# PJM Generator Interconnection
# ***T149 Birchwood 230-kV (580 MW)***
# Feasibility Study

April 2008
DMS #478861

## 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

The Queue Project #T149 was studied as a 580MW injection at the Birchwood 230 kV substation in the Dominion area. Project #T149 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

## Summary

The following provides the transmission owners' cost and time estimates for upgrades based on the results of this Feasibility Report:

| | | Cost | Duration |
|---|---|---|---|
| Attachment Facilities & Direct Connection Network Upgrades | | $ 0.6 M | 1.5 Years |
| Non-Direct Connection Network Upgrades | | | |
| New Reiforcements | Option 1 | $50-100 M | 4 Years |
| | Option 2 | $25-30 M | 4 Years |
| Contribution to Existing Reiforcements | | $294.4 M[1] | 10 Years |

[1] Cost allocation to be determined at the System Impact Study

## Network Impacts

**Generator Deliverability (Single Contingency)**

1) (DOM) The 6SANDERS-6NORNECK 230kV line loads from 33.7% to 185.3% (DC power flow) of its emergency rating (382MVA) for the single line contingency outage (LN 2083). This project contributes approximately 579.2MW to cause this thermal violation.

2) (DOM) The 6BIRCHWD-6FREDBRG 230kV line loads from 40.8% to 140.1% (DC power flow) of its emergency rating (583MVA) for the single line contingency outage (LN 2076). This project contributes approximately 579.2MW to cause this thermal violation.

3) (DOM) The 6COMORN-6ARNOLDS 230kV line loads from 38.3% to 133.6% (DC power flow) of its emergency rating (608MVA) for the single line contingency outage (LN 2083). This project contributes approximately 579.2MW to cause this thermal violation.

4) (DOM) The 6NORNECK-6DUNNSVL 230kV line loads from 18.3% to 147.4% (DC power flow) of its emergency rating (382MVA) for the single line contingency outage (LN 2083). This project contributes approximately 493.2MW to cause this thermal violation.

5) (DOM) The 3GARNER-3LANCAST 115kV line loads from 48.9% to 120.4% (DC power flow) of its emergency rating (120MVA) for the single line contingency outage (LN 2083). This project contributes approximately 85.8MW to cause this thermal violation. Dominion has a project to uprate this section of line in 2010 to 216 MVA.

6) (DOM) The 6ARNOLDS-6OAKGROV 230kV line loads from 33.2% to 128.4% (DC power flow) of its emergency rating (608MVA) for the single line contingency outage (LN 2083). This project contributes approximately 579.2MW to cause this thermal violation.

7) (DOM) The 6DUNNSVL-6LANEXA 230kV line loads from 9.4% to 137.2% (DC power flow) of its emergency rating (386MVA) for the single line contingency outage (LN 2083). This project contributes approximately 493.2MW to cause this thermal violation.

8) (DOM) The 6OAKGROV-6WESTMOR 230kV line loads from 26.9% to 122.2% (DC power flow) of its emergency rating (608MVA) for the single line contingency outage (LN 2083). This project contributes approximately 579.2MW to cause this thermal violation.

9) (DOM) The 6WESTMOR-6SANDERS 230kV line loads from 24.4% to 119.7% (DC power flow) of its emergency rating (608MVA) for the single

line contingency outage (LN 2083). This project contributes approximately 579.2MW to cause this thermal violation.

10) (APS/PENELEC) The 01GREENE-ROXBURY 138kV line loads from 95.3% to 100.2% (DC power flow) of its emergency rating (142MVA) for the single line contingency outage (PJM13B_NNWEST_B). This project contributes approximately 7.0MW to cause this thermal violation.

**Multiple Facility Contingencies**

None.

**Short Circuit Analysis**

PJM and Dominion studies indicate that there is no impact to breaker interrupting capabilities in Dominion's service area due to T149. These results are subject to change due to changing system conditions.

**Stability Analysis**

To be performed at the System Impact Study.

**Contribution to Previously Identified Upgrade Requirements**

11) (BGE) The 01KEMPTN-N-NWEST 500kV line loads from 185.94% to 189.69% (DC power flow) of its normal rating (2078MVA) for non-contingency condition. This project contributes approximately 78.0MW to the thermal violation.

**Dominion Virginia Power Analysis**

Dominion assessed the impact on the Dominion Transmission System that the proposed 580 MW injection of new generation capacity would have at the Birchwood 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 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/elec-transmission/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 T149 evaluation three different assessments were conducted.

A. The first being when local generation including the proposed T149 Facility is operated at their maximum capability. The result of this study is indicating significant system deficiencies and is shown below in Table A.

