

PJM Generator Interconnection
W3-053 Trowbridge 230 kV
33.8 MW Capacity / 260 MW Energy
Feasibility Study Report

January 2011
DMS #628921v1

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 Virginia Electric and 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 W3-053 is an IC 260 MW energy (33.8 MW Capacity) wind farm generation request. W3-053 will be located south of Plymouth, NC in the ITO area. The requested in-service date is December September 30, 2013. The project was studied with its primary interconnection point at Trowbridge 230 kV substation. The project was studied with its secondary interconnection point at Poplar Chapel 230 kV substation. Project W3-053 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Summary

Primary Option:	\$32.5 M	48 months
Secondary Option:	\$40.0 M ¹	48 months

¹ Assumes and includes costs for Merchant Transmission project to convert Everetts to Trowbridge to 230 kV.

Network Impacts: Primary Option - Trowbridge 230 kV

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)

There is no impact to breaker interrupting capabilities as a result of W3-053 for the primary option. These results are subject to change due to changing system conditions.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.

Note: 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

1. The Trowbridge 230 kV - Trowbridge 115 kV 230/115 kV transformer (from bus 314616 to bus 314613 ckt 2) loads

from 0.01% to 143.95% (DC power flow) of its emergency rating (180.600006104 MVA) for the operational contingency 'V 2034'. This project contributes approximately 260.00 MW to the thermal violation.

This overload was resolved with ITO project 99-2192 (PJM RTEP b0342) which installed a 2nd 230-115 kV transformer and 230 kV breakers at Trowbridge.

2. The Poplar Chapel 115 kV - Everetts 115 kV line (from bus 314596 to bus 314573 ckt 1) loads from 9.92% to 115.31% (DC power flow) of its emergency rating (159 MVA) for the operational contingency 'V 2034'. This project contributes approximately 167.57 MW to the thermal violation.

This overload will be resolved with ITO project 99-2193 (PJM RTEP b0325) which installs a 2nd 230-115kV transformer and 25 line upgrade at Everetts.

Network Impacts: Secondary Option - Poplar Chapel 115 kV

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 Overduty breakers here)

There is no impact to breaker interrupting capabilities as a result of W3-053 for the secondary option. These results are subject to change due to changing system conditions.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.

Note: 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

The Poplar Chapel 115 kV-Everetts 115 kV line (from bus 314596 to bus 314573 ckt 1) loads from 33.85% to 197.32% (DC power flow) of its emergency rating (159 MVA) for the operational contingency 'LN 167'. This project contributes approximately 259.91 MW to the thermal violation.

This overload can be resolved with Network Upgrades identified in the ITO analysis for secondary option. This will require the conversion of the 25 line between Everetts and Trowbridge to 230 kV.

ITO Analyses

ITO assessed the impact of the proposed queue project, W3-053, interconnection of 33.8 MW of capacity and 260 MW of energy on the ITO transmission system. The system was assessed using the summer 2014 RTEP case provided to ITO by PJM, where the proposed generation capacity was injected at either primary option, 230 kV at ITO's Trowbridge Substation, or secondary option, 115 kV at ITO's Poplar Chapel Substation. This analysis did include the impacts of the generation capacity for all higher order queue generators within the ITO transmission system. When performing a generation analysis, ITO main analysis was a load flow study results under single contingency (both normal and stressed system conditions) and import/export system conditions. ITO criterion considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import/export studies ITO considers a transmission facility

overloaded if it exceeded 100% of its emergency rating. A full listing of ITO planning criteria and interconnection requirements can be found in the ITO *Facility Connection Requirements* which are publicly available at: <http://www.dom.com>.

Primary Option: Trowbridge 230 kV

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the W3-053 evaluation three different assessments were conducted.

- 1) The first being when local generation including the proposed W3-053 facility is operated at their maximum capability. The result of this study is shown below.

No problems identified for 33.8 MW Capacity or 260 MW energy from W3-053.

- 2) The second being a stressed system condition where the largest generator in the area is unavailable. With the W3-053 generator geographically located in Eastern Virginia, Surry Unit 2 is considered the most critical generating unit in the area. The impact of W3-053 was studied with the outage of Surry Unit 2. The result of this study is shown below.

No problems identified for 33.8 MW Capacity from W3-053.

The results of 260 MW energy from W3-053 are shown below in Table A.

Table A: Stressed System Conditions for W3-053 Energy

Overloaded Element	Cont Loading (MVA)	Rating	Cont Loading (%)	Contingency Label
314137 6FREDBRG 230 314138 6MINE RD 230 1	747.0	797.0	93.7	314212 6FRRIVER 230 314222 6HANOVER 230 1

As shown above in Table A, the impact of the W3-053 generator energy under single contingency conditions comes very close to a thermal overload of one 230 kV line section. This was included because it may show up in the System Impact Study.

- 3) The third being import and export conditions into and out of the ITO system. Any new facility that is interconnected with the ITO system should not significantly decrement First Contingency Incremental Transfer Capability between utilities. This analysis will be performed during the System Impact Study.

