# *Generation Interconnection*
# *Facility Study Report*

# *For*

# *PJM Generation Interconnection Request*
# *Queue Position AB2-174*

# *Emporia – Trego 115kV*
# *42 MW Capacity / 80 MW Energy*

**November / 2018**

# General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Greensville County Solar Project, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). IC has proposed a solar generating facility located on Rock Bridge Road in Greensville County, VA. The installed facilities will have a total capability of 80 MW with 42 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/30/2020. **This study does not imply an ITO commitment to this in-service date.**

## Point of Interconnection

AB2-174 will interconnect with the ITO transmission system Carolina – Clubhouse 115kV line #130 between Emporia and Trego.

## Cost Summary

The AB2-174 project will be responsible for the following costs:

| Description | Total Cost |
|---|---|
| Attachment Facilities | $ 510,440 |
| Direct Connection Network Upgrades | $5,297,125 |
| Non Direct Connection Network Upgrades | $3,033,442 |
| Allocation for New System Upgrades | $0 |
| Contribution for Previously Identified Upgrades | $0 |
| **Total Costs** | **$8,841,007** |

# A. Transmission Owner Facilities Study Summary

## 1. Description of Project

Queue AB2-174 is a request to interconnect 80 MW (42 MW of Capacity) of energy from a new solar facility located on Rock Bridge Road south of the town of Emporia in Greensville County, Virginia. The proposed generation facility will interconnect with the ITO's Emporia – Trego 115 kV line via a new three breaker ringbus switching station. The requested in-service date is December 31, 2020. Attachment Facility and Direct Connection Network upgrade construction is estimated to be 12 - 18 months.

## 2. Amendments to the System Impact Study data or System Impact Study Results

## Network Impacts

The Queue Project AB2-174 was evaluated as a 80.0 MW (Capacity 42.0 MW) injection tapping the Trego-Emporia 115kV line in the VAP area. Project AB2-174 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-174 was studied with a commercial probability of 100%. Potential network impacts were as follows:

**Summer Peak Analysis - 2020**

**Generator Deliverability**

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

None

**Multiple Facility Contingency**

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

None

**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)*

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Cir. | Flow | Initial | Final | Type | MVA | Contribution | Ref |
| 1 | DCTL | LN 208-259 | DVP - DVP | 6CHARCTY-6LAKESD 230 kV line | 314225 | 314227 | 1 | AC | 104.39 | 105.5 | LD | 459 | 6.04 | 1 |
| 2 | DCTL | LN 208-259 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 115.51 | 116.62 | LD | 459 | 6.04 | 2 |
| 3 | DCTL | LN 208-259 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 115.54 | 116.65 | LD | 459 | 6.04 | 3 |
| 4 | LFFB | 562T563 | DVP - DVP | 6CHSTF B-6BASIN 230 kV line | 314287 | 314276 | 1 | AC | 103.29 | 104.41 | LD | 549 | 7.23 | 4 |

**Affected System Analysis & Mitigation**

**Duke, Progress & TVA Impacts:**

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

None

**Delivery of Energy Portion of Interconnection Request**

PJM also studied the delivery of the energy portion of this interconnection request. Any 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 Merchant Transmission Interconnection request.

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 will study all overload conditions associated with the overloaded element(s) identified.

| | Contingency | | Affected | | Bus | | | Power | Loading % | | Rating | | MW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Type | Name | Area | Facility Description | From | To | Circuit | Flow | Initial | Final | Type | MVA | Contribution |
| 5 | N-1 | LN 259 | DVP - DVP | 6CHARCTY-6LAKESD 230 kV line | 314225 | 314227 | 1 | AC | 98.99 | 100.3 | ER | 375 | 5.79 |
| 6 | N-1 | LN 259 | DVP - DVP | 6MESSER-6CHARCTY 230 kV line | 314228 | 314225 | 1 | AC | 112.6 | 113.91 | ER | 375 | 5.79 |
| 7 | N-1 | LN 259 | DVP - DVP | 6CHSTF B-6MESSER 230 kV line | 314287 | 314228 | 1 | AC | 112.64 | 113.95 | ER | 375 | 5.79 |
| 8 | N-1 | LN 563 | DVP - DVP | 6CHSTF B-6BASIN 230 kV line | 314287 | 314276 | 1 | AC | 114.78 | 116.1 | ER | 449 | 6.97 |

## 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 is calculated and reported for in the Impact Study)*

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost | AB2-174 Allocation |
|---|---|---|---|---|---|

| Violation # | Overloaded Facility | Upgrade Description | Network Upgrade Number | Upgrade Cost | AB2-174 Allocation |
|---|---|---|---|---|---|
| # 1 | 6CHARCTY-6LAKESD 230 kV line | Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020 | b2745 | | |
| # 2 | 6MESSER-6CHARCTY 230 kV line | | | | |
| # 3 | 6CHSTF B-6MESSER 230 kV line | | | | |
| # 4 | 6CHSTF B-6BASIN 230 kV line | ITO currently has a reliability project which will reconductor 0.14 miles Chesterfield – Basin 230kV of 1109 ACAR with a conductor which will increase the line rating to approximately 706 MVA (normal), 706 MVA (emergency), and 812 MVA (load dump). Work has been completed. | b2990 | | |
| | | | | **Total New Network Upgrades** | **$0** |

