PJM Generator Interconnection AB2-175 Peach Bottom 44 MW System Impact Study

January 2018

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

The Interconnection Customer (IC) is a proposal for a 44MW uprate (energy and capacity) to Peach Bottom Units 2 and 3 (22 MW each) in York County, Pennsylvania. The end results for these units after this uprate will be:

Unit 2 Maximum Facility Output: 1354.2 MW and Capacity Injection Rights: 1273.2 MW (lost some CIRs due to testing after summer testing 2017. Previous 3 years summer testing results are 1251.2, 1245.1, and 1248.9. So starting point for Unit 2 is 1251.2 MW). Will have up until 2020 to demonstrate the additional 22 MW.

Unit 3 Maximum Facility Output: 1355.6 MW and Capacity Injection Rights: 1307MW (Have 2018 testing left to show V4-045 1285 MW capability. 2016 and 2017 results were 1262.7 and 1261.8 MW). Will have up until 2020 to demonstrate the additional 22 MW.

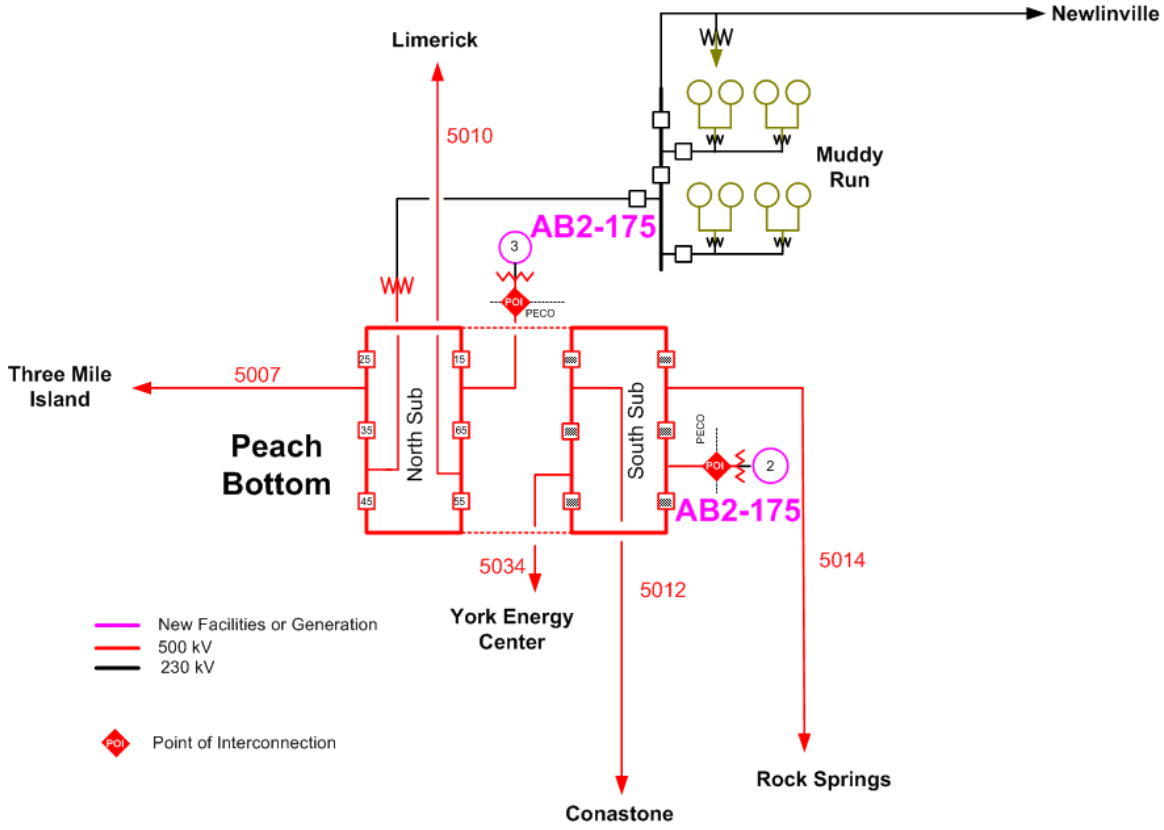
MFO values are based on a maximum winter gross output of 1392 MW for Unit 2 and Unit 3.

The IC had originally proposed a service date for this project of 4th quarter of 2018, but is now expected for initial ascension starting in January 2018 for both units. This is an uprate to V4-045 and it was originally thought that no electrical or physical changes would be made to the turbines or generators themselves. However, Unit 2 is experiencing rotor vibrations whenever the reactive output of the unit exceeds 150 MVAr. This is expected to be remedied by replacing the Unit 2 rotor in the fall of 2018 (PB2R22).

Peach Bottom generating station is located at 1848 Lay Road, Delta, Pennsylvania.

Direct Connection Requirements

The existing interconnection of Peach Bottom Units #2 and #3 is as shown on the one line diagram below.



Interconnection Customer Scope of Direct Connection Work

No new attachment facilities are required.

PECO Energy Scope of Direct Connection work

No new attachment facilities are required.

Network Impacts

The Queue Project AB2-175 was evaluated as a 44.0 MW (Capacity 44.0 MW) uprate to the Peach Bottom units at the Peach Bottom in the PECO area. Project AB2-175 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-175 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)

None

Short Circuit

Not required. No changes to generators or GSUs.

Steady-State Voltage Requirements

None

Stability

No issues identified. See Attachment 1.

Light Load Analysis

Network Impacts

The queue project AB2-175 was studied as a 44 MW (44 MW Capacity) uprate to the Peach Bottom units at the Peach Bottom substation in the PECO. Project AB2-175 was evaluated for compliance with reliability criteria for **Light Load conditions** in 2020. Potential network impacts were as follows:

Generator Deliverability

None

Contribution to Previously Identified Overloads

1. (PECO-BGE) The PEACHBTM – CNASTONE 500kV line (from bus 200013 to bus 200004 ckt 1) loads from 115% to 116% of its normal rating 2338 MVA for the Base Case non-contingency condition. AB2-175 project contributes approximately 30 MW to the overload.

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

None

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

1. To relieve the Peach Bottom - Conastone 500kV line overload:

Existing baseline B2766.1; upgrade substation equipment at Peach Bottom 500 kV (on the Peach Bottom – Conastone 500 kV circuit) to increase facility rating to 2826 MVA normal and 3525 MVA emergency. AB2-175 will require B2766.1 to be advanced from 2021 to 2020. AB2-175 is responsible for the cost required to advance B2766.2 from 2021 to 2020. Cost: PECO advancement cost = $0.

Existing baseline B2766.2; Upgrade substation equipment at Conastone 500 kV (on the Peach Bottom – Conastone 500 kV circuit) to increase facility rating to 2826 MVA normal and 3525 MVA emergency. AB2-175 will require B2766.2 to be advanced from 2021 to 2020. AB2-175 is responsible for the cost required to advance B2766.2 from 2021 to 2020. Cost: BGE advancement cost = $0.

Reactive Power Requirement

See Attachment #3 for data, details and results. This analysis is based only on the generator capability curves supplied by Exelon Generation as indicated in Attachment #3, and any changes to these data will require re-evaluation, and may require additional reactive reinforcements.

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.

No issues identified.