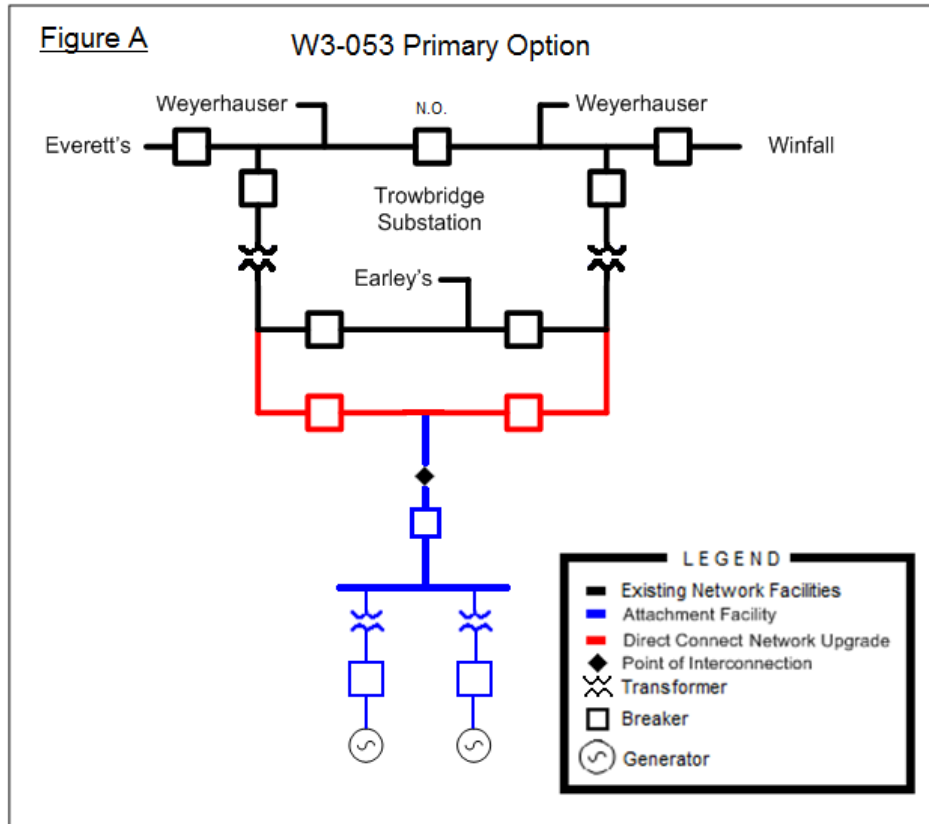
Light load analysis will be necessary during the System Impact Study to determine the effects of energy level generation on the ITO system during light load conditions. System upgrades may be necessary to resolve problems identified in this analysis.

Attachment Facilities

The proposed layout and attachment facilities are illustrated below in Figure A. The interconnection arrangement shown assumes the proposed W3-053 facility is 10 miles from Trowbridge Substation. The Attachment Facility interconnection costs are estimated to be \$30 million dollars (2011 dollars). This cost includes metering, protection equipment and 230 kV line work to directly connect the proposed facility with the 230 kV at Trowbridge Substation. This work will take an estimated time of 36 to 48 months to engineer and construct. This includes obtaining all necessary North Carolina PUC permits.

Direct Connection Network Upgrades

To reliably interconnect the proposed generation with the ITO transmission system it will be necessary to expand the 230 kV bus arrangement at Trowbridge Substation. At Trowbridge Substation, two 230 kV breakers and associated equipment will be installed. This substation may also need to be expanded to accommodate the additional equipment and additional land and permitting may be required. The estimated cost of this work is \$2.5 million dollars (2011 dollars) and is estimated to take 24 to 30 months to engineer and construct.



Secondary Option: Poplar Chapel 115 kV

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the W3-053 evaluation three different assessments were conducted.

- 1) The first being when local generation including the proposed W3-053 facility is operated at their maximum capability. The result of this study is shown below.

No problems indentified for 33.8 MW Capacity from W3-053.

The results of 260 MW energy from W3-053 are shown below in Table B.

Table B: Pmax System Conditions for W3-053 Energy

Overloaded Element	Rating	Cont Loadingw /o W3-053E (MVA)	Cont Loadingw / W3-053E (MVA)	Cont Loading w/o W3-053E (%)	Cont Loading w/ W3-053E (%)	Contingency Label
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	109.2	226.2	45.7	94.6	314569 6EARLEYS 230 314574 6EVERETS 230 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	15.5	239.1	6.5	100.0	314596 3POPLR C 115 314614 3TROWBR2 115 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	53.8	308.4	22.5	129.0	314613 3TRWBRDG 115 314621 3WEYERH 115 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	15.8	238.9	6.6	100.0	314614 3TROWBR2 115 314621 3WEYERH 115 1
314596 3POPLR C 115 314614 3TROWBR2 115 1	239.0	15.3	237.8	6.4	99.5	314573 3EVERETS 115 314596 3POPLR C 115 1
314613 3TRWBRDG 115 314621 3WEYERH 115 1	284.0	54.2	304.3	19.1	107.1	314573 3EVERETS 115 314596 3POPLR C 115 1

As shown above in Table B, the impact of the W3-053 generator energy under single contingency conditions results in the thermal overload of three 115 kV line sections.

