Generation Interconnection
Revised System Impact Study Report

For

PJM Generation Interconnection Request
Queue Position AB2-136

"West Cambridge-Vienna 69 kV"

June 2017
Revised: February 2021

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 Interconnection Customer 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), has proposed a 51.1 MW (24.8 MWC) solar generating facility to be located in Cambridge, Maryland. PJM studied AB2-136 as a 51.1 MW injection into the Delmarva Power and Light Company (DPL) system at a tap of the West Cambridge-Bayly 69 kV circuit and evaluated it for compliance with reliability criteria for summer peak conditions in 2020. The planned in-service date, as requested by the IC during the project kick-off call, is May 1, 2018. This date is not attainable due to additional required PJM studies and the Transmission Owner's construction schedule.

Point of Interconnection

The Interconnection Customer requested a transmission level interconnection. As a result, AB2-136 will interconnect with the DPL transmission system at a new three breaker ring bus 69 kV substation to be constructed adjacent to the West Cambridge-Bayly 69 kV circuit (see Attachment 1).

Transmission Owner Scope of Attachment Facilities Work

Substation Interconnection Estimate

Scope: Build a new 69 kV substation with a 3 position ring bus. Two of the positions on the ring bus will be transmission line terminals for the tie-in of Line 6783 to the substation. The other position will be a terminal configured for the interconnection of a generator.

Estimate: $3,967,000
Construction Time: 24 months

Major Equipment Included in Estimate:

- Control Enclosure, 20' x 15' Qty. 1
- Power Circuit Breaker, 69 kV, 2000A, 40kA, 3 cycle Qty. 3
- Disconnect Switch, 69 kV, 2000A, Manual Wormgear, Arcing Horns Qty. 9
- CT/VT Combination Units, 69 kV Qty. 3
- CVT, 69 kV Qty. 6
- Disconnect Switch Stand, High, 69 kV, Steel Qty. 5
- Disconnect Switch Stand, Low, 69 kV, Steel Qty. 4
- CT/VT Stand, Single Phase, Low, 69 kV, Steel Qty. 3
- CVT Stand, Single Phase, Low, 69 kV, Steel Qty. 6
- SSVT, 69 kV/240-120 V Qty. 1
- Relay Panel, Transmission Line, FL/BU (20") Qty. 3
- Control Panel, 69 kV Circuit Breaker (10") Qty. 3
- Take-off structure, 69 kV Qty. 2
- Bus Support Structure, 3 phase, 69 kV, Steel Qty. 8

Estimate Assumptions:

- Land purchase for the substation is not included.
- A 2.5 acre, relatively square lot is available for use.
- Site clearing and grading performed by Developer.
- Lightning protection (lightning masts) are not required.

Required Relaying and Communications

An SEL-487 will be required for primary protection and an SEL-387 will be required for back-up protection. One 20" relay panel for each line terminal will be required for front line and back-up protection.

New protection relays are required for the new line terminals. An SEL-421 will be required for primary protection and an SEL-311C will be required for back-up protection. A 20" relay panel will be required for each transmission line (2 total).

An SEL-451 relay on a 20" breaker control panel will be required for the control and operation of each new 138 kV circuit breaker.

The project will require re-wiring and adjustment of existing relay schemes to accommodate the new 69 kV substation.

The cost of the required relay and communications listed above is included in the Substation Interconnection Estimate.

In addition protective relays at the new substation, relay upgrades will need to be performed on the remote ends at West Cambridge and Bayly substations. An SEL-421 will be required for primary protection and an SEL-311C will be required for back-up protection at each remote end. The estimate to perform this work is **$300,000** and will take **24 months** to complete.

Metering

Three phase 69 kV revenue metering points will need to be established. DPL will purchase and install all metering instrument transformers as well as construct a metering structure. The secondary wiring connections at the instrument transformers will be completed by DPL's metering technicians. The metering control cable and meter cabinets will be supplied and installed by DPL. DPL will install conduit for the control cable between the instrument transformers and the metering enclosure. The location of the metering enclosure will be determined in the construction phase. DPL will provide both the Primary and the Backup meters. DPL's meter technicians will program and install the Primary & Backup solid state multi-function meters for each new metering position. Each meter will be equipped with load profile, telemetry, and DNP outputs. The IC will be provided with one meter DNP output for each meter. DPL will own the metering equipment for the interconnection point, unless the IC asserts its right to install, own, and operate the metering system.