B. The second being a stressed system condition, specifically when the largest generator in the area is unavailable. The proposed T149 generator is centrally located between two major load areas the first being Northern Virginia and the second being North Hampton Roads. Therefore, the impact of T149 was studied under stressed system conditions where the largest generating unit in Northern Virginia (Possum Point Unit #5) is unavailable and separately when the largest generating unit in North Hampton Roads (Yorktown Unit #3) is unavailable. The results of these studies are indicating significant system deficiencies and are shown below in Tables B and C.

C. 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 D and E.

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

| Overloaded Element | Contingency Conditions | Pmax + T149 |
|---|---|---|
| Birchwood - Fredericksburg | 30+ | 137.2% |
| Birchwood - Northern Neck | 1 | 133.6% |
| Northern Neck - Lanexa | 1 | 144.9% |
| Fredericksburg – Cranes Corner | 5 | 98.0% |
| Fredericksburg 230-115 kV Tx | 1 | 102.6% |
| Possum Point – Woodbridge | 1 | 97.1% |

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)**

| Overloaded Element | Contingency Conditions | Base Case + T149 |
|---|---|---|
| Birchwood- Fredericksburg | 30+ | 135% |
| Birchwood- Northern Neck | 1 | 130.0% |
| Northern Neck - Lanexa | 1 | 139.0% |
| Fredericksburg – Cranes Corner | 5 | 111.0% |
| Fredericksburg 230-115 kV Tx | 1 | 106.0% |

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.

**Table C**
**Summer 2012 Stressed System Conditions (No Yorktown Unit #5)**

| Overloaded Element | Contingency Conditions | Base Case + T149 |
|---|---|---|
| Birchwood- Fredericksburg | 2 | 135% |
| Birchwood- Northern Neck | 1 | 130.0% |
| Northern Neck - Lanexa | 1 | 138.0% |
| Fredericksburg 230-115 kV Tx | 1 | 94.0% |

Note: For this stress system condition Yorktown 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 over a 100 miles of 230 kV lines are overloaded plus the Fredericksburg 230 -115 kV autotransformer. Specifically the following 230 kV lines are overloaded.

a. Line # 2083 (Fredericksburg – Birchwood) 15 miles
b. Line # 2076 (Birchwood – Northern Neck) 44 miles
c. Line # 224 (Lanexa – Northern Neck) 40 miles
d. Line # 252 (Fredericksburg – Cranes Corner) 5 miles
e. Line # 2001 (Possum Point - Woodbridge) 8 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

indicating that the proposed generation facility will impact Dominion's export capability to PJM. However, the same facilities identified in the N-1 Analysis noted above are the limiting facilities in these transfer studies.

**Table D**

| Import Study Results | | | |
|---|---|---|---|
| Area | Summer 2012 | Summer 2012 with T149 | Limiting Element |
| AEP | 2000+ | 2000+ | None |
| APS | 2000+ | 2000+ | None |
| CPL | 2000+ | 2000+ | None |
| PJM | 2000+ | 2000+ | None |

**Table E**

| Export Study Results | | | |
|---|---|---|---|
| Area | Summer 2012 | Summer 2012 with T149 | Limiting Element |
| AEP | 2000+ | 2000+ | None |
| APS | 2000+ | 2000+ | None |
| CPL | 2000+ | 2000+ | None |
| PJM | 2000+ | 1036+ | Fredericksburg – Cranes 230 kV Line |

Either the proposed 230 kV or 500 kV options described subsequently will resolve these above noted transfer limits.

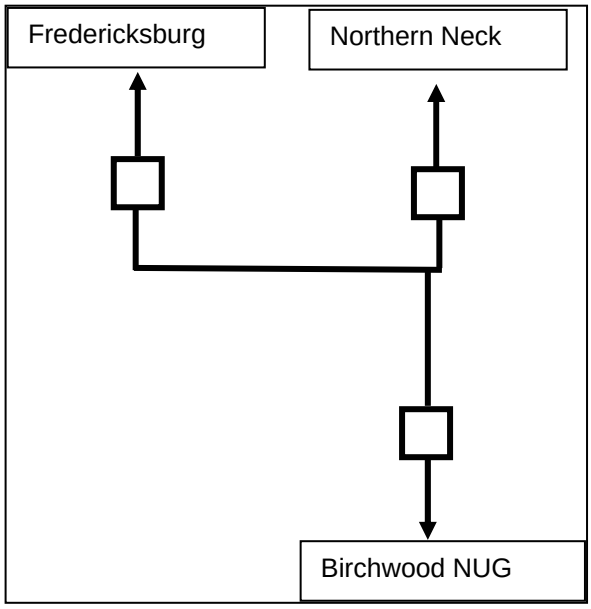
## Interconnection Requirements

The following describes the attachment, direct and non-direct connection network facilities required to interconnect the unit to the system.

