

***Generation Interconnection  
Feasibility Study Report***

***For***

***PJM Generation Interconnection Request Queue  
Position Z1-078***

***Broadford – Jacksons Ferry Phase II 765 kV***

October / 2014

## **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:**

Interconnection Customer (IC) proposes to construct PJM Project #Z1-078, a 777 MW (777 MW capacity) gas-fired, combined-cycle generating facility. The proposed point of interconnection is created by cutting the AEP Broadford – Jacksons Ferry 765 kV line via a modified double ring bus station consisting of five (5) 765 kV circuit breakers (see Exhibit 1). Interconnection Customer (IC) will be required to provide the necessary facilities from their collector station to connect to AEP's Broadford – Jacksons Ferry 765 kV line. The generating facility is to be located in Smyth County, Virginia (see Exhibit 2).

The proposed in service date is June 15, 2018.

The objective of this Feasibility study is to determine budgetary cost estimates and preliminary construction timeline for identified transmission facilities required to connect the proposed generating plant to the AEP transmission system. These new facilities include the Attachment Facilities, Local Upgrades, and Network Upgrades required to maintain adequate reliability of the AEP transmission system. Stability analysis is not included as part of this study.

## **Attachment Facilities**

The point of interconnection is a modified 765 kV 5-breaker double ring bus station that connects to AEP's Broadford – Jacksons Ferry 765 kV line. The IC will be required to provide the necessary facilities from their collector station to connect to the Broadford – Jacksons Ferry 765 kV line. AEP has completed the initial Feasibility study based on the configuration proposed by the customer. AEP notes that the proposed design configuration does not adhere to AEP's design standards thus results in several concerns, including the extent of several single contingency outages of the GSU transformers. AEP has based its current assessment on the proposed configuration; however, this does not constitute an endorsement of the proposal by AEP. The suitability of the proposed configuration will need further study by AEP Protection and Control Engineering during the System Impact Study. AEP notes that among the concerns resulting from the proposed configuration is the following -- an outage of either GSU transformer and/or the failure of three of the five 765kV breakers will result in an outage of ~ 1900 MVA of capacity. AEP recommends that the developer acknowledge this potential risk and investigate the possible installation of an AEP standard 765kV six (6) breaker arrangement in a breaker and one-half station configuration.

The following work will be required to connect the proposed generating facility to AEP's Broadford – Jacksons Ferry 765 kV line:

Attachment Work	Estimated Cost (2012 Dollars)
Establish a new 765 kV interconnection station arranged in a modified double ring bus configuration with 5 circuit breakers including associated disconnect switches and bus work, SCADA and 765kV revenue metering.	\$3,471,000
Modify relaying at Broadford 765kV station	\$197,000
Modify relaying at Jacksons Ferry 765kV station	\$245,000
<b>Total</b>	<b>\$3,913,000*</b>

It is understood that the IC will be responsible for all costs associated with connecting their 777 MW generation facility to the AEP's Broadford – Jacksons Ferry 765 kV line. Note: that the IC's station facilities as well as any facilities outside the new interconnection station were not included in the cost estimates. These are assumed to be the IC's responsibility. 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. It will take approximately 24 months after obtaining the authorization to construct the facilities as outlined above.

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**Local and Network Impacts**

The impact of the proposed generating facility on the AEP Transmission System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet performance parameters prescribed in the AEP FERC Form 715<sup>1</sup> and Connection Requirements for AEP Transmission System<sup>2</sup>. Therefore, these criterion were used to assess the impact of the proposed facility on the AEP System. PJM Queue Project #Z1-078 was studied as a 777.0 MW (Capacity 777.0 MW) injection at a new station to be established on the Broadford – Jacksons Ferry 765 kV line for the companion Y2-058 request, consistent with the interconnection application. Project #Z1-078 was evaluated for compliance with reliability criteria for projected summer peak conditions in 2017 Potential network impacts are as follows:

**Generator Deliverability**

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

None

**Light Load Analysis**

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

**Multiple Facility Contingency**

*(Double Circuit Tower Line, Failed Breaker and Bus Fault contingencies for the full energy output)*

Z1-078 Multiple Facility Contingency												
#	Type	Contingency Name	Affected Area	Facility Description	Bus		Circuit	Loading		Rating		MW Contr
					From	To		Initial	Final	Type	MVA	
1	LFFB	5031_C2_05KAMMER 765-PP2	AEP - AEP	05J.FERR- 05CLOVRD 765 kV line	242514	242512	1	97.07	102.27	ER	3176	187.61

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

**Short Circuit**

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

<sup>1</sup>  
[http://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/GuideLines/2014%20AEP%20PJM%20FERC%20715\\_Financial\\_Part%204.pdf](http://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/GuideLines/2014%20AEP%20PJM%20FERC%20715_Financial_Part%204.pdf)

