

PJM Generator Interconnection  
*T167 Four Rivers 115-kV (120 MWC)*  
Feasibility Study

April 2008  
DMS #479484 (PJM.com Version)

## **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).

## **Preface**

The intent of the 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 the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer 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 system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications for the appropriate transmission owner.

In some instances an interconnection customer 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 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**

At the request of the IC, this queue project, T167, was studied with two different interconnection options. For the first option, T167 was studied as a 120 MW injection at the Four Rivers 115 kV substation. For the second option, T167 was studied as a 120 MW injection at the Four Rivers 230 kV substation. The following study results list each option as an independent study.

## **Summary**

	<u>115-kV</u>	<u>230-kV</u>
Attachment Facilities:	\$0.50M & 1.5yrs.	\$0.60M & 1.5yrs.
Direct Connection Network Upgrades:	\$0.55M & 1.5yrs.	\$0.80M & 1.5yrs.
Non-Direct Connection Network Upgrades:	\$13.41-\$22.41M & 5yrs.	\$0.77M & 1.5yrs.
Contribution to Existing Upgrades:	\$2.2-\$4.9M & 0.5 yrs. <sup>1</sup>	\$2.2-\$4.9M & 0.5 yrs. <sup>1</sup>

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<sup>1</sup> Cost allocation will be determined in the System Impact Study.

## **OPTION: 115-kV**

### **Network Impacts**

The Queue Project #T167 was studied as a 120 MW injection at the Four Rivers 115 kV substation. Project T167 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

### **Generator Deliverability**

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

- 1) (DOM) The 3FRRIVER-3HANOVER 115kV line loads from 84.8% to 145.0% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 47). This project contributes approximately 119.9MW to cause this thermal violation.
- 2) (DOM) The 3FRRIVER-3KINGS D 115kV line loads from 84.8% to 145.0% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 73). This project contributes approximately 119.9MW to cause this thermal violation.
- 3) (DOM) The 3HANOVER-3ELMONT 115kV line loads from 74.0% to 134.2% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 47). This project contributes approximately 119.9MW to cause this thermal violation.
- 4) (DOM) The 3KINGS D-3DOSWELL 115kV line loads from 65.8% to 126.0% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 73). This project contributes approximately 119.9MW to cause this thermal violation.
- 5) (DOM) The 3DOSWELL-3S JOHNS 115kV line loads from 60.1% to 120.3% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 73). This project contributes approximately 119.9MW to cause this thermal violation.
- 6) (DOM) The 3S JOHNS-3WOODPCK 115kV line loads from 56.5% to 116.7% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 73). This project contributes approximately 119.9MW to cause this thermal violation.
- 7) (DOM) The 3WOODPCK-3SLABTWN 115kV line loads from 55.9% to 116.1% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 73). This project contributes approximately 119.9MW to cause this thermal violation.

### **Multiple Facility Contingency**

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

None.

### **Short Circuit**

- 8) There are two (2) breaker interrupting capabilities with more than 100% as a result of T167 (115 kV Option). They are as follow:

<u>Bus</u>	<u>Breaker No.</u>
Elmont 230 kV	216T2075
Elmont 230 kV	283T2075

These results are subject to change due to changing system conditions.

### **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)*

- 9) (DOM) The 6FREDBRG-6CRANES 230kV line loads from 99.6% to 102.1% (DC power flow) of its emergency rating (637MVA) for the single line contingency outage (LN 2032). This project contributes approximately 16.4MW to cause this thermal violation. This line was identified as violating a Dominion maximum and stressed system criteria in a previous queue.

### **Stability Analysis**

*(Results of the dynamic studies should be inserted here)*

To be determined at the System Impact Study.