The Interconnection Customer will be required to make provisions for a voice quality phone line within approximately 3 feet of each Company metering position to facilitate remote interrogation and data collection.

It is the IC's responsibility to send the data that PJM and DPL requires directly to PJM. The IC will grant permission for PJM to send DPL the following telemetry that the IC sends to PJM: real time MW, MVAR, volts, amperes, generator status, and interval MWH and MVARH.
The estimate for DPL to design, purchase, and install metering as specified in the aforementioned scope for metering is included in the Substation Interconnection Estimate.

Interconnection Customer Scope of Work

The Interconnection Customer is responsible for all design and construction related to activities on their side of the Point of Interconnection. Site preparation, including grading and an access road, as necessary, is assumed to be by the IC. Route selection, line design, and right-of-way acquisition of the direct connect facilities is not included in this report, and is the responsibility of the IC. The IC is also required to provide revenue metering and real-time telemetering data to PJM in conformance with the requirements contained in PJM Manuals M-01 and M-14 and the PJM Tariff.

DPL Interconnection Customer Scope of Direct Connection Work Requirements

- DPL requires that an IC circuit breaker is located within 500 feet of West Cambridge substation to facilitate the relay protection scheme between DPL and the IC at the Point of Interconnection (POI).

Special Operating Requirements

1. DPL will require the capability to remotely disconnect the generator from the grid by communication from its System Operations facility. Such disconnection may be facilitated by a generator breaker, or other method depending upon the specific circumstances and the evaluation by DPL.

2. DPL reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering and telecommunications facilities, owned by DPL.

Summer Peak Analysis – 2020

Transmission Network Impacts

Potential transmission network impacts are as follows:

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

Summer Peak Load Flow Analysis Reinforcements

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)

None

Short Circuit

No issues identified.

Stability and Reactive Power Requirement

No issues identified. See Attachment 2 for complete report.