## 3. Interconnection Customer's Submitted Milestone Schedule

Interconnection Customer has requested the following milestones:

- Plan to break ground February 1, 2020
- Permits – state level CPCN and county level Final Site Plan approval complete by January 1, 2020
- Turn over flat, graded site with 1 inch gravel to ITO for new switching station September 17, 2019
- Substantial site work completed July 1, 2020
- Delivery of major electrical equipment August 1, 2020
- Back Feed Power early to October 1, 2020
- Commercial Operation December 31, 2020

Note: ITO is unable to support the milestones and requires the following:

- Turn over flat, graded site with 1 inch gravel to ITO for new switching station September 9, 2019
- Back Feed Power early to November 1, 2020

## 4. Scope of Customer's Work

IC will build a solar generating facility in Greensville County, Virginia. The generating facility will be comprised of 80MW's of solar arrays. AB2-174 consists of 48 x 1.666 MW Easton Xpert inverters and 48 x 34.5/0.355 wye delta 1.835 MW generator step up (GSU) transformers. The generating facility will connect to the Point of Interconnection (POI) on the through a 115/34.5 kV grounded wye grounded wye main power transformer with a rating of 51/68/85 MVA. The AB2-174 POI will be at a new Interconnection switching station on the Emporia – Trego 115 kV line.

## 5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AB2-174 115kV switching station. The position of the switching station will be adjacent to the right of way of the existing 115 kV Transmission Line #130, on a property provided by the IC. The station will be positioned in such a way that the new backbone will be between 130/63 and 130/64 structures. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. The lines will consume two of the three positions in the ring bus. The third position will be for the 115 kV feed from the collector station for the solar farm. The collector substation and ITO switching station will share a common fence. The demarcation point between the switching station and the collector station will be the 4-hole pads on the ITO disconnect switch. The developer will bring its bus to the demarcation point over the common fence. Metering equipment will be installed in the ITO Switching Station. The grounding systems for both stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC.
Remote relay work will be required Queue AB1-173 switching station, Queue AB2-040 switching station, Emporia, Metcalf, Trego, Pleasant Hill, Carolina and Clubhouse Substations.

## 6. Total Costs of Transmission Owner Facilities included in Facilities Study

| Work Description | Direct | | Indirect | | Total Cost |
|---|---|---|---|---|---|
| | Labor | Material | Labor | Material | |
| Substation | $293,076 | $149,171 | $50,806 | $17,387 | $510,440 |
| **Total Attachment Facilities Cost** | $293,076 | $149,171 | $50,806 | $17,387 | $510,440 |
| Queue AB2-174 switching station (n5497) | $2,354,677 | $2,308,825 | $387,479 | $246,144 | $5,297,125 |
| Transmission line relocation (n5498) | $653,320 | $1,970,430 | $117,082 | $126,014 | $2,866,846 |
| Remote relay (n5499) | $112,100 | $24,337 | $26,473 | $3,686 | $166,596 |
| **Total Network Upgrades** | $3,120,097 | $4,303,592 | $531,034 | $375,844 | $8,330,567 |
| **Total Project Costs** | $3,413,173 | $4,452,763 | $581,840 | $393,231 | $8,841,007 |

## 7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

Attached is the facility study for AB2-174 Project. The total project timeline is 30-42 months from ISA execution. The timeline is highly dependent on outage availability for Line 130.

Best case would be:

- Detailed design: 8-12 months
- Permitting: 8-12 months (Timeline runs concurrent with design)
- Construction 12 to 18 months

ITO proposes the following in support of the IC requested milestones:

- Turn over flat, graded site with 1 inch gravel to ITO for new switching station September 9, 2019
- Construction start for new AB2-174 Switching Station September 16, 2019
- Outage to cut in the new AB2-174 Switching Station September 21, 2019 through October 30, 2019
- Back Feed Power early to November 1, 2020

# B. Transmission Owner Facilities Study Results

## 1. Attachment Facilities

The ITO will connect the proposed generator lead via Attachment Facilities to a new AB2-174 115kV switching station. The Attachment Facilities include the portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities collector station. The equipment associated with the Attachment Facilities include the metering accuracy CCVT's, metering accuracy CT's, disconnect switch, conductors and connectors.

**Purchase and install:**

1. One (1) 115 kV, 2000A, 3-phase Center Break Gang Operated Switches
2. Three (3) 115 kV metering accuracy CCVT's
3. Three (3) 115 kV metering accuracy CT's
4. Conductors, connectors, conduits, control cables, foundations, steel structures and grounding material

**Purchase and install relay material:**

1. One (1), 1109 – 28" Dual SEL-587Z Transmission Bus Panel
2. One (1), 4200 – Bus Differential C.T. M.U. Box
3. One (1), 1425 – 28" Dual SEL-735 Metering Panel (Transmission & Generation Interconnect)
4. One (1), 4524 – Revenue Metering C.T. M.U. Box
5. One (1), 4531 – Generator Interconnect CCVT Potential M.U. Box
6. One (1), 1323 – 28" SEL-487E/735 PMU & PQ Monitoring Panel
7. Two (2), 4541 - Control Cable M.U. Box

## 2. Transmission Line – Upgrades

PJM Network Upgrade #n5498 – Re-arrange Emporia DP – Trego 115kV line #130 to loop into and out of the new three (3) breaker AB2-174 Switching station between structures 130/63 and 130/64.

