PJM Generator Interconnection

X2-076 Carson - Wake 500 kV

1376 MW Capacity / 1551 MW Energy

Feasibility Study Report

December 2011
DMS #670413v1

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. Progress Energy is an Affected System Operator (ASO).

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 project X2-076 was studied as a 1551 MW (1376 MW of which was Capacity) injection into Dominion's portion of the Carson – Wake 500 kV line. Project X2-076 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

Network Impacts:

Generator Deliverability

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

1. (DVP) The Fredericksburg 230 kV-Cranes Corner 230 kV line (from bus 314137 to bus 314134 ckt 1) loads from 98.52% to 100.08% (DC power flow) of its emergency rating (637 MVA) for the single contingency '8LDYSMTH _8POSSUM _026'. This project contributes approximately 61.80 MW to the thermal violation.

```
CONTINGENCY '8LDYSMTH _8POSSUM _026'
  DISCONNECT BRANCH FROM BUS 314911 TO BUS 314922 CKT 1     /* 500/500KV, AREA 345/345.
END
```

This issue is addressed by PJM baseline project b1701. While IC has no obligation to this upgrade, this system upgrade must be completed before commercial operation.

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.)

2. (BG&E) The High Ridge 2316-Howard 2332 230 kV line (from bus 220941 to bus 220954 ckt 1) loads from 110.95% to 112.09% (DC power flow) of its emergency rating (941 MVA) for the single contingency 'PP1EB'. This project contributes approximately 66.85 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1           / 200003 BRIGHTON 500 200004
CNASTONE 500 1
END
```

Mitigation: Rebuild line to accommodate double bundle 1272 ACSR. The estimated cost is $24M and will take approximately five years to complete.
Assumptions:

- Length of line is 8.9 miles
- 2+ year CPCN process required

- Existing tower removal included

3. (PENELEC) The Roxbury-Roxbury 138/115 kV transformer (from bus 200532 to bus 200520 ckt 1) loads from 115.32% to 117.4% (DC power flow) of its emergency rating (138 MVA) for the single contingency 'PP1EB'. This project contributes approximately 17.76 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1           / 200003 BRIGHTON 500 200004
CNASTONE 500 1
END
```

Mitigation: The overload can be alleviated by replacing the Roxbury 138/115 kV transformer and associated terminal equipment (circuit breaker, substation conductor, CT circuits), which is estimated to cost approximately $2,250,000 and require a lead time of at least 2 years.

4. (BG&E/PL) The Conastone-Otter Creek Switchyard 230 kV line (from bus 220963 to bus 208048 ckt 1) loads from 139.76% to 141.37% (DC power flow) of its emergency rating (531 MVA) for the single contingency 'PJM17'. This project contributes approximately 53.83 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

Mitigation: The BG&E portion of the Conastone to Otter Creek line can be upgraded by Reconducting from Gorsuch Mills to the Pennsylvania State Line (change of ownership to PPL). The existing circuit 2302 conductor is 1,590 kcmil 45/7 ACSR from Conastone to Gorsuch Mills and 795 kcm 30/19 ACSR from Gorsuch Mills to the PA State Line.

Assumptions:

- Reconductor with 1,590 kcm ACSR from Gorsuch Mills to PA line to match capability of remainder of line.
- Length of this line section is 1.7 miles.
- Towers can be reinforced instead of replaced.
- Based on previous estimate by R.W.M. for PJM (B48) study on circuit 22008

The estimated cost of this upgrade is $700,000. Estimated construction time is 36 months.

A PPL project to re-conductor Manor-Conastone with 1590 ACSR is underway. This project will equip the line to handle 653/793 MVA (Summer Normal/Emergency). Estimated cost: $17M. Estimated in-service date: October 2013.

5. (BG&E) The Sandy Spring 2314-High Ridge 2316 230 kV line (from bus 220983 to bus 220941 ckt 1) loads from 106.92% to 107.74% (DC power flow) of its emergency rating (941 MVA) for the single contingency 'PP28'. This project contributes approximately 47.27 MW to the thermal violation.

```
CONTINGENCY 'PP28'
  OPEN BRANCH FROM BUS 220984 TO BUS 223962 CKT 1           / 220984 SANDY34T 230 223962
BURT2334 230 1
END
```

Mitigation: Rebuild existing line using double bundle 1033 ACSR @ 125 degC (1227 MVA) = $10M, 5 years

Assumptions:

- -Full structure replacement required
- -Existing structure removal included
- -Line length of 3.61 miles
- -2+ year CPCN process required

6. (BG&E/PECO) The Graceton-Cooper 230 kV line (from bus 220964 to bus 214089 ckt 1) loads from 135.34% to 136.97% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 48.85 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

Mitigation: PECO portion: Reconductor Line 220-93 from Cooper Substation to Graceton Substation to get a minimum summer emergency rating of 725 MVA. The line is approximately 4 miles long. This cost is for the PECO portion only. The estimated cost to perform this wrk is $2.8M, and will require 24 months to complete.

BGE portion: a double circuit line will be built with 1033.5kcmil ACSR creating one circuit by connecting the two lines into one. Rating for 2 – 1033.5kcmil 45/7 ACSR (Ortolan) at 125°C = 968/1227MVA SN/SE. BGE ownership is for

1.85 miles and the rebuild of 11 structures. It would be built as a double circuit line with the conductors jumpered across at the terminal ends. The line construction is estimated at $3,000,000. Two breakers ($400,000/breaker) would need to be replaced at Graceton for a cost of $800,000. An additional cost of $200,000 would also be incurred for 4 breaker disconnects and line connections to cover thermal. The project is estimated to take 30 months to complete: 12 months for the CPCN process & design and an additional 18 months for construction. The total cost of the project is estimated at $4.0M.

