PJM Generation Interconnection Request

System Impact Study Report

Queue #O48 and #R40
Hays Mill (Lookout) 115 kV (formerly Hays Mill 23 kV)
37.8 MW

January 2007

DOCS #398101, v2

Preface

The intent of the System Impact Study is to determine a plan, with cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: **(1) Direct Connection Facilities**, which are new facilities and/or facility upgrades that are needed to connect the generator to the PJM network, and **(2) Network Upgrades**, which are facility additions or upgrades to existing facilities that are needed to maintain the reliability of the PJM system.

In some instances, the interconnecting generator may not be responsible for 100% of the identified network upgrade cost because other transmission network uses (e.g. another generation interconnection) 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 System Impact Study, but the actual allocation cannot be fully determined until the other projects that impact the same facilities make a decision on whether or not they will be constructed.

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 generation facilities. The project developer is responsible for the rights-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 developer, Generation Resources, originally proposed the addition of 36 MW of wind turbine generation (18 turbines of 2.0 MW each) under project queue O48. The developer now proposes to install an additional 1.8 MW under project queue R40 by installing 18 turbines rated at 2.1 MW each for a total installation of 37.8 MW of wind turbine generation with 20% (7.6 MW) capacity for the combined project O48/R40 to a new 115 kV three-breaker ring bus configured interconnection switching substation near the Arnold Substation, Somerset County, Pennsylvania. The generation will be interconnected with Pennsylvania Electric Company, a FirstEnergy Company (Penelec), at the 115 kV side of the transformer. The attachment facilities at the terminal will be the responsibility of the Interconnection Customer. The proposed in-service date for the generation is September 2007.

If generation project L13 is constructed, the cost may be reduced due to its cost allocation for fiber optic cable installation required from Rockwood Substation to Meyersdale North Substation. Completion of the work herein described will enable the developer to interconnect the wind generators in the Penelec Service Area. The scope of work and estimated cost for individual project segments is as follows:

Direct Connection Facilities

The developer will construct facilities including the wind turbine collection system, generation step up transformer and line to the point of interconnection with the 115 kV line near Arnold Substation. The point of interconnection with Penelec is at the high side of the 115 kV / 34.5 kV GSU transformer. A fully rated fault interrupting circuit breaker owned by the developer is required to protect the high side of the GSU. This fourth circuit breaker is required between the O48/R40 position on the ring bus and the O48/R40 generating station (see Figure 1).

The direct connection facilities include line terminal equipment on FirstEnergy's side of the point of interconnection. This typically includes metering, dead-end structure, and a 3 phase gang-operated disconnect switch. This is the radial equipment from the terminal to the point of interconnection. The remainder of the ring bus switching-station is a network upgrade because of system through-flow.

NETWORK and LOCAL UPGRADES

Required reinforcements:

It is proposed that the project be connected via a new 115 kV 3-breaker ring bus near Arnold REC. It is to be constructed adjacent – or in close proximity – to the Rockwood-Meyersdale North 115 kV line. The tap would extend approximately 0.1 miles. The developer is responsible for constructing all of the facilities on its side of the point of interconnection, which will be between the Rockwood-Meyersdale North 115 kV line and the customer substation (see Figure 1). A fourth breaker is required between the O48/R40 position on the ring bus and the O48/R40 generating station.

The developer will also be responsible for any costs associated with remote relay and control work at Rockwood or L13, at Arnold REC, at Meyersdale North and at Berkley Flats Wind that is required due to the connection of the wind facility.

The proposed interconnection facilities must be designed in accordance with the FirstEnergy "Requirements for Transmission Connected Facilities" located at:

http://www.firstenergycorp.com/feconnect/Requirements_for_Transmission_Connected_Facilities.html

Generation Connection Requirements
The following is an excerpt taken from the FirstEnergy "Requirements for Transmission Connected Facilities" document.

