coordinate this upgrade with NIPSCO as well to make sure that their equipment will not set a limit lower than what is specified here.	(1) Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 36 to 48 months after signing an interconnection agreement.

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#	Contingency Name	Contingency Description	Facility Description	Limiting element	Mitigation and Cost	Schedule
4	'2978_C2_05DUMONT 765-B_A'	CONTINGENCY '2978_C2_05DUMONT 765-B_A' OPEN BRANCH FROM BUS 243206 TO BUS 907040 CKT 1 / 243206 05DUMONT 765 907040 X1-020 TAP 765 1 OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1 END	(AEP - AEP) The X2-052 TAP-05DUMONT 345 kV line (from bus 909144 to bus 243219 ckt 2) loads from 111.51% to 112.22% (DC power flow) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '2978_C2_05DUMONT 765-B_A'. This project contributes approximately 22.27 MW to the thermal violation.	The ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1	A sag check will be required for the ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1 to determine if the line section can be operated above its emergency rating of 1409 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 14 mile section of line would need to be rebuilt. Estimated Cost for the Sag Study: $56,000. If deemed necessary to rebuild section of line, Estimated Cost: $28,000,000.	(1) Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 36 to 48 months after signing an interconnection agreement.
5	CONTINGENCY '112-65-BT4-5__'	TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765 TRIP BRANCH FROM BUS 275233 TO BUS 270644 CKT 1 / WILTO;4M 345 WILTO; 765 TRIP BRANCH FROM BUS 275233 TO BUS 270927 CKT 1 / WILTO;4M 345 WILTO; R 345 TRIP BRANCH FROM BUS 275233 TO BUS 275333 CKT 1 / WILTO;4M 345 WILTO;4C 33 END	(AEP - AEP) The X2-052 TAP-05DUMONT 345 kV line (from bus 909144 to bus 243219 ckt 2) loads from 101.04% to 101.6% (DC power flow) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '112-65-BT4-5__'. This project contributes approximately 17.72 MW to the thermal violation.	The ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1	A sag check will be required for the ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1 to determine if the line section can be operated above its emergency rating of 1409 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 14 mile section of line would need to be rebuilt. Estimated Cost for the Sag Study: $56,000. If deemed necessary to rebuild section of line, Estimated Cost: $28,000,000.	(1) Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 36 to 48 months after signing an interconnection agreement.

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#	Contingency Name	Contingency Description	Facility Description	Limiting element	Mitigation and Cost	Schedule
6	CONTINGENCY '112-65-BT3-4__'	TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765 TRIP BRANCH FROM BUS 275232 TO BUS 270644 CKT 1 / WILTO;3M 345 WILTO; 765 TRIP BRANCH FROM BUS 275232 TO BUS 270926 CKT 1 / WILTO;3M 345 WILTO; B 345 TRIP BRANCH FROM BUS 275232 TO BUS 275332 CKT 1 / WILTO;3M 345 WILTO;3C 33 END	(AEP - AEP) The X2-052 TAP-05DUMONT 345 kV line (from bus 909144 to bus 243219 ckt 2) loads from 101.03% to 101.59% (DC power flow) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '112-65-BT3-4__'. This project contributes approximately 17.72 MW to the thermal violation.	The ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1	A sag check will be required for the ACSR ~ 954 ~ 45/7 ~ RAIL Conductor Section 1 to determine if the line section can be operated above its emergency rating of 1409 MVA. The result could prove that no additional upgrades are necessary, that some upgrades on the circuit are necessary, or that the entire 14 mile section of line would need to be rebuilt. Estimated Cost for the Sag Study: $56,000. If deemed necessary to rebuild section of line, Estimated Cost: $28,000,000.	(1) Sag Study: 6 to 12 months. (2) Rebuild: The standard time required for construction differs from state to state. An approximate construction time would be 36 to 48 months after signing an interconnection agreement.
7	'8808_B2'	CONTINGENCY '8808_B2' OPEN BRANCH FROM BUS 243229 TO BUS 243878 CKT 1 / 243229 05OLIVE 345 243878 05MEADOW 345 1 END	(AEP - MISO NIPS) The 05MEADOW-17REYNOLDS 345 kV line (from bus 243878 to bus 255205 ckt 1) loads from 101.11% to 102.36% (DC power flow) of its normal rating (1409 MVA) for the single line contingency outage of '8808_B2'. This project contributes approximately 17.64 MW to the thermal violation.	Based on our current record, limiting element is: Meadow Lake Wavetrap (3000A).	AEP is in the process of rebuilding the Meadow Lake – Reynolds 345 kV line. The rebuild is expected to be completed by mid-2018 provided there are no outage cancelations.	Provided there are no outage cancelations, the rebuild is expected to be completed by mid-2018. The rebuild cannot be advanced.