<sup>2</sup>  
[http://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/Requirements/AEP\\_Interconnection\\_Requirements\\_Rev1.pdf](http://www.aep.com/about/codeofconduct/OASIS/TransmissionStudies/Requirements/AEP_Interconnection_Requirements_Rev1.pdf)

A short circuit assessment was completed by both PJM and AEP in order to investigate the contribution of the Z1-078 project on the breaker fault interrupting duties per the AEP's criteria contained in AEP's FERC 715 documentation. PJM and AEP have identified and confirmed that two 138kV breakers located at the Jacksons Ferry 138kV station (Circuit Breakers P and P2) will exceed the fault current interrupting capabilities with the installation of the proposed 777 MW of generation (Z1-078 project).

**Overdutied Equipment:**

- (1) Jacksons Ferry 138kV Circuit Breakers P and P2

**Mitigation:**

- (1) Replace 138kV Circuit Breakers P and P2.

Estimated cost **\$2,800,000**

**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)*

Z1-078 Contribution to Previously Identified Overloads												
#	Type	Contingency Name	Affected Area	Facility Description	Bus		Circuit	Loading		Rating		MW Contr
					From	To		Initial	Final	Type	MVA	
1	N-1	707_B2_TOR8315	AEP - AEP	05MOUNTN-05BELMON 765 kV line	242516	242920	1	122.69	124.25	ER	4055	139.56
2	LFFB	7445_C2_05MAR YSV 765-B	AEP - AEP	05MOUNTN-05BELMON 765 kV line	242516	242920	1	124.52	125.76	ER	4253	137.86

Please refer to Appendix 2 and 3 respectively for a table containing the generators having contributions to these flowgates.

**Steady-State Voltage Requirements**

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

To be determined

## **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)*

1. (AEP - AEP) The 05J.FERR-05CLOVRD 765 kV line:

(1) An engineering study will need to be conducted to determine if the Jacksons Ferry's Relay Thermal Limit settings can be adjusted to mitigate the overload. A new relay package will be required if the relay thermal settings cannot be adjusted. Estimated Cost: **\$300,000**

(2) An engineering study will need to be conducted to determine if the Cloverdale's Relay Thermal Limit settings can be adjusted to mitigate the overload. A new relay package will be required if the relay thermal settings cannot be adjusted. Estimated Cost: **\$300,000**

## **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)*

(AEP - AEP) The 05MOUNTN-05BELMON 765 kV line:

1. Replace Mountaineer wave trap. Estimated Cost: **\$200,000**
2. An engineering study will need to be conducted to determine if the Mountaineer Relay Compliance Trip Limit settings can be adjusted to mitigate the overload. A new relay package will be required if the relay thermal settings cannot be adjusted. Estimated Cost: **\$300,000**

### **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.

Not Applicable

## **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 05J.FERR-05CLOVRD 765 kV line (from bus 242514 to bus 242512 ckt 1) loads from 97.07% to 102.27% (**DC power flow**) of its emergency rating (3176 MVA) for the line fault with failed breaker contingency outage of '5031\_C2\_05KAMMER 765-PP2'. This project contributes approximately 187.61 MW to the thermal violation.

CONTINGENCY '5031\_C2\_05KAMMER 765-PP2'

OPEN BRANCH FROM BUS 242920 TO BUS 242925 CKT 1 / 242920  
 05BELMON 765 242925 05KAMMER 765 1  
 OPEN BRANCH FROM BUS 242920 TO BUS 242516 CKT 1 / 242920  
 05BELMON 765 242516 05MOUNTN 765 1  
 OPEN BRANCH FROM BUS 242920 TO BUS 235102 CKT 1 / 242920  
 05BELMON 765 235102 BELMONT 500 1  
 OPEN BRANCH FROM BUS 242925 TO BUS 235117 CKT 1 / 242925  
 05KAMMER 765 235117 KAMMER 500 1  
 OPEN BRANCH FROM BUS 235111 TO BUS 235117 CKT 1 / 235111 502  
 JUNCTION 500 235117 KAMMER 500 1  
 END

Bus Number	Bus Name	Full Contribution
242902	05CRG2L	1.38
242903	05CRG3H	20.61
242904	05CRG3L	17.02
246895	05VACITY	3.7
242850	05WOLFH1	0.94
242851	05WOLFH2	0.6
244159	BUCK	1.54
244160	BYLLESBY	0.15
244165	FRIES	0.03
900350	V1-024	1.83
900351	V1-025	2.08
W3-083	W3-083	10.86
905362	W4-037 E	3.33
X1-056	X1-056	7.16
X1-057	X1-057	7.16
X1-058	X1-058	7.16
X2-042	X2-042	84.39
909182	X2-060 E	-8.52
X3-020	X3-020	24.01
X3-096	X3-096	33.98
X3-097	X3-097	27.26

