Revised
Generation Interconnection
System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AB1-169

"Stuart 345 kV"
1150 MW Energy, 1100 MW Capacity

June 2017

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.

Revised System Impact Study Report Changes:

The AB1-169 System Impact Study report has been revised to include the final Stability analysis results. See Network Impacts below for the "*Stability and Reactive Power Requirement for Low Voltage Ride Through*" section and **Attachment 3** for the final Stability analysis report. No additional system reinforcements have been identified as being required from the original System Impact Study issued in February 2017.

General

Invenergy Thermal Development LLC, the Interconnection Customer (IC), has proposed a natural gas generating facility located in Mason, Kentucky. The installed facilities will have a total capability of **1150 MW** with **1100 MW** of this output being recognized by PJM as capacity. The proposed in-service date for this project is **June 2020**. **This study does not imply a Dayton Power & Light (DP&L) commitment to this in-service date.**

Point of Interconnection

AB1-169 will interconnect with the Dayton Power & Light Company transmission system via a new 345 kV bay position at the Stuart 345-138 kV Substation. The Point of Interconnection (POI) will be the first dead-end structure outside the Stuart Substation fence (refer to one line diagram in **Attachment 1)**.

Cost Summary

The **AB1-169** project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 0
Non Direct Connection Network Upgrades	$ 2,500,000
Allocation for New System Upgrades	$ 100,000
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 2,600,000**

Attachment Facilities

The Interconnection Customer will construct the attachment lines into the proposed Point of Interconnection as depicted on the one-line diagram in Attachment 1.

Direct Connection Cost Estimate

None.

Non-Direct Connection Cost Estimate

The substation non-direct connection work for this project includes the construction of a 345 kV breaker bay with two new 345kV breakers at Stuart Substation. Dayton will install a single 345 kV line from the new 345 kV breaker bay to a developer owned dead-end structure immediately outside of the Stuart Substation fence (POI). The 345 kV generator lead line constructed by the developer will be terminated onto this POI deadened structure immediately outside of the Stuart Substation fence. DP&L will install the associated disconnect switches, line relaying, and, interconnection metering to accommodate the interconnection of the AB-169 generator.

The PJM Network Upgrade Number for this work is **n5211**.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Substation (n5211)	$2,500,000
Transmission	$ 0
Total Non-Direct Facilities Cost Estimate	**$2,500,000**

Schedule

Based on the extent of the Dayton primary Non-Direct Connection upgrades required to support the AB1-169 generation project, it is expected to take a minimum of **13 months** from the date of a fully executed Interconnection Construction Service Agreement to complete the installation subject to market conditions and vendor lead times. This includes the requirement for the

Interconnection Customer to make a preliminary payment to Dayton which funds the first three months of engineering design that is related to the construction of the Non-Direct Connection facilities. It assumes that there will be no environmental or permitting issues to implement the Non-Direct Connection upgrades for this project and that all system outages will be allowed when requested.

Interconnection Customer Requirements

Requirement from the PJM Open Access Transmission Tariff:

1. 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.

2. The Interconnection Customer may be required to install and/or pay for metering as necessary to properly track real time output of the facility as well as installing metering which shall be used for billing purposes. See Section 8 of Appendix 2 to the Interconnection Service Agreement as well as Section 4 of PJM Manual 14D for additional information.

Dayton Interconnection Requirements

The Dayton Power and Light Company (DP&L) has prepared this Facilities Connection Requirements document to ensure compliance with North American Electric Reliability Council (NERC) Reliability Standards and applicable Regional Reliability Organization, sub regional, Power Pool, and individual Transmission Owner planning criteria and facility connection requirements in compliance to NERC Standard FAC-001-2. These connection requirements apply to all generation facilities, transmission facilities, and end-users connecting to the DP&L transmission system. Detailed information outlining DP&L interconnection requirements can be reviewed utilizing the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-dayton/dayton-facilities-connection-requirements.ashx

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer 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.

Dayton Requirements

The Interconnection Customer will be required to comply with all Dayton Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the Dayton Power & Light Co. "Requirements for the Connection of Facilities to the Dayton Power & Light Co. Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-dayton/dayton-facilities-connection-requirements.ashx

The metering point for this interconnection will be located at the Stuart 345kV substation as shown in **Attachment 1**.

Network Impacts

The Queue Project AB1-169 was evaluated as an **1100.0 MW** (**Capacity 1100.0 MW**) injection into the Stuart 345 kV substation in the Dayton area for the Summer Peak analysis. Project AB1-169 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB1-169 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Base Case Used

Summer Peak Analysis – 2019 Case

Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
'764_B2_TOR9237'	CONTINGENCY '764_B2_TOR9237' OPEN BRANCH FROM BUS 242938 TO BUS 253038 CKT 1 / 242938 05MARQUI 345 253038 09KILLEN 345 1 END
'892_B2'	CONTINGENCY '892_B2' OPEN BRANCH FROM BUS 253014 TO BUS 253077 CKT 1 / 253014 09CLINTO 345 253077 09STUART 345 1 END

Generator Deliverability

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

Contingency					Bus				Loading %		Rating			
#	Type	Name	Affected Area	Facility Description	From	To	Circuit	Power Flow	Initial	Final	Type	MVA	MW Contribution	Ref
1	N-1	'764_B2_TOR9237'	DAY - AEP	09ADKINS-05BEATTY 345 kV line	253110	243453	1	AC	93.4	107.85	NR	1233	178.18	1
2	N-1	'892_B2'	DAY - AEP	09ADKINS-05BEATTY 345 kV line	253110	243453	1	AC	94.81	107.17	NR	1233	154.85	

Note: Please see Attachment 2 for projects providing impacts to flowgate violations. The values in the Reference column correspond to the proper Appendix in the Attachment.

Light Load Analysis

Not applicable.

Multiple Facility Contingency

None.

Issues were not identified in the scope of this report but in real-time operations it is possible that multiple facility outages outside of the scope of this study could cause curtailments of generation in this region.

Short Circuit

(Summary of impacted circuit breakers)

None.

Contribution to Previously Identified Overloads

None.

Steady-State Voltage Requirements

None.

Stability and Reactive Power Requirement for Low Voltage Ride Through

(Summary of the VAR requirements based upon the results of the dynamic studies)

Find the finalized AB1-169 Stability study report in **Attachment 3.**

Affected System Analysis & Mitigation

LGEE, MISO, and OVEC Impacts to be provided in the Facilities Study phase.