### **Dominion Analysis**

Dominion assessed the impact on the Dominion Transmission System that the proposed 120 MW injection of new generation capacity would have at the Four Rivers 115 kV Substation. The system was assessed using the Summer 2012 RTEP case provided to Dominion by PJM for this analysis. This analysis did include the impacts that higher order queue generators may have on the study results, specifically those generators located on the Dominion Transmission System which have a signed a PJM ISA or IISA and their associated network upgrades were also modeled. The following higher order queue projects were modeled in the PJM Summer 2012 case; P16, P27, Q69, Q71, R17, R63, S86-S96 and T10. When performing a generation analysis Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions) and import/export system conditions. Dominion Criteria consider a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import /export studies

Dominion considers a transmission facility overloaded if it exceed 100% of its emergency rating. A full listing of Dominion’s Planning Criteria and interconnection requirements can be found in the Company’s Facility Connection Requirements which are publicly available at “[http://www.dom.com/about/electransmission/pdf/Facility\\_Connection\\_Requirements.pdf](http://www.dom.com/about/electransmission/pdf/Facility_Connection_Requirements.pdf)”

As part of its generation impact analysis Dominion routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the T167 evaluation three different assessments were conducted.

- 1) The first being when local generation including the proposed T167 Facility is operated at their maximum capability. The result of this study is indicating significant system deficiencies and is shown below in Table A.
- 2) The second being a stressed system condition, specifically when the largest generator in the area is unavailable. The proposed T167 generator is located on the 115 kV system between Richmond and Northern Virginia load areas. Therefore, the impact of T167 was studied under stressed system conditions where the most critical generating unit located on the 115 kV system in this load area is unavailable. Therefore, Possum Point Unit #3 was outaged to create this critical system condition. The result of this study is shown below in Table B.
- 3) The third being import and export conditions into and out of the Dominion System. Any new facility that is interconnected with the Dominion System should not significantly decrement FCITC (First Contingency Incremental Transfer Capability) between utilities. The results of these studies can be found in Tables C and D.

**Table A**  
**Summer 2012 Pmax System Conditions (Local Generators at Pmax)**

<b>Overloaded Element</b>	<b>Contingency Conditions</b>	<b>Pmax + T167</b>
Four Rivers - Fredericksburg	1	145%
Four Rivers - Elmont	1	145%

Note: For this study condition generation at Possum Point, Birchwood and Four Rivers was scaled to its maximum value (Pmax) and generation was proportionally reduced throughout the PJM System.

**Table B**  
**Summer 2012 Stressed System Conditions (No Possum Point Unit #3)**

<b>Overloaded Element</b>	<b>Contingency Conditions</b>	<b>Base Case + T167</b>
Four Rivers - Fredericksburg	1	145%
Four Rivers - Elmont	1	145%

Note: For this stress system condition Possum Point Unit #3 was removed from service and generation was increased within the Dominion System proportionally to make-up for the reduced generation.

The results of these studies indicate that approximately 43 miles of 115 kV lines are overloaded. Specifically the following 115 kV lines are overloaded.

- a. Line # 47 (Four Rivers - Fredericksburg) 34 miles
- b. Line # 73 (Four Rivers - Elmont) 9 miles

Dominion’s Planning Criteria also indicates a need to have approximately 2000 MW of import and export capability. The results of import and export studies are shown in Tables C and D below and are indicating that the proposed generation facility will not negatively impact Dominion’s export or import capability.

**Table C**

<b>Import Study Results</b>			
<b>Area</b>	<b>Summer 2012</b>	<b>Summer 2012 with T167</b>	<b>Limiting Element</b>
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

**Table D**

<b>Export Study Results</b>			
<b>Area</b>	<b>Summer 2012</b>	<b>Summer 2012 with T167</b>	<b>Limiting Element</b>
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

**Non-Direct Connection Network Upgrades**

**New System Reinforcements**

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

The estimated cost to replace the two over-dutied 230 kV breakers is \$360,000 and will take about 4 weeks to complete. The equipment order time will take about 6 to 8 months.

As noted in the Dominion study results, the following 115 kV lines are overloaded:

- a. Line # 47 (Four Rivers - Fredericksburg) 34 miles
- b. Line # 73 (Four Rivers - Elmont) 9 miles

The solution to resolve these overloads would be to rebuild both of these lines to achieve a greater thermal rating. This solution would require the re-conductoring/rebuilding of the 43 miles of 115 kV line(s) located between Elmont and Fredericksburg Substations. This solution is estimated to cost approximately \$13-\$22 million depending on whether the line(s) can be re-conducted, or if they need to be rebuilt. This work is estimated to require 14 months of outage time since the majority of outages can not be scheduled concurrently. This upgrade is estimated to take 4-5 years to complete.

