Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AB2-190

Hopewell – Surry 230kV
112 MW Capacity / 160 MW Energy

February / 2019

Introduction

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Fort Powhatan Solar, LLC, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

General

IC has proposed a solar generating facility located in Disputanta, VA (Prince George County). The installed facilities will have a total capability of 160 MW with 112 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

Queue AB2-190 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Hopewell – Surry 230kV line #240 (north side).

Cost Summary

The AB2-190 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 559,108
Direct Connection Network Upgrades	$6,146,212
Non Direct Connection Network Upgrades	$2,275,295
Allocation for New System Upgrades	$3,441,235
Contribution for Previously Identified Upgrades	$0
Total Costs	**$12,421,850**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AB2-190 is a request to interconnect a 160 MW new solar generating facility to be located in Prince George County, Virginia. The proposed generating facility will interconnect with the ITO's new Wards Creek 230kV Switching Station via a new breaker bay (Line Terminal). The requested in-service date is December 30, 2020. Attachment Facility and Network upgrade construction is estimated to be 16 – 22 months.

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

Network Impacts

The Queue Project AB2-190 was evaluated as a 160.0 MW (Capacity 112.0 MW) injection tapping the Hopewell-Surry 230kV line in the ITO area. Project AB2-190 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-190 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
562T563	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
LN 208-259	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
LN 211-228	CONTINGENCY 'LN 211-228' OPEN BRANCH FROM BUS 314287 TO BUS 314303 CKT 1 /* 6CHSTF B 230.00 - 6HOPEWLL 230.00 OPEN BRANCH FROM BUS 314278 TO BUS 314286 CKT 1 /* 6BERMUDA 230.00 - 6CHSTF A 230.00 OPEN BRANCH FROM BUS 314278 TO BUS 314303 CKT 1 /* 6BERMUDA 230.00 - 6HOPEWLL 230.00 OPEN BUS 314278 /* ISLAND END

Contingency Name	Description
LN 259	CONTINGENCY 'LN 259' OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00 END
LN 563	CONTINGENCY 'LN 563' OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00 END
LN 576	CONTINGENCY 'LN 576' OPEN BRANCH FROM BUS 314322 TO BUS 314914 CKT 1 /* 6MDLTHAN 230.00 - 8MDLTHAN 500.00 OPEN BRANCH FROM BUS 314914 TO BUS 314918 CKT 1 /* 8MDLTHAN 500.00 - 8NO ANNA 500.00 END

Summer Peak Analysis – 2020

Generator Deliverability

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
1	N-1	LN 563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	98.87	101.56	ER	449	12.01

Multiple Facility Contingency

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
2	DCTL	LN 211-228	DVP - DVP	6PRGEORG 230/115 kV transformer	314269	314291	1	AC	88.97	102.27	LD	220	29.58	1

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 Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
3	DCTL	LN 208-259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	AC	104.54	108.32	LD	459	17.5	2
4	DCTL	LN 208-259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	115.66	119.45	LD	459	17.5	3

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
5	N-1	LN 259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	107.6	110.55	ER	375	11.02	
6	N-1	LN 576	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	104.01	106.46	ER	375	9.1	
7	DCTL	LN 208-259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	115.69	119.48	LD	459	17.5	4
8	N-1	LN 259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	107.64	110.58	ER	375	11.02	
9	N-1	LN 576	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	104.04	106.49	ER	375	9.1	
10	LFFB	562T563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	103.14	106.18	LD	549	16.63	5

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 Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
11	N-1	LN 259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	AC	100.35	103.9	ER	375	15.74

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
12	N-1	LN 259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	113.96	117.52	ER	375	15.74
13	N-1	LN 259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	114	117.55	ER	375	15.74
14	N-1	LN 563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	114.89	118.72	ER	449	17.15
15	N-1	LN 576	DVP - DVP	8ELMONT-8LDYSMTH 500 kV line	314908	314911	1	AC	114.97	116.75	ER	2442	51.44

Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

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

None

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-190 Allocation
# 1	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		