Design Requirements
The generation owner is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with the FirstEnergy Transmission System. The generation owner is also responsible for meeting any applicable federal, state, and local codes.

It will be the developer's responsibility to obtain any needed right-of-way between the plant site and FirstEnergy's facilities.

The developer will be required to obtain and maintain a fiber optic communications channel from Rockwood to L13 to Arnold REC to Berkley Flats Wind for direct transfer trip. If PJM Queue #L13 proceeds forward, then the communications may need to be changed at the remote terminals because Project #L13 also requires the installation of fiber optic communication channel along the same route.

Detailed protection requirements will be furnished with the Facilities Study. FirstEnergy will complete detailed relay coordination studies to identify off-site relay setting changes required due to this generation interconnection. This may result in additional individual relay replacements being required. These relay replacements will be done at the cost of the Developer and will be identified during the Facility Study.

Below are conceptual estimates for the engineering/construction associated with Direct Connection requirements based upon similar projects that have been designed and/or constructed.

The following details assume that #L13 proceeds prior to #048/R40:

Item	Description	Conceptual Cost Estimate
1	New 115 kV 3-breaker ring bus termination point at a new interconnection switching station approximately 0.1miles east of Arnold REC Substation.	$1,900,000

2	New tap structure in 115 kV line to get transmission line tap to the new interconnection switching station adjacent to the transmission line right-of-way. Approximately 0.1 miles of 115 kV transmission line extending from the Rockwood-Meyersdale North 115 kV line to the generation plant substation. Final distance TBD in the Facility Study.	$250,000
3	Relay, control, and communication work at L13 Substation.	$25,000
4	Relay, control and communication work at Meyersdale North Substation.	$25,000
5	Possible relay and control work at Arnold REC substation. This is not a FirstEnergy facility and work will have to be coordinated with the owner.	TBD by Arnold REC.
6	Relay, control and communication work at Berkley Flats Wind substation.	TBD by Berkley Flats

Conceptual Estimate: **$2,200,000** Estimated Lead Time: **2.0 years from signed IA**

The following details assume that #O48/R40 proceeds prior to #L13:

Item	Description	Conceptual Cost Estimate
1	New 115 kV 3-breaker ring bus termination point at a new interconnection switching station approximately 0.1miles east of Arnold REC Substation.	$1,900,000
2	New tap structure in 115 kV line to get transmission line tap to the new interconnection switching station adjacent to the transmission line right-of-way. Approximately 0.1 miles of 115 kV transmission line extending from the Rockwood-Meyersdale North 115 kV line to the generation plant substation. Final distance TBD in the Facility Study.	$250,000
3	Relay, control and communication work at Rockwood Substation. Includes relays, carrier set, line trap, tuner and review of relay settings.	$110,000
4	Relay, control and communication work at Meyersdale North substation. Includes relays, carrier set, line trap, tuner and review of relay settings.	$110,000

5	Possible relay and control work at Arnold REC substation. This is not a FirstEnergy facility and work will have to be coordinated with the owner.	TBD by Arnold REC.
6	Relay, control and communication work at Berkley Flats Wind substation.	TBD by Berkley Flats
7	The existing transfer trip from Rockwood substation to Meyersdale North over leased telephone line shall be replaced with a fiber optic communications channel for Project #L13. If Project #O48 proceeds prior to #L13, it will be responsible for installation of the fiber optic channel.	$700,000

Conceptual Estimate: **$3,070,000** Estimated Lead Time: **2.0 years from signed IA**

- The Garrett Tap-Garret 115 kV line loads to 103.6% of its emergency rating for the loss of the Rockwood-Somerset 115 kV line for the capacity portion of O48/R40. To mitigate this overload condition will require the replacement of substation conductor at one substation. The line loads to 125.5% of its emergency rating if the energy portion is studied. Replacement of the affected substation conductor is estimated to cost approximately $100,000.