7. (DVP) The North Anna 500 kV-Ladysmith 500 kV 500 kV line (from bus 314918 to bus 314911 ckt 1) loads from 102.77% to 111.44% (DC power flow) of its emergency rating (3117 MVA) for the single contingency '8MORRSVL _8NO ANNA _033'. This project contributes approximately 270.10 MW to the thermal violation.

```
CONTINGENCY '8MORRSVL _8NO ANNA _033'
  DISCONNECT BRANCH FROM BUS 314916 TO BUS 314918 CKT 1     /* 500/500KV, AREA 345/345.
END
```

This exceeds the conductor rating of the existing line 575 (North Anna – Ladysmith) and will require the construction of the 2nd North Anna –Ladysmith 500 kV line identified n Q65 (n0718.1).

8. (DVP) The North Anna 500 kV-Morrisville 500 kV 500 kV line (from bus 314918 to bus 314916 ckt 1) loads from 109.29% to 120.06% (DC power flow) of its emergency rating (2598 MVA) for the single contingency '8LDYSMTH _8NO ANNA _025'. This project contributes approximately 279.93 MW to the thermal violation.

```
CONTINGENCY '8LDYSMTH _8NO ANNA _025'
  DISCONNECT BRANCH FROM BUS 314911 TO BUS 314918 CKT 1     /* 500/500KV, AREA 345/345.
END
```

The construction of the upgrade noted in 7 above resolves this contingency condition.

9. (PECO) The Cooper-Peach Bottom 230 kV line (from bus 214089 to bus 213869 ckt 1) loads from 132.86% to 134.48% (DC power flow) of its emergency rating (485 MVA) for the single contingency 'PJM17'. This project contributes approximately 48.85 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

Mitigation: Reconductor Line 220-08 from Peach Bottom tap to Cooper Substation to get a minimum summer emergency rating of 741 MVA. The line is approximately 1.4 miles long. The estimated cost to perform this work is $1.0M, and will require 24 months to complete.

10. (PEPCO) The 12Th & Irving-Ft Slocum Par 69 kV line (from bus 224119 to bus 224121 ckt 1) loads from 171.95% to 172.84% (DC power flow) of its emergency rating (125 MVA) for the tower contingency '7PEPCO_A'. This project contributes approximately 6.89 MW to the thermal violation.

```
CONTINGENCY '7PEPCO_A'     /* BOWIE045 TO OAKGV23
  DISCONNECT BRANCH FROM BUS 223978 TO BUS 223961 CKT 1     /* OAKGV05 TO CHALK230
  DISCONNECT BRANCH FROM BUS 223982 TO BUS 223978 CKT 1
  DISCONNECT BRANCH FROM BUS 224061 TO BUS 223980 CKT 1
  DISCONNECT BRANCH FROM BUS 292454 TO BUS 224061 CKT 1     /BUS 223983 -> 292454
END
```

This violation will not be valid once the Benning and Buzzard units retire. Once the project moves to impact phase these will be studied on the updated case.

11. (BG&E) The Sandy Spring 2334-High Ridge 2316 230 kV line (from bus 220984 to bus 220941 ckt 1) loads from 107.30% to 108.11% (DC power flow) of its emergency rating (941 MVA) for the single contingency 'PP27'. This project contributes approximately 47.11 MW to the thermal violation.

```
CONTINGENCY 'PP27'
  OPEN BRANCH FROM BUS 220983 TO BUS 223961 CKT 1           / 220983 SANDY14T 230 223961
BURT2314 230 1
END
```

Mitigation: Rebuild existing line using double bundle 1033 ACSR @ 125 degC (1227 MVA) = $10M, 5 years

Assumptions:

- -Full structure replacement required
- -Existing structure removal included
- -Line length of 3.61 miles
- -2+ year CPCN process required

12. (PL) The Safe Harbor Units 3-4 Tap-Manor Substation 230 kV line (from bus 208071 to bus 208019 ckt 1) loads from 100.43% to 101.59% (DC power flow) of its emergency rating (579 MVA) for the single contingency 'PJM17'. This project contributes approximately 42.20 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

Mitigation: Upgrade current 795 kcmil 30/19 (140 degrees C) line section to 1590 kcmil 45/7 (125 degrees). The cost of this upgrade would be approximately $56,000.

13. (BG&E) The Howard 2312-Granite 2311 & 2312 230 kV line (from bus 220953 to bus 220972 ckt 1) loads from 110.29% to 111.57% (DC power flow) of its emergency rating (728 MVA) for the single contingency 'PP1EB'. This project contributes approximately 58.18 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1 / BRIGHTON 500 CNASTONE 500
END
```

Mitigation: 500K replace wire drops and upgrade structures. Estimate is $100,000 and 12-18 months to provided a new rating of 825 MVA.

14. (PJM) The Conastone-Peach Bottom 500 kV line (from bus 200004 to bus 200013 ckt 1) loads from 128.00% to 128.96% (DC power flow) of its emergency rating (2815 MVA) for the single contingency 'PJM76'. This project contributes approximately 203.92 MW to the thermal violation.

```
CONTINGENCY 'PJM76'
  REMOVE MACHINE 1 FROM BUS 200034       /* PB2
END
```

Mitigation: BGE: (n2138) Rebuild bay with breakers A, B and C to 4000 A. New rating is 2939/3733. To rebuild bay cost estimate is $6,600,000, time estimate is 24-36 months.

PECO: (n2139)Replace existing Peach Bottom-Conastone 500 kV line (5012) terminal equipment at Peach Bottom Substation to match the conductor summer normal and emergency rating of

2920 / 3707 MVA (PECO portion only). Cost estimate is $5 million, duration estimate 3 years.

15. (BG&E) The High Ridge 2316-Columbia 230 kV line (from bus 220941 to bus 221010 ckt 1) loads from 105.19% to 106.18% (DC power flow) of its emergency rating (941 MVA) for the single contingency 'PP1EB'. This project contributes approximately 57.83 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1 / BRIGHTON 500 CNASTONE 500
END
```

Mitigation: This line is at its full rating requires a total rebuild. Estimated cost is $15M for the 4.4 mile 230kV line. A CPCN is needed and it will take 4-5 years to build. Rebuild with bundle 1590 MCM rate 1604 SE. Further studies need to be done once the final rating is determined by PJM in the queue process.

