

**PJM Generator Interconnection
W3-155 Alabama Avenue
1 MW Energy
Feasibility Study Report**

*January 2011
DMS #630497v1*

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, §36.2, as well as the Feasibility Study Agreement between Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Potomac Electric Power Company.

Preface

The intent of this Feasibility Study is to determine a plan, with preliminary cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by IC. As a requirement for interconnection, IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM and the underlying system. All facilities required for interconnection of a generation interconnection project must be designed to meet ITO technical specifications.

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. IC is responsible for its right of way, real estate, and construction permit issues.

General

Queue W3-155 is an IC 1 MW energy injection generation request. The facility will also serve 39 MW of behind the meter load. Generation resources will consist of two combustion turbine generators (2 x 7.5 MW) one Steam turbine (5.0 MW) and eight Diesel generators (8 x 2.5 MW). The excess 1 MW generation will be injected into ITO Alabama Avenue 13.8 kV substation feeders 15192, 15193, 15194 and 15195 at St. Elizabeth Hospital's West Campus, located at 1100 Alabama Avenue, Washington, DC. Queue W3-155 is scheduled to begin commercial operation in the 1st Quarter of 2014. Project W3-155 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Network Impacts:

Generator Deliverability

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

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line Contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)

No problems identified.

Contribution to Previously Identified Overloads

(Overloads initially caused by prior queue positions with additional contribution to overloading by this project. This project may have % allocation of cost responsibility which will be calculated and reported for the Impact Study.)

No problems identified.

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)

None.

Short Circuit

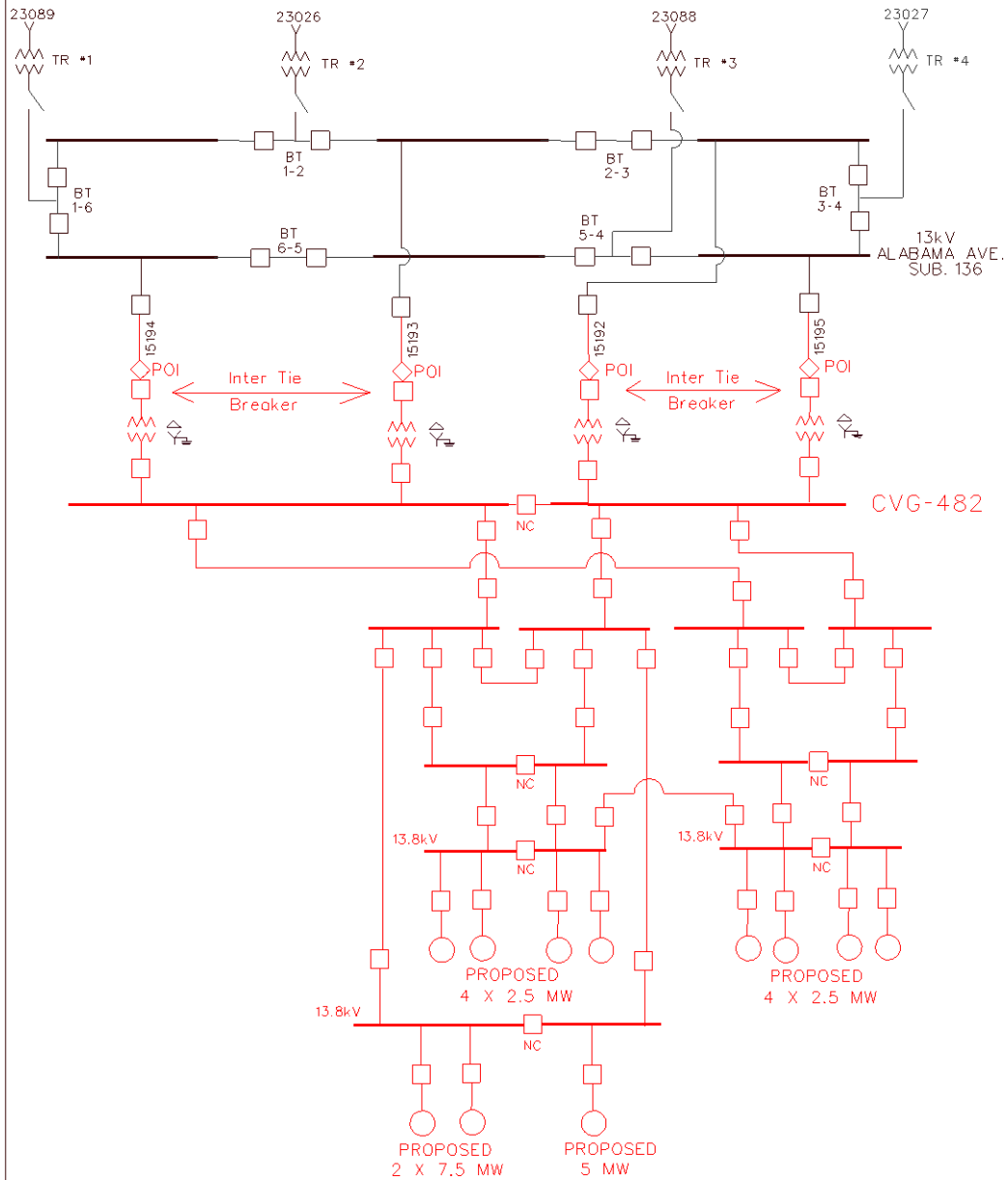
(Report Overdutied breakers here)