Attachment 1

AB2-175 Stability Study Report
Peach Bottom 500 kV

November 8, 2016

Executive Summary

This study evaluates the stability capability for the Peach Bottom generating Units 2 & 3. They were dispatched at their maximum ratings of 1392 MW and 1392 MW, respectively.

This study is based on the RTEP 2018 light load case v04_2015_05_20 and modified to include applicable queue projects. PJM queue project AB2-175 was dispatched at a maximum power transfer of 1392 MW for Peach Bottom unit 2 and 1392 MW for unit 3 POI voltage of 525.0 kV (1.05 p.u.), consistent with the default generator reference voltage specified in PJM Manual 03 Transmission Operations Section 3.3.3 for generator connections to the PJM 500 kV system.

AB2-175 was tested for compliance with NERC, PJM and other applicable criteria. 45 contingencies were studied, each with a 20 second simulation time period.

Based on the contingencies tested, AB2-175 meets criteria for all the contingencies tested.

Description

This study evaluates the stability capability for the Peach Bottom generating Units 2 & 3. They were dispatched at their maximum ratings of 1392MW respectively.

Criteria

The stability study for AB2-175 was performed on a RTEP 2018 light load case v04_2015_05_20 for normal operating conditions, and modified to include applicable queue projects. The range of contingencies evaluated was limited to those necessary to assess compliance with NERC, PJM and other applicable criteria. Simulation time was 20 seconds for all faults.

Simulated NERC Standard TPL-001faults include:

1. Three-phase (3ph) fault with normal clearing (Category P1)
2. Operating of a line section w/o a fault, Single-line-to-ground (slg) on Bus Section and Breaker. (Category P2)
3. Single-line-to-ground (slg) with delayed clearing as a result of breaker failure (Category P4)
4. Single-line-to-ground (slg) with delayed clearing as a result of protection failure (Category P5)
5. Single-line-to-ground (slg) with normal clearing for common structure (Category P7)

Note: For generator interconnection studies, Category P3 and P6 faults will be studied on an as needed basis. In this study, P2, P3, P5, and P7 are not applicable.

Other applicable criteria tested include:

1. Transmission Owner (TO) specific criteria
2. Other criteria

The system was tested for an all lines in service condition and the faults listed above. Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

All generators were monitored to assess transient stability and satisfactory post-contingency conditions.

Case Setup

Generators within 5 buses from the generator(s) under study are dispatched at their maximum power output and were set to hold scheduled voltages.

Specific dispatch conditions at the generator terminals for the AB2-175 generators, as obtained in the power flow solution, are illustrated below:

	PB #2	PB #3
Gross power output (MW)	1392.0	1392.0
Reactive power output (MVARS)	459.5	459.5
Auxiliary Load (MW/MVARS)	34.7/15.0	32.1/19.0
Station Service Load (MW/MVARS)	3.0/1.5	3.0/1.5
Net real power injection (MW)	1351.8	1354.4
Voltage at the POI (P.U.)	1.05	1.05

Results

Simulation Initialization
The case was initialized successfully. No errors were reported.

20 second no fault test (Steady State evaluation)
The system successfully met the 20 second run test without any significant deviations in system states.

Simulation Results
Dynamics and stability was tested using Siemens/PTI PSS/E Version 32, the 2018 case v04_2015_05_20 with a Light Load condition and the data supplied by the developer.

Transient Stability: For all cases studied, transient stability is maintained, with all oscillations stabilized in less than 20 seconds. Also, the voltage levels returned to acceptable levels for all cases following the fault clearance. Hence, no transient stability issues were identified.

Small Signal (if applicable):

SPS:

Maintenance outage: No maintenance outage conditions were evaluated.

Conclusion

No issues were identified for the stability study performed for PJM queue project AB2-175.

Mitigations

None required.

Appendix A: Fault Table

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
01	AB2-175-PECH-P1-01	TPL 001-4_P1	3ph fault on Peach Bottom – Rock Spring 500 kV (5014)	3.5	N/A	Stable
02	AB2-175-PECH-P1-02	TPL 001-4_P1	3ph fault on Peach Bottom – Three Miles Island 500 kV (5007)	3.5	N/A	Stable
03	AB2-175-PECH-P1-03	TPL 001-4_P1	3ph fault on Peach Bottom – Conastone 500 kV (5012)	3.5	N/A	Stable
04	AB2-175-PECH-P1-04	TPL 001-4_P1	3ph fault on Peach Bottom – Limerick 500 kV (5010)	3.5	N/A	Stable
05	AB2-175-PECH-P1-05	TPL 001-4_P1	3ph fault on Peach Bottom 500/230 kV TF SPS activated – Trips Muddy Run unit 5-8	3.5	N/A	Stable
06	AB2-175-PECH-P1-06	TPL 001-4_P1	3ph fault on Peach Bottom 230/500 kV TF SPS activated – Trips Muddy Run unit 5-8	4.5	N/A	Stable
07	AB2-175-PECH-P1-07	TPL 001-4_P1	3ph fault on Peach Bottom – Cochar – Newlinville 230 kV	4.5	N/A	Stable
08	AB2-175-PECH-P1-08	TPL 001-4_P1	3ph fault on Peach Bottom 230/34.5 kV TF + 230/500 kV TF SPS activated – Trips Muddy Run unit 5-8	4.5	N/A	Stable
09	AB2-175-ROCK-P1-01	TPL 001-4_P1	3ph fault on Rock Spring – Keeney 500 kV (5025)	3.5	N/A	Stable
10	AB2-175-ROCK-P1-02	TPL 001-4_P1	3ph fault on Rock Spring – Peach Bottom 500 kV (5014)	3.5	N/A	Stable
11	AB2-175-TMIS-P1-01	TPL 001-4_P1	3ph fault on Three Miles Island – N LANC 500 kV	4.0	N/A	Stable
12	AB2-175-TMIS-P1-02	TPL 001-4_P1	3ph fault on Three Miles Island – Junita 500 kV	4.0	N/A	Stable
13	AB2-175-TMIS-P1-03	TPL 001-4_P1	3ph fault on Three Miles Island 500/230 kV TF	4.0	N/A	Stable
14	AB2-175-TMIS-P1-04	TPL 001-4_P1	3 phase fault on Three Miles Island – Peach Bottom 500 kV	4.0	N/A	Stable
15	AB2-175-CONA-P1-01	TPL 001-4_P1	3ph fault on Conastone – Brighton 500 kV	4.5	N/A	Stable
16	AB2-175-CONA-P1-02	TPL 001-4_P1	3ph fault on Conastone – Hunters Run 500 kV	4.5	N/A	Stable
17	AB2-175-CONA-P1-03	TPL 001-4_P1	3ph fault on Conastone 500/230 kV TF1	4.5	N/A	Stable
18	AB2-175-CONA-P1-04	TPL 001-4_P1	3ph fault on Conastone 500/230 kV TF2	4.5	N/A	Stable
19	AB2-175-LIME-P1-01	TPL 001-4_P1	3ph fault on Limerick – Whitepain 500 kV Ckt1	3.5	N/A	Stable
20	AB2-175-LIME-P1-02	TPL 001-4_P1	3ph fault on Limerick – Whitepain 500 kV Ckt2	3.5	N/A	Stable
21	AB2-175-LIME-P1-03	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF1	3.5	N/A	Stable
22	AB2-175-LIME-P1-04	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF2	3.5	N/A	Stable
23	AB2-175-LIME-P1-05	TPL 001-4_P1	3ph fault on Limerick – Peach Bottom 500 kV	3.5	N/A	Stable