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-190 Allocation
# 2	6PRGEORG 230/115 kV transformer	Replace the existing Prince George 230/115 kV transformer to increase its rating to 276.8 MVA (normal), 292.4 MVA (emergency), and 328.7 MVA (load dump). Estimated to take 12 months to engineer and construct. **Queue** / **Impact (MW)** / **Cost** **AB2-190** / 5.04 / **$3,441,235**	n5807	$3,441,235	**$3,441,235**
				Total New Network Upgrades	**$3,441,235**

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	AB2-190 Allocation
# 3	6CHARCTY-6LAKESD 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745		
# 4 - 6	6MESSER-6CHARCTY 230 kV line				
# 7 – 9	6CHSTF B-6MESSER 230 kV line				
# 10	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		

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-190 Allocation
				Total New Network Upgrades	**$0**

3. Interconnection Customer's Submitted Milestone Schedule

- Plan to break ground 1/15/2020
- Permits – state level Permit By Rule and county level Final Site Plan approval complete by early 2020
- Substantial site work completed 2/28/2020
- Delivery of major electrical equipment 4/30/2020
- Back Feed Power 10/31/2020
- Commercial Operation 12/31/2020

4. Scope of Customer's Work

IC will build a solar generating facility in Prince George County, Virginia. The generating facility (Fort Powhatan Solar) will be comprised of solar arrays. AB2-190 consists of 80 x 2 MW SMA inverters. The 80 x 34.5/0.385 kV grounded wye wye generator step up (GSU) transformers with a rating of 2.0 MVA will connect the solar inverters to the 34.5 kV collector system. The generating facility will connect to the Point of Interconnection (POI) via two 230/34.5 kV wye grounded wye grounded main power transformer with a rating of 48/64/80 MVA. The AB2-190 POI will be at a tap of the Hopewell – Surry 230kV line #240.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new Wards Creek 230kV ring bus switching station adjacent to the transmission right of way. The Hopewell – Surry 230kV line #240 will loop into and out of the new switching station which is 30.7 miles from Surry and 12 miles from Hopewell substations. All substation permitting, site preparation and grading activity will be performed by the IC. There will be transmission line protection and anti-islanding work required at the remote lines terminals in Hopewell and Surry 230kV substations. Site plan (Attachment 1) was developed by the ITO during PJM's Generation Queue Process. The single line is shown in Attachment 2.

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

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities	$283,914	$205,034	$49,049	$21,111	$559,108
Total Attachment Facilities Cost	$283,914	$205,034	$49,049	$21,111	$559,108
Wards Creek 230 kV Switching Station (n5202)	$2,418,482	$2,962,627	$416,487	$348,616	$6,146,212
Line #240 Transmission work (n5203)	$1,084,186	$796,453	$270,758	$62,088	$2,213,485
Remote relay (n5204)	$27,738	$22,986	$7,604	$3,482	$61,810
Prince George 230/115kV transformer (n5807)	$655,398	$2,534,310	$100,528	$150,999	$3,441,235
Total Network Upgrades	$4,213,542	$6,339,362	$802,981	$568,667	$11,862,742
Total Project Costs	$4,497,456	$6,544,396	$852,030	$589,778	$12,421,850

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

Facilities are estimated to take 14 - 24 months to construct and this is based on the ability to obtain outages to construct and test the proposed facilities.

Proposed Schedule

- Detailed design: 6-12 months
- Permitting: 6-12 months (Timeline runs concurrent with design)
- Construction 8 to 12 months

ITO requires the site to be fully graded and permitted site so they can start construction by October 2019.

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

The Attachment Facilities include that portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities. The Point of Interconnection with the generator will be the 4-hole pad on the ITO disconnect switch. The IC will bring its bus to the demarcation point. Metering equipment will be installed in the ITO Switching Station. The equipment associated with the Attachment Facilities includes the following.

Purchase and install:

1. One (1) 230kV, 3000A, 3-phase Center Break Gang Operated Switches;
2. Three (3) 230kV metering accuracy CCVT's;
3. Three (3) 230kV 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), 1421 – Generation/NUG/PJM/IPP Metering Panel;
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), 1611 – 28" SEL-451 PMU Panel w/SEL 735/735;
7. One (1), Customer Interface Box.