The new AB2-174 115kV switching station will be positioned in such a way that the new backbone will be between 130/63 and 130/64 structures. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line to two positions in the ring bus. This project will rebuild utilizing Dominion 2017, 115kV standards. The conceptual estimate includes cost for the following:

**Structure Installations:**

1. Install (1) 115kV Galvanized Steel Backbone Structure (no switches) with 31'-6" spacing with foundations.
2. Install (2) Galvanized Static Pole Structure with Foundations.

**Conductor / Shield Wire Installations:**

1. Cut and Transfer (2) existing spans of 3-Phase 768 ACSS/TW conductor to the new backbone structures (one span will run from Ex. Str. number 130/63 – 130/63A, the other span will run from Str. 130/63A – 130/64).

2. Cut and Transfer (1) existing spans of 3#6 shield wire to the new backbone structures (one span will run from Ex. Str. number 130/63 – Proposed BB, the other span will run from Str. Proposed BB – 130/64).
3. Cut and Transfer (1) existing spans of OPGW to the new backbone structures (one span will run from Ex. Str. number 130/63 – 130/63A, the other span will run from Str. 130/63A – 130/64).
4. Install approximately 0.12 miles (3 pans) of 1-7#7 static wire from the Proposed Backbone Structures to the Proposed Static poles.
5. Install approximately 2.1 miles of 1-OPGW wire from the Proposed Backbone Structures to the existing 3 pole str. 130/85. Include Fiber splicing.
6. Renumber approximately 135 structures with the new line number between AB2-174 and Carolina Substation.

## 3. New Substation/Switchyard Facilities

**Direct Connection Network Upgrades:**
PJM Network Upgrade #n5497 - Build a three (3) breaker AB2-174 115 kV switching station. The site is located adjacent to the ITO's existing right of way for the Emporia DP – Trego 115kV line #130.

A new AB2-174 115kV switching station will be adjacent to the right of way of the existing 115 kV Transmission Line #130, on a property provided by the IC. The station will be positioned between the existing 130/63 and 130/64 structures. The cut lines will consume two of the three positions in the ring bus. The third position will be for the 115 kV feed from the collector station for the solar farm. The collector substation and ITO switching station will share a common fence. The demarcation point between the switching station and the collector station will be the 4-hole pads on the ITO disconnect switch. The developer will bring its bus to the demarcation point over the common fence. Metering equipment will be installed in the ITO Switching Station. The grounding systems for both stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC.

**Purchase and install substation material:**
1. Approximately 285' X 260' site preparation and grading as required for installation of the switching station (by the IC)
2. Approximately 1050 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the station along with the security cameras and integrators as per Design 4 fence standards
3. Full substation ground grid
4. One (1) 115 kV, Heavy Duty Steel Backbone (by ITO Transmission)
5. Two (2) shield wire poles and two span of shield wires (by ITO Transmission)
6. Three (3) 115 kV, 3000A, 40 kA $SF_6$ Circuit Breakers
7. Six (6) 115 kV, 2000A, 3-phase Center Break Gang Operated Switches
8. Nine (9) 90 kV MO, 74 kV MCOV Station Class Arresters
9. Six (6) 115 kV CCVTs, Relay Accuracy
10. One (1), 115 kV, 2000 Amps Wave Trap and Line Tuner
11. One (1) 24' X 40' Control Enclosure

12. One (1) 125 VDC, 200 Ah Station Battery and 50 Amp Charger (size to be verified during detail engineering)
13. Approximately 240 FT of Cable Trough, with a 20 FT road crossing section
14. Four (4) 100 kVA Power Potential Transformers for station service
15. Oil Containment system for the 115 kV PVTs.
16. Two (2) 115 kV, 2000A, 2-phase Center Break Gang Operated Switches
17. High Voltage Protection Cabinet
18. Two (2), 2" conduits from structure outside the substation to the cable trough
19. Conduit Tracer Wire, 1/C #10, Green
20. 1-1/4" Orange Polyethylene conduits for fiber in the cable trough
21. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports
22. Foundations as required including control house, equipment and bus support stands
23. Conductors, connectors, conduits, control cables, cable trough, and grounding materials