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
23	AB2-175-LIME-P1-06	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF1 and TF2	3.5	N/A	Stable
24	AB2-175-PECH-P4-01	TPL 001-4_P4	SLG fault on Peach Bottom – Rock Spring 500 kV, SB '55' @ Peach Bottom 500 kV, Loss of Peach Bottom #2 Bus	3.5	8.0	Stable
25	AB2-175-PECH-P4-02	TPL 001-4_P4	SLG fault on Peach Bottom G3 500 kV Bus , SB '65' @ Peach Bottom, Loss of Peach Bottom – Rock Spring 500 kV	3.5	8.0	Stable
26	AB2-175-PECH-P4-03	TPL 001-4_P4	SLG fault on Peach Bottom – Limerick 500 kV, SB '65' @ Peach Bottom 500 kV, Loss of Peach Bottom G3	3.5	8.0	Stable
27	AB2-175-PECH-P4-04	TPL 001-4_P4	SLG fault on Peach Bottom – Three Miles Island 500 kV, SB '25'@ Peach Bottom 500 kV, Loss of Peach Bottom 500 kV #1 Bus	3.5	8.0	Stable
28	AB2-175-PECH-P4-05	TPL 001-4_P4	SLG fault on Peach Bottom – Three Miles Island 500 kV, SB '35'@ Peach Bottom 500 kV, Loss of Peach Bottom 500/230 kV TF SPS activated – Trips Muddy Run unit 5-8	3.5	8.0	Stable
29	AB2-175-PECH-P4-06	TPL 001-4_P4	SLG fault on Peach Bottom 500/230 kV TF, SPS activated – Trips Muddy Run unit 5-8, SB '35'@ Peach Bottom 500 kV, Loss Peach Bottom – Three Miles Island 500 kV	3.5	8.0	Stable
30	AB2-175-PECH-P4-07	TPL 001-4_P4	SLG fault on Peach Bottom 500/230 kV TF, SPS activated – Trips Muddy Run unit 5-8, SB '45'@ Peach Bottom 500 kV, Loss Peach Bottom 500 kV #2 Bus	3.5	8.0	Stable
31	AB2-175-PECH-P4-08	TPL 001-4_P4	SLG fault on Peach Bottom – Rock Spring 500 kV, SB '205' @ Peach Bottom 500 kV, Loss of Peach Bottom #1 Bus	3.5	8.0	Stable
32	AB2-175-PECH-P9-09	TPL 001-4_P4	SLG fault on Peach Bottom – Conastone 500 kV, SB '235' @ Peach Bottom 500 kV, Loss of Peach Bottom #1 Bus	3.5	8.0	Stable
33	AB2-175-ROCK-P4-01	TPL 001-4_P4	SLG fault @ Rock Spring – Keeney 500 kV, SB @ Keeney 500 kV, No additional loss	3.5	12.0	Stable
34	AB2-175-ROCK-P4-02	TPL 001-4_P4	SLG fault @ Rock Spring – Keeney 500 kV, SB @ Keeney 500 kV, Loss of Keeney G1 & G2	3.5	12.0	Stable
35	AB2-175-TMIS-P4-01	TPL 001-4_P4	SLG fault @ Three Miles Island – N LANC 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island 500/230 kV TF	4.0	13.0	Stable
36	AB2-175-TMIS-P4-02	TPL 001-4_P4	SLG fault @ Three Miles Island 500/230 kV TF, SB @ TMI 500 kV, Loss of Three Miles Island – N LANC 500 kV	4.0	13.0	Stable
37	AB2-175-TMIS-P4-03	TPL 001-4_P4	SLG fault @ Three Miles Island – Junita 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island 500/230 kV TF	4.0	13.0	Stable
38	AB2-175-TMIS-P4-04	TPL 001-4_P4	SLG fault @ Three Miles Island – Junita 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island – Peach Bottom 500 kV	4.0	13.0	Stable

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
39	AB2-175-CONA-P4-01	TPL 001-4_P4	SLG fault @ Conastone – Hunters Run 500 kV, SB @ Conastone 500 kV, Loss of on Conastone 500/230 kV	4.5	13.0	Stable
40	AB2-175-CONA-P4-02	TPL 001-4_P4	SLG fault @ Conastone 500/230 kV, SB @ Conastone 500 kV, Loss of Conastone – Hunters Run 500 kV	4.5	13.0	Stable
41	AB2-175-CONA-P4-03	TPL 001-4_P4	SLG fault @ Conastone 500/230 kV, SB @ Conastone 500 kV, Loss of Conastone – Peach Bottom 500 kV	4.5	13.0	Stable
42	AB2-175-CONA-P4-04	TPL 001-4_P4	SLG fault @ Conastone – Brighton 500 kV, SB @ Conastone 500 kV, No additional loss	4.5	13.0	Stable
43	AB2-175-LIME-P4-01	TPL 001-4_P4	SLG fault @ Limerick – Whitepain 500 kV Ckt1, SB '135' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable
44	AB2-175-LIME-P4-02	TPL 001-4_P4	SLG fault @ Limerick – Whitepain 500 kV Ckt2, SB '235' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable
45	AB2-175-LIME-P4-03	TPL 001-4_P4	SLG fault @ Limerick 500/230 kV TF1 and TF2, SB '115' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable

Appendix B: Breaker Diagram

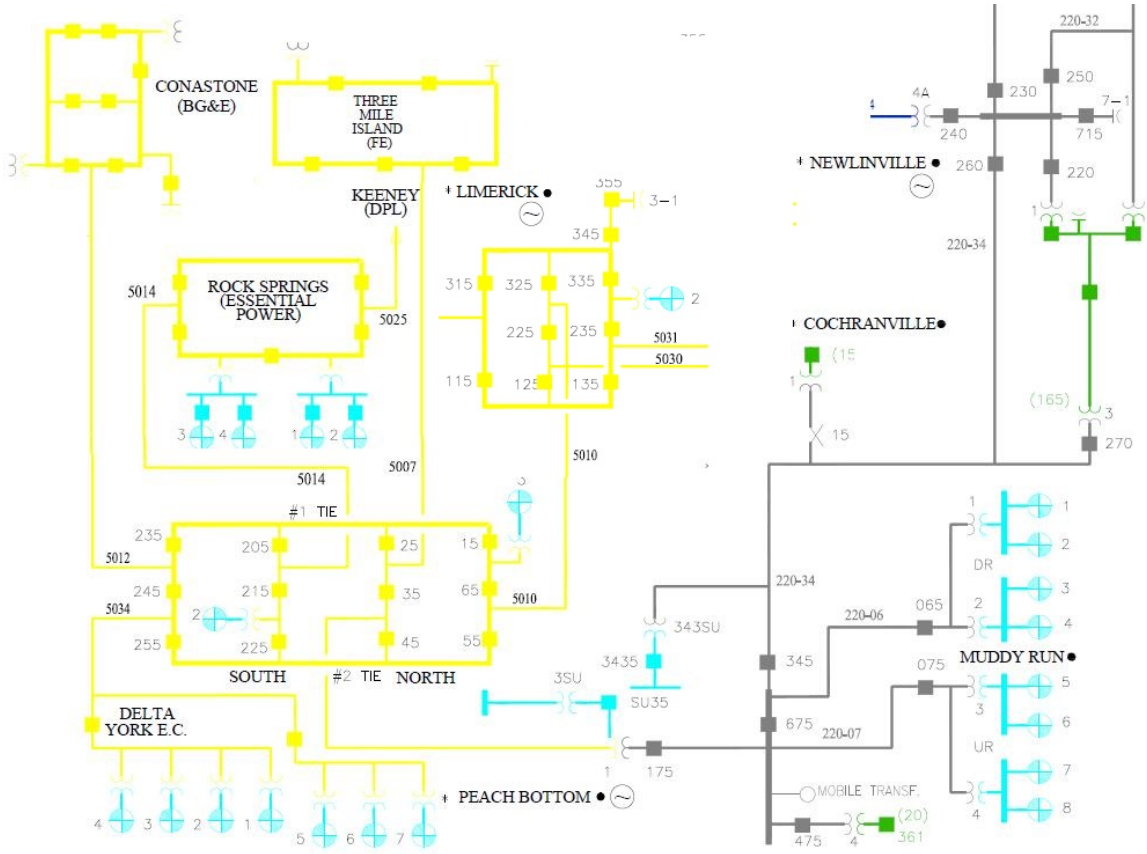


Figure B-1: PJM AB2-175 modeling details

Appendix C: Power Flow and Dynamic Models

C.1) PSS/E Models

PSS/E Models for Peach Bottom #2:

Generator model: GENROU
Excitation model: USAC6AU
Governor model: --------
Power System Stabilizer model: PSS2B

```
 200034 'GENROU' 1     8.7960      0.36000E-01  0.44000      0.62000E-01
         5.4180       0.0000       2.0980       1.9730      0.44900
        0.67100      0.35400      0.27600      0.11500      0.43910    /
200034 'PSS2B'  1          1            0            3            0
              5          1       7.0000       7.0000      0.85000E-02
         7.0000       0.0000       7.0000      0.64600       1.0000
        0.50000      0.10000       3.0000      0.30000      0.60000E-01
        0.25000      0.50000E-01  0.25000      0.50000E-01   2.0000
        -2.0000       2.0000      -2.0000      0.10000     -0.50000E-01 /
200034 'USRMDL' 1  'USAC6AU' 4   0   0   23   5   0
        0.17000E-02   1000.0       35.000       7.0000      0.20000
         1.0000       54.300      -47.800       54.300      -47.800
         5.1200       13.300       100.00       99.000      0.80000E-01
        0.20000E-01  0.15350       1.1936       1.0000       6.3780
        0.10260       8.5050      0.56000    /
```

PSS/E Models for Peach Bottom #3:
Generator model: GENROU
Excitation model: USAC6AU
Governor model: --------
Power System Stabilizer model: PSS2B

```
200035 'GENROU' 1     8.7250      0.36000E-01  0.45400E-01  0.64000E-01
         5.4110       0.0000       2.1770       2.0440      0.44000
        0.66900      0.34700      0.27300      0.22820      0.59650    /
 200035 'PSS2B'  1          1            0            3            0
              5            1       7.0000       7.0000      0.85000E-02
         7.0000       0.0000       7.0000      0.64200       1.0000
        0.50000      0.10000       3.0000      0.30000      0.60000E-01
        0.25000      0.50000E-01  0.25000      0.50000E-01   2.0000
        -2.0000       2.0000      -2.0000      0.10000     -0.50000E-01 /
 200035 'USRMDL' 1  'USAC6AU' 4   0   0   23   5   0
        0.85000E-02   1000.0       35.000       7.0000      0.20000
         1.0000       51.900      -45.700       51.900      -45.700
         4.6100       12.780       100.00       99.000      0.80000E-01
        0.20000E-01  0.13800       1.0150       1.0000       6.1640
        0.72000E-01   8.2180      0.55500    /
```

C.2) PSS/E Single Line Diagram

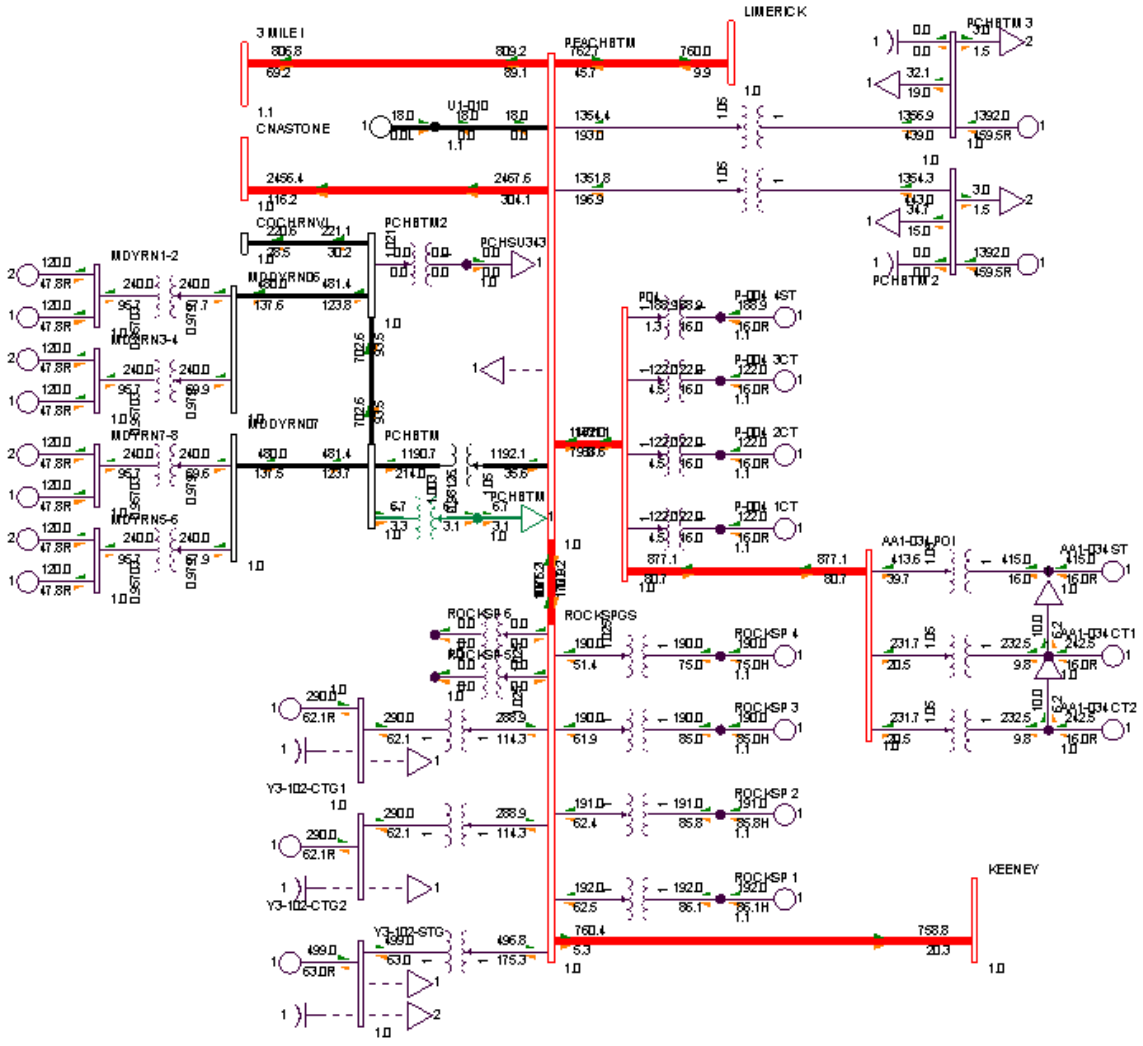


Figure C-1: Single-line diagram for AB2-175 (LL case) (Breaker information not shown)

Attachment 2

AB2-175 Interim Stability Study Report
Peach Bottom 500 kV

December 19, 2016

Executive Summary

This study evaluates the stability capability for the Peach Bottom generating Units 2 & 3. They were dispatched at their maximum ratings of 1392 MW and 1392 MW, respectively.