- 2) The second being a stressed system condition where the largest generator in the area is unavailable. With the W3-053 generator geographically located in Eastern Virginia, Surry Unit 2 is considered the most critical generating unit in the area. The impact of W3-053 was studied with the outage of Surry Unit #2. The result of this study is shown below.

No problems indentified for 33.8 MW Capacity from W3-053.

The results of 260 MW energy from W3-053 are shown below in Table C.

Table C: Stressed System Conditions for W3-053 Energy

Overloaded Element	Rating	Cont Loading w/o W3-053E (MVA)	Cont Loading w/ W3-053E (MVA)	Cont Loading w/o W3-053E (%)	Cont Loading w/ W3-053E (%)	Contingency Label
314137 6FREDBRG 230 314138 6MINE RD 230 1	797.0	738.2	747.3	92.6	93.8	314212 6FRIVER 230 314222 6HANOVER 230 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	15.5	237.6	6.5	99.4	314596 3POPLR C 115 314614 3TROWBR2 115 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	48.8	302.0	20.4	126.4	314613 3TRWBRDG 115 314621 3WEYERH 115 1
314573 3EVERETS 115 314596 3POPLR C 115 1	239.0	15.8	237.4	6.6	99.3	314614 3TROWBR2 115 314621 3WEYERH 115 1
314596 3POPLR C 115 314614 3TROWBR2 115 1	239.0	15.3	237.0	6.4	99.2	314573 3EVERETS 115 314596 3POPLR C 115 1
314613 3TRWBRDG 115 314621 3WEYERH 115 1	284.0	49.6	298.5	17.5	105.1	314573 3EVERETS 115 314596 3POPLR C 115 1

As shown above in Table C, the impact of the W3-053 generator energy under single contingency conditions results in the thermal overload of three 115 kV line sections. A 230 kV portion is identified because it is close to being overloaded and may show as overloaded in the System Impact Study.

- 3) The third being import and export conditions into and out of the ITO system. Any new facility that is interconnected with the ITO system should not significantly decrement First Contingency Incremental Transfer Capability between utilities. This analysis will be performed during the System Impact Study.

Light load analysis will be necessary during the System Impact Study to determine the effects of energy level generation on the ITO system during light load conditions. System upgrades may be necessary to resolve problems identified in this analysis.

Optional Merchant Network Upgrades

The results of these studies, as indicated above in Tables B and C, show an overload on three 115 kV line sections. In order to resolve these thermal violations, IC would need to submit a Merchant Transmission queue request for the following work to be completed prior to adding the generation energy of W3-053 in the secondary location.

Convert the 25 line between Everetts and Trowbridge to 230 kV. This will require two 230 kV breakers at Everetts, two 230 kV breakers at Trowbridge and the replacement of the distribution transformer at Poplar Chapel Substation. The cost of this upgrade is estimated to be \$7.0 million dollars (2011 dollars) and is expected to take 36 to 48 months to complete. Both Everetts and Trowbridge Substations may also need to be expanded to accommodate the additional equipment and additional land and permitting may be required. This includes obtaining all necessary North Carolina PUC permits.

Attachment Facilities

ITO determined this project could interconnect the facility on the 115 kV system, however, the majority of the energy above the Capacity level will be constrained. ITO provided its Attachment Facilities assuming IC would want to inject the full energy portion.

The proposed layout and attachment facilities are illustrated below in Figure B. The interconnection arrangement shown assumes the proposed W3-053 facility is 10 miles from Poplar Chapel Substation. The Direct Assigned interconnection costs are estimated to be \$30 Million dollars (2011 dollars). This cost includes metering, protection equipment and 230 kV line work to directly connect the proposed facility with the 230 kV at Poplar Chapel Substation. This work will take an estimated time of 36 to 48 months to engineer and construct. These attachment facilities are listed and quoted at 230 kV due to the Non-Direct Connection Upgrades needed for the energy rating of this queue request. This includes obtaining all necessary North Carolina PUC permits.

Direct Connection Network Upgrades

To reliably interconnect the proposed generation with the ITO transmission system it will be necessary to create a three breaker 230 kV ring bus at Poplar Chapel Substation. At Poplar Chapel Substation, three

230 kV breakers and associated equipment will be installed. The estimated cost of this work is \$3.0 Million dollars (2011 dollars) and is estimated to take 24 to 30 months to engineer and construct. This substation may also need to be expanded to accommodate the additional equipment and additional land and permitting may be required. These direct connection network upgrades are listed and quoted at 230 kV because the energy portion of this request would be so constrained.