Stability (MAAC Stability Criteria) and Reactive Power Design Criteria

Stability analysis was performed at 2009 summer peak load condition, with plant gross output of 37.8 MW associated with the proposed O48&R40 queue project. Suzlon 2.1MW turbines were used to perform the study.

Several contingencies were found to cause instability or voltage violations at the maximum output of the proposed plant. The instability is due to the wind generator plant becoming islanded with load. When the wind generator plant is islanded with load the plant shall be isolated from the PJM system at the interconnection point. We recommend the following values for trip settings;

Voltage at the point of interconnection:
0.8 pu or lower for 2 seconds
1.11 pu or higher for 0.1 second
1.2 pu or higher for 0.02 second
Frequency at the point of interconnection:
57Hz or lower for 0.05 seconds
62Hz or higher for 0.05 second

With the turbines specified, Suzlon S88 2.1MW, the Impact Study shows that when the turbines are operated at the default unity power factor mode, no additional reactive compensation is required with the following voltage and frequency trip levels and times for each turbine:

Voltage (V) at the terminal of the generator:

0.90 pu >/= V > 0.75 pu for 60 seconds
0.75 pu >/= V > 0.50 pu for 60 seconds
0.50 pu >/= V > 0.2 pu for 20 seconds
0.2 pu >/= V > 0.15 pu for 0.4 seconds
0.15 pu or lower for 0.17 second
1.20 pu >/= V > 1.14 pu for 0.4 seconds
1.14 pu or higher for 0.08 second

These relay settings satisfy system requirements. It is the developer's responsibility to make sure that those settings also provide adequate protections for the WTG equipment.

Attachment #1 lists the fault cases evaluated. The range of contingencies evaluated was limited to that necessary to demonstrate compliance with MAAC reliability criteria.

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system load levels and operating conditions would disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in that or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and unit specific dynamics data for the turbine generators and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall be performed to verify impact on the dynamic performance of the system. As more accurate or unit specific dynamics data for the proposed facility, as well as Plant layout become available, it must be forwarded to PJM.

COST AND TIMING SUMMARY

Total Estimated Cost for interconnection is dependent upon if Project #L13 is constructed first. If L13 is constructed the cost will be reduced to due to L13's cost allocation for fiber optic cable installation that is required from Rockwood Substation to Meyersdale North substation.

It is estimated that the construction will take 24 months after the Construction Service Agreement is executed. This does not meet the Interconnection Customer's requested in-service date. The developer, FirstEnergy, and PJM should meet to discuss how to proceed.

Notes:

- Detailed Engineering & Construction Estimates TBD via Facility Study
- The above estimates do not include 1) tax gross-up, 2) property costs, 3) interconnection metering and generation SCADA to be provided by the developer, 4) engineering and field activities for design review and commissioning of the developer's facilities, and 5) real estate costs that may be required for right-of-way easements.

Network Impacts

The **#O48/R40 project was studied as a total injection of 37.8 MW (7.6 MW Capacity) into the 115 kV system near the Arnold Substation**. Project #O48/R40 was evaluated for compliance with reliability criteria for summer peak conditions in 2009. Potential network impacts were as follows:

Generator Deliverability

No problems were identified.

Multiple Facility Contingency

1. The #O48/R40 project contributes 25 MW to the loading of the SOMERST-ROCKWOOD 115 line for the outage of the BEDINGTON-BLACK OAK 500 kV circuit. The loading on that line increases from 91% to 107% of its 4-hour emergency rating (159MW).

   To mitigate this overload condition requires replacement/upgrade of the following:

   Rockwood Substation:

   Replacement/upgrade of a 115 kV disconnect switch (estimated to cost approximately $60,000)

   Somerset Substation:

   Replacement/upgrade of a 115 kV disconnect switch (estimated to cost approximately $60,000)

Contribution to Previously Identified Overloads

None identified.