16. (AP/PJM) The Kemptown-EMORY GR500 500 kV line (from bus 235632 to bus 200101 ckt 1) loads from 123.54% to 124.47% (DC power flow) of its emergency rating (2901 MVA) for the single contingency 'PJM67'. This project contributes approximately 183.45 MW to the thermal violation.

```
CONTINGENCY 'PJM67'
  DISCONNECT BRANCH FROM BUS 200026 TO BUS 200004 CKT 1 /* HUNTERTN CNASTONE 500 500
END
```

Mitigation: The two breaker bay at Conastone for the Brighton line is over the continuous rating. Upgrade Conastone bay with two 4000A breakers, four 4000A breaker disconnects and a 4000 A line switch need to be either. $3M take 24-36 months to complete. The New rating will be 3710 A.

17. (AP/PJM) The Kemptown-EMORY GR500 500 kV line (from bus 235632 to bus 200101 ckt 1) loads from 134.44% to 135.49% (DC power flow) of its normal rating (2338 MVA) for non contingency condition. This project contributes approximately 188.68 MW to the thermal violation.

Mitigation: The two breaker bay at Conastone for the Brighton line is over the continuous rating. Upgrade Conastone bay with two 4000A breakers, four 4000A breaker

disconnects and a 4000 A line switch need to be either. $3M take 24-36 months to complete. The New rating will be 3710 A.

18. (DVP) The Cannon Branch 230 kV-Prince WillamsDel Pt 230 kV 230 kV line (from bus 314016 to bus 314117 ckt 1) loads from 131.78% to 132.69% (DC power flow) of its emergency rating (319 MVA) for the single contingency 'LN 2030'. This project contributes approximately 17.89 MW to the thermal violation.

```
CONTINGENCY 'LN 2030'     /* LOUDOUN - GAINESVILLE AND TX 2 & LN 172
  OPEN BRANCH FROM BUS 314061 TO BUS 314037 CKT 1        /* LOUDON TO GAINESVILLE
  OPEN BRANCH FROM BUS 314037 TO BUS 314115 CKT 1        /* GAINESVILLE TX 2 (DVP LN 172)
  OPEN BRANCH FROM BUS 314037 TO BUS 314045 CKT 1        /* GAINESVILLE TX 3 TO NOVEC
  OPEN BRANCH FROM BUS 314115 TO BUS 314123 CKT 1        /* GAINESVILLE TO WELLINGTON DP
  OPEN BRANCH FROM BUS 314123 TO BUS 314157 CKT 1        /* WELLINGTON DP TO GODW172
  OPEN BRANCH FROM BUS 314147 TO BUS 314157 CKT 1        /* LN 197 MICRON TO GODWIN
  OPEN BRANCH FROM BUS 314049 TO BUS 314147 CKT 1        /* MICR172 - LOMA172
  OPEN BRANCH FROM BUS 314049 TO BUS 314159 CKT 1        /* LOMAR TX
  OPEN BRANCH FROM BUS 314147 TO BUS 314160 CKT 1        /* MICRON TX
  OPEN BRANCH FROM BUS 314147 TO BUS 314161 CKT 1        /* MICRON TX
  OPEN BRANCH FROM BUS 314157 TO BUS 314162 CKT 1        /* GODWIN TX
END
```

Network protectors on 13 kV side of transformers were uprated to prevent reverse power flow and associated overloads.

Short Circuit

(Report Overdutied breakers here)

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With x2-076_DOM	Duty Percent Without x2-076_DOM	Duty Percent Difference	Note
777	YADKIN 2&4 230.kV	SC112	S	101.00%	99.70%	1.30%	19. New Over-duty
1366	CHICKAHOMINY 230.kV	2050T2091	S	100.30%	100.00%	0.30%	20. New Over-duty

The 40 kA breakers 2050T2091 at Chickahominy 230 kV bus and SC112 at Yakin 230 kV bus would be overdutied with X2-076. The estimated cost to replace each breaker with 50 kA breaker is $205,000 and will take about 9 months including equipment order time.

The x2-076 queue did not have a significant fault contribution (i.e. above 3%) to any of the already existing over-duty breakers.

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 IC 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.

21. (BG&E) The High Ridge 2316-Howard 2332 230 kV line (from bus 220941 to bus 220954 ckt 1) loads from 108.47% to 109.76% (DC power flow) of its emergency rating (941 MVA) for the operational contingency 'PP1EB'. This project contributes approximately 75.35 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1   /  BRIGHTON 500  CNASTONE 500 1
END
```

22. (PENELEC) The Roxbury-Roxbury 138/115 kV transformer (from bus 200532 to bus 200520 ckt 1) loads from 162.16% to 164.03% (DC power flow) of its emergency rating (138 MVA) for the operational contingency 'PP1EB'. This project contributes approximately 20.02 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1           / 200003 BRIGHTON 500 200004
CNASTONE 500 1
END
```

23. (PENELEC) The Roxbury-Roxbury 138/115 kV transformer (from bus 200532 to bus 200520 ckt 1) loads from 115.77% to 117.58% (DC power flow) of its normal rating (124 MVA) for non contingency condition. This project contributes approximately 13.93 MW to the thermal violation.