2. Transmission Line – Upgrades

PJM Network Upgrade #n5203 - Re-arrange Line #240 to loop into and out of the new three breaker Wards Creek 230 kV switching station between 240/167 and 240/168 transmission structures on the Hopewell to Surry 230kV line #240**.** The line connection will require the installation of (1) backbone structure. The cut lines will be attached to the new backbone structures and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. Two Static pole structures will also be installed for the protection of the substation equipment.

Purchase and install the following:

1. Install one (1) 230kV SC Steel double dead ended backbone structure (no switches) with foundations;
2. Install two (2) Steel Static Poles with foundations;
3. Cut and Transfer (2) Spans of 3-Phased 2-721 ACAR conductor to new backbone (Line 240);
4. Modify (2) existing corten N1 Series suspension structures for additional dead end static and crossing insulators;
5. Install approximately 0.19 miles of 1-3#6 shield wire from the proposed Backbone to structures 240/167 & 240/168;
6. Install approximately 0.13 miles of 1-3#6 shield wire from the between Proposed Backbone and Static poles;

7. Renumber approximately 74 structures with new line number 2XXX between the new Wards Creek Substation and Hopewell Substation.

Facilities to be removed:
1. Remove approximately 0.8 miles of existing OPGW from the cut span between structures 240/167 and 240/168 to the existing splice point Str. 240/172.

3. New Substation/Switchyard Facilities

PJM Network Upgrade #n5202 - Build a three breaker Wards Creek 230 kV switching station. The site is located along the ITO's existing right of way for the Hopewell to Surry 230kV line #240. The station will be positioned in such a way that the new backbone will align with the perpendicular bisector between 240/167 and 240/168 structures. The lines will consume two of the three positions in the ring bus. The third position will be for the 230-kV feed from the collector station for the solar farm. The work required is as follows:

Purchase and install the following:
1. Approximately 340' X 280' site preparation and grading as required for installation of the switching station (by IC);
2. Approximately 1200 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the station along with the security cameras and integrators as per security standards;
3. Full substation ground grid as per engineering standards;
4. One (1) 230 kV, Heavy Duty Steel Backbone;
5. Two (2) shield wire poles and three span of shield wires;
6. Three (3) 230 kV, 3000A, 50 kA SF6 Circuit Breakers;
7. Six (6) 230 kV, 3000A, 3-phase Center Break Gang Operated Switches;
8. Nine (9) 180 kV, Station Class Arresters;
9. Six (6) 230 kV CCVTs, Relay Accuracy;
10. Two (2), 230 kV, 3000 Amps Waves Traps and Line Tuners;
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 230 kV PVTs;
16. Two (2) 230 kV, 3000A, 2-phase Center Break Gang Operated Switches;
17. Two (2), 2" conduits from structure outside the substation to the cable trough
18. Conduit Tracer Wire, 1/C #10, Green
19. 1-1/4" Orange Polyethylene conduits for fiber in the cable trough
20. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports;
21. Foundations as required including control house, equipment and bus support stands;
22. 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. Two (2), 4000 – Station Service Potential M.U. Box;
7. Two (2), 4018 – 800A Station Service AC Distribution Panel;
8. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD;
9. Two (2), 4019 – 225A Three Phase Throwover Switch;
10. One (1), 4153 – Wall Mount Station Battery Monitor;
11. One (1), 5612 - SEL-3530 Data Concentrator Panel;
12. One (1), 1255 – Station Annunciator Panel;
13. One (1), 5021 – SEL-2411 RTU Panel;
14. One (1), 5609 – Fiber Optic Management Panel;
15. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box;
16. One (1), 5202 – 26" APP 601 Digital Fault Recorder;
17. One (1), 5603 – Station Network Panel;
18. One (1), 4523 – Security Camera Interface Box;
19. One (1), 5603 – Station Network Panel;
20. One (1), 5611 – Transmission Fiber Patch Panel;
21. One (1), Telephone Interface Box.

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n5204 - 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 Hopewell and Surry 230kV substations. These costs include the following:

Hopewell 230 kV Substation

Project Summary
Drawing work, relay resets, and field support necessary to change the Line 240 destination to the new Wards Creek Generator Interconnect Substation. Install Islanding Transfer Trip Transmitter for Line 240. The estimated cost of this scope $30,905.