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Conclusion

Based upon the results of this Feasibility Study, the construction of the 200 MW wind generating facility of INTERCONNECTION CUSTOMER (PJM Project #AB1-006) will require the following additional interconnection charges. This plan of service will interconnect the proposed wind generating facility in a manner that will provide operational reliability and flexibility to both the AEP system and the INTERCONNECTION CUSTOMER wind generating facility.

Estimated Direct Connection Cost: To be determined in System Impact Study

- **AEP Protection and Control (P&C) has rejected the IC's proposed direct connection. Costs will be estimated once the IC elects either Option 1 or Option 2 as proposed by AEP in the "Attachment Facilities" section of this report.**

Estimated Local/Network Upgrade Cost: $189,840 to $95,000,000*

- **The $189,840 is the estimated cost for the sag studies. The $95M cost is the worst case scenario which assumes that the sag study results require all lines to be reconductored.**

The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. The cost of remediation for the sag study and line reconductoring is not included in this estimate. Final estimates will require an on-site review and coordination to determine final construction requirements.

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Additional Interconnection Customer Responsibilities:

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.

3. The Interconnection Customer seeking to interconnect a wind generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per item 5.iv. of Schedule H to the Interconnection Service Agreement.

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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.

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Appendix 1

(AEP - OVEC) The 05JEFRSO-06CLIFTY 345 kV line (from bus 242865 to bus 248000 ckt Z1) loads from 89.41% to 90.74% (**DC power flow**) of its emergency rating (2354 MVA) for the line fault with failed breaker contingency outage of '6189_C2_05HANG R 765-D1'. This project contributes approximately 27.28 MW to the thermal violation.

CONTINGENCY '6189_C2_05HANG R 765-D1'
OPEN BRANCH FROM BUS 242921 TO BUS 242924 CKT 1 / 242921 05CORNU 765 242924 05HANG R 765 1
OPEN BRANCH FROM BUS 242924 TO BUS 243208 CKT 1 / 242924 05HANG R 765 243208 05JEFRSO 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
243441	*05CKG2*	*9.72*
243859	*05FR-11G C*	*0.22*
247900	*05FR-11G E*	*10.35*
243862	*05FR-12G C*	*0.22*
247901	*05FR-12G E*	*10.18*
243864	*05FR-21G C*	*0.23*
247902	*05FR-21G E*	*10.88*
243866	*05FR-22G C*	*0.22*
247903	*05FR-22G E*	*10.42*
243870	*05FR-3G C*	*0.45*
247904	*05FR-3G E*	*21.1*
243873	*05FR-4G C*	*0.35*
247905	*05FR-4G E*	*15.86*
246909	*05MDL-1G C*	*0.46*
247906	*05MDL-1G E*	*21.78*
246910	*05MDL-2G C*	*0.23*
247907	*05MDL-2G E*	*10.8*
246976	*05MDL-3G C*	*0.23*
247912	*05MDL-3G E*	*11.29*
246979	*05MDL-4G C*	*0.46*
247913	*05MDL-4G E*	*10.77*
243442	*05RKG1*	*35.61*
243443	*05RKG2*	*35.07*
927171	*G798 C*	*0.92*
884780	*S-058 C*	*36.62*
884782	*S-058 C1*	*36.62*
884781	*S-058 E*	*120.74*
884783	*S-058 E1*	*120.74*
890570	*U3-026 C1*	*25.74*
890571	*U3-026 C2*	*25.74*