New System Reinforcements

Depends upon if Generation Project Queue L13 (Casselman Windfarm) moves forward:

- If L13 does not move forward, the existing transfer trip from Rockwood Substation over leased telephone line shall be replaced with a fiber optic communications channel. Estimated cost is $920,000.
- If L13 does move forward prior to Project #O48/R40, then some changes for the communication channel may need to be made at the terminals as well as the installation of a short distance of fiber optic cable.

Contribution to Previously Identified System Reinforcements

None identified.

Short Circuit

No problems were identified. A circuit breaker analysis was completed for the #O48/R40 study. No overdutied breakers were found to be directly attributable to the #O48/R40 project.

Potential Congestion Issues

There are several wind generation plants proposed in the general area of the O48/R40 project, each with only 20% of their peak output level considered as a Capacity Resource, and the

remaining 80% as an energy only resource. If all of the wind generation plants are at their maximum out put level simultaneously, a significant number of the 115 kV and 230 kV facilities, and many underlying system facilities are likely to be overloaded, restricting operation to a lower output level.

PJM and FirstEnergy studied the delivery of the energy portion of this interconnection request. The following analysis has been performed to inform the Interconnection Customer (Queue O48/R40) of potential congestion issues (operational restrictions) that may occur and affect the O48/R40 project's ability to operate at full output for certain system conditions. **The upgrades listed below are not required reliability upgrades for the Queue O48/R40 interconnection.** Please note that the number of facilities identified below as requiring upgrades may be quite extensive – with a number of these facilities requiring reconductoring/rebuilding of transmission lines. Some of the reconductoring/rebuilding projects can be done in a "short" time frame while others are quite extensive and will require a "long" time to complete. In general, the time necessary to design and rebuild an extensive facility upgrade will take approximately 2-3 years to complete. If the O48/R40 Interconnection Customer wants to pursue construction of any of these upgrades, a separate "Transmission Interconnection" request must be submitted and the upgrades must be performed as merchant transmission projects.

Category A – Transmission System Impacts (Facilities monitored and operated by PJM)

Load flow model used for analysis: Generator Deliverability dispatch with all generators (in-service or active Queue generators preceding O48/R40) at 100% energy output and Peak summer loading (80/20 load forecast).

O48/R40 Operational considerations: The facilities below (potentially overloaded) are monitored and operated by PJM. PJM rules and methods for readjusting pre-contingency (N-1) dispatch will be followed if this system condition occurs. This may or may not cause curtailment of O48/R40 generation to below its 100% energy output.

None.

Category B – Underlying Transmission System Impacts (Facilities monitored and operated by Penelec)

Load flow model used for analysis: Generator Deliverability dispatch with all generators (in-service or active Queue generators preceding O48/R40) at 100% energy output and Peak summer loading (80/20 load forecast).

O48 Operational considerations: The facilities below (potentially overloaded) are not monitored and operated by PJM. Penelec monitors these facilities in real time and will readjust the system according to Penelec's rules and methods if this system condition occurs. This may or may not cause curtailment of O48/R40 generation to below its 100% energy output.

1. The O48/R40 project contributes 12 MW to the overload of the Garrett 115/138kV transformer to 134% of its emergency rating of 90 MVA for the **contingency** outage of

the Keystone-Shelocta-Homer 230 kV circuit, which was previously identified as a potential congestion issue for the energy portion of the O17 project.

To mitigate this overload condition would require replacement/upgrade of the following:
Garrett Substation:

Replacement/upgrade of 138-115 kV transformer, circuit breaker and substation conductor (estimated to cost approximately $1,750,000)

2. The O48/R40 project overloads the Garrett Tap-Garrett 115 kV line to 125.5% of its 125 MVA emergency rating for the **contingency** outage of the Rockwood-Somerset 115 kV line. The overload is caused by the energy portion of the O48 project.