This study is based on the RTEP 2019 light load case and modified to include applicable queue projects. PJM queue project AB2-175 was dispatched at a maximum power transfer of 1392 MW for Peach Bottom unit 2 and 1392 MW for unit 3 POI voltage of 525.0 kV (1.05 p.u.), consistent with the default generator reference voltage specified in PJM Manual 03 Transmission Operations Section 3.3.3 for generator connections to the PJM 500 kV system.

AB2-175 was tested for compliance with NERC, PJM and other applicable criteria. 50 contingencies were studied, each with a 20 second simulation time period.

Based on the contingencies tested, AB2-175 meets criteria for all the contingencies tested.

Description

This study evaluates the stability capability for the Peach Bottom generating Units 2 & 3. They were dispatched at their maximum ratings of 1392MW respectively.

Criteria

The stability study for AB2-175 was performed on a RTEP 2019 light load case for normal operating conditions, and modified to include applicable queue projects. The range of contingencies evaluated was limited to those necessary to assess compliance with NERC, PJM and other applicable criteria. Simulation time was 20 seconds for all faults.

Simulated NERC Standard TPL-001faults include:

6. Three-phase (3ph) fault with normal clearing (Category P1)
7. Operating of a line section w/o a fault, Single-line-to-ground (slg) on Bus Section and Breaker. (Category P2)
8. Single-line-to-ground (slg) with delayed clearing as a result of breaker failure (Category P4)
9. Single-line-to-ground (slg) with delayed clearing as a result of protection failure (Category P5)
10. Single-line-to-ground (slg) with normal clearing for common structure (Category P7)

Note: For generator interconnection studies, Category P3 and P6 faults will be studied on an as needed basis. In this study, P2, P5, and P7 are not applicable.

Other applicable criteria tested include:

3. Transmission Owner (TO) specific criteria
4. Nuclear Plant Interface Requirements (NPIR) criteria

The system was tested for an all lines in service condition and the faults listed above. Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

All generators were monitored to assess transient stability and satisfactory post-contingency conditions.

Case Setup

Generators within 5 buses from the generator(s) under study are dispatched at their maximum power output and were set to hold scheduled voltages.

Specific dispatch conditions at the generator terminals for the AB2-175 generators, as obtained in the power flow solution, are illustrated below:

	PB #2	PB #3
Gross power output (MW)	1392.0	1392.0
Reactive power output (MVARS)	316	316
Auxiliary Load (MW/MVARS)	34.7/15.0	32.1/19.0
Station Service Load (MW/MVARS)	3.0/1.5	3.0/1.5
Net real power injection (MW)	1351.8	1354.4
Voltage at the POI (P.U.)	1.05	1.05

Results

Simulation Initialization
The case was initialized successfully. No errors were reported.

20 second no fault test (Steady State evaluation)
The system successfully met the 20 second run test without any significant deviations in system states.

Simulation Results
Dynamics and stability was tested using Siemens/PTI PSS/E Version 32.1.1, the 2019 case with a Light Load condition and the data supplied by the developer.

Transient Stability: For all cases studied, transient stability is maintained, with all oscillations stabilized in less than 20 seconds. Also, the voltage levels returned to acceptable levels for all cases following the fault clearance. Hence, no transient stability issues were identified.

Small Signal (if applicable):

SPS:

Maintenance outage: No maintenance outage conditions were evaluated.

Conclusion

No issues were identified for the stability study performed for PJM queue project AB2-175.

Mitigations

None required.

Appendix A: Fault Table

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
01	AB2-175-PECH-P1-01	TPL 001-4_P1	3ph fault on Peach Bottom – Rock Spring 500 kV (5014)	3.5	N/A	Stable
02	AB2-175-PECH-P1-02	TPL 001-4_P1	3ph fault on Peach Bottom – Three Miles Island 500 kV (5007)	3.5	N/A	Stable
03	AB2-175-PECH-P1-03	TPL 001-4_P1	3ph fault on Peach Bottom – Conastone 500 kV (5012)	3.5	N/A	Stable
04	AB2-175-PECH-P1-04	TPL 001-4_P1	3ph fault on Peach Bottom – Limerick 500 kV (5010)	3.5	N/A	Stable
05	AB2-175-PECH-P1-05	TPL 001-4_P1	3ph fault on Peach Bottom 500/230 kV TF SPS activated – Trips Muddy Run unit 5-8	3.5	N/A	Stable
06	AB2-175-PECH-P1-06	TPL 001-4_P1	3ph fault on Peach Bottom 230/500 kV TF SPS activated – Trips Muddy Run unit 5-8	4.5	N/A	Stable
07	AB2-175-PECH-P1-07	TPL 001-4_P1	3ph fault on Peach Bottom – Cochar – Newlinville 230 kV	4.5	N/A	Stable
08	AB2-175-PECH-P1-08	TPL 001-4_P1	3ph fault on Peach Bottom 230/34.5 kV TF + 230/500 kV TF SPS activated – Trips Muddy Run unit 5-8	4.5	N/A	Stable
09	AB2-175-ROCK-P1-01	TPL 001-4_P1	3ph fault on Rock Spring – Keeney 500 kV (5025)	3.5	N/A	Stable
10	AB2-175-ROCK-P1-02	TPL 001-4_P1	3ph fault on Rock Spring – Peach Bottom 500 kV (5014)	3.5	N/A	Stable
11	AB2-175-TMIS-P1-01	TPL 001-4_P1	3ph fault on Three Miles Island – N LANC 500 kV	4.0	N/A	Stable
12	AB2-175-TMIS-P1-02	TPL 001-4_P1	3ph fault on Three Miles Island – Junita 500 kV	4.0	N/A	Stable
13	AB2-175-TMIS-P1-03	TPL 001-4_P1	3ph fault on Three Miles Island 500/230 kV TF	4.0	N/A	Stable
14	AB2-175-TMIS-P1-04	TPL 001-4_P1	3 phase fault on Three Miles Island – Peach Bottom 500 kV	4.0	N/A	Stable
15	AB2-175-CONA-P1-01	TPL 001-4_P1	3ph fault on Conastone – Brighton 500 kV	4.5	N/A	Stable
16	AB2-175-CONA-P1-02	TPL 001-4_P1	3ph fault on Conastone – Hunters Run 500 kV	4.5	N/A	Stable
17	AB2-175-CONA-P1-03	TPL 001-4_P1	3ph fault on Conastone 500/230 kV TF1	4.5	N/A	Stable
18	AB2-175-CONA-P1-04	TPL 001-4_P1	3ph fault on Conastone 500/230 kV TF2	4.5	N/A	Stable
19	AB2-175-LIME-P1-01	TPL 001-4_P1	3ph fault on Limerick – Whitepain 500 kV Ckt1	3.5	N/A	Stable
20	AB2-175-LIME-P1-02	TPL 001-4_P1	3ph fault on Limerick – Whitepain 500 kV Ckt2	3.5	N/A	Stable
21	AB2-175-LIME-P1-03	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF1	3.5	N/A	Stable
22	AB2-175-LIME-P1-04	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF2	3.5	N/A	Stable
23	AB2-175-LIME-P1-05	TPL 001-4_P1	3ph fault on Limerick – Peach Bottom 500 kV	3.5	N/A	Stable