Light Load Analysis - 2020

Not required for AB2-136

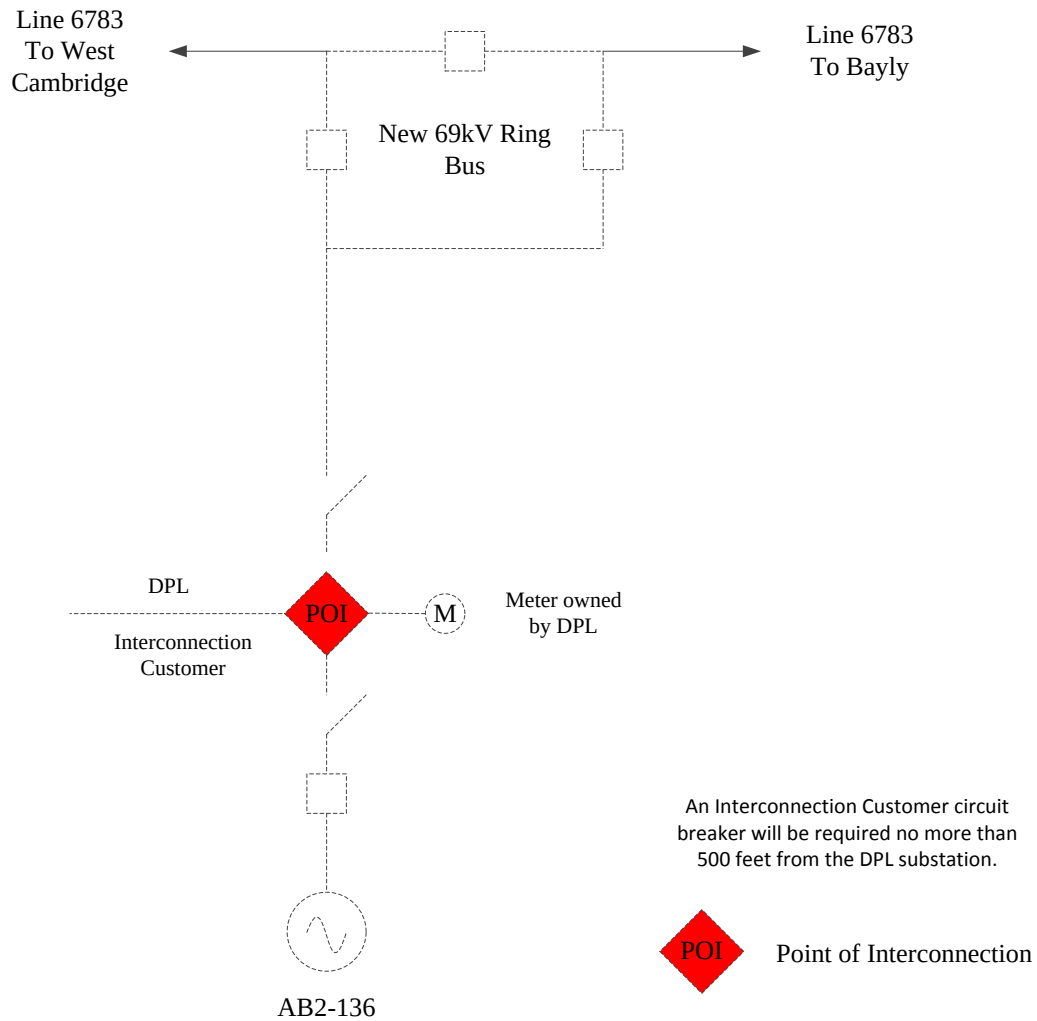
Delivery of Energy Portion of Interconnection Request
PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate 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.

None

Delmarva Power and Light Costs
Cost estimates will further be refined as a part of the Facilities Study for this project. The Interconnection Customer will be responsible for all costs incurred by DPL in connection with the AB2-136 project. DPL reserves the right to reassess issues presented in this document and, upon appropriate justification, submit additional costs related to the AB2-136 project.

Attachment 1

AB2-136
West Cambridge - Bayly 69kV Ckt. 6783
New 69kV Substation



Attachment 2

Specialist Consultants
to the Electricity Industry

AB2-136 System Impact Study

Dynamic Simulation Analysis

Prepared by	**Ramesh Hariharan** **PSC North America**
For	**PJM Interconnection, LLC**
Reference	**AB2-136-3-0**
Date	**February 28, 2017**
	Proprietary & Confidential

Revision Table

Revision	Issue Date	Description
0	February 28, 2017	Initial Release

Reviewers

Name	Interest	Date
Kalyan Chilukuri	Peer Review	February 28, 2017

Approval

Name	Position	Date
Kalyan Chilukuri	Senior Power Systems Engineer	February 28, 2017

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Executive Summary

Generator Interconnection Request AB2-136 is for a 51.1 MW Maximum Facility Output (MFO) solar powered generating facility.

This report describes a dynamic simulation analysis of AB2-136 as part of the overall system impact study.

The load flow scenarios for the analysis were based on the RTEP 2020 Peak Load case, modified to include applicable queue projects. AB2-136 was set to maximum power output.

AB2-136 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. 32 contingencies were studied, each with at least a 20 second simulation time period. Studied scenarios included:

a) Steady state operation (20 second simulation);

b) Three-phase faults with normal clearing time;

c) Single phase faults with stuck breaker;

d) Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from fault due to primary communications/relay failure.

No relevant Bus, Tower or High Speed Reclosing (HSR) contingencies were found.

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 all 32 of the fault contingencies tested on the 2020 peak load case:

a) AB2-136 is able to ride through the faults (except for faults where protective action trips a generator(s)),

b) The system with AB2-136 included is transiently stable and post-contingency oscillations are 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.

No mitigations were found to be required.

1. Introduction

Generator Interconnection Request AB2-136 is for a 51.1 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) on the Cambridge – West Cambridge 69 kV circuit in the Delmarva Power Transmission Network.