**Purchase and install relay material:**

1. Three (3), 1510 – 28" Dual SEL-351-7 Transmission Breaker w/ Reclosing Panel
2. Three (3), 4510 - SEL-2411 Breaker Annunciator
3. Two (2), 1320 – 28" Dual SEL-421-5 DCB Line Panel
4. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box
5. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel
6. One (1), 1604 – 28" Transmission Transfer Trip Panel
7. Two (2), 4000 – Station Service Potential M.U. Box
8. Two (2), 4018 – 500A Station Service AC Distribution Panel
9. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD
10. Two (2), 4019 – 225A Three Phase Throwover Switch
11. Two (2), 4016 – 600A PVT Disconnect Switch
12. One (1), 4153 – Wall Mount Station Battery Monitor
13. One (1), 5612 - SEL-3530 Data Concentrator Panel
14. One (1), 1255 – Station Annunciator Panel
15. One (1), 5021 – SEL-2411 RTU Panel
16. One (1), 5609 – Fiber Optic Management Panel
17. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box
18. One (1), 5202 – 26" APP 601 Digital Fault Recorder
19. One (1), 5603 – Station Network Panel 1
20. One (1), 5603 – Station Network Panel 2
21. One (1), 5616 – Station Security Panel
22. One (1), Telephone Interface Box
23. One (1), High Voltage Protection (HVP) Box (Provided by IT)

## 4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n5499 - Remote protection and communication work. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Queue AB1-173 "Meherrin" switching station, Queue AB2-040 switching station, Emporia, Metcalf, Trego, Pleasant Hill, and Carolina Substations.

Carolina 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:
1. No Material

Purchase and install relay material:
1. No Material

Emporia 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:
1. No Material

Purchase and install relay material:
1. No Material

Queue AB1-173 Meherrin 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:
1. No Material

Purchase and install relay material:
1. No Material

Metcalf 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:
1. No Material

Purchase and install relay material:
1. No Material

Pleasant Hill 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:
1. No Material

Purchase and install relay material:
1. No Material

Skippers 115kV Substation

Replace Clubhouse Line relays with 311Ls, remove wave trap and update Islanding Scheme and drawings to reflect new Line destination.

Purchase and install:

1. Retire- Clubhouse Line Wave trap and associated equipment.

Purchase and install relay material:

1. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel
2. One (1), SEL-2411 Islanding T.T. transmitter
3. Retire One (1), Old SEL-421 Line panel

Trego 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:

1. No Material

Purchase and install relay material:

1. No Material

AB2-040 115kV Substation

Project Summary - provides for the Drawing Updates necessary to reflect the line 130 Terminal Destination to the new AB2-174 switching station.

Purchase and install:

1. No Material

Purchase and install relay material:

1. No Material

| Work Description | Direct | | Indirect | | Total Cost |
|---|---|---|---|---|---|
| | Labor | Material | Labor | Material | |
| | | | | | |
| Carolina | $6,523 | $0 | $1,841 | $0 | $8,364 |
| Emporia | $6,523 | $0 | $1,841 | $0 | $8,364 |
| AB1-173 Meherrin | $6,523 | $0 | $1,841 | $0 | $8,364 |
| Metcalf | $6,523 | $0 | $1,841 | $0 | $8,364 |
| Pleasant Hill | $6,523 | $0 | $1,841 | $0 | $8,364 |
| Skippers | $66,4439 | $24,337 | $13,586 | $3,686 | $108,048 |
| Trego | $6,523 | $0 | $1,841 | $0 | $8,364 |
| AB2-040 switching station | $6,523 | $0 | $1,841 | $0 | $8,364 |
| **Total Remote Relay Upgrades** | $112,100 | $24,337 | $26,473 | $3,686 | $166,596 |

## 5. Metering & Communications

**PJM Requirements**

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

**Meteorological Data Reporting Requirement**

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

**ITO Requirements**

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Interconnection Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

At the IC's expense, the ITO will supply and own at the Point of Interconnection bi-directional revenue metering equipment that will provide the following data:

a. Hourly compensated MWh received from the Customer Facility to the ITO;
b. Hourly compensated MVARh received from the Customer Facility to the ITO;
c. Hourly compensated MWh delivered from the ITO to the Customer Facility; and
d. Hourly compensated MVARh delivered from the ITO to the Customer Facility.

The IC will supply and own metering equipment that will provide Instantaneous net MW and MVar per unit values in accordance with PJM Manuals M-01 and M-14D, and Sections 8.1 through 8.5 of Appendix 2 to the ISA;

The IC will access revenue meter via wireless transceivers or fiber cabling to meter with RS-485 or Ethernet communication port for dial-up reads. IC must provide revenue and real time data to PJM from Interconnection Customer Market Operations Center per "PJM Telemetry Data Exchange Summary" document available at PJM.com.