Potential Congestion due to Local Energy Deliverability

Not applicable.

New System Reinforcements

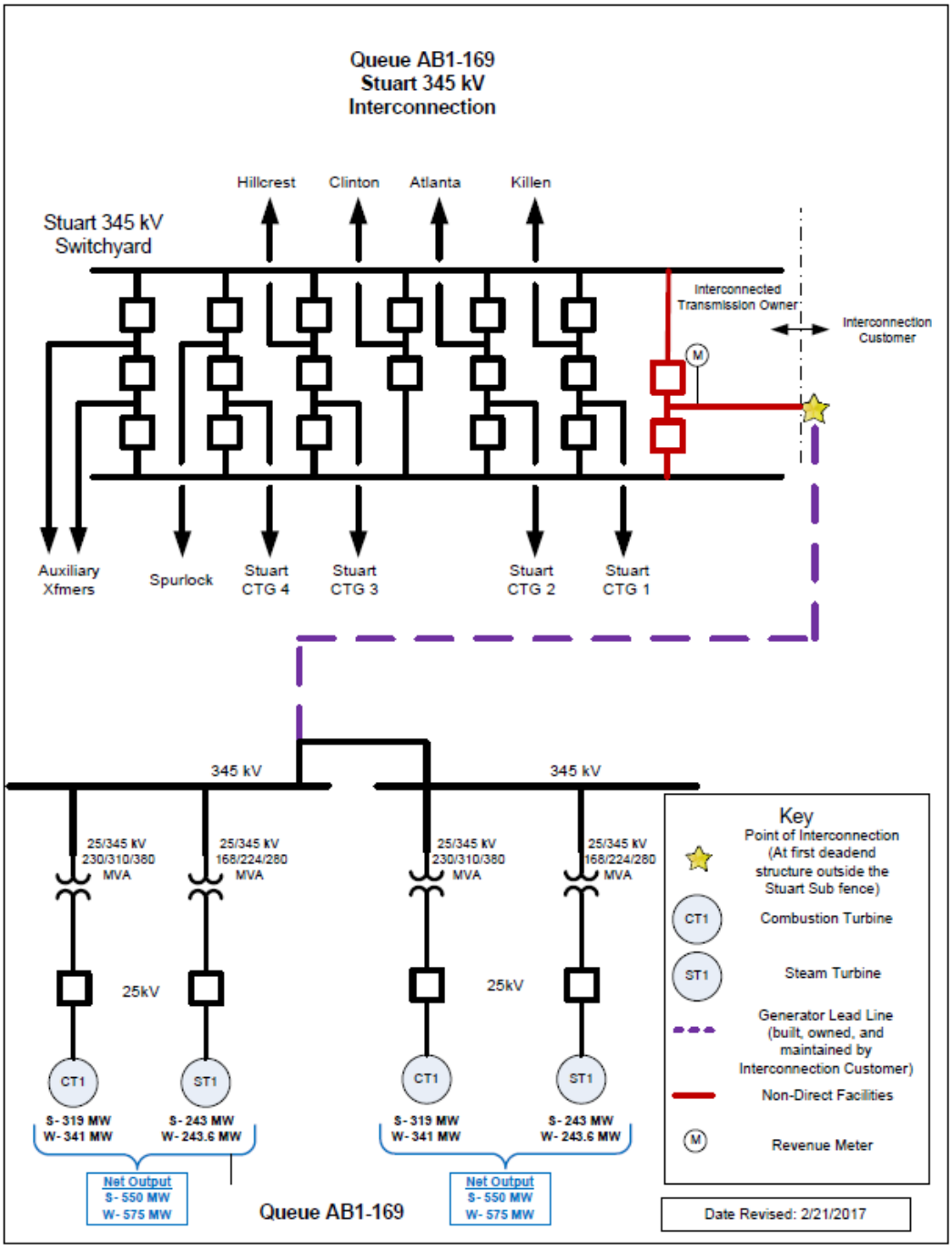
(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB1-169 Allocation
1, 2	09ADKINS-05BEATTY 345 kV line	The Beatty Road Line Riser section (substation conductor 2-1024.5 ACAR) will have to be replaced which will raise the AEP-end ratings to SN/SE 1414/1414 MVA.	N5136	**$ 100,000**	**$100,000**
				Total New Network Upgrades	**$ 100,000**

Contribution to Previously Identified System Reinforcements

None.

Attachment 1



Attachment 2

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 – Flowgate Details

(DAY - AEP) The 09ADKINS-05BEATTY 345 kV line (from bus 253110 to bus 243453 ckt 1) loads from 93.4% to 107.85% (AC power flow) of its normal rating (1233 MVA) for the single line contingency outage of '764_B2_TOR9237'. This project contributes approximately 178.18 MW to the thermal violation.

CONTINGENCY '764_B2_TOR9237'
OPEN BRANCH FROM BUS 242938 TO BUS 253038 CKT 1 / 242938 05MARQUI 345 253038 09KILLEN 345 1
END

Bus Number	*Bus Name*	*Full Contribution*
253110	*09ADKINS*	*38.41*
253077	*09STUART*	*43.24*
342910	*1DALE 3G*	*4.63*
342911	*1DALE 4G*	*4.94*
916411	*Z1-097*	*2.53*
917151	*Z2-029*	*0.38*
920061	*AA2-100*	*0.55*
930061	*AB1-014 C*	*4.72*
931181	*AB1-169 C OP*	*178.18*

Attachment 3

Stability Analysis Report

TABLE OF CONTENTS

Executive Summary

Generator Interconnection Request AB1-169 is for a 1150 MW Maximum Facility Output (MFO) 2 x 1x1 combined cycle natural gas facility. AB1-169 consists of 2 x 341 MW CT generators and 2 x 243.6 MW ST generators with a Point of Interconnection (POI) at the Stuart 345 kV Substation in the Dayton Power and Light Transmission System (DAY), Mason County, Kentucky.

This report describes a dynamic simulation analysis of AB1-169 as part of the overall system impact study.

The load flow scenario for the analysis was based on the RTEP 2019 light load case, modified to include applicable queue projects. AB1-169 has been dispatched online at maximum power output.