The proposed solutions resolve all the projected overloads identified in the Dominion and PJM Analysis (Generator Deliverability overloads 1-8) as they relate to Dominion Transmission Facilities. More precise engineering cost and construction details will be developed as part of the System Impact Study.

### **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)*

This addresses item #9 from the previously identified overloads listed above: The section of 230 kV line located between Fredericksburg and Cranes Corner Substation needs to be re-conducted to mitigate the overload condition. The cost of upgrading this 5 mile line is \$2.2-\$4.9M and is expected to take six months to complete.

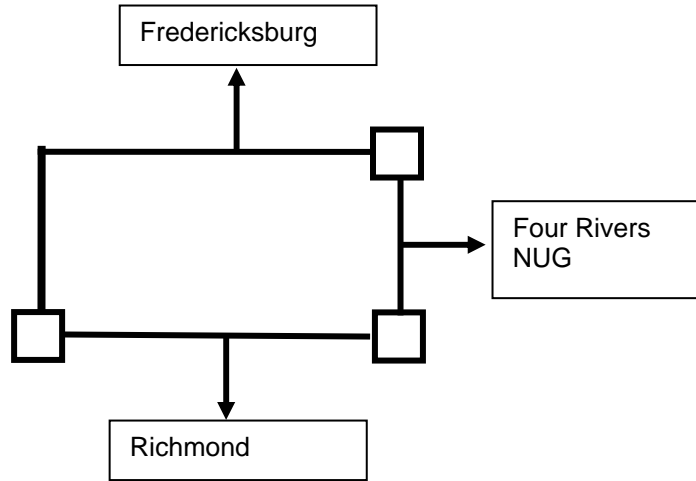
### **Attachment Facilities**

The potential transmission solution will require a rearrangement of the existing Four Rivers 115 kV Substation (Figure A) to accommodate the proposed new generation. The proposed attachment facilities can be found in Figure B. The estimated cost of these facilities which also includes metering, protection equipment along with a 0.5 mile 115 kV line and associated equipment is \$500,000 dollars.

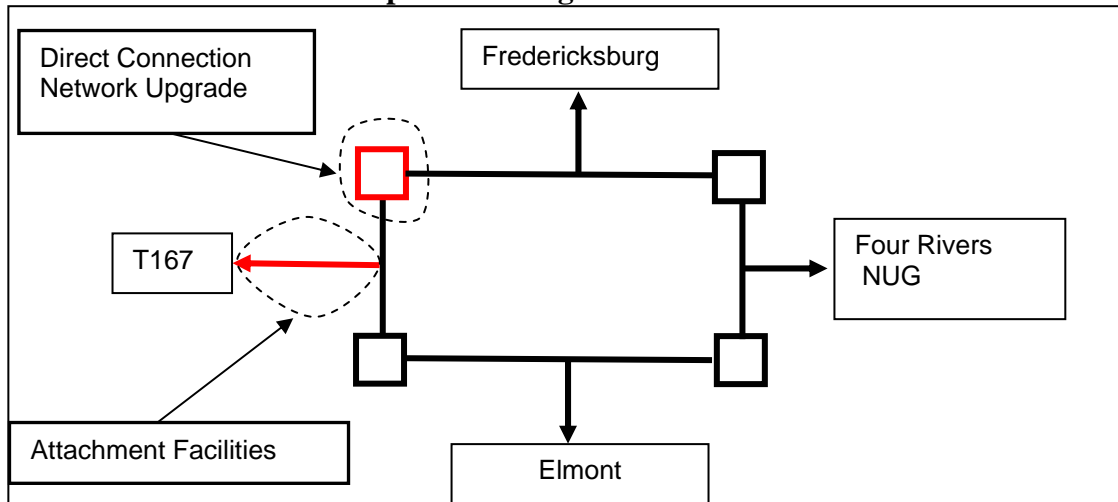
### **Direct Connection Network Upgrades**

The network attachment facilities include the installation of one 115 kV breaker and associated equipment and are estimated to cost \$550,000 dollars. This work is estimated to take 12-18 months to complete.

**Figure A**  
**Existing Arrangement**



**Figure B**  
**Proposed Arrangement**



## **OPTION: 230-kV**

### **Network Impacts**

The Queue Project #T167 was studied as a 120 MW injection at the Four Rivers 230 kV substation in the Dominion area. Project #T167 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

### **Generator Deliverability**

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

None.