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247523	*U4-039 C*	*15.56*
247927	*U4-039 E*	*104.13*
907041	*X1-020 C*	*30.61*
907042	*X1-020 E*	*204.82*
909145	*X2-052*	*70.58*
900404	*X3-028 C*	*254.06*
900405	*X3-028 E*	*338.74*
915151	*Y3-038*	*11.43*
915662	*Y3-099 E*	*0.25*
915672	*Y3-100 E*	*0.25*
LTF	*Z1-043*	*25.25*
916091	*Z1-051 C*	*8.92*
916092	*Z1-051 E*	*2.04*
916182	*Z1-065 E*	*0.67*
LTF	*Z1-070*	*104.82*
916272	*Z1-080 E*	*0.52*
LTF	*Z1-112*	*8.46*
LTF	*AA1-001*	*4.92*
LTF	*AA1-071*	*5.64*
918802	*AA1-099 E*	*0.35*
919591	*AA2-035 C OP*	*106.65*
919592	*AA2-035 E OP*	*8.27*
LTF	*AA2-038*	*29.07*
930041	*AB1-006 C*	*3.55*
930042	*AB1-006 E*	*23.73*
930391	*AB1-080*	*4.18*
930461	*AB1-087 C OP*	*93.47*
930462	*AB1-087 E OP*	*4.25*
930471	*AB1-088 C OP*	*93.47*
930472	*AB1-088 E OP*	*4.25*

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Appendix 2

(AEP - MISO NIPS) The 05MEADOW-17REYNOLDS 345 kV line (from bus 243878 to bus 255205 ckt 1) loads from 138.11% to 144.27% (**DC power flow**) of its emergency rating (1918 MVA) for the line fault with failed breaker contingency outage of '8648_C2_05JEFRSO 765-B1'. This project contributes approximately 118.1 MW to the thermal violation.

CONTINGENCY '8648_C2_05JEFRSO 765-B1'
OPEN BRANCH FROM BUS 243208 TO BUS 243209 CKT 1 / 243208 05JEFRSO 765 243209 05ROCKPT 765 1
OPEN BRANCH FROM BUS 243208 TO BUS 242865 CKT 1 / 243208 05JEFRSO 765 242865 05JEFRSO 345 1
OPEN BRANCH FROM BUS 242865 TO BUS 248000 CKT Z1 / 242865 05JEFRSO 345 248000 06CLIFTY 345 Z1
END

Bus Number	*Bus Name*	*Full Contribution*
243859	*05FR-11G C*	*0.82*
247900	*05FR-11G E*	*38.44*
243862	*05FR-12G C*	*0.8*
247901	*05FR-12G E*	*37.8*
243864	*05FR-21G C*	*0.86*
247902	*05FR-21G E*	*40.4*
243866	*05FR-22G C*	*0.82*
247903	*05FR-22G E*	*38.69*
243870	*05FR-3G C*	*1.66*
247904	*05FR-3G E*	*78.35*
243873	*05FR-4G C*	*1.29*
247905	*05FR-4G E*	*58.91*
246909	*05MDL-1G C*	*2.01*
247906	*05MDL-1G E*	*94.3*
246910	*05MDL-2G C*	*1.*
247907	*05MDL-2G E*	*46.77*
246976	*05MDL-3G C*	*1.*
247912	*05MDL-3G E*	*48.89*
246979	*05MDL-4G C*	*2.01*
247913	*05MDL-4G E*	*46.65*
243442	*05RKG1*	*18.61*
243443	*05RKG2*	*18.33*
927331	*J196 C*	*1.1*
927332	*J196 E*	*4.41*
927621	*J333*	*17.94*
927631	*J334*	*20.74*
900404	*X3-028 C*	*249.09*