AB1-169 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. 134 contingencies were studied, each with a 20 second simulation time period, with the exception of three phase faults with high speed reclosing (40 second). Studied faults included:

a) Steady state operation (20 second);

b) Three phase faults with normal clearing time on the intact network and during a scheduled outage of transmission or generation element;

c) Single phase faults with stuck breaker;

d) Single phase bus faults with normal clearing time;

e) Single phase faults with loss of multi-circuit tower line;

f) Three phase faults with speed reclosing (HSR).

Four high speed reclosing (HSR) contingencies (with less than 1 s reclosing time in the first attempt) were identified. Only unsuccessful high speed reclosing into a fault was considered.

There are no delayed (Zone 2) clearing faults since dual primary relays are employed in the DAY Transmission System.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For 114 out of 134 of the fault contingencies tested on the 2019 light load case:

a) AB1-169 was able to ride through the faults (except for faults where protective action trips a generator(s)),

b) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recovered to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element tripped, other than those either directly connected or designed to trip as a consequence of that fault.

A single instance of non-convergence at the AB1-014 inverter bus was observed for three phase fault contingencies at Spurlock 345 kV (3N.13 – 20), and nine instances of non-convergence were observed for contingency MG.3N.06. These instances of non-convergence are not considered to effect the results of the study.

AB1-169 units tripped for 20 of the 37 contingencies under maintenance outage scenarios.

Units connecting at Stuart 345 kV, Killen 345, and Brown 138 kV lost synchronism for contingency MG.3N.06. Pre AB1-169 simulation shows this contingency is stable.

It is recommended that AB1-169 units remain out of service during all maintenance outage conditions studied in this report.

1. Introduction

Generator Interconnection Request AB1-169 is for a 1150 MW Maximum Facility Output (MFO) 2 x 1x1 combined cycle natural gas facility. AB1-169 consists of 2 x 341 MW CT generators and 2 x 243.6 MW ST generators with a Point of Interconnection (POI) at the Stuart 345 kV Substation in the Dayton Power and Light Transmission System (DAY), Mason County, Kentucky.

This analysis is effectively a screening study to determine whether the addition of AB1-169 will meet the dynamic requirements of the NERC, PJM and Transmission Owner reliability standards.

In this report the AB1-169 project and how it is proposed to be connected to the grid are first described, followed by a description of how the project is modeled in this study. The fault cases are then described and analyzed, and lastly a discussion of the results is provided.

2. Description of Project

AB1-169 consists of 2 x 341 MW (CT) and 2 x 243.6 MW (ST). AB1-169 will be connected to the POI via two 230 MVA 345/25 kV main collector transformers for the CTs and two 168 MVA 345/25 kV collector transformers for the STs. AB1-169 connects at the Stuart 345 kV substation, as shown in Figure 1.

Table 1 lists the parameters given in the impact study data and the corresponding parameters of the AB1-169 loadflow model.