24. (BG&E/PL) The Conastone-Otter Creek Switchyard 230 kV line (from bus 220963 to bus 208048 ckt 1) loads from 122.04% to 123.89% (DC power flow) of its emergency rating (531 MVA) for the operational contingency 'PJM17'. This project contributes approximately 60.67 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

25. (BG&E) The Sandy Spring 2314-High Ridge 2316 230 kV line (from bus 220983 to bus 220941 ckt 1) loads from 103.84% to 104.75% (DC power flow) of its emergency rating (941 MVA) for the operational contingency 'PP28'. This project contributes approximately 53.28 MW to the thermal violation.

```
CONTINGENCY 'PP28'
  OPEN BRANCH FROM BUS 220984 TO BUS 223962 CKT 1           / 220984 SANDY34T 230 223962
BURT2334 230 1
END
```

26. (BG&E/PECO) The Graceton-Cooper 230 kV line (from bus 220964 to bus 214089 ckt 1) loads from 128.62% to 130.07% (DC power flow) of its emergency rating (485 MVA) for the operational contingency 'PJM17'. This project contributes approximately 55.06 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

27. (DVP) The North Anna 500 kV-Ladysmith 500 kV 500 kV line (from bus 314918 to bus 314911 ckt 1) loads from 105.67% to 115.44% (DC power flow) of its emergency rating (3117 MVA) for the operational contingency '8MORRSVL _8NO ANNA _033'. This project contributes approximately 304.45 MW to the thermal violation.

```
CONTINGENCY '8MORRSVL _8NO ANNA _033'
  DISCONNECT BRANCH FROM BUS 314916 TO BUS 314918 CKT 1     /* 500/500KV, AREA 345/345.
END
```

28. (AP) The Lake Lynn-Lardin 138 kV line (from bus 235122 to bus 235207 ckt 2) loads from 98.46% to 99.5% (DC power flow) of its emergency rating (113 MVA) for the operational contingency 'APS_B_G100'. This project contributes approximately 7.26 MW to the thermal violation.

```
CONTINGENCY 'APS_B_G100'     / 235122 01LKLYNN 138 235207 01LARDIN 138 1
  OPEN BRANCH FROM BUS 235122 TO BUS 235207 CKT 1
END
```

29. (DVP) The North Anna 500 kV-Morrisville 500 kV 500 kV line (from bus 314918 to bus 314916 ckt 1) loads from 113.48% to 125.58% (DC power flow) of its emergency rating (2598 MVA) for the operational contingency '8LDYSMTH _8NO ANNA _025'. This project contributes approximately 315.54 MW to the thermal violation.

```
CONTINGENCY '8LDYSMTH _8NO ANNA _025'
  DISCONNECT BRANCH FROM BUS 314911 TO BUS 314918 CKT 1     /* 500/500KV, AREA 345/345.
END
```

30. (METED) The Germantown Reactor-Germantown 138/115 kV transformer (from bus 204531 to bus 204529 ckt 1) loads from 107.41% to 109.26% (DC power flow) of its emergency rating (104 MVA) for the operational contingency 'PP1EB'. This project contributes approximately 11.91 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1           / 200003 BRIGHTON 500 200004
CNASTONE 500 1
END
```

31. (METED) The Germantown-Germantown Reactor 138 kV line (from bus 204530 to bus 204531 ckt 1) loads from 107.42% to 109.27% (DC power flow) of its emergency rating (104 MVA) for the operational contingency 'PP1EB'. This project contributes approximately 11.91 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1          / BRIGHTON 500 CNASTONE 500
END
```

32. (PECO) The Cooper-Peach Bottom 230 kV line (from bus 214089 to bus 213869 ckt 1) loads from 126.58% to 128.03% (DC power flow) of its emergency rating (485 MVA) for the operational contingency 'PJM17'. This project contributes approximately 55.06 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

33. (CPLE/DVP) The Person 230-Halifax 230 kV 230 kV line (from bus 304070 to bus 314697 ckt 1) loads from 78.08% to 116.07% (DC power flow) of its emergency rating (608 MVA) for the operational contingency '8CARSON _8DBGEN

_014_X2-076A'. This project contributes approximately 230.99 MW to the thermal violation.

```
CONTINGENCY '8CARSON _8DBGEN _014_X2-076A'
  DISCONNECT BRANCH FROM BUS 314902 TO BUS 909840 CKT 1     /* 500/500KV, AREA 345/340.
END
```

34. (PEPCO) The 12Th & Irving-Ft Slocum Par 69 kV line (from bus 224119 to bus 224121 ckt 1) loads from 147.57% to 148.38% (DC power flow) of its emergency rating (125 MVA) for the operational contingency 'PP31'. This project contributes approximately 6.28 MW to the thermal violation.

```
CONTINGENCY 'PP31'
  OPEN BRANCH FROM BUS 223961 TO BUS 223978 CKT 1  / BURT2314 230 BOWIE045 230
END
```

35. (BG&E) The Sandy Spring 2334-High Ridge 2316 230 kV line (from bus 220984 to bus 220941 ckt 1) loads from 104.34% to 105.25% (DC power flow) of its emergency rating (941 MVA) for the operational contingency 'PP27'. This project contributes approximately 53.11 MW to the thermal violation.

```
CONTINGENCY 'PP27'
  OPEN BRANCH FROM BUS 220983 TO BUS 223961 CKT 1  / SANDY14T 230 BURT2314 230
END
```

36. (AP) The Lake Lynn-Lardin 138 kV line (from bus 235122 to bus 235207 ckt 1) loads from 98.46% to 99.5% (DC power flow) of its emergency rating (113 MVA) for the operational contingency 'APS_B_G101'. This project contributes approximately 7.26 MW to the thermal violation.

```
CONTINGENCY 'APS_B_G101'     / 235122 01LKLYNN 138 235207 01LARDIN 138 2
  OPEN BRANCH FROM BUS 235122 TO BUS 235207 CKT 2
END
```

37. (PL) The Safe Harbor Units 3-4 Tap-Manor Substation 230 kV line (from bus 208071 to bus 208019 ckt 1) loads from 106.80% to 108.12% (DC power flow) of its emergency rating (579 MVA) for the operational contingency 'PJM17'. This project contributes approximately 47.57 MW to the thermal violation.

```
CONTINGENCY 'PJM17'
  DISCONNECT BRANCH FROM BUS 200004 TO BUS 200013 CKT 1     /* CNASTONE PEACHBTM 500 500
END
```