No problems identified.

ITO Analyses

Queue W3-155 can connect to ITO's Alabama Avenue 13.8kV substation Feeders 15192, 15193, 15194 and 15195 as shown on the one-line circuit diagram below.

W3-155 CO GEN CVG-482 ST. ELIZABETHS WEST CAMPUS



Attachment Facilities and Direct Connection Local Upgrades

The IC will design and construct all Attachment Facilities on the IC's side of the Point of Interconnection (POI).

1. ITO will provide a 13.8 kV supply to the queue W3-155. ITO will not install a transformer between the point of interconnection and the ITO substation.

ITO will require transfer trip equipment between the ITO normal supply Feeders 15192, 15193, 15194 and 15195 breakers and the IC's inter-tie breakers. It is difficult to estimate the frequency of such requests, but it will be an operational constraint for ITO as well. The transfer trip scheme should also be designed such that loss of communication between ITO's normal supply substation and the IC facility should result in tripping of the intertie breakers. The alternatives to employing this operating restriction are either (1) to install direct transfer trip of queue W3-155 from each possible source substation, or (2) interconnect queue W3-155 via dedicated feeders to Alabama Avenue substation at an estimated cost of more than \$20,000,000 (\$5,000,000 per feeder).

2. IC shall install transformers that will be used as isolation transformers. The transformers shall have a BIL level of 95 kV. ITO recommends the isolation transformers be connected in a delta-wye configuration according to ITO's "Engineering Requirements and Performance Standards for Interconnection Customers on the Potomac Electric Power Company System", Revision I, Dated 1-31-2007. A delta-wye configuration is desirable between the ITO and IC systems, in order to block zero sequence current flow through the transformer.
3. Islanding protection requirements: A transfer trip scheme for Feeders 15192, 15193, 15194 and 15195 is required to provide islanding protection. This protection is required for the event where Feeder breakers 15192, 15193, 15194 and 15195 at Alabama Avenue opens and leaves queue W3-155 generation islanded as the only source of generation connected to

ITO retail customer load. Islanding protection involves the installation of a dedicated communications system between queue W3-155 facility and ITO's Alabama Avenue Substation. ITO will be responsible for providing communications from its Control Center and its Alabama Avenue Substation. The IC will be responsible for providing suitable DC power and 19 inch rack space in close proximity to the inter-tie breakers where ITO can terminate a "dry" contact from the communication equipment for the purposes of tripping the inter-tie breakers in the event Feeders 15192, 15193, 15194 and 15195 trips or is otherwise opened by ITO.

Fiber and Telemetry Cost (Excluding Revenue Metering Requirement):

The IC will be responsible for the fiber and telemetry costs as follows:

1. Purchase and install fiber and related equipment between Alabama Avenue Substation and IC's facility = \$90,000
2. Purchase and install transfer trip and related equipment at Alabama Avenue Substation = \$90,000
3. Purchase and install transfer trip and related equipment at IC's facility = \$90,000
4. Contingency = \$30,000
5. Total Cost = \$300,000

For PJM:

The IC will be required to install the facilities necessary to provide revenue metering (KWH, KVARH) and real time data (KW, KVAR) for the IC's generating resource based on size requirements. See PJM Manuals M-01 and M-14, and the PJM Tariff.

PJM revenue and real time metering data for the generator installation will be at the POI to ITO's System. This metered value is the net of generator output and generator ancillary load which is acceptable for this size unit.

The IC will use the Arccom director-based internet option as described in Attachment H, "Small Generator (10 MW and Below) Technical Requirements and Standards", to PJM Manual 14B. The SCADA requirement for PJM will be coordinated with PJM.

For ITO:

Revenue Metering and SCADA Requirements:

The IC will use the Arccom director-based internet option as described in Attachment H, "Small Generator (10 MW and Below) Technical Requirements and Standards", to PJM Manual 14B.