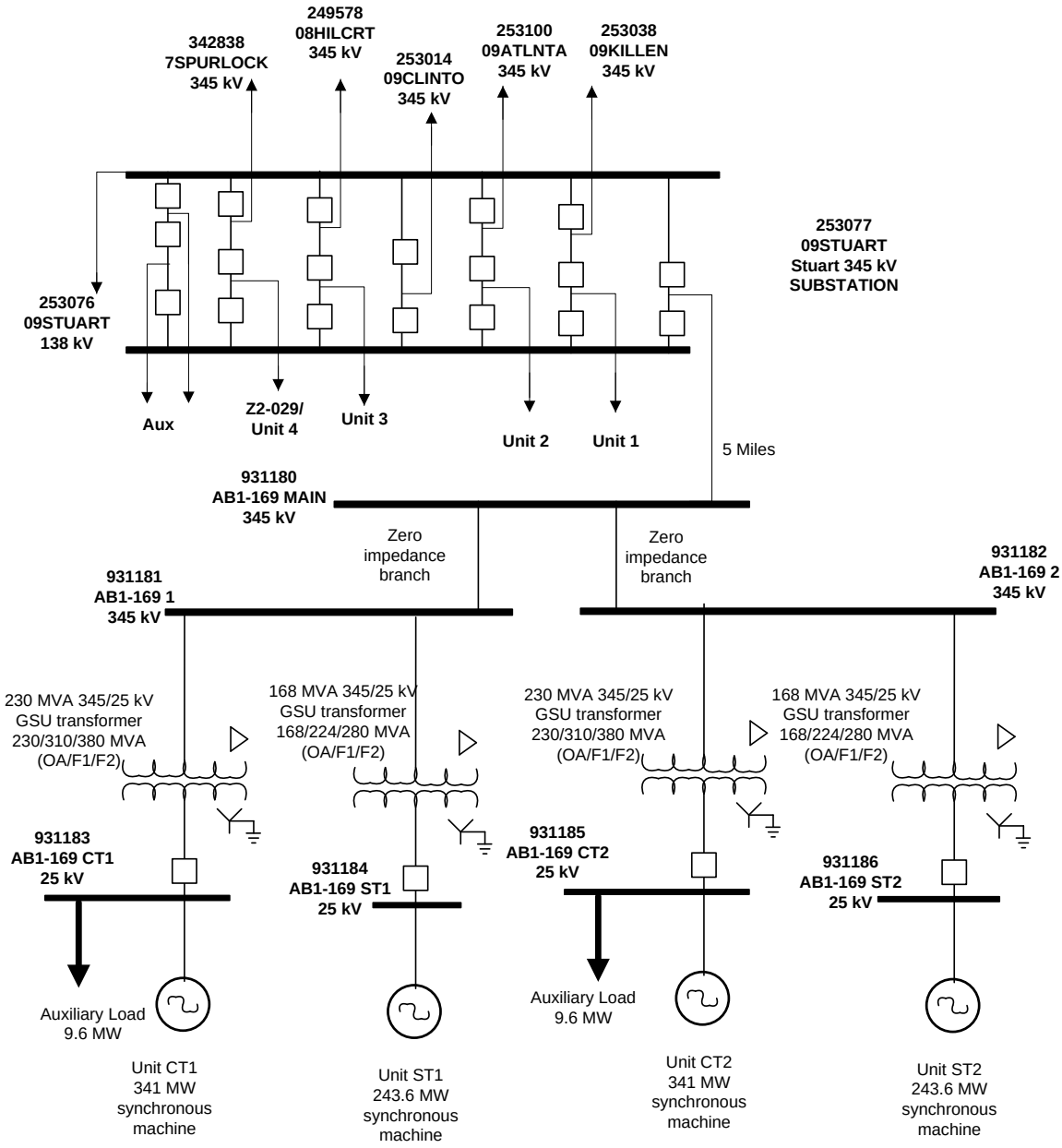


Figure 1: AB1-169 Plant Model

Table 1: AB1-169 Plant Model

	Impact Study Data	Model
Combustion Turbine Generators	2 x 341 MW generators MVA base = 380 MVA Vt = 25 kV Unsaturated sub-transient reactance = 0.210 pu @ MVA base	2 x 341 MW generators Pgen 341 MW Pmax 341 MW Pmin 0 MW Qgen 10.65 MVAr Qmax 165.6 MVAr Qmin -112.4 MVAr Mbase 380 MVA Zsorce j0.210 pu @ Mbase
Steam Turbine Generator	2 x 243.6 MW generators MVA base = 437 MVA Vt = 25 kV Unsaturated sub-transient reactance = 0.240 pu @ MVA base	2 x 243.6 MW generators Pgen 243.6 MW Pmax 243.6 MW Pmin 0 MW Qgen 8.82 MVAr Qmax 300 MVAr Qmin -177 MVAr Mbase 437 MVA Zsorce j0.240 pu @ Mbase

CT GSU Transformers	2x 345/25 kV transformers Rating = 230/310/380 MVA (OA/F1/F2) Transformer base = 230 MVA Impedance = 0.00225 + j0.09 pu @ MVA base Number of taps = N/A Tap step size = N/A	2x 345/25 kV two winding transformer Rating = 230/310/380 MVA Transformer base = 230 MVA Impedance = 0.00225 + j0.09 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
ST GSU Transformers	2x 345/25 kV transformer Rating = 168/224/280 MVA (OA/F1/F2) Transformer base = 168 MVA Impedance = 0.0025 + j0.095 pu @ MVA base Number of taps = N/A Tap step size = N/A	2x 345/25 kV two winding transformer Rating = 168/224/280 MVA Transformer base = 168 MVA Impedance = 0.0025 + j0.095 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Auxiliary load	19.2 MW	9.6 MW on LV side of CT1 and CT2 GSU.
Station Load	N/A	N/A

Transmission line	Length = 5 miles Impedance = 0.0025 + j0.031 pu Charging B = 0.05047 pu	Impedance = 0.0025 + j0.031 pu Charging B = 0.05047 pu

3. Loadflow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 32.2.4.

The load flow scenario and fault cases for this study are based on PJM's Regional Transmission Planning Process[1].

The selected load flow scenario is the RTEP 2019 light load case with the following modifications:

a) Addition of all applicable queue projects prior to AB1-169.

b) Addition of AB1-169 queue project.

c) Removal of withdrawn and subsequent queue projects in the vicinity of AB1-169.

d) Dispatch of units in the PJM system to maintain slack generators within limits.

The AB1-169 initial conditions are listed in Table 2, indicating maximum power output.

Table 2: AB1-169 machine initial conditions

Bus	Name	Unit	PGEN	QGEN	ETERM	POI Voltage
931183	AB1-169 CT1	1	341 MW	10.65 MVAr	0.95 pu	1.0347 pu
931184	AB1-169 ST1	1	243.6 MW	8.82 MVAr	0.95 pu	1.0347 pu
931185	AB1-169 CT2	1	341 MW	10.65 MVAr	0.95 pu	1.0347 pu
931186	AB1-169 ST2	1	243.6 MW	8.82 MVAr	0.95 pu	1.0347 pu

Generation within the PJM500 system (area 225 in the PSS/E case) and within the vicinity of AB1-169 has been dispatched online at maximum output (PMAX).

[1] Manual 14B: PJM Region Transmission Planning Process, Rev 33, May 5 2016, Attachment G : PJM Stability, Short Circuit, and Special RTEP Practices and Procedures.

4. Fault Cases

Tables 3 to 15 list the contingencies that were studied, with representative worst case total clearing times provided by PJM. Each contingency was studied over a 20 second simulation time interval, with the exception of three phase faults with high speed reclosing (40 second).

The studied contingencies include:

a) Steady state operation (20 second);

b) Three phase faults with normal clearing time on the intact network and during a scheduled outage of transmission or generation element;

c) Single phase faults with stuck breaker;

d) Single phase bus faults with normal clearing time;

e) Single-phase faults with loss of multi-circuit tower line;

f) Three phase faults with speed reclosing (HSR).

Four high speed reclosing (HSR) contingencies (with less than 1 s reclosing time in the first attempt) were identified. Only unsuccessful high speed reclosing into a fault was considered.

There are no delayed (Zone 2) clearing faults since dual primary relays are employed in the DAY Transmission System.

The contingencies listed above were applied to:

- Stuart 345 kV (AB1-169 POI)
- Spurlock 345 kV
- Stuart 138 kV
- Killen 345 kV
- Clinton 345 kV
- Hillcrest 345 kV
- Atlanta 345 kV

The three phase faults with normal clearing time were performed under network intact conditions.

The three phase faults with normal clearing time were performed for the following maintenance outage scenarios:

1. N-1: Loss of Stuart-Spurlock 345kV followed by a fault on:
    a. Stuart-Hillcrest 345kV circuit
    b. Stuart-Clinton 345kV circuit
    c. Stuart-Atlanta 345kV circuit
    d. Stuart-Killen 345kV circuit
    e. Stuart 345/138kV transformer

2. N-1 Loss of Stuart-Hillcrest 345kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Clinton 345kV circuit
    c. Stuart-Atlanta 345kV circuit
    d. Stuart-Killen 345kV circuit
    e. Stuart 345/138kV transformer
    f. Foster-Hillcrest 345kV circuit
    g. Hillcrest 345/138 kV transformer
3. N-1 Loss of Stuart-Clinton 345kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Hillcrest 345kV circuit
    c. Stuart-Atlanta 345kV circuit
    d. Stuart-Killen 345kV circuit
    e. Stuart 345/138kV transformer
4. N-1 Loss of Stuart-Atlanta 345kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Hillcrest 345kV circuit
    c. Stuart-Clinton 345kV circuit
    d. Stuart-Killen 345kV circuit
    e. Stuart 345/138kV transformer
5. N-1 Loss of Stuart-Killen 345kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Hillcrest 345kV circuit

c. Stuart-Clinton 345kV circuit
d. Stuart-Atlanta 345kV circuit
e. Stuart 345/138kV transformer