Purchase and install material:
1. One (1), CT-51C Islanding Transfer Trip Transmitter;
2. Any necessary Conductor, Coax cable, connectors, conduit and control cable.

Surry 230 kV Substation

Project Summary
Drawing work, relay resets, and field support necessary to change the Line 240 destination to the new Wards Creek Generator Interconnect Substation. Install Islanding Transfer Trip Transmitter for Line 240. The estimated cost of this scope $30,905.

Purchase and install material:
1. One (1), CT-51C Islanding Transfer Trip Transmitter;
2. Any necessary Conductor, Coax cable, connectors, conduit and control cable.

PJM Network Upgrade #n5807 – Replace the Prince George 230/115 kV transformer #1.
Replace the existing Prince George 230/115kV transformer with a larger device. The work is estimated to take 18 months to complete. The existing transformer has a rating of 168MVA (normal) and 220MVA (emergency) and the new transformer will have a rating of 224MVA (normal) and 280 MVA (emergency). Estimated cost is $3,441,235.

Purchase and install at Prince George Substation:
1. One (1), 230-115-13.2 kV, 224 MVA, AD Transformer
2. Three (3), 180 kV MO (S), 144 kV MCOV, Surge Arresters
3. Three (3), 90 kV MO (S), 74 kV MCOV, Surge Arresters
4. Three (3), 18 kV MO (S), 15.3 kV MCOV, Surge Arresters
5. Modify existing Oil Containment system as required
6. Two (2), 13.2-.12/.24 kV, 167 KVA Station Service Transformers
7. Two (2), SMD-20 Fused Disconnects and current limiting fuses
8. Conductor, connectors, conduits, control cables, foundations, steel structures and grounding materials
9. Remove- Existing Transformer No. 1, station service and accessories

Purchase and install relay material at Prince George Substation:
1. One (1), SPR Relay Auxiliary Package
2. One (1), 7607 – TX Critical Low Oil Trip Assembly
3. One (1), 4510 - SEL-2411 Transformer Annunciator
4. One (1), 4526_C – Transmission Transformer Fiber Optic M.U. Box
5. One (1), 4000 – Station Service Potential M.U. Box
6. One (1), 5609 – Fiber Optic Management Panel

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.

An Interconnection Customer entering the New Services Queue on or after October 1, 2012 with a proposed new Customer Facility that has a Maximum Facility Output equal to or greater than 100 MW shall install and maintain, at its expense, phasor measurement units (PMUs). See Section 8.5.3 of Appendix 2 to the Interconnection Service Agreement as well as section 4.3 of PJM Manual 14D for additional information.