This analysis is effectively a screening study to determine whether the addition of AB2-136 will meet the dynamics requirements of the NERC, PJM and Transmission Owner reliability standards.
In this report the AB2-136 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

Generator Interconnection Request AB2-136 is for a 51.1 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) at the new AB2-136 POI (Point of Interconnection) substation located on the Cambridge – West Cambridge 69 kV circuit in the Delmarva Power Transmission Network.

Figure 1 shows the simplified one-line diagram of the AB2-136 loadflow model. Table 1 lists the corresponding parameters of the AB2-136 loadflow model.
Additional project details are provided in Attachments 1 through 3:

- Attachment 1 shows the one line diagram of the DPL system in the vicinity of AB2-136.
- Attachment 2 provides a diagram of the PSS/E model in the vicinity of AB2-136.
- Attachment 3 gives the PSS/E loadflow and dynamic models of the AB2-136 plant.

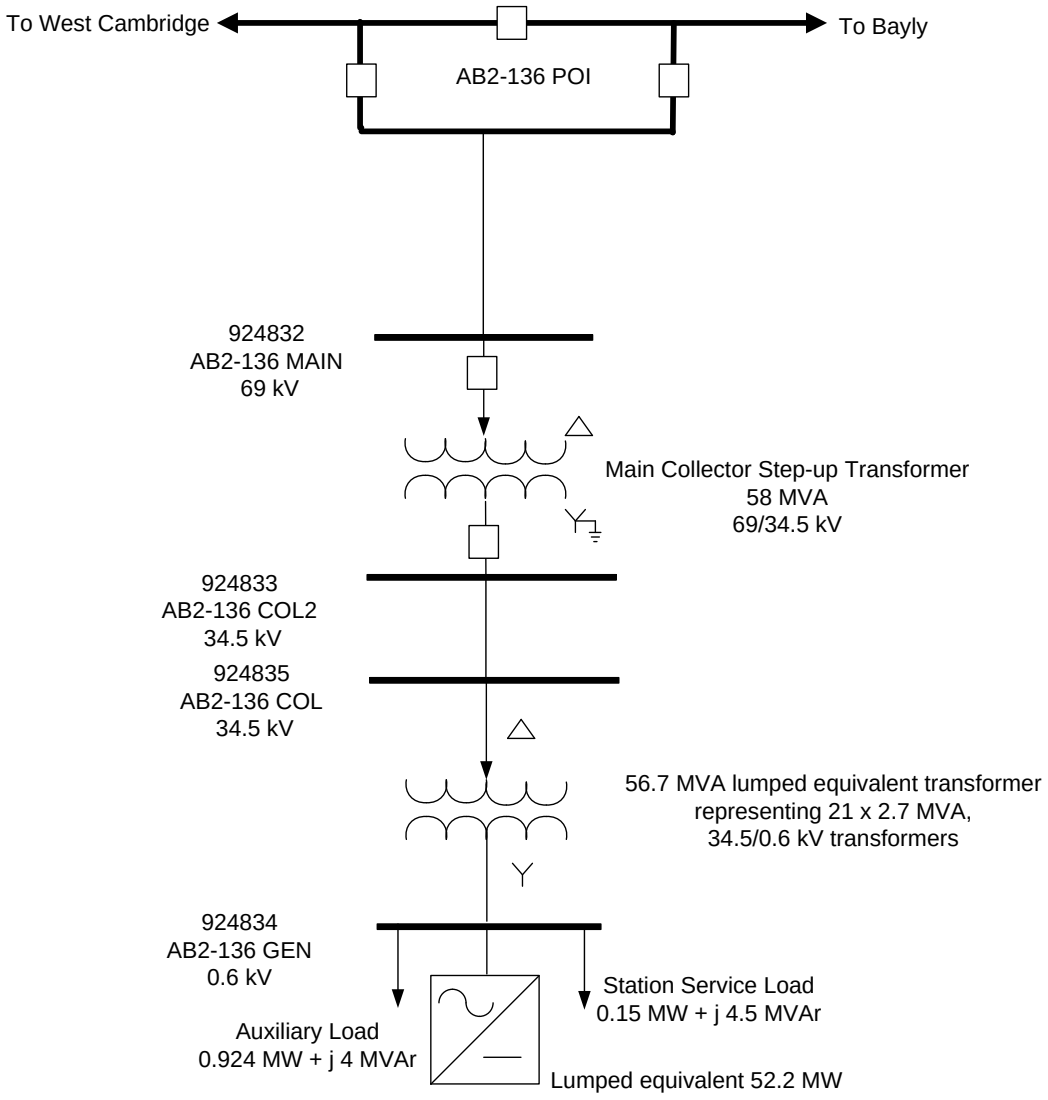

Figure 1: AB2-136 Plant Model

Table 1: AB2-136 Plant Model

	Model
Inverter Type	Lumped equivalent Pgen 52.2 MW Pmax 52.2 MW Pmin 0 MW Qmax 17.2 MVAr Qmin -17.2 MVAr Mbase 56.7 MVA Zsorce j9999.99 pu @ Mbase
GSU transformer(s)	Lumped equivalent Transformer base = 56.7 MVA Rating = 56.7 MVA Impedance = 0.007130 + j0.057060 pu @ MVA base Number of taps = 5
Main collector step-up transformer	Rating = 58 MVA Transformer base = 58 MVA Impedance @ MVA base = 0.003300+ j0.099940pu Number of taps = 5
Station load	0.15 MW + 4.5 MVAr at inverter bus
Collector System Losses	0.1 MW + 0.3 MVAr at collector bus
Auxiliary load	0.92 MW + 5 MVAr at inverter bus
Transmission line	Voltage = 69 kV Line Base = 100 MVA Impedance = 0.003640+ j0.014560 B = 0.000290

3. Loadflow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 33.7.0.
The load flow scenarios and fault cases for this study are based on PJM's Regional Transmission Planning Process[1] and discussions with PJM.
The selected load flow scenarios were the RTEP 2020 peak load case with the following modifications:

a) Addition of all applicable queue projects prior to AB2-136.

b) Addition of AB2-136 queue project.

c) Removal of withdrawn and subsequent queue projects in the vicinity of AB2-136.

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

e) Merchant transmission projects X3-028 and S57/S58 set online and at maximum power import into PJM.