6. N-1 Loss of Stuart 345/138kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Hillcrest 345kV circuit
    c. Stuart-Clinton 345kV circuit
    d. Stuart-Atlanta 345kV circuit
    e. Stuart –Killen 345kV circuit

7. N-1 Loss of Killen-Marquis 345kV followed by a fault on:
    a. Stuart-Spurlock 345kV circuit
    b. Stuart-Hillcrest 345kV circuit
    c. Stuart-Clinton 345kV circuit
    d. Stuart-Atlanta 345kV circuit
    e. Stuart 345/138kV transformer

Clearing times listed in Tables 4 to 15 are as per Revision 18 of "*2016 Revised Clearing times for each PJM company"* spreadsheet.

The positive sequence fault impedances for single line to ground faults were derived from a separate short circuit case, modified to ensure that connected generators in the vicinity of AB1-169 have not withdrawn from the PJM queue, and are not greater than the queue position under study.

All baseline and supplemental upgrades in DAY were included except capacitor banks.

5. Evaluation Criteria

This study is focused on AB1-169, along with the rest of the PJM system, maintaining synchronism and having all states return to an acceptable new condition following the disturbance. The recovery criteria applicable to this study are as per PJM's Regional Transmission Planning Process and Transmission Owner criteria:

a) AB1-169 is able to ride through the faults (except for faults where protective action trips a generator(s)),

b) The system with AB1-169 included is transiently stable and post-contingency oscillations should be positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

6. Summary of Results

Dynamic simulations results are summarized in Table 3 through Table 15.

For 114 out of 134 of the fault contingencies tested on the 2019 light load case:

a) AB1-169 was able to ride through the faults (except for faults where protective action trips a generator(s)),

b) Post-contingency oscillations were positively damped with a damping margin of at least 3% for interarea modes and 4% for local modes.

c) Following fault clearing, all bus voltages recovered to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element tripped, other than those either directly connected or designed to trip as a consequence of that fault.

A single instance of non-convergence at the AB1-014 inverter bus was observed for three phase fault contingencies at Spurlock 345 kV (3N.13 – 20), and nine instances of non-convergence were observed for contingency MG.3N.06. These instances of non-convergence are not considered to effect the results of the study.

AB1-169 units tripped during 20 of the 37 maintenance outage scenarios.

Units connecting at Stuart 345 kV, Killen 345, and Brown 138 kV lost synchronism for contingency MG.3N.06. Pre AB1-169 simulation shows this contingency is stable.

7. Mitigations

If an outage on any of the circuits listed in tables 9-14 is scheduled then AB1-169 may need to be curtailed. This is not a requirement for system reinforcement.

Table 3: Steady State Operation

Fault ID	Duration	Result No Mitigation
SS.01	Steady state 20 sec	Stable

Table 4: Three-phase Faults with Normal Clearing

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
3N.01	Fault at Stuart 345 kV (AB1-169 POI) on AB1-169 circuit (Trips AB1-169).	6	Stable
3N.02	Fault at Stuart 345 kV (AB1-169 POI) on Z2-029 circuit (Trips Z2-029).	6	Stable
3N.03	Fault at Stuart 345 kV (AB1-169 POI) on Stuart Unit 1 circuit (Trips Stuart Unit 1).	6	Stable
3N.04	Fault at Stuart 345 kV (AB1-169 POI) on Stuart Unit 2 circuit (Trips Stuart Unit 2).	6	Stable
3N.05	Fault at Stuart 345 kV (AB1-169 POI) on Stuart Unit 3 circuit (Trips Stuart Unit 3).	6	Stable
3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Stable
3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Stable
3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Stable
3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Stable
3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Stable
3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable
3N.12	Fault at Spurlock 345 kV on Stuart circuit 34553.	5	Stable*
3N.13	Fault at Spurlock 345 kV on Spurlock Unit 2 circuit (Trips Spurlock unit 2).	5	Stable*
3N.14	Fault at Spurlock 345 kV on Spurlock Unit 3 circuit (Trips Spurlock unit 3).	5	Stable*
3N.15	Fault at Spurlock 345 kV on Spurlock Unit 4 circuit (Trips Spurlock unit 4).	5	Stable*

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
3N.16	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 9.	5	Stable*
3N.17	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 10.	5	Stable*
3N.18	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 12.	5	Stable*
3N.19	Fault at Spurlock 345 kV on North Clark circuit.	5	Stable*
3N.20	Fault at Spurlock 345 kV on Meldahl Dam IC circuit 34541.	5	Stable*
3N.21	Fault at Stuart 138 kV on Stuart 138/345 kV Transformer 7.	7	Stable
3N.22	Fault at Stuart 138 kV on Stuart 138/69 kV Transformer 16 (Trips Raven – Brown Hill – Poplar Flat – West Union – Seaman circuit 13816).	7	Stable
3N.23	Fault at Stuart 138 kV on Brown circuit 13817.	7	Stable
3N.24	Fault at Killen 345 kV on Stuart circuit 34510.	6	Stable
3N.25	Fault at Killen 345 kV on Killen Unit 2 and Unit 3 circuit (Trips Killen Unit 2 and Unit 3).	6	Stable
3N.26	Fault at Killen 345 kV on Don Marquis circuit 34549.	6	Stable
3N.27	Fault at Clinton 345 kV on Stuart circuit 34509.	6	Stable
3N.28	Fault at Clinton 345 kV on Clinton 345/69 kV Transformer 1 (Trips Clinton 345/69 kV Transformer 2 and Clinton – Greene circuit 34522.	6	Stable
3N.29	Fault at Hillcrest 345 kV on Stuart circuit 34511.	3	Stable
3N.30	Fault at Hillcrest 345 kV on Foster circuit 34569.	3	Stable

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
3N.31	Fault at Hillcrest 345 kV on Hillcrest 345/138 kV Transformer.	3	Stable
3N.32	Fault at Atlanta 345 kV on Stuart circuit 34552.	6	Stable
3N.33	Fault at Atlanta 345 kV on Adkins circuit 34551 (Trips Atlanta 345/69 kV Transformer).	6	Stable