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900405	*X3-028 E*	*332.12*
915151	*Y3-038*	*5.98*
LTF	*Z1-007*	*5.09*
LTF	*Z1-029*	*3.12*
LTF	*Z1-070*	*71.53*
LTF	*AA1-001*	*5.14*
930041	*AB1-006 C*	*15.35*
930042	*AB1-006 E*	*102.75*
LTF	*AB1-023*	*6.18*
930461	*AB1-087 C OP*	*91.33*
930462	*AB1-087 E OP*	*4.15*
930471	*AB1-088 C OP*	*91.33*
930472	*AB1-088 E OP*	*4.15*

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Appendix 3

(MISO NIPS - AEP) The 17HIPLE-05COLNGW 345 kV line (from bus 255105 to bus 243214 ckt 1) loads from 103.25% to 103.3% (**DC power flow**) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '7444_C2_05DUMONT 765-A2'. This project contributes approximately 16.16 MW to the thermal violation.

CONTINGENCY '7444_C2_05DUMONT 765-A2'
OPEN BRANCH FROM BUS 243206 TO BUS 246999 CKT 1 / 243206 05DUMONT 765 246999 05SORENS 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 243219 CKT 2 / 243206 05DUMONT 765 243219 05DUMONT 345 2
OPEN BRANCH FROM BUS 243219 TO BUS 909144 CKT 2 / 243219 05DUMONT 345 909144 X2-052 TAP 345 2
END

Bus Number	*Bus Name*	*Full Contribution*
247900	*05FR-11G E*	*5.75*
247901	*05FR-12G E*	*5.65*
247902	*05FR-21G E*	*6.04*
247903	*05FR-22G E*	*5.78*
247904	*05FR-3G E*	*11.72*
247905	*05FR-4G E*	*8.81*
247906	*05MDL-1G E*	*12.91*
247907	*05MDL-2G E*	*6.4*
247912	*05MDL-3G E*	*6.69*
247913	*05MDL-4G E*	*6.38*
275146	*BOONE HTG;1E*	*5.54*
274883	*BOONE HTG;1U*	*1.39*
275145	*BOONE HTG;2E*	*5.54*
274884	*BOONE HTG;2U*	*1.39*
246431	*BUCHANAN*	*0.36*
274890	*CAYUG;1U E*	*7.98*
274891	*CAYUG;2U E*	*7.98*
274859	*EASYR;U1 E*	*6.47*
274860	*EASYR;U2 E*	*6.47*
246397	*ELKHARTH*	*0.47*
290051	*GSG-6; E*	*6.08*
275149	*KEMPTON ;1E*	*10.81*
274881	*KEMPTON ;1U*	*2.7*
290108	*LEEDK;1U E*	*14.03*
274850	*MENDOTA H;RU*	*3.5*
275148	*MILKS GRV;1E*	*10.81*
274880	*MILKS GRV;1U*	*2.7*
246536	*MOTTVILL*	*0.2*