The IC must provide the following status data:

- Open / Close status for IC inter-tie circuit breakers;
- Real time KW ;
- Real time amperes;
- Single phase voltage;
- Trip control of the IC inter-tie breaker(s);
- Three phase amperes for the IC inter-tie circuit breaker;
- KWH from bi-directional revenue meter; and
- The IC must submit a switching sequence of operation as well as additional documentation for ITO's review.

Non-Direct Connection Local Upgrades

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

As shown in the attached short circuit results, the 13.8 kV breakers at Alabama Avenue are overdutied at 101.8% and 102.7% of rating, respectively (See Table 1), with W3-155 generation. Several alternatives for reducing the fault current at the substation were reviewed and most were found to be infeasible. These include adding transformer secondary reactors for which there is no room available either indoors or outdoors of the substation.

The option to replace the 13 kV switchgear with 1500 MVA gear is a feasible option. The ballpark estimate for replacing the switchgear is \$9,000, 000 and does not include CIAC tax. The schedule to complete the switchgear

replacement is approximately 24-30 months and is outage dependent. Another possible option that would require study and design by the Operations, Planning and Engineering Departments is to add bus tie reactors to two of the switchgear bus ties. Space and connectivity to the switchgear bus could be an issue with this option as well as operational limitations.

An option to supply the IC from a different source station at 13 kV or 69 kV was reviewed but would be significantly more costly than the switchgear replacement. Additionally such options would most likely delay the in-service date as a new design would need to be developed, permitted and constructed.

The IC should review the design of their connected generation and may be able to reduce the fault current contribution by making changes to their proposed design.

Short Circuit

The fault study was performed by modeling an Aspen Oneliner file that depicts the proposed configuration of the W3-155 project at the IC facility at St. Elizabeth Hospital, CVG-482 in Washington, DC. The system modeled consisted of two 13.8 kV 9.5 MVA gas turbines and one 13.8 kV 6.875 MVA steam turbine connected to the main incoming 13.8 kV bus at St. Elizabeth Hospital, CVG-482. The main incoming 13.8 kV bus at St. Elizabeth Hospital, CVG-482 is supplied by four 13.8 kV feeders from ITO's Alabama Avenue Substation. Each supply feeder is connected to the primary side of a separate 13.8/13.8 kV 10 MVA IC owned isolation transformer connected delta-wye grounded. The four IC owned isolation transformers are connected to the main incoming 13.8 kV bus at St. Elizabeth, CVG-482.

Assumptions:

No assumptions were made by ITO.

The saturated sub-transient reactance for the steam turbine generator was estimated by the IC. Impedance data for the 13.8/13.8kV isolation transformers, gas turbine generators and diesel generators were modeled as provided by the IC. (Email dated 01/10/11)

Modeling Tool:

Aspen Oneliner Version 11.6

Analysis:

The following cases were evaluated for this project:

Case 1 The short-circuit program was used to determine the existing three-phase and single-phase fault duties at the 13.8 kV bus (ITO bus No. 224010) at Alabama Avenue. The ANSI X/R ratio was determined. (No CVG482 Generation)

Case 2 The short-circuit program was used to determine the three-phase and single-phase fault duties at the 13.8 kV bus (ITO Bus No. 224010) at Alabama Avenue when two gas turbines and one steam turbine are connected to the 13.8 kV bus at St. Elizabeth Hospital, CVG482. The ANSI X/R ratio was determined. (2 CT 9.5 MVA, and 1 ST 6.875 MVA; [Total Generation = 20MW])

Case 3 The short-circuit program was used to determine the three-phase and single-phase fault duties at the 13.8 kV bus (ITO Bus No. 224010) at Alabama Avenue when two gas turbines, one steam turbine and eight 2.5 MW diesel generators are connected to the 13.8 kV bus at St. Elizabeth Hospital, CVG482. The ANSI X/R ratio was determined. (2 CT 9.5 MVA, 1 ST 6.875 MVA and 8 diesel generators [2.5 MW each]); [Total generation = 40 MW]

Comments:

Short circuit study alternatives identified to resolve breaker fault current interrupting concerns include; replacing the 13 kV switchgear with 1500 MVA gear, installing transformer secondary series reactors, or installing series bus tie reactors. The proposed IC generation installation increases the Alabama Avenue available 13 kV fault current by more than 7000 amps and requires a switch gear replacement or a duty mitigation alternative be deployed, since the additional 7000 amps of IC generation fault current causes the existing breakers to exceed their interrupting capability.