38. (AP) The West Run-Lake Lynn 138 kV line (from bus 235424 to bus 235122 ckt 1) loads from 111.95% to 112.93% (DC power flow) of its emergency rating (176 MVA) for the operational contingency '01YUKON _01BRNRUN _084_A'. This project contributes approximately 10.70 MW to the thermal violation.

```
CONTINGENCY '01YUKON _01BRNRUN _084_A'
  DISCONNECT BRANCH FROM BUS 235116 TO BUS 292625 CKT 1     /* 500/500KV, AREA 201/201. /
BUS 235850 -> 292625. T174.
END
```

39. (BG&E) The Riverside 2317-Northeast 2315 & 2317 230 kV line (from bus 220966 to bus 220979 ckt 1) loads from 104.49% to 105.43% (DC power flow) of its emergency rating (632 MVA) for the operational contingency 'BG_CKT2344'. This project contributes approximately 36.59 MW to the thermal violation.

```
CONTINGENCY 'BG_CKT2344'     /* BRANDON TO RIVERSIDE CKT #2344
  DISCONNECT BUS 220989                                  /*CKT 2344 BRANDON – HAWKINS-
SOLLERS
  DISCONNECT BUS 220990                                   /*CKT 2344 HAWKINS-SOLLERS-
RIVERSIDE
  DISCONNECT BUS 220977                                   /* RIVERSIDE 230-1 H/S AND
2339 TO NORTHEAST
  DISCONNECT BUS 221230                                  /*RIVERSIDE 230-1 & L/S BUS
CONNECTION
END
```

40. (AP/PENELEC) The Greene-Roxbury 138 kV line (from bus 235188 to bus 200532 ckt 1) loads from 107.53% to 109.24% (DC power flow) of its emergency rating (189 MVA) for the operational contingency 'PP1EB'. This project contributes approximately 20.02 MW to the thermal violation.

```
CONTINGENCY 'PP1EB'     / NO PATH
  OPEN BRANCH FROM BUS 200101 TO BUS 235632 CKT 1           / 200003 BRIGHTON 500 200004
CNASTONE 500 1
END
```

41. (PJM) The Conastone-Peach Bottom 500 kV line (from bus 200004 to bus 200013 ckt 1) loads from 112.63% to 113.66% (DC power flow) of its emergency rating (2815 MVA) for the operational contingency 'PJM76'. This project contributes approximately 229.86 MW to the thermal violation.

```
CONTINGENCY 'PJM76'
  REMOVE MACHINE 1 FROM BUS 200034                        /* PB2
END
```

42. (AP/PJM) The Kemptown-EMORY GR500 500 kV line (from bus 235632 to bus 200101 ckt 1) loads from 113.75% to 114.69% (DC power flow) of its emergency rating (2901 MVA) for the operational contingency 'PJM76'. This project contributes approximately 212.67 MW to the thermal violation.

```
CONTINGENCY 'PJM76'
  REMOVE MACHINE 1 FROM BUS 200034                          /* PB2
END
```

43. (AP/PJM) The Kemptown-EMORY GR500 500 kV line (from bus 235632 to bus 200101 ckt 1) loads from 123.77% to 124.94% (DC power flow) of its normal rating (2338 MVA) for non-contingency condition. This project contributes approximately 212.67 MW to the thermal violation.

44. (DVP) The Fredericksburg 230 kV-Cranes Corner 230 kV 230 kV line (from bus 314137 to bus 314134 ckt 1) loads from 101.17% to 102.86% (DC power flow) of its emergency rating (637 MVA) for the operational contingency '8LDYSMTH _8POSSUM _026'. This project contributes approximately 69.66 MW to the thermal violation.

```
CONTINGENCY '8LDYSMTH _8POSSUM _026'
  DISCONNECT BRANCH FROM BUS 314911 TO BUS 314922 CKT 1     /* 500/500KV, AREA 345/345.
END
```

45. (DVP) The Cannon Branch 230 kV-Prince WillamsDel Pt 230 kV 230 kV line (from bus 314016 to bus 314117 ckt 1) loads from 130.73% to 131.75% (DC power flow) of its emergency rating (319 MVA) for the operational contingency 'LN 2030'. This project contributes approximately 20.16 MW to the thermal violation.

```
CONTINGENCY 'LN 2030'     /* LOUDOUN - GAINESVILLE AND TX 2 & LN 172
  OPEN BRANCH FROM BUS 314061 TO BUS 314037 CKT 1           /* LOUDON TO GAINESVILLE
  OPEN BRANCH FROM BUS 314037 TO BUS 314115 CKT 1             /* GAINESVILLE TX 2 (DVP LN
172)
  OPEN BRANCH FROM BUS 314037 TO BUS 314045 CKT 1           /* GAINESVILLE TX 3 TO NOVEC
  OPEN BRANCH FROM BUS 314115 TO BUS 314123 CKT 1            /* GAINESVILLE TO WELLINGTON
DP
  OPEN BRANCH FROM BUS 314123 TO BUS 314157 CKT 1           /* WELLINGTON DP TO GODW172
  OPEN BRANCH FROM BUS 314147 TO BUS 314157 CKT 1           /* LN 197 MICRON TO GODWIN
  OPEN BRANCH FROM BUS 314049 TO BUS 314147 CKT 1           /* MICR172 - LOMA172
  OPEN BRANCH FROM BUS 314049 TO BUS 314159 CKT 1           /* LOMAR TX
  OPEN BRANCH FROM BUS 314147 TO BUS 314160 CKT 1           /* MICRON TX
  OPEN BRANCH FROM BUS 314147 TO BUS 314161 CKT 1           /* MICRON TX
  OPEN BRANCH FROM BUS 314157 TO BUS 314162 CKT 1           /* GODWIN TX
END
```

ASO Analysis

The following is detailed in Appendix A

Persons-Halifax 230kV line:

Dominion: The estimated cost would be $32 Million and would take 18-24 months to engineer and construct. This assumes no temporary construction, the outage of this line does normally cause congestion on the PJM System and issues at Clover PS which is one bus away from Halifax Substation. If a temporary line is required then an additional $20 Million will be needed.