The AB2-136 initial conditions are listed in Table 2, indicating maximum power output.

Table 2: AB2-136 initial conditions

Bus	Name	Unit	PGEN (MW)	QGEN (MVar)	ETERM (pu)	POI Voltage (pu)
924834	AB2-136 GEN	1	52.2 MW	7.12	1	1.027

Generation within the PJM500 system (area 235 in the PSS/E case) and within the vicinity of AB2-136 was dispatched online at maximum output (PMAX). The dispatch of generation in the vicinity of AB2-136 is given in Attachment 4.

[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

Table 3 to Table 6 list the contingencies that were studied, with representative worst case total clearing times provided by PJM. Each contingency was studied over at least a 20 second simulation time interval.
The studied contingencies include:

a) Steady state operation (20 second);

b) Three phase faults with normal clearing time;

c) Single phase faults with stuck breaker;

d) Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure.

No relevant Bus, Tower or High Speed Reclosing (HSR) contingencies were found.
Buses at which the faults listed above will be applied are:

- AB2-136 POI 69 kV
- Cambridge 69 kV
- West Cambridge 69 kV

The one line diagram of the DPL network in the vicinity of AB2-136 is included in Attachment 1.
Clearing times listed in Tables 3 to 6 are as per revision 19 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 AB2-136 have not withdrawn from the PJM queue, and are not greater than the queue position under study.

5. Evaluation Criteria

This study is focused on AB2-136, 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:

a) AB2-136 is able to ride through the faults (except for faults where protective action trips a generator(s)),

b) The system with AB2-136 included should be transiently stable and post-contingency oscillations are 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 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

Plots from the dynamic simulations are provided in Attachment 5 with results summarized in Table 3 to Table 6.
All fault contingencies tested on the 2020 Peak Load case met the recovery criteria:

a) AB2-136 is able to ride through the faults (except for faults where protective action trips a generator(s)),

b) The system with AB2-136 included is transiently stable and post-contingency oscillations are 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 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.