* Single instance of non-convergence at the AB1-014 generator bus was observed during fault application (at 0.1083 s). The non-convergence was not report when AB1-014 was placed offline.
** Actual clearing time provided by the TO

Table 5: Single-phase Faults with Stuck Breaker

Fault ID	Fault description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation
1B.01	Fault at Stuart 345 kV (AB1-169 POI) on AB1-169 circuit (Trips AB1-169). Breaker stuck to Stuart 345 kV bus 1. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	6 / 18	Stable
1B.02	Fault at Stuart 345 kV (AB1-169 POI) on Z2-029 circuit (Trips Z2-029). Breaker GG stuck. Fault cleared with loss of Spurlock circuit 34553.	5 / 12**	Stable
1B.03	Fault at Stuart 345 kV (AB1-169 POI) on Stuart unit 1 circuit (Trips Stuart unit 1). Breaker VV stuck. Fault cleared with loss of Killen circuit 34510.	6 / 18	Stable
1B.04	Fault at Stuart 345 kV (AB1-169 POI) on Stuart unit 2 circuit (Trips Stuart unit 2). Breaker SS stuck. Fault cleared with loss of Atlanta circuit 34552.	6 / 18	Stable
1B.05	Fault at Stuart 345 kV (AB1-169 POI) on Stuart unit 3 circuit (Trips Stuart unit 3). Breaker JJ stuck. Fault cleared with loss of Hillcrest circuit 34511.	6 / 18	Stable
1B.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553. Breaker HH stuck. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	5 / 12**	Stable
1B.07	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553. Breaker GG stuck. Fault cleared with loss of Z2-029.	5 / 12**	Stable
1B.08	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7. Breaker stuck to AB1-169 circuit. Fault cleared with loss of AB1-169.	6 / 18	Stable
1B.09	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7. Breaker HH stuck. Fault cleared with loss of Spurlock circuit 34553.	5 / 12**	Stable
1B.10	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510. Breaker VV stuck. Fault cleared with loss of Stuart Unit 1.	5 / 12**	Stable

Fault ID	Fault description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation
1B.11	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510. Breaker WW stuck. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	5 / 12**	Stable
1B.12	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552. Breaker SS stuck. Fault cleared with loss of Stuart Unit 2.	5 / 12**	Stable
1B.13	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552. Breaker TT stuck. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	5 / 12**	Stable
1B.14	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509. Breaker NN stuck. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	5 / 12**	Stable
1B.15	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511. Breaker JJ stuck. Fault cleared with loss of Stuart Unit 3.	5 / 12**	Stable
1B.16	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511. Breaker KK stuck. Fault cleared with loss of Stuart 345/138 kV Transformer 7.	5 / 12**	Stable
1B.17	Fault at Spurlock 345 kV on Stuart circuit 34553. Breaker 153T stuck. Fault cleared with loss of Spurlock Unit 4.	5 / 11	Stable
1B.18	Fault at Spurlock 345 kV on Stuart circuit 34553. Breaker 1474 stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 10.	5 / 11	Stable
1B.19	Fault at Spurlock 345 kV on Spurlock Unit 2 circuit (Trips Spurlock Unit 2). Breaker 150T stuck. Fault cleared with loss of North Clark circuit.	5 / 11	Stable
1B.20	Fault at Spurlock 345 kV on Spurlock Unit 2 circuit (Trips Spurlock Unit 2). Breaker 214G stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 9.	5 / 11	Stable

Fault ID	Fault description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation
1B.21	Fault at Spurlock 345 kV on Spurlock Unit 3 circuit (Trips Spurlock Unit 3). Breaker 314G stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 9.	5 / 11	Stable
1B.22	Fault at Spurlock 345 kV on Spurlock Unit 4 circuit (Trips Spurlock Unit 4). Breaker 414G stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 9.	5 / 11	Stable
1B.23	Fault at Spurlock 345 kV on Spurlock Unit 4 circuit (Trips Spurlock unit 4). Breaker 153T stuck. Fault cleared with loss of Stuart circuit 34553.	5 / 11	Stable
1B.24	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 9. Breaker 1418 stuck. Fault cleared without additional losses.	5 / 11	Stable
1B.25	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 10. Breaker 1438 stuck. Fault cleared without additional losses.	5 / 11	Stable
1B.26	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 12. Breaker 151T stuck. Fault cleared with loss of Spurlock Unit 3.	5 / 11	Stable
1B.27	Fault at Spurlock 345 kV on Spurlock 345/138 kV Transformer 12. Breaker 1458 stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 10.	5 / 11	Stable
1B.28	Fault at Spurlock 345 kV on North Clark circuit. Breaker 150 T stuck. Fault cleared with loss of Spurlock Unit 2.	5 / 11	Stable
1B.29	Fault at Spurlock 345 kV on North Clark circuit. Breaker 1444 stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 10.	5 / 11	Stable
1B.30	Fault at Spurlock 345 kV on Meldahl Dam IC circuit 34541. Breaker 1464 stuck. Fault cleared with loss of Spurlock 345/138 kV Transformer 10.	5 / 11	Stable