Bus Number	Bus Name	Full Contribution
X3-098	X3-098	12.52
X4-041	X4-041	19.8
Y1-002	Y1-002	79.21
Y1-004	Y1-004	104.52
913031	Y1-006 C	1.71
913032	Y1-006 E	11.47
Y1-007	Y1-007	72.59
Y1-058	Y1-058	4.16
Y1-059	Y1-059	4.16
913292	Y1-068 E	-5.68
Y1-089	Y1-089	7.73
Y1-090	Y1-090	14.17
Y1-091	Y1-091	7.59
Y2-004	Y2-004	40.49
Y2-005	Y2-005	15.78
Y2-006	Y2-006	40.46
Y2-030	Y2-030	22.77
Y2-031	Y2-031	22.77
Y2-032	Y2-032	22.77
Y2-033	Y2-033	13.91
Y2-034	Y2-034	44.59
Y2-036	Y2-036	24.87
Y2-056	Y2-056	59.06
914141	Y2-058 OP1	183.99
914192	Y2-067 E	1.96
Y2-068	Y2-068	410.97
Y2-114	Y2-114	13.09
Y2-115	Y2-115	14.22
Y3-028	Y3-028	27.8
915161	Y3-039	3.27
915171	Y3-040	3.27
Y3-069	Y3-069	41.38
Y3-072	Y3-072	41.38
Y3-094	Y3-094	69.21
Z1-007	Z1-007	12.17
Z1-023	Z1-023	41.82
Z1-025	Z1-025	41.82
Z1-027	Z1-027	17.52
Z1-029	Z1-029	8.26

Bus Number	Bus Name	Full Contribution
Z1-043	Z1-043	32.96
Z1-046	Z1-046	147.19
Z1-070A	Z1-070A	25.82
Z1-070B	Z1-070B	109.1
Z1-071	Z1-071	30.91
916321	Z1-078	187.61

## Appendix 2

(AEP - AEP) The 05MOUNTN-05BELMON 765 kV line (from bus 242516 to bus 242920 ckt 1) loads from 122.69% to 124.25% (**DC power flow**) of its emergency rating (4055 MVA) for the single line contingency outage of '707\_B2\_TOR8315'. This project contributes approximately 139.56 MW to the thermal violation.

CONTINGENCY '707\_B2\_TOR8315'

OPEN BRANCH FROM BUS 242922 TO BUS 242928 CKT 1 / 242922

05FLTLCK 765 242928 05MARYSV 765 1

END

Bus Number	Bus Name	Full Contribution
242893	05AMG3	13.11
242903	05CRG3H	22.11
242904	05CRG3L	18.25
242922	05FLTLCK	10.09
242650	05GLENL1	14.95
242651	05GLENL2	39.06
243186	05GVG1	15.95
243187	05GVG2	15.95
242895	05KRG1H	14.76
242896	05KRG1L	25.23
242897	05KRG2H	14.76
242898	05KRG2L	25.23
242894	05MTG1	16.68
246848	05SPG1H	7.97
246849	05SPG1L	20.22
246850	05SPG2H	7.97
246851	05SPG2L	20.22
246852	05SPG3H	7.97
246853	05SPG3L	20.22
246854	05SPG4H	7.97
246855	05SPG4L	20.22
W2-033	W2-033	41.56
X1-056	X1-056	6.67
X1-057	X1-057	6.67
X1-058	X1-058	6.67
909001	X2-006 C1	75.89
909002	X2-006 C2	60.72
X2-042	X2-042	77.67

Bus Number	Bus Name	Full Contribution
910701	X3-051	200.32
X3-097	X3-097	24.97
912151	X4-025	14.67
X4-041	X4-041	19.52
Y1-002	Y1-002	78.11
Y1-004	Y1-004	98.93
913031	Y1-006 C	1.62
Y1-007	Y1-007	68.71
Y1-090	Y1-090	12.98
Y2-004	Y2-004	39.58
Y2-005	Y2-005	15.56
Y2-006	Y2-006	39.92
Y2-030	Y2-030	23.75
Y2-031	Y2-031	23.75
Y2-032	Y2-032	23.75
Y2-033	Y2-033	13.49
Y2-034	Y2-034	43.3
Y2-035	Y2-035	26.11
914071	Y2-045 1	0.84
914072	Y2-045 2	0.56
914141	Y2-058 OP1	136.87
Y2-068	Y2-068	355.26
914311	Y2-086	10.23
Y2-114	Y2-114	12.91
Y2-115	Y2-115	14.16
915061	Y3-025	0.71
Y3-028	Y3-028	26.76
915131	Y3-036	0.43
915161	Y3-039	3.51
915171	Y3-040	3.51
Y3-069	Y3-069	40.31
Y3-072	Y3-072	40.31
Y3-094	Y3-094	66.78
915661	Y3-106	1.17
Z1-007	Z1-007	11.97
Z1-023	Z1-023	41.66
Z1-025	Z1-025	41.66
Z1-027	Z1-027	17.06
Z1-029	Z1-029	7.87