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

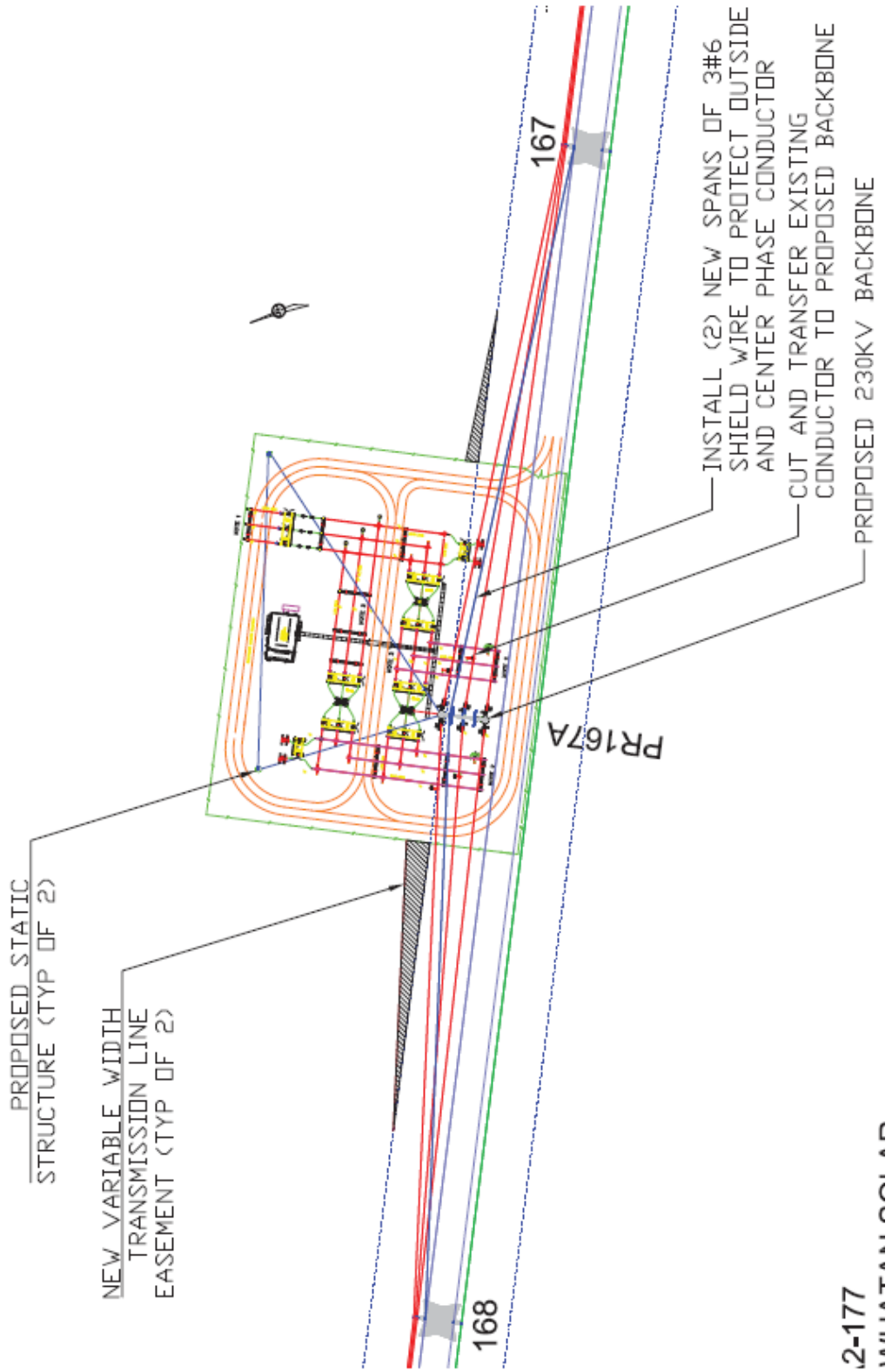
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a