Multiple instances of non-convergence were reported for all three phase faults tested at the AB2-136 POI (3N01 – 3N03). As the non-convergence was only observed during fault application it was not deemed an issue.

7. Recommendations and Mitigations

No adverse impacts attributable to the queue project under study were found and as such, no mitigations were found to be required.

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 (Cycles)	Result No mitigation
3N.01	Fault at AB2-136 POI 69 kV on Bayly - Cambridge circuit resulting in the loss of all equipment at Bayly 69 kV	9	Stable[2]
3N.02	Fault at AB2-136 POI 69 kV on AB2-136 circuit resulting in the loss of AB2-136	9	Stable[1]
3N.03	Fault at AB2-136 POI 69 kV on West Cambridge circuit.	9	Stable[1]
3N.04	Fault at Cambridge 69 kV on Bayly - AB2-136 POI circuit resulting in the loss of all equipment at Bayly 69 kV	9	Stable
3N.05	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer 3	9	Stable
3N.06	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer 4	9	Stable
3N.07	Fault at Cambridge 69 kV on Jacktown - AA1-061 POI circuit resulting in the loss of all equipment at Jacktown 69 kV	9	Stable
3N.08	Fault at West Cambridge 69 kV on AB2-136 POI circuit	9	Stable
3N.09	Fault at West Cambridge 69 kV on West Cambridge 69/12 kV Transformer T1	9	Stable
3N.10	Fault at West Cambridge 69 kV on X3-015 POI circuit.	9	Stable

Table 5: Single-Phase Faults With Stuck Breaker

Fault ID	Fault description	Clearing Time Primary and Delayed (Cycles)	Result No mitigation
1B.01	Fault at AB2-136 POI 69 kV on AB2-136 circuit resulting in the loss of AB2-136. Breaker stuck to West Cambridge circuit. Fault is cleared with the loss of West Cambridge circuit	9/22	Stable
1B.02	Fault at AB2-136 POI 69 kV on AB2-136 circuit resulting in the loss of AB2-136. Breaker stuck to Bayly - Cambridge circuit. Fault is cleared with the loss of Bayly - Cambridge circuit and all equipment at Bayly 69 kV	9/22	Stable
1B.03	Fault at AB2-136 POI 69 kV on West Cambridge circuit. Breaker stuck to AB2-136 circuit. Fault is cleared with the loss of AB2-136 circuit and AB2-136	9/22	Stable
1B.04	Fault at AB2-136 POI 69 kV on West Cambridge circuit. Breaker stuck to Bayly - Cambridge circuit. Fault is cleared with the loss of AB2-136, Bayly - Cambridge circuit and all equipment at Bayly 69 kV	9/22	Stable

[2] Solution Non-convergence observed during the fault at AB2-136 generator bus (924834) and X1-096 generator bus (907573). As this was only observed during fault application it was not deemed an issue.