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293061	*N-015 E*	*8.86*
293644	*O-022 E1*	*5.97*
293645	*O-022 E2*	*11.58*
293715	*O-029 E*	*5.33*
293716	*O-029 E*	*2.92*
293717	*O-029 E*	*2.69*
290021	*O-050 E*	*11.25*
294392	*P-010 E*	*11.25*
294763	*P-046 E*	*5.47*
274830	*PWR VTREC;1U*	*3.52*
274831	*PWR VTREC;2U*	*3.52*
274722	*S-055 E*	*6.44*
884780	*S-058 C*	*25.18*
884782	*S-058 C1*	*25.18*
884781	*S-058 E*	*83.01*
884783	*S-058 E1*	*83.01*
295111	*SUBLETTE E*	*1.58*
890570	*U3-026 C1*	*17.69*
890571	*U3-026 C2*	*17.69*
900371	*V4-046*	*1.38*
900381	*V4-047*	*1.38*
900391	*V4-048*	*1.54*
900401	*V4-049*	*1.54*
903432	*W3-046*	*3.71*
903434	*W3-046*	*3.44*
903435	*W3-046*	*3.71*
903436	*W3-046*	*3.44*
274873	*WALNR;1U*	*1.41*
294500	*WALNR;1U E*	*5.64*
274874	*WALNR;2U*	*1.41*
294502	*WALNR;2U E*	*5.64*
295109	*WESTBROOK E*	*3.25*
909145	*X2-052*	*57.74*
910542	*X3-005 E*	*0.44*
914321	*Y2-103*	*25.76*
915011	*Y3-013 1*	*2.15*
915021	*Y3-013 2*	*2.15*
915031	*Y3-013 3*	*2.15*
915041	*Y3-023*	*0.04*
915601	*Y3-088*	*1.48*
915611	*Y3-089*	*1.48*
915621	*Y3-090*	*1.48*
915631	*Y3-091*	*1.48*
LTF	*Z1-043*	*17.33*
916091	*Z1-051 C*	*6.1*

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916092	*Z1-051 E*	*1.4*
LTF	*Z1-070*	*58.08*
916221	*Z1-073*	*0.42*
916502	*Z1-106 E1*	*0.72*
916504	*Z1-106 E2*	*0.72*
916512	*Z1-107 E*	*1.49*
916522	*Z1-108 E*	*1.43*
LTF	*Z1-112*	*6.07*
916651	*Z1-127 1*	*1.02*
916652	*Z1-127 2*	*0.51*
917451	*Z2-081*	*0.94*
917531	*Z2-090 C*	*0.03*
917532	*Z2-090 E*	*0.32*
917701	*Z2-113 C*	*0.19*
917702	*Z2-113 E*	*0.19*
917711	*Z2-114 C*	*0.22*
917712	*Z2-114 E*	*0.22*
917731	*Z2-116 C*	*0.12*
917732	*Z2-116 E*	*0.12*
918051	*AA1-018 C OP*	*1.42*
918052	*AA1-018 E OP*	*9.47*
918251	*AA1-040 1*	*0.73*
918261	*AA1-040 2*	*0.73*
LTF	*AA1-071*	*4.04*
918611	*AA1-078*	*1.55*
918972	*AA1-116 E*	*1.54*
918982	*AA1-117 E*	*1.54*
919071	*AA1-129*	*1.96*
919221	*AA1-146*	*10.45*
919581	*AA2-030 C*	*10.45*
919582	*AA2-030 E*	*2.2*
919591	*AA2-035 C OP*	*73.32*
919592	*AA2-035 E OP*	*5.68*
LTF	*AA2-038*	*20.91*
919811	*AA2-067 OP*	*0.7*
920112	*AA2-107 E*	*1.41*
920211	*AA2-116*	*108.27*
920272	*AA2-123 E*	*1.41*
930041	*AB1-006 C*	*2.1*
930042	*AB1-006 E*	*14.06*
930381	*AB1-079*	*0.81*
930391	*AB1-080*	*3.42*
930442	*AB1-085 E*	*1.45*
930481	*AB1-089 C*	*38.68*
930482	*AB1-089 E*	*1.76*

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930491	*AB1-090 C*	*38.68*
930492	*AB1-090 E*	*1.76*
930501	*AB1-091 C OP*	*42.58*
930502	*AB1-091 E OP*	*1.94*
930751	*AB1-121*	*132.56*
930761	*AB1-122 1*	*26.26*
930762	*AB1-122 2*	*26.26*
930763	*AB1-122 3*	*29.37*
930852	*AB1-131 E*	*0.45*
930972	*AB1-146 E*	*0.14*
931201	*AB1-170 C OP*	*2.7*
931202	*AB1-170 E OP*	*16.3*
931221	*AB1-172*	*0.46*

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Appendix 4

(AEP - AEP) The X2-052 TAP-05DUMONT 345 kV line (from bus 909144 to bus 243219 ckt 2) loads from 111.51% to 112.22% (**DC power flow**) of its emergency rating (1409 MVA) for the line fault with failed breaker contingency outage of '2978_C2_05DUMONT 765-B_A'. This project contributes approximately 22.27 MW to the thermal violation.