Progress Energy: Rebuild progress portion (4.85 Miles) with bundled 1590 ACSR. Estimated cost is $7.5M.

Wake-Rocky Mount 230kV line:

Construct new line with bundled 1590 ACSR. Estimated cost $60M.

Rocky Mt.-Battleboro 115 kV Line:

This overload will be remedied by operating procedures as well as a future Dominion project which will be confirmed in the System Impact Study.

ITO Analysis

ITO assessed the impact of the proposed queue project X2-076 interconnection as a 1551 MW of energy (1376 MW Capacity) on the ITO system. The system was assessed using the summer 2015 RTEP case provided to ITO by PJM, this 1376 MW capacity injection occurred at a new Brunswick Substation which will be looked on the Carson to Wake 500 kV Line. Wake is owned by Progress Energy. This analysis did include the impacts of the generation capacity for all W-queue and X-queue generators within the ITO system. When performing a generation analysis, ITO main analysis will be load flow study results under single contingency, both normal and stressed system conditions, and import and export system conditions. ITO criteria consider a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import and 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.

As part of its generation impact analysis ITO routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions, stress system conditions and import and export system conditions. The results of these studies are discussed in more detail below.

1) The first being when local generation including the proposed X2-076 Facility is operated at their maximum capability. The result of this study is shown below.

   The Possum Point to Dumfries section of Line #2002 is loaded to 101% of its STE Rating(633 MVA) for an outage of Line #237. This line and associated upgrade to resolve this deficiency has been identified as a network upgrade required for V1-031. Should this project not sign a ISA this deficiency condition and associated network upgrade may no longer be valid or may become the responsibility of this request.

2) Two different critical system conditions were studied. The first critical system condition studied was when Possum Point Unit #5 is off-line.

   No identified deficiencies.

3) The second critical system condition which was studied was when Yorktown Unit #3 is off-line.

   No identified deficiencies.

4) The fourth 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 A and B.

Table A: Import Study Results

Area	Summer 2015	Summer 2015 with X2-076	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Table B: Export Study Results

Area	Summer 2015	Summer 2015 with X2-076	Limiting Element
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

ITO planning criteria indicates a need to have approximately 2000 MW of import and export capability. The results of these import and export studies are indicate that the proposed generation facility will not impact ITO import or export capability.

5) The proposed generation facility is located one bus away from Progress Energy's System (Wake Substation). Therefore, it is possible that the proposed new generation facility would have an impact to the Progress System. PJM is coordinating a joint study with Progress Energy and the results of this study will be available in the Impact study.

The results of these studies evaluate the system under a limited set of operating conditions and do not guarantee the full delivery of the capacity and associated energy of this proposed generation facility under all operating conditions. NERC Planning and Operating Reliability Criteria allow for

the re-dispatch of generating units to resolve projected and actual deficiencies in real time and planning studies. Specifically, NERC Category C Contingency Conditions, bus fault, tower line, N-1-1, and stuck breaker scenarios, allow for re-dispatch of generating units to resolve potential reliability deficiencies. For ITO planning criteria the re-dispatch of generating units for these contingency conditions is allowed as long as the projected loading does not exceed 130% of a facility short term emergency rating. These study results are also predicated on the PJM PATH and MAPP projects being in-service. Both of these projects have been deferred by PJM. The System Impact Study will capture the baseline deferments and this change may impact the study results.

Required Interconnection Facilities:

Attachment Facilities

Generation Substation: Install metering and associated protection equipment at an estimated cost of $700,000.

Transmission Line: Construct a one-mile long 500 kV attachment line between the generation substation and the proposed Brunswick Switching Station. The estimated cost is $3,500,000. This work is estimated to take 24-30 months to complete.

Direct Connection Network Facilities

Substation: At the IC site a new 500 kV switching station (three breaker 500 kV interconnection substation) will need to be constructed. The new station will be called Brunswick Switching Substation. This will split the existing Carson – Wake 500 kV line into the Carson – Brunswick 500 kV line and the Brunswick to Wake 500 kV line as shown in the one-line diagram below. The estimated cost of this facility is $7,000,000.

Transmission Line: It will be necessary to loop, approximately 5 miles each way, the existing 500 kV line in and out of the proposed generation site. The estimated cost of this work is $32,500,000 and is estimated to take 36-42 months to complete.