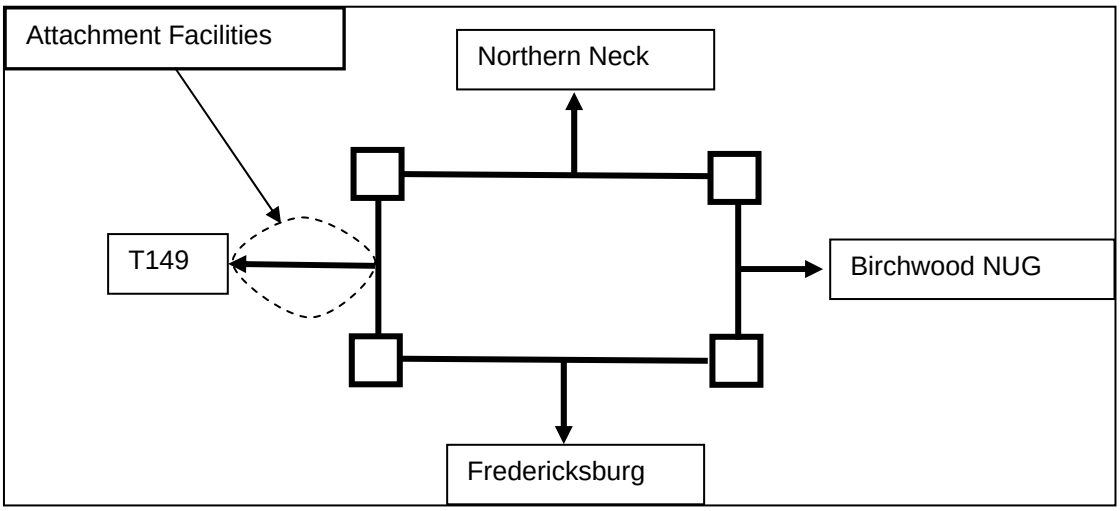
### Attachment & Direct Connection Facilities

Either potential transmission solution will require a rearrangement of the existing Birchwood Substation (Figure A) to accommodate the proposed new generation since the aggregate generation amount at the substation will exceed 500 MW. The proposed attachment facilities can be found in Figure B. Any change to the existing Birchwood Substation between Figure A and B, not identified as an Attachment Facility, is a Direct Connection Network Upgrade. The estimated cost of the attachment and direct connection facilities, which also includes metering, protection equipment along with a 0.5 mile 230 kV line and associated equipment, is $600,000 dollars. This work is estimated to take 12-18 months to complete.

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




**Potential Arrangement**
**Figure B**



## Non-Direct Connection Network Upgrades

### New Reinforcements

Two possible solutions were evaluated to resolve Dominion criteria violations. Both solutions would resolve all the projected overloads identified in the Dominion and PJM Analysis as they relate to Dominion Transmission Facilities. Better detailed engineering cost and construction details will be developed by Dominion as part of the System Impact Study.

A. The first solution evaluated was re-conductoring/ rebuilding the 100 miles of the 230 kV lines and adding an additional 230-115 kV autotransformer at Fredericksburg Substation. The first solution is estimated to cost approximately $50 – 110 million dollars depending on whether the line(s) can be re-conductored or if they need to be rebuilt. This alternative is estimated to require 40-50 months of outage time since the majority of outages can not be scheduled concurrently.

B. The second solution evaluated was looping (2.5 miles) the existing Ladysmith–Possum Point 500 kV Line #568 to the proposed site and installing a 500-230 kV autotransformer at Birchwood Substation. For the second solution the section of 230 kV line located between Fredericksburg and Cranes Corner Substation still needs to be re-conductored. The second alternative is estimated to cost $25-30 million dollars and will require a SCC Certificate of Public Convenience and Necessity. This alternative is estimated to take 36-48 months to complete based on standard permitting schedules.

Both solutions would resolve all the projected overloads identified in the Dominion and PJM Analysis as they relate to Dominion Transmission Facilities. Exact engineering cost and construction details will be developed as part of the Facilities Study.

To mitigate Generator Deliverability overload item 10, the Roxbury 138/115-kv transformer should be operated open, consistent with existing FirstEnergy procedures to control thermal contingencies that occur on the Penelec/AP tie lines.

### Contribution to Previously Identified System Reinforcements

Kemptown to North Northwest 500 kV – Two new single circuit lines at an estimated cost of $279 million and estimated time of 10 years to permit and complete. Necessary substation work is estimated at $15.4M and will be coordinated with the line completion. This project's cost allocation to the reinforcements will be determined at the System Impact Study.