CONTINGENCY '2978_C2_05DUMONT 765-B_A'
OPEN BRANCH FROM BUS 243206 TO BUS 907040 CKT 1 / 243206 05DUMONT 765 907040 X1-020 TAP 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1
END

Bus Number	*Bus Name*	*Full Contribution*
247900	*05FR-11G E*	*7.67*
247901	*05FR-12G E*	*7.55*
247902	*05FR-21G E*	*8.07*
247903	*05FR-22G E*	*7.72*
247904	*05FR-3G E*	*15.64*
247905	*05FR-4G E*	*11.76*
247906	*05MDL-1G E*	*17.78*
247907	*05MDL-2G E*	*8.82*
247912	*05MDL-3G E*	*9.22*
247913	*05MDL-4G E*	*8.8*
274832	*ANNAWAN ; 1U*	*7.27*
275146	*BOONE HTG;1E*	*6.06*
274883	*BOONE HTG;1U*	*1.51*
275145	*BOONE HTG;2E*	*6.06*
274884	*BOONE HTG;2U*	*1.51*
294401	*BSHIL;1U E*	*5.75*
294410	*BSHIL;2U E*	*5.75*
274890	*CAYUG;1U E*	*8.61*
274891	*CAYUG;2U E*	*8.61*
274849	*CRESCENT ;1U*	*3.95*
274859	*EASYR;U1 E*	*7.09*
274860	*EASYR;U2 E*	*7.09*
290051	*GSG-6; E*	*6.65*
275149	*KEMPTON ;1E*	*11.34*
274881	*KEMPTON ;1U*	*2.84*
990901	*L-005 E*	*8.52*
290108	*LEEDK;1U E*	*15.34*
274850	*MENDOTA H;RU*	*3.82*
275148	*MILKS GRV;1E*	*11.34*

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274880	*MILKS GRV;1U*	*2.84*
293061	*N-015 E*	*9.77*
293516	*O-009 E1*	*5.98*
293517	*O-009 E2*	*3.04*
293518	*O-009 E3*	*3.34*
293644	*O-022 E1*	*6.38*
293645	*O-022 E2*	*12.39*
293715	*O-029 E*	*6.39*
293716	*O-029 E*	*3.5*
293717	*O-029 E*	*3.22*
293771	*O-035 E*	*4.3*
290021	*O-050 E*	*12.3*
294392	*P-010 E*	*12.4*
294763	*P-046 E*	*5.99*
274830	*PWR VTREC;1U*	*3.85*
274831	*PWR VTREC;2U*	*3.85*
274722	*S-055 E*	*7.03*
884780	*S-058 C*	*27.48*
884782	*S-058 C1*	*27.48*
884781	*S-058 E*	*90.61*
884783	*S-058 E1*	*90.61*
295111	*SUBLETTE E*	*1.73*
890570	*U3-026 C1*	*19.32*
890571	*U3-026 C2*	*19.32*
274814	*UNIV PK N;0U*	*0.42*
274805	*UNIV PK N;1U*	*0.42*
274806	*UNIV PK N;2U*	*0.42*
274807	*UNIV PK N;3U*	*0.42*
274808	*UNIV PK N;4U*	*0.42*
274809	*UNIV PK N;5U*	*0.42*
274810	*UNIV PK N;6U*	*0.42*
274811	*UNIV PK N;7U*	*0.42*
274812	*UNIV PK N;8U*	*0.42*
274813	*UNIV PK N;9U*	*0.42*
274815	*UNIV PK N;XU*	*0.42*
274816	*UNIV PK N;YU*	*0.42*
900371	*V4-046*	*1.51*
900381	*V4-047*	*1.51*
900391	*V4-048*	*1.71*
900401	*V4-049*	*1.71*
903432	*W3-046*	*4.07*
903434	*W3-046*	*3.77*
903435	*W3-046*	*4.07*
903436	*W3-046*	*3.77*
274873	*WALNR;1U*	*1.55*