## 6. Environmental, Real Estate and Permitting Issues

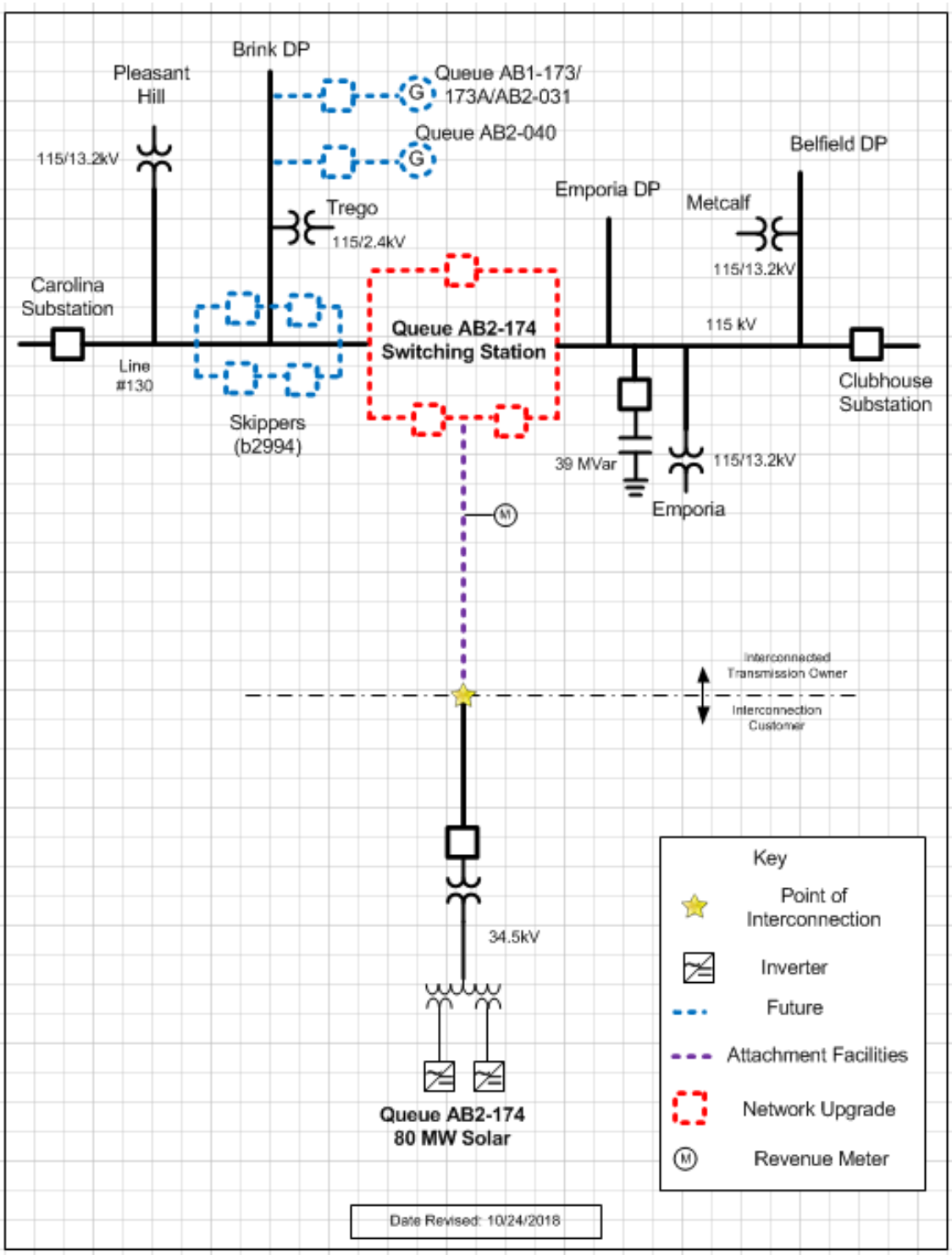
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a North Carolina Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.