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
24	AB2-175-LIME-P1-06	TPL 001-4_P1	3ph fault on Limerick 500/230 kV TF1 and TF2	3.5	N/A	Stable
25	AB2-175-PECH-P4-01	TPL 001-4_P4	SLG fault on Peach Bottom – Rock Spring 500 kV, SB '55' @ Peach Bottom 500 kV, Loss of Peach Bottom #2 Bus	3.5	8.0	Stable
26	AB2-175-PECH-P4-02	TPL 001-4_P4	SLG fault on Peach Bottom G3 500 kV Bus , SB '65' @ Peach Bottom, Loss of Peach Bottom – Rock Spring 500 kV	3.5	8.0	Stable
27	AB2-175-PECH-P4-03	TPL 001-4_P4	SLG fault on Peach Bottom – Limerick 500 kV, SB '65' @ Peach Bottom 500 kV, Loss of Peach Bottom G3	3.5	8.0	Stable
28	AB2-175-PECH-P4-04	TPL 001-4_P4	SLG fault on Peach Bottom – Three Miles Island 500 kV, SB '25'@ Peach Bottom 500 kV, Loss of Peach Bottom 500 kV #1 Bus	3.5	8.0	Stable
29	AB2-175-PECH-P4-05	TPL 001-4_P4	SLG fault on Peach Bottom – Three Miles Island 500 kV, SB '35'@ Peach Bottom 500 kV, Loss of Peach Bottom 500/230 kV TF SPS activated – Trips Muddy Run unit 5-8	3.5	8.0	Stable
30	AB2-175-PECH-P4-06	TPL 001-4_P4	SLG fault on Peach Bottom 500/230 kV TF, SPS activated – Trips Muddy Run unit 5-8, SB '35'@ Peach Bottom 500 kV, Loss Peach Bottom – Three Miles Island 500 kV	3.5	8.0	Stable
31	AB2-175-PECH-P4-07	TPL 001-4_P4	SLG fault on Peach Bottom 500/230 kV TF, SPS activated – Trips Muddy Run unit 5-8, SB '45'@ Peach Bottom 500 kV, Loss Peach Bottom 500 kV #2 Bus	3.5	8.0	Stable
32	AB2-175-PECH-P4-08	TPL 001-4_P4	SLG fault on Peach Bottom – Rock Spring 500 kV, SB '205' @ Peach Bottom 500 kV, Loss of Peach Bottom #1 Bus	3.5	8.0	Stable
33	AB2-175-PECH-P4-09	TPL 001-4_P4	SLG fault on Peach Bottom – Conastone 500 kV, SB '235' @ Peach Bottom 500 kV, Loss of Peach Bottom #1 Bus	3.5	8.0	Stable
34	AB2-175-ROCK-P4-01	TPL 001-4_P4	SLG fault @ Rock Spring – Keeney 500 kV, SB @ Keeney 500 kV, No additional loss	3.5	12.0	Stable
35	AB2-175-ROCK-P4-02	TPL 001-4_P4	SLG fault @ Rock Spring – Keeney 500 kV, SB @ Keeney 500 kV, Loss of Keeney G1 & G2	3.5	12.0	Stable
36	AB2-175-TMIS-P4-01	TPL 001-4_P4	SLG fault @ Three Miles Island – N LANC 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island 500/230 kV TF	4.0	13.0	Stable
37	AB2-175-TMIS-P4-02	TPL 001-4_P4	SLG fault @ Three Miles Island 500/230 kV TF, SB @ TMI 500 kV, Loss of Three Miles Island – N LANC 500 kV	4.0	13.0	Stable
38	AB2-175-TMIS-P4-03	TPL 001-4_P4	SLG fault @ Three Miles Island – Junita 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island 500/230 kV TF	4.0	13.0	Stable
39	AB2-175-TMIS-P4-04	TPL 001-4_P4	SLG fault @ Three Miles Island – Junita 500 kV, SB @ TMI 500 kV, Loss of Three Miles Island – Peach Bottom 500 kV	4.0	13.0	Stable

No.	Contingency ID	Criteria	Type of Fault	Clearing time (cycles)		Results
				Normal	Delayed	
40	AB2-175-CONA-P4-01	TPL 001-4_P4	SLG fault @ Conastone – Hunters Run 500 kV, SB @ Conastone 500 kV, Loss of on Conastone 500/230 kV	4.5	13.0	Stable
41	AB2-175-CONA-P4-02	TPL 001-4_P4	SLG fault @ Conastone 500/230 kV, SB @ Conastone 500 kV, Loss of Conastone – Hunters Run 500 kV	4.5	13.0	Stable
42	AB2-175-CONA-P4-03	TPL 001-4_P4	SLG fault @ Conastone 500/230 kV, SB @ Conastone 500 kV, Loss of Conastone – Peach Bottom 500 kV	4.5	13.0	Stable
43	AB2-175-CONA-P4-04	TPL 001-4_P4	SLG fault @ Conastone – Brighton 500 kV, SB @ Conastone 500 kV, No additional loss	4.5	13.0	Stable
44	AB2-175-LIME-P4-01	TPL 001-4_P4	SLG fault @ Limerick – Whitepain 500 kV Ckt1, SB '135' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable
45	AB2-175-LIME-P4-02	TPL 001-4_P4	SLG fault @ Limerick – Whitepain 500 kV Ckt2, SB '235' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable
46	AB2-175-LIME-P4-03	TPL 001-4_P4	SLG fault @ Limerick 500/230 kV TF1 and TF2, SB '115' @ Limerick 500 kV, No Additional loss	3.5	8.0	Stable
47	NPIR1_PB2off	NPIR	3ph fault @ Peach Bottom Unit 2 GSU, trip GSU and Peach Bottom Unit 2	3.5	N/A	Stable
48	NPIR2_PB3off	NPIR	3ph fault @ Peach Bottom Unit 3 GSU, trip GSU and Peach Bottom Unit 3	3.5	N/A	Stable
49	NPIR3_SUSQ1off	NPIR	3ph fault @ Susquehanna Unit 1 GSU, trip GSU and Susquehanna Unit 1	3.5	N/A	Stable
50	NPIR4_SUSQ2off	NPIR	3ph fault @ Susquehanna Unit 2 GSU, trip GSU and Susquehanna Unit 2	3.5	N/A	Stable