Virginia State 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.

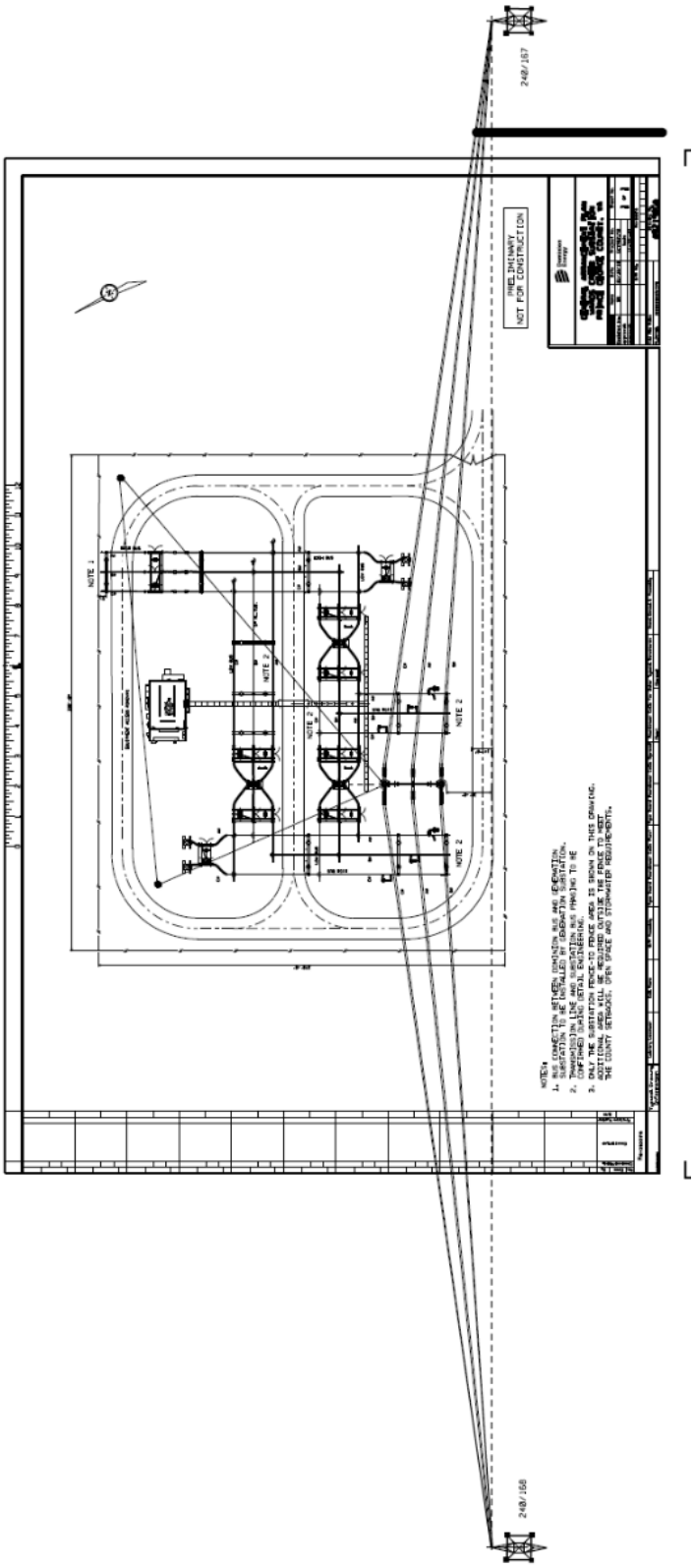
ITO Real Estate Needs:

- The substation layout is complete and ITO requires a 300'x 350' 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 October 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 then 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.

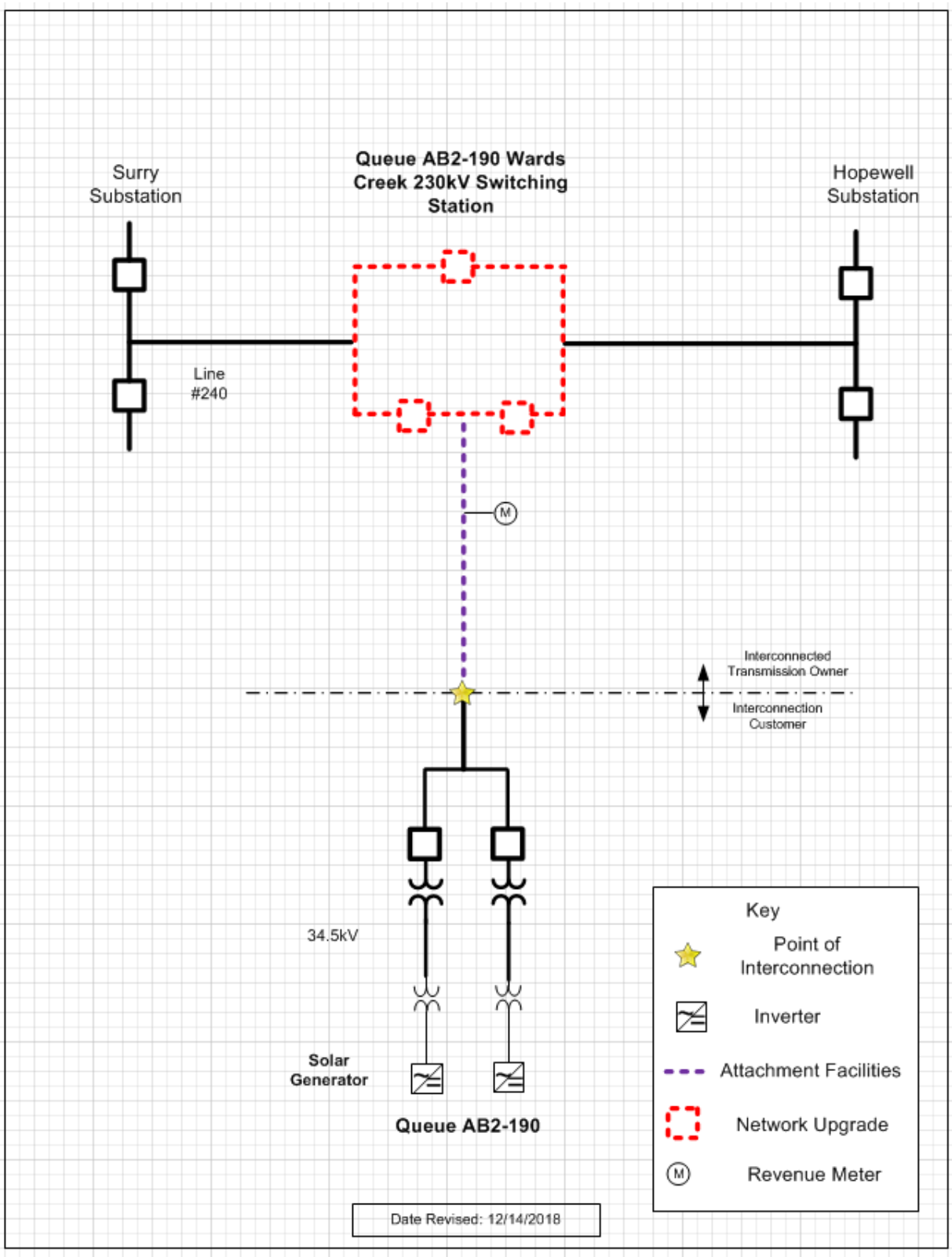
Attachment 1.
Site Plan



Attachment 2.
Site Plan



Attachment 3.
Single Line



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 6PRGEORG 230/115 kV transformer (from bus 314269 to bus 314291 ckt 1) loads from 88.97% to 102.27% (AC power flow) of its load dump rating (220 MVA) for the tower line contingency outage of 'LN 211-228'. This project contributes approximately 29.58 MW to the thermal violation.

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CONTINGENCY 'LN 211-228'
  OPEN BRANCH FROM BUS 314287 TO BUS 314303 CKT 1              /* 6CHSTF B
230.00 - 6HOPEWLL 230.00
  OPEN BRANCH FROM BUS 314278 TO BUS 314286 CKT 1              /* 6BERMUDA
230.00 - 6CHSTF A 230.00
  OPEN BRANCH FROM BUS 314278 TO BUS 314303 CKT 1              /* 6BERMUDA
230.00 - 6HOPEWLL 230.00
  OPEN BUS 314278                                  /* ISLAND
  END
```

Bus Number	*Bus Name*	*Full Contribution*
315119	*1GRAVEL3*	*2.06*
315120	*1GRAVEL4*	*2.07*
315121	*1GRAVEL5*	*2.03*
315122	*1GRAVEL6*	*2.07*
315077	*1HOPHCF1*	*4.28*
315078	*1HOPHCF2*	*4.28*
315079	*1HOPHCF3*	*4.28*
315080	*1HOPHCF4*	*6.5*
315076	*1HOPPOLC*	*3.66*
315073	*1STONECA*	*10.73*
315116	*1SURRY 1*	*21.5*
315074	*CIR_AB2-152*	*1.11*
315075	*CIR_AB2-152*	*-0.49*
292791	*U1-032 E*	*5.59*
914231	*Y2-077*	*1.72*
924811	*AB2-134 C OP*	*14.17*
924812	*AB2-134 E OP*	*13.93*
925331	*AB2-190 C*	*20.71*
925332	*AB2-190 E*	*8.88*

Appendix 2

(DVP - DVP) The 6CHARCTY-6LAKESD 230 kV line (from bus 314225 to bus 314227 ckt 1) loads from 104.54% to 108.32% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 17.5 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*
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 6MESSER-6CHARCTY 230 kV line (from bus 314228 to bus 314225 ckt 1) loads from 115.66% to 119.45% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 17.5 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*
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-6MESSER 230 kV line (from bus 314287 to bus 314228 ckt 1) loads from 115.69% to 119.48% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 17.5 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*
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 5

(DVP - DVP) The 6CHSTF B-6BASIN 230 kV line (from bus 314287 to bus 314276 ckt 1) loads from 103.14% to 106.18% (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 16.63 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*
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*
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*