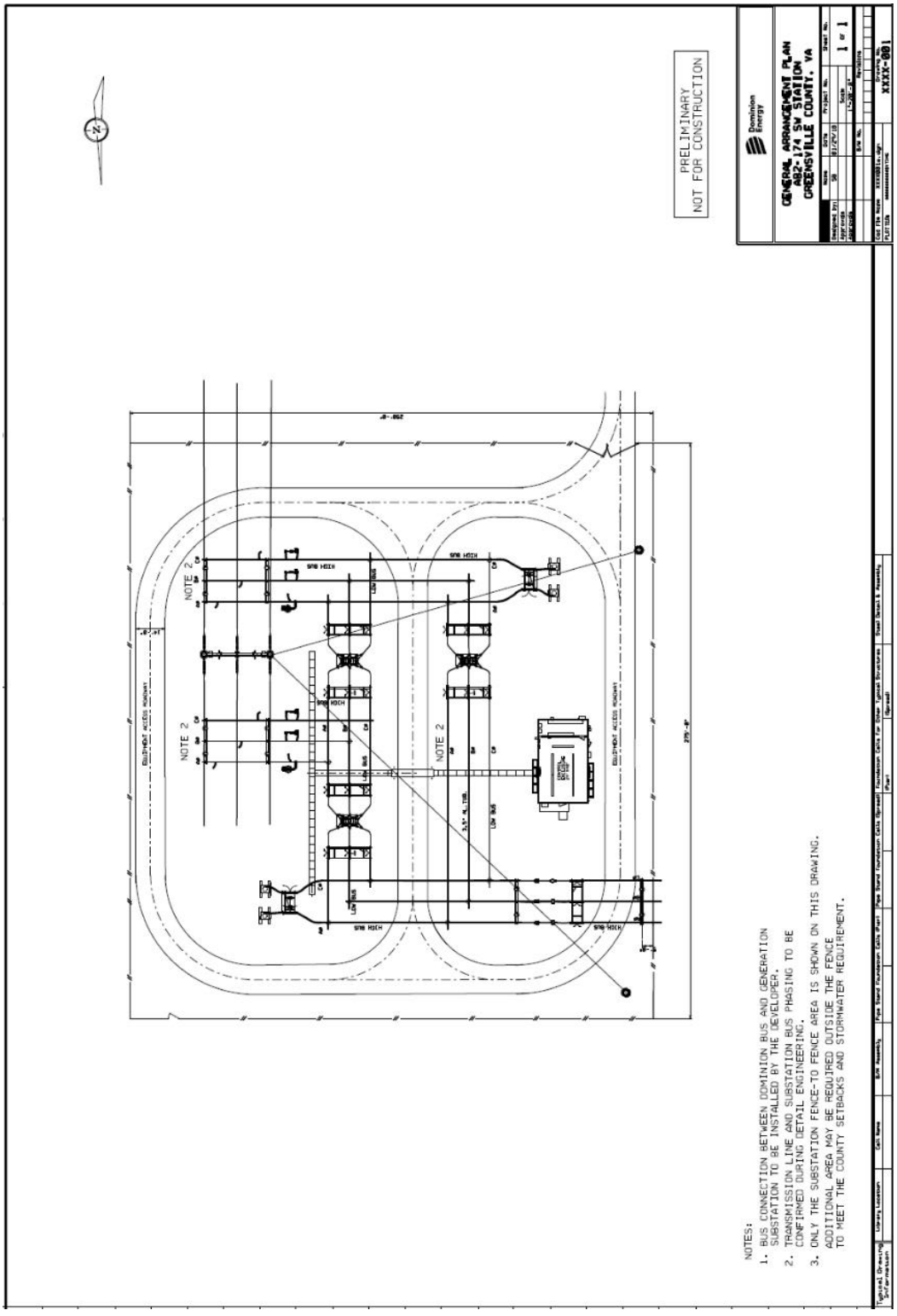
ITO Real Estate Needs:

- The substation layout is complete and ITO requires a 250'x 275' piece of property (title in fee) to build the substation. The property includes the piece of property between the substation and collector station for the strain bus.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by September 9, 2019.
    - The size of the station assumes ITO will not need a separate storm water management system for the substation. If the county rules differently than the ITO will need to revisit the land requirements.
- ITO will need a letter similar to the zoning letter from the county stating that if the solar farm is retired and / or decommissioned the substation will remain.

## *Attachment 1.*
### *Single Line*



## *Attachment 2.*
### *AB2-174 Switching Station*



## *Attachment 3.*
### *Switching Station Plan View*

# Appendices

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

# Appendix 1

(DVP - DVP) The 6CHARCTY-6LAKESD 230 kV line (from bus 314225 to bus 314227 ckt 1) loads from 104.39% to 105.5% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 6.04 MW to the thermal violation.

```
CONTINGENCY 'LN 208-259'
  OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1              /* 6CHSTF A
230.00 - 6IRON208 230.00
  OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1              /* 6IRON208
230.00 - 6SOUWEST 230.00
  OPEN BUS 314309                                  /* ISLAND
  OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1              /* 6BASIN 230.00 -
6CHSTF B 230.00
  END
```

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314314 | 3LOCKS | 1.06 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 0.59 |
| 315075 | CIR_AB2-152 | -0.26 |
| 292791 | U1-032 E | 2.97 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.17 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.31 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |
| 918562 | AA1-072 E | 0.06 |
| 921752 | AA2-053 C | 3.22 |

| | | |
|---|---|---|
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |
| 923912 | AB2-031 E OP | 0.48 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.5 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924811 | AB2-134 C OP | 8.22 |
| 924812 | AB2-134 E OP | 8.09 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.93 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |

| | | |
|---|---|---|
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |

# Appendix 2

(DVP - DVP) The 6MESSER-6CHARCTY 230 kV line (from bus 314228 to bus 314225 ckt 1) loads from 115.51% to 116.62% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 6.04 MW to the thermal violation.

```
CONTINGENCY 'LN 208-259'
  OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1              /* 6CHSTF A
230.00 - 6IRON208 230.00
  OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1              /* 6IRON208
230.00 - 6SOUWEST 230.00
  OPEN BUS 314309                                  /* ISLAND
  OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1              /* 6BASIN 230.00 -
6CHSTF B 230.00
  END
```

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314314 | 3LOCKS | 1.06 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 0.59 |
| 315075 | CIR_AB2-152 | -0.26 |
| 292791 | U1-032 E | 2.97 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.17 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.31 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |
| 918562 | AA1-072 E | 0.06 |
| 921752 | AA2-053 C | 3.22 |

| | | |
|---|---|---|
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |
| 923912 | AB2-031 E OP | 0.48 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.5 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924811 | AB2-134 C OP | 8.22 |
| 924812 | AB2-134 E OP | 8.09 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.93 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |

| | | |
|---|---|---|
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |

# Appendix 3

(DVP - DVP) The 6CHSTF B-6MESSER 230 kV line (from bus 314287 to bus 314228 ckt 1) loads from 115.54% to 116.65% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 6.04 MW to the thermal violation.

```
CONTINGENCY 'LN 208-259'
  OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1              /* 6CHSTF A
230.00 - 6IRON208 230.00
  OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1              /* 6IRON208
230.00 - 6SOUWEST 230.00
  OPEN BUS 314309                                  /* ISLAND
  OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1              /* 6BASIN 230.00 -
6CHSTF B 230.00
  END
```