### **Multiple Facility Contingency**

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

None.

### **Short Circuit**

- 1) There are four (4) breaker interrupting capabilities with more than 100% as a result of T167 (230kV Option). They are as follow:

<u>Bus</u>	<u>Breaker No.</u>
Elmont 230 kV	216T2075
Elmont 230 kV	283T2075
Elmont 230 kV	21692
Elmont 230 kV	22192

These results are subject to change due to changing system conditions.

### **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)*

- 2) (DOM) The 6FREDBRG-6CRANES 230kV line loads from 99.6% to 111.5% (DC power flow) of its emergency rating (637MVA) for the single line contingency outage (LN 2032). This project contributes approximately 75.9MW to cause this thermal violation. This line was identified as violating a Dominion maximum and stressed system criteria in a previous queue.

### **Stability Analysis**

*(Results of the dynamic studies should be inserted here)*

To be determined at the System Impact Study.

### **Dominion Analysis**

Dominion assessed the impact on the Dominion Transmission System that the proposed 120 MW injection of new generation capacity would have at the Four Rivers 230 kV Substation. The system was assessed using the Summer 2012

RTEP case provided to Dominion by PJM for this analysis. This analysis did include the impacts that higher order queue generators may have on the study results, specifically those generators located on the Dominion Transmission System which have a signed a PJM ISA or IISA and their associated network upgrades were also modeled. The following higher order queue projects were modeled in the PJM Summer 2012 case; P16, P27, Q69, Q71, R17, R63, S86-S96 and T10. When performing a generation analysis Dominion’s main analysis will be load flow study results under single contingency (both normal and stressed system conditions) and import/export system conditions. Dominion Criteria consider a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import / export studies Dominion considers a transmission facility overloaded if it exceeded 100% of its emergency rating. A full listing of Dominion’s Planning Criteria and interconnection requirements can be found in the Company’s Facility Connection Requirements which are publicly available at “[http://www.dom.com/about/electransmission/pdf/Facility\\_Connection\\_Requirements.pdf](http://www.dom.com/about/electransmission/pdf/Facility_Connection_Requirements.pdf)”

As part of its generation impact analysis Dominion routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the T167 evaluation three different assessments were conducted.

- 1) The first being when local generation including the proposed T167 Facility is operated at their maximum capability. The result of this study is indicating significant system deficiencies and is shown below in Table A.
- 2) The second being a stressed system condition, specifically when the largest generator in the area is unavailable. The proposed T167 generator is located on the 230 kV system between Richmond and Northern Virginia load areas. Therefore, the impact of T167 was studied under stressed system conditions where the most critical generating unit located on the 230 kV system in this load area is unavailable. Therefore, Possum Point Unit #5 was outaged to create this critical system condition. The result of this study is shown below in Table B.
- 3) The third being import and export conditions into and out of the Dominion System. Any new facility that is interconnected with the Dominion System should not significantly decrement FCITC between utilities. The results of these studies can be found in Tables C and D.

**Table A**  
**Summer 2012 Pmax System Conditions (Local Generators at Pmax)**

Overloaded Element	Contingency Conditions	Pmax + T167
Four Rivers - Elmont	1	93%

Note: For this study condition generation at Possum Point, Birchwood and Four Rivers was scaled to its maximum value (Pmax) and generation was proportionally reduced throughout the PJM System.

**Table B**  
**Summer 2012 Stressed System Conditions (No Possum Point Unit #5)**

<b>Overloaded Element</b>	<b>Contingency Conditions</b>	<b>Base Case + T167</b>
None		

Note: For this stress system condition Possum Point Unit #5 was removed from service and generation was increased within the Dominion System proportionally to make-up for the reduced generation.

Dominion concurs with the PJM Generator Deliverability Study indicating that the 230 kV Line located between Fredericksburg – Cranes Corner (Line #252) is overloaded.

Dominion’s Planning Criteria also indicates a need to have approximately 2000 MW of import and export capability. The results of these import and export studies are indicating that the proposed generation facility will not impact Dominion’s import or export capability.