Fault ID	Fault description	Clearing Time Primary and Delayed (Cycles)	Result No mitigation
1B.05	Fault at AB2-136 POI 69 kV on Bayly - Cambridge circuit resulting in the loss of all equipment at Bayly 69 kV. Breaker stuck to AB2-136 circuit. Fault is cleared with loss of AB2-136 circuit and AB2-136	9/22	Stable
1B.06	Fault at AB2-136 POI 69 kV on Bayly - Cambridge circuit resulting in the loss of all equipment at Bayly 69 kV. Breaker stuck to West Cambridge circuit. Fault is cleared with loss of West Cambridge circuit and AB2-136	9/22	Stable
1B.07	Fault at West Cambridge 69 kV on AB2-136 circuit. Breaker 60 stuck to West Cambridge 69 kV bus. Fault is cleared with the loss of West Cambridge 69/12 kV Transformer T1 and 1x10.8 Mvar West Cambridge Capacitor Bank	9/22	Stable
1B.08	Fault at West Cambridge 69 kV on X3-015 POI circuit. Breaker 61 stuck to West Cambridge 69 kV bus. Fault is cleared with the loss of West Cambridge 69/12 kV Transformer T1 and 1x10.8 Mvar West Cambridge Capacitor Bank	9/22	Stable
1B.09	Fault at West Cambridge 69 kV on West Cambridge 69/12 kV Transformer T1. Breaker 60 stuck to West Cambridge 69 kV bus. Fault is cleared with the loss of 1x10.8 Mvar West Cambridge Capacitor Bank	9/22	Stable
1B.10	Fault at Cambridge 69 kV on Bayly - AB2-136 circuit resulting in the loss of all equipment at Bayly. Breaker 7170 stuck to Cambridge 69 kV bus. Fault is cleared with the loss of Cambridge 69/12 kV Transformer 3	9/22	Stable
1B.11	Fault at Cambridge 69 kV on Bayly - AB2-136 circuit resulting in the loss of all equipment at Bayly[4]. Breaker 7150 stuck to Cambridge 69 kV bus. Fault is cleared with the loss of Cambridge 69/12 kV Transformer 4	9/22	Stable
1B.12	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer T3. Breaker 7170 stuck to Bayly - AB2-136 circuit. Fault is cleared with the loss of Bayly - AB2-136 circuit and all equipment at Bayly 69 kV[4]	9/22	Stable
1B.13	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer T3. Breaker 60 stuck to Jacktown - AA1-061 POI circuit 6719. Fault is cleared with the loss of Jacktown - AA1-061 POI circuit and 1x12.15 Mvar Cambridge Capacitor bank, all equipment at Jacktown 69 kV	9/22	Stable
1B.14	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer T4. Breaker 7150 stuck to Bayly - AB2-136 circuit. Fault is cleared with the loss of Bayly - AB2-136 circuit and all equipment at Bayly 69 kV[4]	9/22	Stable
1B.15	Fault at Cambridge 69 kV on Cambridge 69/12 kV Transformer T4. Breaker 7140 stuck to Jacktown - AA1-061 POI circuit 6719. Fault is cleared with the loss of Jacktown - AA1-061 POI circuit, 1x12.15 Mvar Cambridge Capacitor bank and all equipment at Jacktown 69 kV	9/22	Stable
1B.16	Fault at Cambridge 69 kV on Jacktown - AA1-061 POI circuit 6719 resulting in the loss of 1x12.15 Mvar Cambridge Capacitor bank and all equipment at Jacktown 69 kV. Breaker 60 stuck to Cambridge 69 kV bus. Fault is cleared with the loss of Cambridge 69/12 kV Transformer T3	9/22	Stable
1B.17	Fault at Cambridge 69 kV on Jacktown - AA1-061 POI circuit 6719 resulting in the loss of 1x12.15 Mvar Cambridge Capacitor bank and all equipment at Jacktown 69 kV. Breaker 7140 stuck to Cambridge 69 kV bus. Fault is cleared with the loss of Cambridge 69/12 kV Transformer T4	9/22	Stable

Table 6: Single-phase Faults With Delayed (Zone 2) Clearing at line end closest to AB2-136 POI

Fault ID	Fault description	Clearing Time Primary and Delayed (Cycles)	Result No mitigation
1D.01	Fault at 80 % of 69 kV line from AB2-136 POI to Bayly - Cambridge resulting in the loss of all equipment at Bayly 69 kV. Delayed clearing at AB2-136 69 kV	9/42	Stable
1D.02	Fault at 80 % of 69 kV line from AB2-136 POI to West Cambridge. Delayed Clearing at AB2-136 69kV.	9/42	Stable
1D.03	Fault at 80 % of 69 kV line from Cambridge to Jacktown - AA1-061 POI resulting in the loss of all equipment at Jacktown 69 kV. Delayed clearing at Cambridge 69 kV.	9/42	Stable
1D.04	Fault at 80 % of 69 kV line from West Cambridge to X3-015 POI. Delayed Clearing at West Cambridge 69 kV.	9/42	Stable