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.25 |
| 315077 | 1HOPHCF1 | 2.28 |
| 315078 | 1HOPHCF2 | 2.28 |
| 315079 | 1HOPHCF3 | 2.28 |
| 315080 | 1HOPHCF4 | 3.46 |
| 315076 | 1HOPPOLC | 1.95 |
| 315073 | 1STONECA | 5.71 |
| 314784 | 1WEYRHSB | 0.65 |
| 314314 | 3LOCKS | 1.06 |
| 314539 | 3UNCAMP | 0.81 |
| 314541 | 3WATKINS | 0.23 |
| 314229 | 6MT R221 | -0.33 |
| 315074 | CIR_AB2-152 | 0.59 |
| 315075 | CIR_AB2-152 | -0.26 |
| 292791 | U1-032 E | 2.97 |
| 900672 | V4-068 E | 0.1 |
| 901082 | W1-029E | 13.17 |
| 907092 | X1-038 E | 2.02 |
| 914231 | Y2-077 | 0.92 |
| 916042 | Z1-036 E | 13.31 |
| 917332 | Z2-043 E | 0.34 |
| 917342 | Z2-044 E | 0.18 |
| 921163 | AA1-063AE | 1.48 |
| 918512 | AA1-065 E OP | 1.46 |
| 918562 | AA1-072 E | 0.06 |
| 921752 | AA2-053 C | 3.22 |

| | | |
|---|---|---|
| 921753 | AA2-053 E | 1.38 |
| 921762 | AA2-057 C | 2.33 |
| 921763 | AA2-057 E | 1.16 |
| 921982 | AA2-088 C | 2.25 |
| 921983 | AA2-088 E | 3.67 |
| 922442 | AA2-165 C | 0.32 |
| 922443 | AA2-165 E | 0.15 |
| 922512 | AA2-174 C | 0.15 |
| 922513 | AA2-174 E | 0.16 |
| 922532 | AA2-178 C | 2.91 |
| 922533 | AA2-178 E | 1.25 |
| 922602 | AB1-013 C | 0.88 |
| 922603 | AB1-013 E | 5.87 |
| 923262 | AB1-132 C OP | 5.95 |
| 923263 | AB1-132 E OP | 2.55 |
| 923572 | AB1-173 C OP | 0.98 |
| 923573 | AB1-173 E OP | 0.46 |
| 923582 | AB1-173AC OP | 0.98 |
| 923583 | AB1-173AE OP | 0.46 |
| 923801 | AB2-015 C OP | 2.9 |
| 923802 | AB2-015 E OP | 2.38 |
| 923851 | AB2-025 C | 1.64 |
| 923852 | AB2-025 E | 0.74 |
| 923911 | AB2-031 C OP | 0.98 |
| 923912 | AB2-031 E OP | 0.48 |
| 923991 | AB2-040 C OP | 3.2 |
| 923992 | AB2-040 E OP | 2.62 |
| 924071 | AB2-051 C OP | 38.5 |
| 924501 | AB2-099 C | 0.2 |
| 924502 | AB2-099 E | 0.09 |
| 924511 | AB2-100 C | 6.24 |
| 924512 | AB2-100 E | 3.07 |
| 924811 | AB2-134 C OP | 8.22 |
| 924812 | AB2-134 E OP | 8.09 |
| 925051 | AB2-160 C OP | 4.25 |
| 925052 | AB2-160 E OP | 6.93 |
| 925061 | AB2-161 C OP | 3.11 |
| 925062 | AB2-161 E OP | 5.07 |
| 925122 | AB2-169 E | 1.77 |
| 925171 | AB2-174 C OP | 3.17 |
| 925172 | AB2-174 E OP | 2.87 |
| 925281 | AB2-186 C | 0.18 |
| 925282 | AB2-186 E | 0.08 |
| 925291 | AB2-188 C OP | 0.72 |
| 925292 | AB2-188 E OP | 0.32 |

| | | |
|---|---|---|
| 925331 | AB2-190 C | 12.25 |
| 925332 | AB2-190 E | 5.25 |

# Appendix 4

(DVP - DVP) The 6CHSTF B-6BASIN 230 kV line (from bus 314287 to bus 314276 ckt 1) loads from 103.29% to 104.41% (AC power flow) of its load dump rating (549 MVA) for the line fault with failed breaker contingency outage of '562T563'. This project contributes approximately 7.23 MW to the thermal violation.