Bus Number	Bus Name	Full Contribution
Z1-046	Z1-046	145.47
Z1-067	Z1-067	6.58
Z1-071	Z1-071	30.78
916321	Z1-078	139.56

## Appendix 3

(AEP - AEP) The 05MOUNTN-05BELMON 765 kV line (from bus 242516 to bus 242920 ckt 1) loads from 124.52% to 125.76% (**DC power flow**) of its emergency rating (4253 MVA) for the line fault with failed breaker contingency outage of '7445\_C2\_05MARYSV 765-B'. This project contributes approximately 137.86 MW to the thermal violation.

CONTINGENCY '7445\_C2\_05MARYSV 765-B'

OPEN BRANCH FROM BUS 242922 TO BUS 242928 CKT 1 / 242922

05FLTLCK 765 242928 05MARYSV 765 1

OPEN BRANCH FROM BUS 242928 TO BUS 246999 CKT 1 / 242928

05MARYSV 765 246999 05SORENS 765 1

END

Bus Number	Bus Name	Full Contribution
242903	05CRG3H	22.07
242904	05CRG3L	18.22
242650	05GLENL1	14.67
242651	05GLENL2	38.32
242895	05KRG1H	14.43
242896	05KRG1L	24.67
242897	05KRG2H	14.43
242898	05KRG2L	24.67
242894	05MTG1	16.41
246848	05SPG1H	7.73
246849	05SPG1L	19.6
246850	05SPG2H	7.73
246851	05SPG2L	19.6
246852	05SPG3H	7.73
246853	05SPG3L	19.6
246854	05SPG4H	7.73
246855	05SPG4L	19.6
244159	BUCK	1.54
290074	P-059 E	-4.05
W2-033	W2-033	38.4
902402	W2-057 E	3.44
W3-083	W3-083	9.95
X1-056	X1-056	7.32
X1-057	X1-057	7.32
X1-058	X1-058	7.32
909001	X2-006 C1	74.96
909002	X2-006 C2	59.97

Bus Number	Bus Name	Full Contribution
X2-042	X2-042	84.62
X3-020	X3-020	24.91
910701	X3-051	197.1
X3-096	X3-096	33.3
X3-097	X3-097	29.22
X3-098	X3-098	13.09
912151	X4-025	14.39
X4-041	X4-041	21.1
Y1-002	Y1-002	84.44
Y1-004	Y1-004	105.06
913031	Y1-006 C	1.59
913032	Y1-006 E	10.66
Y1-007	Y1-007	72.96
Y1-089	Y1-089	7.58
Y1-090	Y1-090	15.19
Y1-091	Y1-091	7.94
Y2-004	Y2-004	43.07
Y2-005	Y2-005	16.84
Y2-006	Y2-006	43.19
Y2-030	Y2-030	25.76
Y2-031	Y2-031	25.76
Y2-032	Y2-032	25.76
Y2-033	Y2-033	13.88
Y2-034	Y2-034	44.54
Y2-035	Y2-035	26.
Y2-036	Y2-036	25.62
914071	Y2-045 1	0.83
914072	Y2-045 2	0.55
Y2-056	Y2-056	57.49
914141	Y2-058 OP1	135.19
914192	Y2-067 E	2.1
Y2-068	Y2-068	426.3
914311	Y2-086	10.32
Y2-114	Y2-114	13.95
Y2-115	Y2-115	15.16
915061	Y3-025	0.7
Y3-028	Y3-028	29.34
915161	Y3-039	3.5
915171	Y3-040	3.5

Bus Number	Bus Name	Full Contribution
Y3-069	Y3-069	43.91
Y3-072	Y3-072	43.91
Y3-094	Y3-094	73.15
915562	Y3-096 E	2.28
915661	Y3-106	1.12
Z1-007	Z1-007	13.16
Z1-023	Z1-023	44.6
Z1-025	Z1-025	44.6
Z1-027	Z1-027	18.59
Z1-029	Z1-029	8.74
Z1-043	Z1-043	32.32
Z1-046	Z1-046	154.4
Z1-067	Z1-067	6.58
Z1-070A	Z1-070A	26.05
Z1-070B	Z1-070B	110.06
Z1-071	Z1-071	32.26
916321	Z1-078	137.86