**Table C**

<b>Import Study Results</b>			
<b>Area</b>	<b>Summer 2012</b>	<b>Summer 2012 with T167</b>	<b>Limiting Element</b>
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

**Table D**

<b>Export Study Results</b>			
<b>Area</b>	<b>Summer 2012</b>	<b>Summer 2012 with T167</b>	<b>Limiting Element</b>
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

**Non-Direct Connection Network Upgrades**

**New System Reinforcements**

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

The estimated cost to replace the four over-duty 230 kV breakers (item #1 above) is \$720,000 and will take about 8 weeks to complete. The equipment order time will take about 6 to 8 months.

The results of these studies indicate that potentially the 230 kV line between Four Rivers – Elmont may be overloaded. If this occurs in the impact study the estimated cost to upgrade the terminal equipment at Four Rivers 230-kV Substation is \$ 50,000 dollars and it would take 18 months to engineer and complete.

The proposed solutions would resolve all the projected overloads identified in the Dominion and PJM Analysis as they relate to Dominion Transmission Facilities. More precise engineering cost and construction details will be developed as part of the System Impact Study.

### **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)*

This addresses item #2 from the previously identified overloads listed above: The section of 230 kV line located between Fredericksburg and Cranes Corner Substation needs to be re-conducted to mitigate the overload condition. The cost of upgrading this 5 mile line is \$2.2-\$4.9M and is expected to take six months to complete.

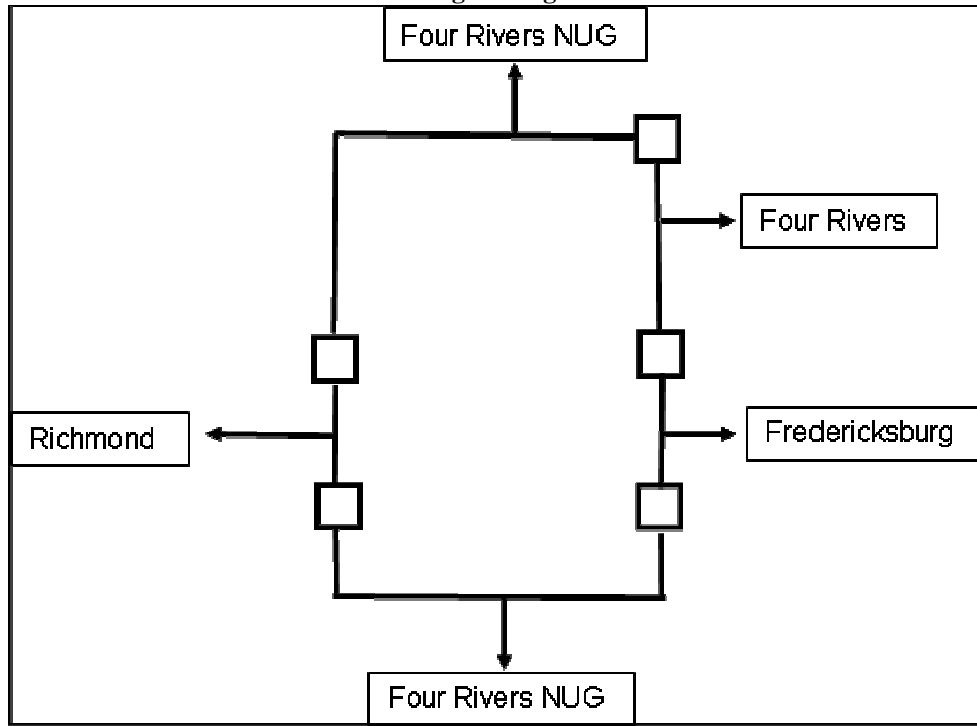
### **Attachment Facilities**

The potential transmission solution will require a rearrangement of the existing Four Rivers 230 kV Substation (Figure A) to accommodate the proposed new generation. The proposed attachment facilities can be found in Figure B. The estimated cost of these facilities which also includes metering, protection equipment along with a 0.5 mile 230 kV line and associated equipment is \$ 600,000 dollars.

### **Direct Connection Network Upgrades**

The network attachment facilities include the installation of one 230 kV breaker and associated equipment and are estimated to cost \$800,000 dollars. This work is estimated to take 12-18 months to complete.

**Figure A**  
**Existing Arrangement**



**Figure B**  
**Proposed Arrangement**