CONTINGENCY '562T563' /*CARSON
OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /*CARSON TO MIDLOTHIAN
OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /*CARSON 500.00 - 8SEPTA 500.00
END

| Bus Number | Bus Name | Full Contribution |
|---|---|---|
| 315065 | 1CHESTF6 | 39.53 |
| 315077 | 1HOPHCF1 | 2.1 |
| 315078 | 1HOPHCF2 | 2.1 |
| 315079 | 1HOPHCF3 | 2.1 |
| 315080 | 1HOPHCF4 | 3.19 |
| 315076 | 1HOPPOLC | 1.8 |
| 315073 | 1STONECA | 5.27 |
| 314784 | 1WEYRHSB | 0.8 |
| 314314 | 3LOCKS | 0.99 |
| 314539 | 3UNCAMP | 0.96 |
| 314541 | 3WATKINS | 0.28 |
| 315074 | CIR_AB2-152 | 0.55 |
| 315075 | CIR_AB2-152 | -0.24 |
| 292791 | U1-032 E | 2.74 |
| 900672 | V4-068 E | 0.13 |
| 901082 | W1-029E | 15.55 |
| 907092 | X1-038 E | 2.4 |
| 913392 | Y1-086 E | 0.73 |
| 914231 | Y2-077 | 0.85 |
| 916042 | Z1-036 E | 15.87 |
| 916192 | Z1-068 E | 0.6 |
| 916302 | Z1-086 E | 3.97 |
| 917122 | Z2-027 E | 0.35 |
| 917332 | Z2-043 E | 0.42 |
| 917342 | Z2-044 E | 0.24 |
| 917512 | Z2-088 E OP1 | 3.16 |
| 921163 | AA1-063AE | 1.8 |
| 918512 | AA1-065 E OP | 1.79 |
| 921183 | AA1-067 E | 0.28 |

| | | |
|---|---|---|
| 918562 | AA1-072 E | 0.07 |
| 921583 | AA1-139 E | 2.05 |
| 921752 | AA2-053 C | 3.95 |
| 921753 | AA2-053 E | 1.7 |
| 921762 | AA2-057 C | 2.99 |
| 921763 | AA2-057 E | 1.5 |
| 921982 | AA2-088 C | 2.7 |
| 921983 | AA2-088 E | 4.41 |
| 922442 | AA2-165 C | 0.41 |
| 922443 | AA2-165 E | 0.2 |
| 922512 | AA2-174 C | 0.18 |
| 922513 | AA2-174 E | 0.2 |
| 922532 | AA2-178 C | 3.52 |
| 922533 | AA2-178 E | 1.51 |
| 922602 | AB1-013 C | 1.06 |
| 922603 | AB1-013 E | 7.1 |
| 922922 | AB1-081 C OP | 3.62 |
| 922923 | AB1-081 E OP | 1.55 |
| 923262 | AB1-132 C OP | 7.21 |
| 923263 | AB1-132 E OP | 3.09 |
| 923572 | AB1-173 C OP | 1.18 |
| 923573 | AB1-173 E OP | 0.55 |
| 923582 | AB1-173AC OP | 1.18 |
| 923583 | AB1-173AE OP | 0.55 |
| 923801 | AB2-015 C OP | 3.45 |
| 923802 | AB2-015 E OP | 2.83 |
| 923831 | AB2-022 C | 0.76 |
| 923832 | AB2-022 E | 0.41 |
| 923851 | AB2-025 C | 1.87 |
| 923852 | AB2-025 E | 0.84 |
| 923911 | AB2-031 C OP | 1.17 |
| 923912 | AB2-031 E OP | 0.58 |
| 923941 | AB2-035 C | 0.14 |
| 923942 | AB2-035 E | 0.06 |
| 923991 | AB2-040 C OP | 3.85 |
| 923992 | AB2-040 E OP | 3.15 |
| 924071 | AB2-051 C OP | 43.82 |
| 924151 | AB2-059 C | 4.27 |
| 924152 | AB2-059 E | 2.2 |
| 924391 | AB2-088 C | 0.17 |
| 924392 | AB2-088 E | 0.08 |
| 924401 | AB2-089 C | 0.8 |
| 924402 | AB2-089 E | 0.41 |
| 924491 | AB2-098 C | 0.22 |
| 924492 | AB2-098 E | 0.09 |

| | | |
|---|---|---|
| 924501 | AB2-099 C | 0.24 |
| 924502 | AB2-099 E | 0.1 |
| 924511 | AB2-100 C | 7.3 |
| 924512 | AB2-100 E | 3.6 |
| 924811 | AB2-134 C OP | 7.78 |
| 924812 | AB2-134 E OP | 7.65 |
| 925051 | AB2-160 C OP | 3.95 |
| 925052 | AB2-160 E OP | 6.45 |
| 925061 | AB2-161 C OP | 3.17 |
| 925062 | AB2-161 E OP | 5.17 |
| 925122 | AB2-169 E | 2.23 |
| 925171 | AB2-174 C OP | 3.8 |
| 925172 | AB2-174 E OP | 3.44 |
| 925281 | AB2-186 C | 0.21 |
| 925282 | AB2-186 E | 0.09 |
| 925291 | AB2-188 C OP | 0.87 |
| 925292 | AB2-188 E OP | 0.39 |
| 925331 | AB2-190 C | 11.64 |
| 925332 | AB2-190 E | 4.99 |