Fault ID	Fault description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation
1B.31	Fault at Stuart 138 kV on Stuart 138/345 kV Transformer. Breaker M stuck. Fault cleared with loss of Stuart 138 kV bus.	7 / 21	Stable
1B.32	Fault at Stuart 138 kV on Stuart 138/69 kV Transformer (Trips Raven – Brown Hill – Poplar Flat – West Union – Seaman 69 kV circuit 13816). Breaker J stuck. Fault cleared with loss of Stuart 138 kV bus.	7 / 21	Stable
1B.33	Fault at Stuart 138 kV on Brown circuit 13817. Breaker G stuck. Fault cleared with loss of Stuart 138 kV bus.	7 / 21	Stable
1B.34	Fault at Killen 345 kV on Stuart circuit 34510. Breaker MM stuck to Killen Unit 2 and Unit 3 circuit. Fault cleared with loss of Killen Unit 2 and Unit 3.	6 / 18	Stable
1B.35	Fault at Killen 345 kV on Killen Unit 2 and Unit 3 circuit (Trips Killen Unit 2 and Unit 3). Breaker NN stuck. Fault cleared with loss of Don Marquis circuit 34549.	6 / 18	Stable
1B.36	Fault at Killen 345 kV on Killen Unit 2 and Unit 3 circuit (Trips Killen Units 2 and Unit 3). Breaker MM stuck. Fault cleared with loss of Stuart circuit 34510.	6 / 18	Stable
1B.37	Fault at Killen 345 kV on Don Marquis circuit 34549. Breaker NN stuck. Fault cleared with loss of Killen Unit 2 and Unit 3.	6 / 18	Stable
1B.38	Fault at Clinton 345 kV on Clinton 345/69 kV Transformer 1(Trips Clinton 345/69 kV Transformer 2 and Clinton - Greene circuit 34522). Breaker EE stuck. Fault cleared with loss of Stuart circuit 34509.	6 / 18	Stable
1B.39	Fault at Clinton 345 kV on Stuart circuit 34509. Breaker EE stuck. Fault cleared with loss of Clinton 345/69 kV Transformer 1, Clinton 345/69 kV Transformer 2 and Clinton – Greene circuit 34522.	6 / 18	Stable
1B.40	Fault at Hillcrest 345 kV on Stuart circuit 34511. Breaker 1427 stuck. Fault cleared with loss of Foster circuit 34569.	3 / 10	Stable

Fault ID	Fault description	Clearing Time Normal & Delayed (Cycles)	Result No Mitigation
1B.41	Fault at Hillcrest 345 kV on Foster circuit 34569. Breaker 1427 stuck. Fault cleared with loss of Stuart circuit 34511.	3 / 10	Stable
1B.42	Fault at Hillcrest 345 kV on Hillcrest 345/138 kV Transformer. Breaker 1423 stuck. Fault cleared with loss of Stuart circuit 34511.	3 / 10	Stable
1B.43	Fault at Hillcrest 345 kV on Hillcrest 345/138 kV Transformer. Breaker 1425 stuck. Fault cleared with loss of Foster circuit 34569.	3 / 10	Stable
1B.44	Fault at Atlanta 345 kV on Adkins circuit 34551 (Trips Atlanta 345/69 kV Transformer). Breaker BB stuck. Fault cleared with loss of Stuart circuit 34552.	6 /18	Stable
1B.45	Fault at Atlanta 345 kV on Stuart circuit 34552. Breaker BB stuck. Fault cleared with loss of Atlanta 345/69 kV Transformer and Atlanta – Adkins circuit 34551.	6 /18	Stable

** Actual clearing time provided by the TO

Table 6: Single-phase Bus Faults with Normal Clearing

Fault ID	Fault description	Clearing Time Normal and Delayed (Cycles)	Result No Mitigation
1S.01	Fault at Brown 138 kV Bus. Fault cleared with loss of: • Brown 138/69/34.5 kV Three Winding Transformer • Brown – Eastwood circuit 5884. • Brown – Stuart circuit 13817. • Trips AA2-100 units 1-4. CONTINGENCY ‘C1 BROWN'	4	Stable

Table 7: Single-phase Faults with Loss of Multiple-Circuit Tower Line

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
1T.01	Fault at Stuart 345 kV on Hillcrest circuit 34511 resulting in tower failure. Fault cleared with loss of: • Stuart – Hillcrest circuit 34511 • Stuart – Clinton circuit 34509. CONTINGENCY '4511HILLCRESTSTUARTCLINTONSTUARTDPL'	6	Stable
1T.02	Fault at Stuart 345 kV on Spurlock circuit 34553 resulting in tower failure. Fault cleared with loss of: • Stuart – Spurlock circuit 34553 • Meldahl Dam IC – Zimmer circuit 34576. CONTINGENCY 'C5 4541ZIMMERSPRLCKSTUARTSPURLOCKDPLEK'	6	Stable
1T.03	Fault at Stuart 345 kV on Spurlock circuit 34553 resulting in tower failure. Fault cleared with loss of: • Stuart – Spurlock circuit 34553 • Spurlock – Meldhal Dam IC circuit 34541. CONTINGENCY 'C5 4541MELDAHLSPRLCKSTUARTSPURLOCKDPLEK'	6	Stable
1T.04	Fault at Hillcrest 345 kV on Foster circuit 34569 resulting in tower failure. Fault cleared with loss of: • Hillcrest – Foster circuit 34569 • Foster – Bath circuit 34598. CONTINGENCY 'C5 34569FOSTERHILLCREST34598FOSTERBATH'	3	Stable

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
1T.05	Fault at Hillcrest 345 kV on Foster circuit 34569 resulting in tower failure. Fault cleared with loss of: • Hillcrest – Foster circuit 34569 • Foster – Sugarcreek circuit 34524. CONTINGENCY 'C5 34569FOSTERHILLCREST4524FOSTRSUGRCRK'	3	Stable
1T.06	Fault at Spurlock 345 kV on North Clark circuit resulting in tower failure. Fault cleared with loss of: • Spurlock – North Clark circuit 1438 • Spurlock – Flemingsburg – Goddard 138 kV circuit 954. CONTINGENCY 'TOWER_2'	5	Stable
1T.07	Fault at Clinton 345 kV on Greene circuit 34522 resulting in tower failure. Fault cleared with loss of: • Foster – Bath circuit 34598 • Clinton – Greene circuit 34522 • Clinton 345/69 kV Transformers. CONTINGENCY '495'	6	Stable
1T.08	Fault at Greene 345 kV on Sugarcreek circuit 34503 resulting in tower failure. Fault cleared with loss of: • Greene – Sugarcreek circuit 34503 • Sugarcreek – Foster circuit 34524 CONTINGENCY '497'	6	Stable
1T.09	Fault at Hillcrest 345 kV on Foster circuit 34569 resulting in tower failure. Fault cleared with loss of: • Hillcrest – Foster circuit 34569 • Foster – Bath circuit 34598. • Foster – Sugarcreek circuit 34524	3	Stable