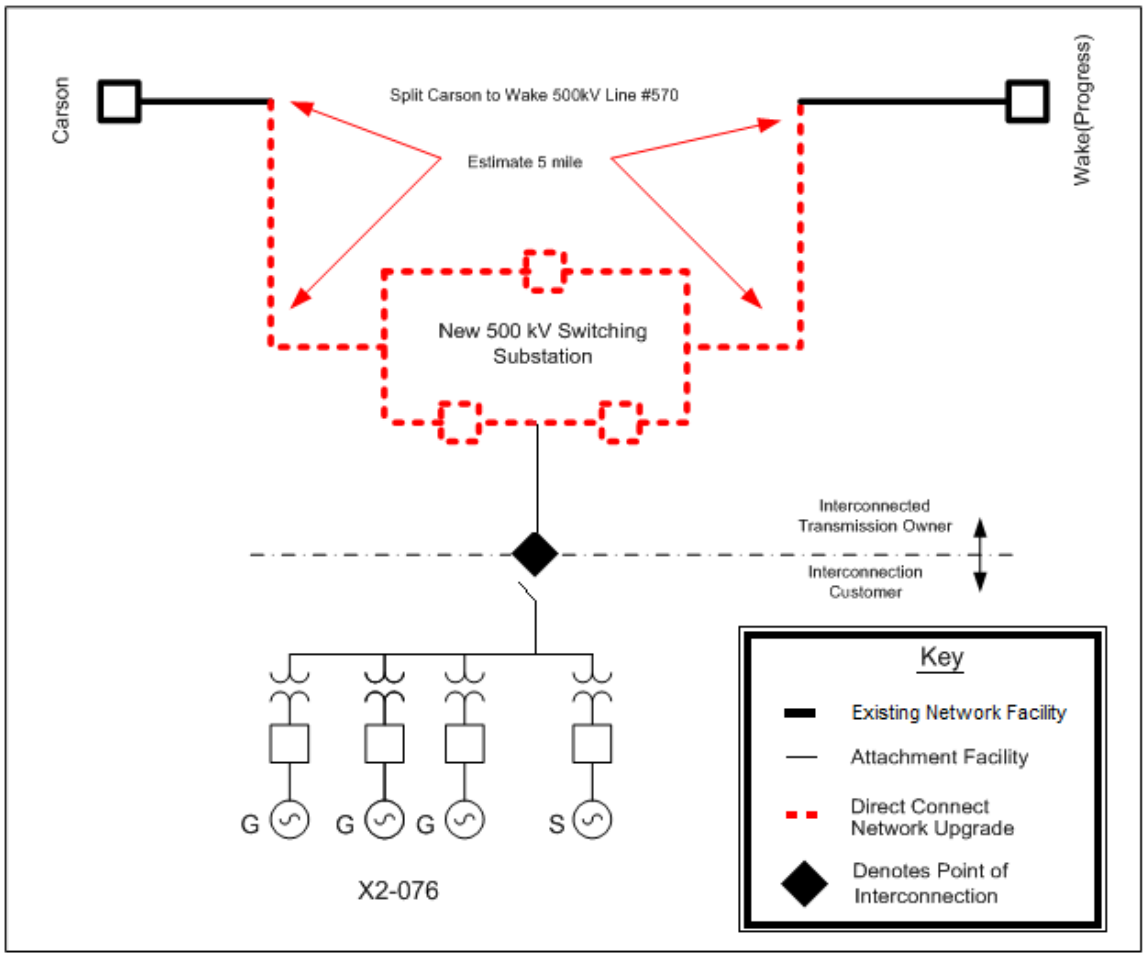
The estimated total cost of the Attachment Facilities is $4,200,000 and the estimated cost of the Direct Connection Network Upgrades is $39,500,000. These preliminary cost estimates are based on typical engineering costs and detailed engineering cost estimates are normally done during the Facility Study phase and also will not be done until the developer provides an exact site plan location for the generation substation and proposed Brunswick Switching Station.

IC has indicated that it would like ITO to support a May 2012 CPCN filing in Virginia. To accomplish this, ITO will need to start routing and permitting studies by November 2011. The ITO has estimated that this work would cost $700,000 and this would need to be funded by the generation developer.

Alternative Solution

Other constructible options, which may avoid contingency event flows onto the ASO, will be more closely considered and evaluated at the Impact Study should a new line from the X2-076 site be considered a least cost solution compared to resolving reliability deficiencies on the ASO.

Proposed One-Line:



Appendix A

Generator Interconnection Affected System Feasibility Study Report

1550 MW Combined Cycle Facility
Connects to (PEC) Wake – (DVP) Carson 500 kV Line

December 21, 2011
Progress Energy Carolinas, Inc.
Transmission Operations & Planning Department

PURPOSE

The purpose of this study was to determine the necessary additions to the PEC transmission system to accommodate a PJM generation queue request (X2-076) for a new Combined Cycle Generation Facility with interconnection of 1550 MW generation, summer rating, to the (PEC) Wake – (DVP) Carson 500 kV Line. The generator in-service date requested was May, 2016.

ASSUMPTIONS

The following affected system feasibility study results are from the PEC internal power-flow and short circuit models that reflect specific conditions of the PEC system at points in time consistent with the generator interconnection request being evaluated. The cases include the most recent information for load, generation additions, transmission additions, interchange, and other pertinent data necessary for analysis. Future years may include transmission, generation, and interchange modifications that are not budgeted for and for which no firm commitments have been made. Further, PEC retains the right to make modifications to power-flow cases as needed if additional information is available or if specific scenarios necessitate changes. For the systems surrounding PEC, data is based on the ERAG MMWG model. The suitability of the model for use by others is the sole responsibility of the user. Higher queued generator interconnection requests were considered in this analysis.

The results of this analysis are based on Interconnection Customer's queue request including generation equipment data provided. If the facilities' technical data or interconnection points to the transmission system change, the results of this analysis may need to be reevaluated.

RESULTS

Power-flow Analysis Results

Facilities that may require upgrade within the first three to five years following the in-service date are identified. Based on projected load growth on the PEC transmission system, facilities of concern are those with post-contingency loadings of 95% or greater of their thermal rating and low voltage of 0.92 pu and below, for the requested in-service year. The identification of these facilities is crucial due to the construction lead times necessary for certain system upgrades. This process will ensure that appropriate focus is given to these problem areas to investigate whether construction of upgrade projects is achievable to accommodate the requested interconnection service.

As requested, the generators were studied interconnected to a new generation facility 5 miles west of the (PEC) Wake – (DVP) Carson 500 kV Line. Contingency analysis study results show that interconnection of this generation facility results in thermal overload issues on the PEC system. Based on study results for 2016 summer, Table 1 shows thermal facility loadings for this request:

Table 1: Power-flow Thermal Results

Transmission Facility	Loading %	Contingency
Person – (DVP) Halifax 230 kV Line	122.6	(DVP) Carson – New Generation Facility 500 kV Line
Rocky Mt. – (DVP) Battleboro 115 kV Line	120.6	(DVP) Carolina – (DVP) Horner Town 115 kV Line
Wake – Wilson 230 kV Line	104.3	(DVP) Carson – New Generation Facility 500 kV Line

Estimate of Resolutions for Power-flow Impacts

The following are PEC's current best estimates for resolution of impacts identified in Table 1. Solutions, cost estimates and implementation schedules will be refined in the Customer's Generator Interconnection Impact Study Report.