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294500	*WALNR;1U E*	*6.18*
274874	*WALNR;2U*	*1.55*
294502	*WALNR;2U E*	*6.18*
295109	*WESTBROOK E*	*3.56*
909145	*X2-052*	*380.25*
910542	*X3-005 E*	*0.41*
914321	*Y2-103*	*28.11*
915011	*Y3-013 1*	*2.34*
915021	*Y3-013 2*	*2.34*
915031	*Y3-013 3*	*2.34*
915601	*Y3-088*	*1.61*
915611	*Y3-089*	*1.61*
915621	*Y3-090*	*1.61*
915631	*Y3-091*	*1.61*
LTF	*Z1-043*	*19.06*
LTF	*Z1-070*	*64.64*
916211	*Z1-072*	*0.73*
916221	*Z1-073*	*0.46*
916502	*Z1-106 E1*	*0.79*
916504	*Z1-106 E2*	*0.79*
916512	*Z1-107 E*	*1.63*
916522	*Z1-108 E*	*1.56*
LTF	*Z1-112*	*6.71*
916651	*Z1-127 1*	*1.04*
916652	*Z1-127 2*	*0.61*
917451	*Z2-081*	*1.04*
917531	*Z2-090 C*	*0.03*
917532	*Z2-090 E*	*0.35*
917711	*Z2-114 C*	*0.4*
917712	*Z2-114 E*	*0.4*
918051	*AA1-018 C OP*	*1.58*
918052	*AA1-018 E OP*	*10.57*
918251	*AA1-040 1*	*0.8*
918261	*AA1-040 2*	*0.8*
LTF	*AA1-071*	*4.47*
918611	*AA1-078*	*2.38*
918972	*AA1-116 E*	*1.62*
918982	*AA1-117 E*	*1.62*
919071	*AA1-129*	*2.14*
919221	*AA1-146*	*11.46*
919581	*AA2-030 C*	*11.46*
919582	*AA2-030 E*	*2.41*
919591	*AA2-035 C OP*	*80.04*
919592	*AA2-035 E OP*	*6.2*
LTF	*AA2-038*	*22.9*

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919621	*AA2-039 C*	*1.4*
919622	*AA2-039 E*	*9.37*
919811	*AA2-067 OP*	*0.76*
920112	*AA2-107 E*	*1.54*
920272	*AA2-123 E*	*1.54*
930041	*AB1-006 C*	*2.89*
930042	*AB1-006 E*	*19.37*
930381	*AB1-079*	*0.88*
930391	*AB1-080*	*22.53*
930442	*AB1-085 E*	*1.58*
930481	*AB1-089 C*	*42.27*
930482	*AB1-089 E*	*1.92*
930491	*AB1-090 C*	*42.27*
930492	*AB1-090 E*	*1.92*
930501	*AB1-091 C OP*	*44.34*
930502	*AB1-091 E OP*	*2.02*
930751	*AB1-121*	*145.05*
930761	*AB1-122 1*	*28.71*
930762	*AB1-122 2*	*28.71*
930763	*AB1-122 3*	*32.1*
930852	*AB1-131 E*	*0.49*
930972	*AB1-146 E*	*0.15*
931201	*AB1-170 C OP*	*2.99*
931202	*AB1-170 E OP*	*18.05*
931221	*AB1-172*	*0.51*

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