Appendix B: Breaker Diagram

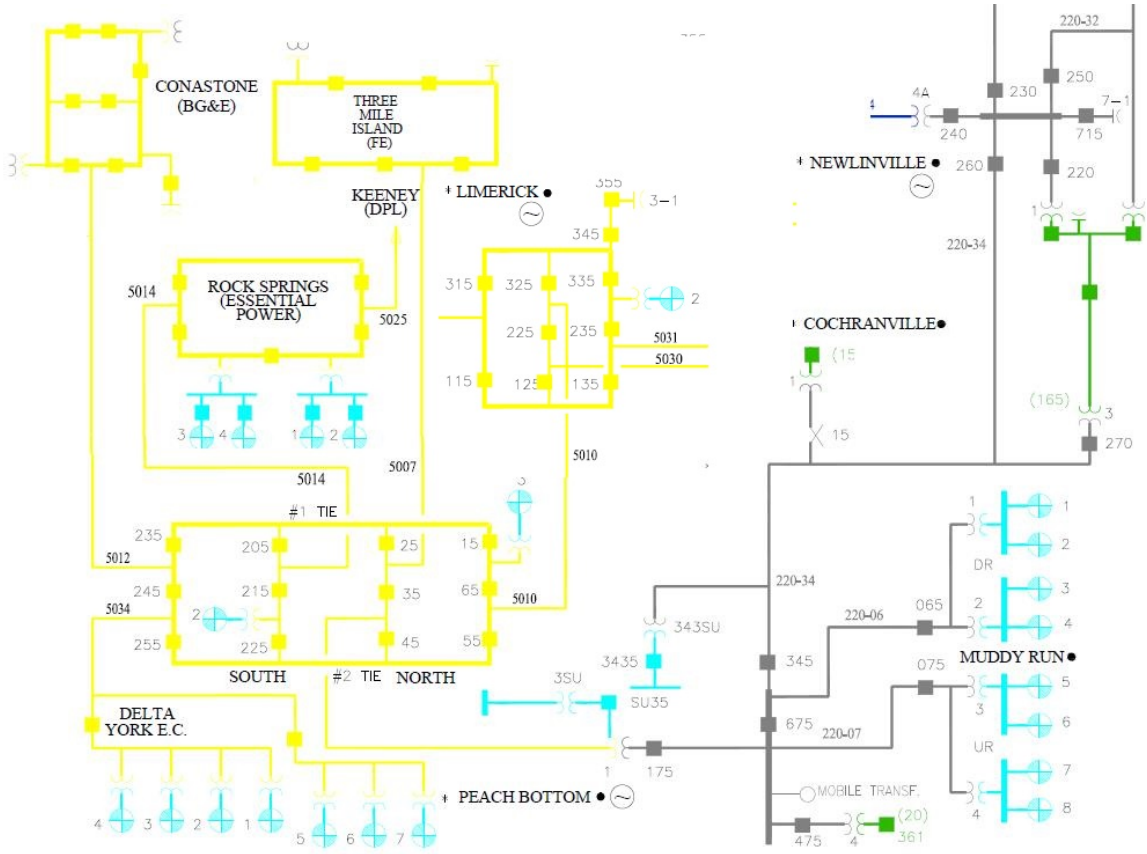


Figure B-1: PJM AB2-175 modeling details

Appendix C: Power Flow and Dynamic Models

C.3) PSS/E Models

PSS/E Models for Peach Bottom #2:

Generator model: GENROU
Excitation model: USAC6AU
Governor model: --------
Power System Stabilizer model: PSS2B

```
 200034 'GENROU' 1     8.7960      0.36000E-01  0.44000      0.62000E-01
         5.4180       0.0000       2.0980       1.9730      0.44900
        0.67100      0.35400      0.27600      0.11500      0.43910    /
200034 'PSS2B'  1          1           0           3           0
             5          1       7.0000       7.0000      0.85000E-02
         7.0000       0.0000       7.0000      0.64600       1.0000
        0.50000      0.10000       3.0000      0.30000      0.60000E-01
        0.25000      0.50000E-01  0.25000      0.50000E-01   2.0000
        -2.0000       2.0000      -2.0000      0.10000     -0.50000E-01 /
200034 'USRMDL' 1  'USAC6AU' 4   0   0   23   5   0
        0.17000E-02   1000.0       35.000       7.0000      0.20000
         1.0000       54.300      -47.800       54.300      -47.800
         5.1200       13.300       100.00       99.000      0.80000E-01
        0.20000E-01  0.15350       1.1936       1.0000       6.3780
        0.10260       8.5050      0.56000    /
```

PSS/E Models for Peach Bottom #3:
Generator model: GENROU
Excitation model: USAC6AU
Governor model: --------
Power System Stabilizer model: PSS2B

```
200035 'GENROU' 1     8.7250      0.36000E-01  0.45400E-01  0.64000E-01
         5.4110       0.0000       2.1770       2.0440      0.44000
        0.66900      0.34700      0.27300      0.22820      0.59650    /
 200035 'PSS2B'  1          1            0            3            0
              5            1       7.0000       7.0000      0.85000E-02
         7.0000       0.0000       7.0000      0.64200       1.0000
        0.50000      0.10000       3.0000      0.30000      0.60000E-01
        0.25000      0.50000E-01  0.25000      0.50000E-01   2.0000
        -2.0000       2.0000      -2.0000      0.10000     -0.50000E-01 /
 200035 'USRMDL' 1  'USAC6AU' 4   0   0   23   5   0
        0.85000E-02   1000.0       35.000       7.0000      0.20000
         1.0000       51.900      -45.700       51.900      -45.700
         4.6100       12.780       100.00       99.000      0.80000E-01
        0.20000E-01  0.13800       1.0150       1.0000       6.1640
        0.72000E-01   8.2180      0.55500    /
```