Fault ID	Fault description	Clearing Time Near & Remote (Cycles)	Result No Mitigation
1T.10	Fault at Adkins 345 kV on Beatty circuit 34542 resulting in tower failure. Fault cleared with loss of: • Adkins – Beatty circuit 34542 • Beatty – New South Charleston circuit 34506 • Beatty 345/138 kV Transformer #3. CONTINGENCY '8123'	6	Stable
1T.11	Fault at Greene 345 kV on Bath circuit 34526 resulting in tower failure. Fault cleared with loss of: • Greene – Bath circuit 34526 • Bath – Foster circuit 34598 CONTINGENCY '494'	6	Stable
1T.12	Fault at Foster 345 kV on Bath circuit 34598 resulting in tower failure. Fault cleared with loss of: • Foster – Bath circuit 34598 • Greene – Sugarcreek circuit 34503. CONTINGENCY '493'	3	Stable
1T.13	Fault at Foster 345 kV on Bath circuit 34598 resulting in tower failure. Fault cleared with loss of: • Foster – Bath circuit 34598 • Foster – Sugarcreek circuit 34524. CONTINGENCY 'C5 4524FOSTRSUGRCRK34598FOSTERBATH'	3	Stable

Table 8: Three-phase Faults with Unsuccessful High Speed Reclosing

Fault ID	Fault description	Clearing/HSR/ Reclosing Times (Cycles)	Result No Mitigation
3R.01	Fault at Greene 345 kV on Sugarcreek circuit 34503. • Fault cleared after 6 cycles with loss of Greene – Sugarcreek circuit 34503 • High speed reclosers AA and BB close after 1.5 cycles (7.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (13.5 cycles total) by opening reclosers AA and BB • Reclosers AA and BB close after 300 cycles (313.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (319.5 cycles total) by opening reclosers AA and BB	6/1.5/300	Stable
3R.02	Fault at Greene 345 kV on New South Charleston circuit 34506. • Fault cleared after 6 cycles with loss of Greene - New South Charleston circuit 34506 • High speed reclosers DD and EE close after 1.5 cycles (7.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (13.5 cycles total) by opening reclosers DD and EE • Reclosers DD and EE close after 300 cycles (313.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (319.5 cycles total) by opening reclosers DD, EE	6/1.5/300	Stable
3R.03	Fault at Greene 345 kV on Bath circuit 34526. • Fault cleared after 6 cycles with loss of Greene - Bath circuit 34526 • High speed reclosers EE and FF close after 1.5 cycles (7.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (13.5 cycles total) by opening reclosers EE and FF • Reclosers EE and FF close after 300 cycles (313.5 cycles total) • Reclose unsuccessful, fault cleared after 6 cycles (319.5 cycles total) by opening reclosers EE and FF	6/1.5/300	Stable
3R.04	Fault at Atlanta 69 kV Bus on New Holland – Valero Renewable Fuels - Robinson circuit 6638. • Fault cleared after 8 cycles with loss of Atlanta – New Holland – Valero Renewable Fuels -	8/1.5/600,1200	Stable

Fault ID	Fault description	Clearing/HSR/ Reclosing Times (Cycles)	Result No Mitigation
	Robinson circuit 6638. • High speed recloser 1 closes after 1.5 cycles (9.5 cycles total) • Reclose unsuccessful, fault cleared after 8 cycles (17.5 cycles total) by opening recloser 1 • Recloser 1 closes after 600 cycles (617.5 cycles total) • Reclose unsuccessful, fault cleared after 8 cycles (625.5 cycles total) by opening recloser 1 • Recloser closes after 1200 cycles (1817.5 cycles total) • Reclose unsuccessful, fault cleared after 8 cycles (1825.5 cycles total) by opening recloser 1		

Table 9: Three-phase Faults with Normal Clearing – Prior outage of Stuart (AB1-169 POI) - Spurlock 345 kV circuit 34553

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MA.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MA.3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MA.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MA.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MA.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable

** Actual clearing time provided by the TO

Table 10: Three-phase Faults with Normal Clearing – Prior outage of Stuart (AB1-169 POI) - Hillcrest 345 kV circuit 34511

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MB.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MB.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MB.3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Stable
MB.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MB.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable
MB.3N.31	Fault at Hillcrest 345 kV on Hillcrest 345/138 kV Transformer.	3	Stable
MB.3N.34	Fault at Foster 345 kV on Hillcrest circuit 34569.	3	Stable

** Actual clearing time provided by the TO

Table 11: Three-phase Faults with Normal Clearing – Prior outage of Stuart (AB1-169 POI) - Clinton 345 kV circuit 34509

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MC.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MC.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, and CT2
MC.3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Stable
MC.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Stable
MC.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable

** Actual clearing time provided by the TO

Table 12: Three-phase Faults with Normal Clearing – Prior outage of Stuart (AB1-169 POI) - Atlanta 345 kV circuit 34552

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MD.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MD.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MD.3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Stable
MD.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MD.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Stable

** Actual clearing time provided by the TO

Table 13: Three-phase Faults with Normal Clearing – Prior outage of Stuart (AB1-169 POI) - Killen 345 kV circuit 34510

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
ME.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
ME.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
ME.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
ME.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Stable
ME.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable

** Actual clearing time provided by the TO

Table 14: Three-phase Faults with Normal Clearing – Prior outage of Stuart 345/138 kV Transformer 7

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MF.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Stable
MF.3N.08	Fault at Stuart 345 kV (AB1-169 POI) on Killen circuit 34510.	5**	Stable
MF.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1 and CT2
MF.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Stable
MF.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable

** Actual clearing time provided by the TO

Table 15: Three-phase Faults with Normal Clearing – Prior outage of Killen - Don Marquis 345 kV circuit 34549

Fault ID	Fault description	Clearing Time (Cycles)	Result No Mitigation
MG.3N.06	Fault at Stuart 345 kV (AB1-169 POI) on Spurlock circuit 34553.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2, AA2-100 Units 1-4, Stuart Units 1-3, Killen unit 2, Z2-029 unit 4*
MG.3N.07	Fault at Stuart 345 kV (AB1-169 POI) on Stuart 345/138 kV Transformer 7.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MG.3N.09	Fault at Stuart 345 kV (AB1-169 POI) on Clinton circuit 34509.	6	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MG.3N.10	Fault at Stuart 345 kV (AB1-169 POI) on Hillcrest circuit 34511.	5**	Loss of synchronism for AB1-169 CT1, CT2, ST1, and ST2
MG.3N.11	Fault at Stuart 345 kV (AB1-169 POI) on Atlanta circuit 34552.	5**	Stable

* Multiple instances of non-convergence reported (during 1 - 10 s simulation time)

** Actual clearing time provided by the TO