As a result, the Alabama Avenue 13 kV switchgear could be replaced with 1500 MVA gear. The alternative of installing 2 ohm, 3000 amp series bus tie reactors on BT 2-3 and BT 5-6 should be evaluated for operational and loading/planning criteria problems. This would result in two, three bus section buses; solidly tie together, with the two solid connected buses being tied together by each bus tie reactor to maintain the ring bus configuration. If operationally and planning acceptable, the installation of the bus tie reactors would also be an acceptable duty mitigation alternative for the Alabama Avenue 13 kV switchgear.

Note that the conclusions derived from this study are based on IC supplied estimated impedance values for the proposed equipment additions and present PJM provided equivalents of external utility systems. If actual impedance values are less than the estimated values, and / or equivalents of external utility systems change, any resulting ramifications will be at the expense of the IC.

Case 1: Existing condition (No Generation)						
LOCATION	CIRCUIT BREAKER TYPES	ACTUAL SHORT CIRCUIT DUTY (kA)	ANSI X/R RATIO	ADJUSTED DUTY (AD) (kA)	BREAKER INTERRUPTING RATING (BIR) (kA)	PERCENT OF INTERRUPTING RATING (AD / BIR) (%)
Sub. 136 13.8kV Alabama Avenue	ABB 15VHK-X-1000 Three Phase	27.8	43.6	33.8	41.8	80.7
		29.4	43.8	35.6	48.1	74.2
	ITE 15HK-1000 Three Phase	27.8	43.6	34.3	41.8	82.0
		29.4	43.8	36.3	48.1	75.4

Case 2: 2 CT (2 x 9.5 MVA) and 1 ST 6.87 MVA (20 MW Generation Addition at CVG482)						
LOCATION	CIRCUIT BREAKER TYPES	ACTUAL SHORT CIRCUIT DUTY (kA)	ANSI X/R RATIO	ADJUSTED DUTY (AD) (kA)	BREAKER INTERRUPTING RATING (BIR) (kA)	PERCENT OF INTERRUPTING RATING (AD / BIR) (%)
Sub. 136 13.8kV Alabama Avenue	ABB 15VHK-X-1000 Three Phase	32.8	41.0	39.5	41.8	94.4
		32.9	42.0	39.7	48.1	82.6
	ITE 15HK-1000 Three Phase	32.8	41.0	40.0	41.8	95.6
		32.9	42.0	40.3	48.1	83.8

Case 3: 2 CT (2 x 9.5 MVA); 1 ST 6.87 MVA and 8 Diesel Units (2.5 MW Each) (40 MW Generation Addition at CVG482)						
LOCATION	CIRCUIT BREAKER TYPES	ACTUAL SHORT CIRCUIT DUTY (kA)	ANSI X/R RATIO	ADJUSTED DUTY (AD) (kA)	BREAKER INTERRUPTING RATING (BIR) (kA)	PERCENT OF INTERRUPTING RATING (AD / BIR) (%)
Sub. 136 13.8kV Alabama Avenue	ABB 15VHK-X-1000 Three Phase	35.9	37.5	42.6	41.8	101.8
		34.9	39.6	41.8	48.1	86.8
	ITE 15HK-1000 Three Phase	35.9	37.5	42.9	41.8	102.7
		34.9	39.6	42.3	48.1	87.8

Voltage Regulation:

Based on the utility proposed four 13.8 kV feeder supply plan, St. Elizabeth's proposed generation will not produce any steady state power flow problem in the Alabama Avenue Sub 136 system. High voltage on the feeders may occur for the loss of load without prompt generation shutdown at the DHS campus. It is recommended that the St. Elizabeth's generation have leading voltage regulation capability to control bus voltage.

Standby Service Charge:

The IC has asked that ITO standby capacity to supply the IC's load in the event the IC's generation is offline for any reason. Based on the utility proposed four 13.8 kV feeder supply plan, ITO has estimated the monthly standby service charge the IC would pay. The Schedule "S" Standby Service tariff stipulates the monthly Standby Service charge shall consist of a Facilities Charge and a Production and Transmission Reservation Charge. The calculations for these charges are as follows:

1. Facilities Charge - 2% of the total installed cost of facilities constructed specifically to provide standby service.

Cost estimate for extending 2 new 13.8 kV feeders to Cogen = \$1,083,000

Monthly Facilities Charge = \$1,083,000 X 2% = \$21,660

2. Production and Transmission Reservation Charge - \$.45 per kW of contract demand for which the ITO will provide standby service.

Contract Demand to Standby = 20,000 kW

Monthly P & T Reservation Charge = 20,000 X \$0.45 = \$9,000

3. Total monthly Standby Service Charge Estimate

\$21,660 + \$9,000 = \$30,660