C.4) PSS/E Single Line Diagram

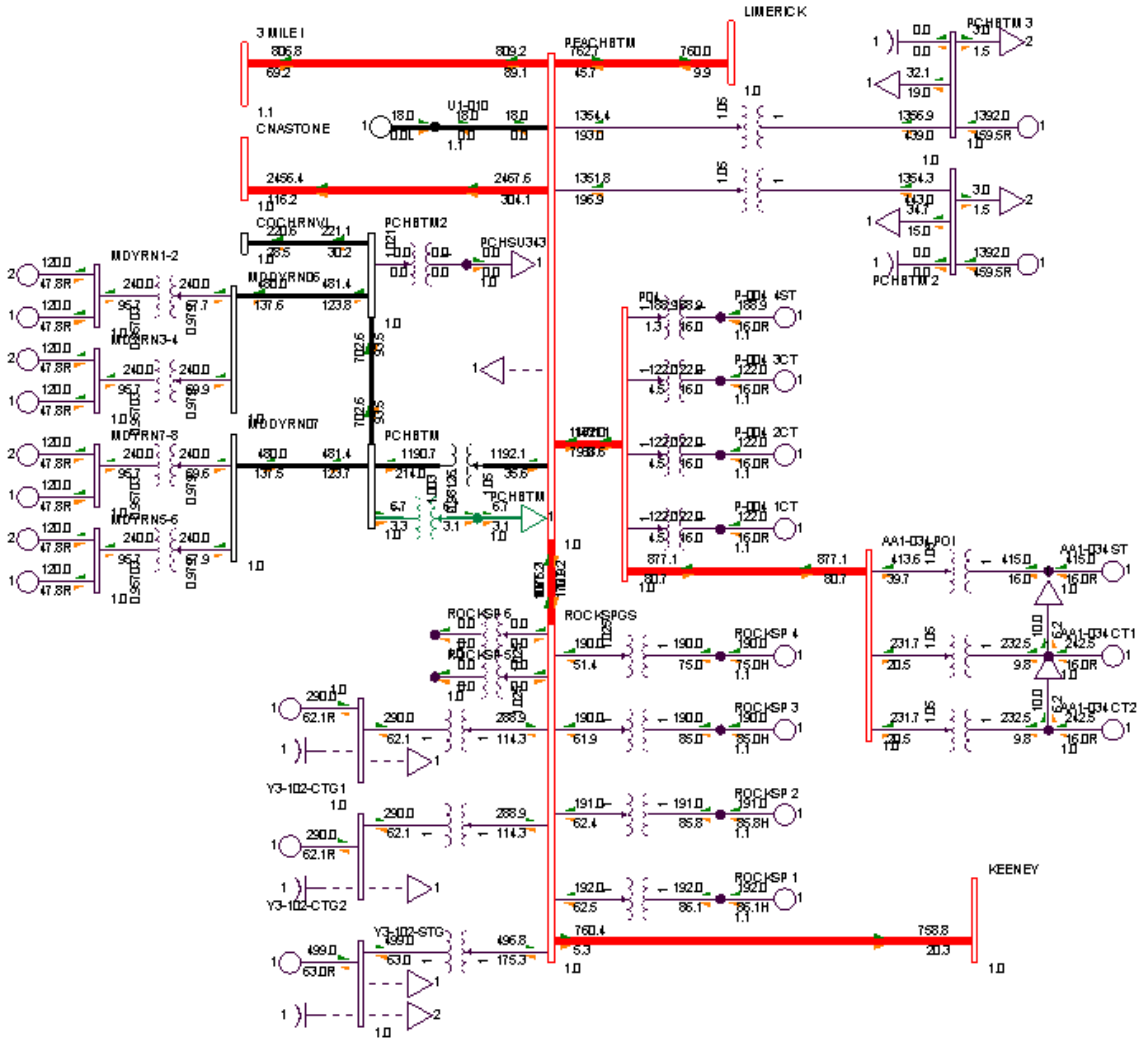


Figure C-1: Single-line diagram for AB2-175 (LL case) (Breaker information not shown)

Attachment 3
Power Factor Analysis

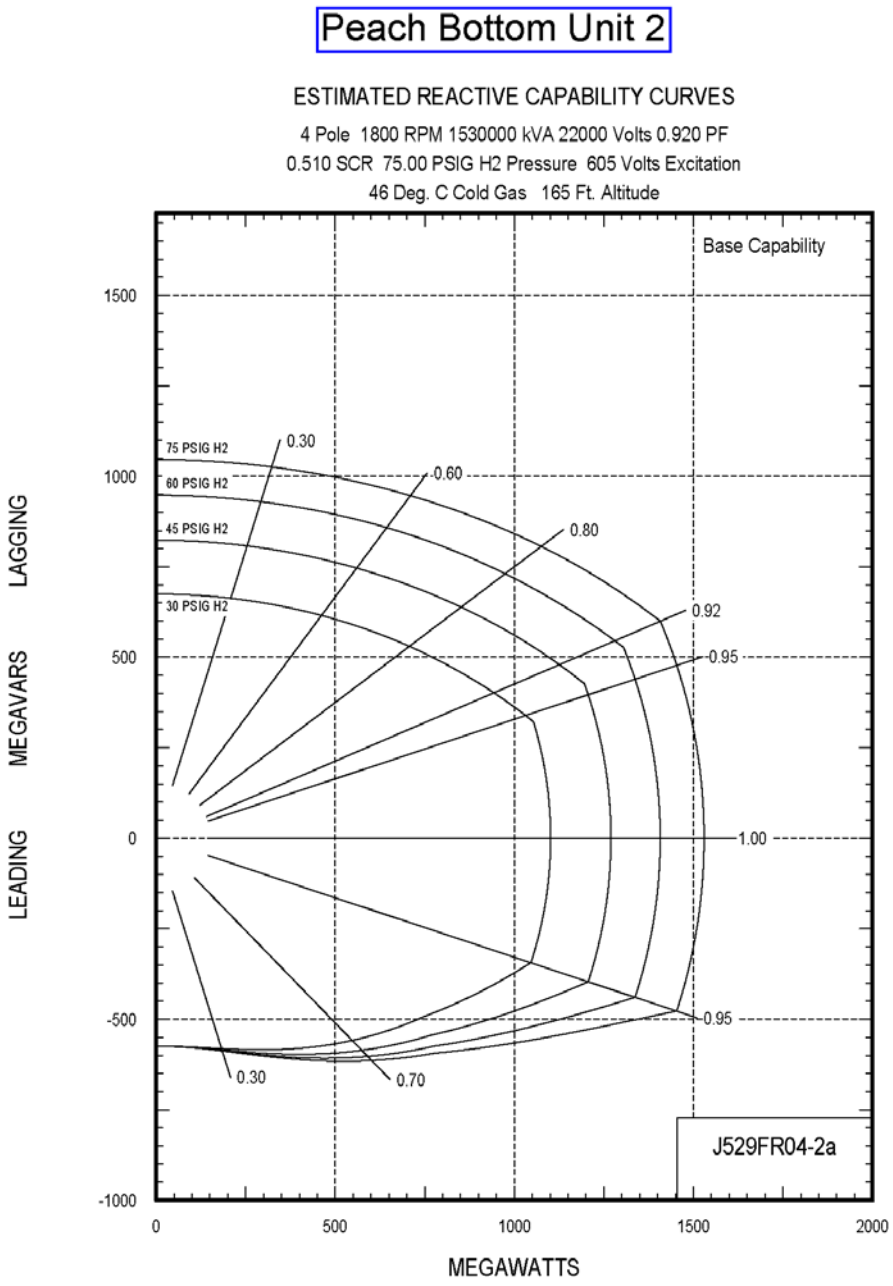
Reactive power requirement and assessment

Table I. Reactive power requirement

	Lagging MVAR Unit 2	Lagging MVAR Unit 3	Leading MVAR Same for Unit 2	Leading MVAR Same for Unit 3	Notes
Old Generator Max Winter Gross (MW) (V4-045)	1370	1370	1370	1370	
Old Reactive Requirement (MVAR)	663.5	663.5	450.3	450.3	From V4-045
New Generator Max Winter Gross	1392	1392	1392	1392	
Additional MVAR Required	10.6	10.6	0	0	
Total Reactive Requirement (MVAR)	674.1	674.1	450.3	450.3	Based on 0.9 Lagging (existing + new) to 0.95 leading power factor (legacy requirement from V4-045)
MVAR Capability at Max Winter Gross	150[1]	635.0	490	490	
Reactive Deficiency	524.1	39.1			
Credit from Elroy Caps (Q47)	260.9	39.1			Total 300 MVAR from Q47
Additional requirements	263.2	0			$31,584,000 based on leading deficiency only

[1] Unit 2 is experiencing rotor vibrations whenever the lagging reactive output of the unit exceeds 150 MVAr. This is expected to be remedied by replacing the Unit 2 rotor in the fall of 2018 (PB2R22).

Reactive Capability Curves for AB2-175



Peach Bottom Unit 3

ESTIMATED REACTIVE CAPABILITY CURVES

4 Pole 1800 RPM 1530000 kVA 22000 Volts 0.900 PF

0.540 SCR 75.00 PSIG H2 Pressure 705 Volts Excitation

46 Deg. C Cold Gas 165 Ft. Altitude