Primary Resolution

Dominion constructs a new 500 kV line between DVP's Carson 500 kV substation and New Generation Facility.

Estimated Cost: NA
Estimated Schedule: NA

Alternate Resolution

Person – (DVP) Halifax 230 kV Line

Project Description: Rebuild/Reconductor approximately 4.85 miles of this line between PEC's Person 230 kV Substation and DVP's Halifax 230 kV Substation. The Dominion owned portion of this line would also need to be upgraded. Only the cost of the PEC portion of this line is estimated below.
Estimated Cost: $7,500,000
Estimated Schedule: 6/1/2017 (Coincides with Wake - Rocky Mt. new line schedule)

Wake – Rocky Mt. 230 kV Line

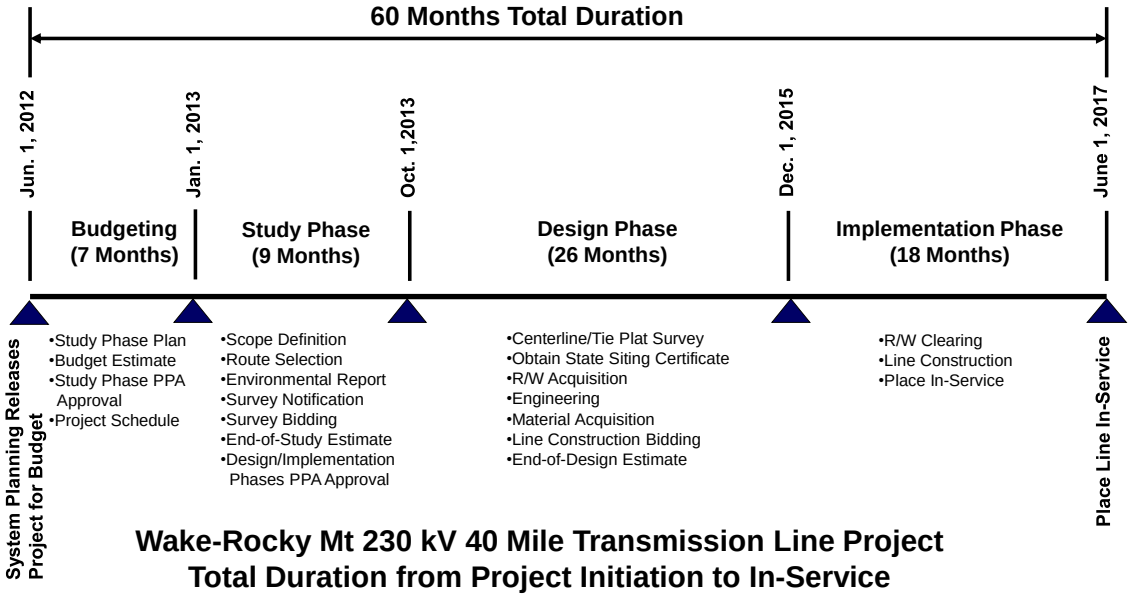
Project Description: Construct approximately 40 miles of new 230 kV line between Wake 230 kV substation and Rocky Mt. 230 kV substation.
Estimated Cost: $60,000,000
Estimated Schedule: 6/1/2017 (See Figure 1 below)

Rocky Mt. – Battleboro 115 kV Line

Potential Solution: DVP already has a planned project to install a 230/115 kV 200 MVA transformer at DVP's Battleboro 115 kV Substation
Estimated Cost: NA
Estimated Schedule: 6/1/2016

PEC Total Power-flow Transmission Addition Cost Estimate: $67,500,000 (total)

Figure 1 – Initial Schedule for Proposed Wake-Rocky Mt 230 kV Line



Short Circuit Analysis Results

A short circuit analysis was performed to assess the impact of the proposed 2016 Customer generation addition on the Progress Energy transmission system. The analysis was performed using generator data and generator step up transformer data provided by the customer. Both the suggested resolution (new 500 kV line) and alternate resolution (new line and reconductor existing line) were individually evaluated. The new Wake-Rocky Mt 230 kV line was assumed to be H-frame, 2-bundle, 1590 MCM. The Person-Halifax 230 kV tie line was assumed to be rebuilt and reconductored with 2-bundle, 1590 MCM for the entire length, including the Dominion owned sections of the line. A planned new 230/115 kV transformer addition project at Battleboro was not known to Progress Energy at the time of the study and, therefore, was not included in the short circuit analysis. Progress Energy reserves the right to

reevaluate the short circuit results with this transformer included at the next stage of the process. The short circuit analysis results indicate that the interrupting capability will not be exceeded for area equipment. The results of the short circuit study are based on Customer provided generation equipment data and location and the above noted assumptions. If the units' technical data, generator interconnection point, or assumptions regarding the transmission system upgrades change, the results of this analysis may need to be reevaluated.

Estimate of Resolution for Short Circuit Issues

The analysis results indicate that the interrupting capability will not be exceeded for any area equipment.

PEC Short Circuit Estimated Costs: $0

SUMMARY

This Generator Interconnection Affected System Feasibility Study assesses the feasibility of interconnecting a new generation facility consisting with a total NET rating of 1550 MW to the (PEC) Wake – (DVP) Carson 500 kV line. Studies indicate that thermal upgrades are necessary to the DVP and/or PEC Transmission System to accommodate this request.

Current estimates are that the proposed upgrades cannot be completed to meet the Customer's schedule. **This is based on an assumption that PEC would have a firm commitment from the customer by June of 2012**

Power-flow	$67,500,000
Short Circuit	$0
Total Estimate	$67,500,000