To mitigate this overload condition would require replacement/upgrade of the following:
Garrett Substation:

- **Replacement/upgrade of substation conductor (estimated to cost approximately $125,000)**
- **Replacement/upgrade of a disconnect switch (estimated to cost approximately $80,000)**
- **Replacement/upgrade of a CT circuit (estimated to cost approximately $100,000)**

Reconductor/upgrade of approximately 1.9 miles of transmission line between Garrett Tap and Garrett Substation (estimated to cost approximately $450,000)

3. The Somerset-Rockwood 115 kV line does not overload past its emergency rating for the **contingency** outage of the Garrett 138-115 kV transformer if only capacity for project queue O48/R40 is accounted for. However, the line overloads past its emergency rating of 159 MVA (104%) if the energy portion is studied. All 37.8 MW of the O48/R40 project contribute to the overload, of which the line is overloaded by 6.36 MW.

To mitigate this overload condition for the energy portion of the O48/R40 project would require the upgrade of terminal equipment – (2) 115 kV disconnect switches, one each at Somerset and Rockwood.

Rockwood Substation:

- **Replacement/upgrade of a 115 kV disconnect switch (estimated to cost approximately $80,000**

Somerset substation:

- **Replacement/upgrade of a 115 kV disconnect switch (estimated to cost approximately $80,000)**

Appendix

Attachment #1

O48

BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Zone 2 (total)
Rockwood 115 kV	7	20	36
Somerset 115 kV	7	20	36
Penn-Mar 115 kV	7	20	36
Hooversville 115 kV	7	20	36
Allegheny 115 kV	7	20	36

CRITERIA TEST FAULTS (Faults in red are unstable in both peak and light load cases Due to the isolation to load)

With no pre-disturbance outage:

1a 3ph @ L13 Tap 115 kV on L13 Tap – Rockwood 115 kV
1b slg @ L13 on Rockwood – Penn Mar 115 kV, BF@ L13
1c slg @ 80% of L13 Tap - Rockwood 115 kV, zone 2 clearing from L13

2a 3ph @ O48 Tap 115 kV on O48 Tap – Meyersdale North 115 kV
2c slg @ 80% of O48 Tap - Meyersdale North 115 kV, zone 2 clearing from O48

4a 3ph @ Rockwood 115 kV on Rockwood – Somerset 115 kV
4b slg @ Rockwood 115 kV on Rockwood – Somerset 115 kV, BF@ Rockwood
4c slg @ 80% of Rockwood – Somerset 115 kV, zone 2 clearing from Rockwood

5a 3ph @ Somerset 115 kV on Somerset – Hooversville 115 kV
5b slg @ Somerset 115 kV on Somerset – Hooversville 115 kV, BF@ Somerset
5c slg @ 80% of Somerset – Hooversville 115 kV, zone 2 clearing from Somerset

6a 3ph @ Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV
6b slg @ Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV, BF@ Somerset
6c slg @ 80% of Somerset – Ralphton – Hooversville 115 kV, zone 2 clearing from Somerset

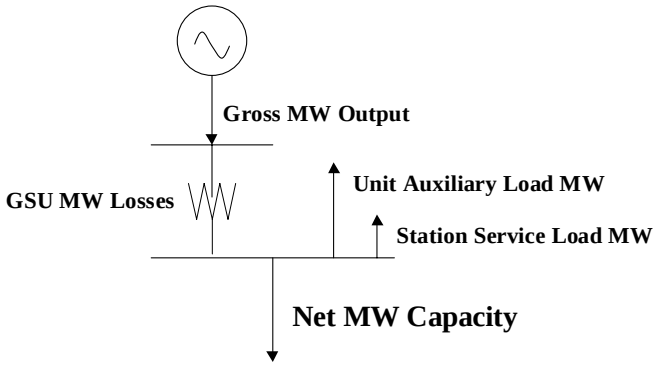
7a 3ph @ Somerset 115 kV on Somerset – Pride 115 kV
7b slg @ Somerset 115 kV on Somerset – Pride 115 kV, BF@ Somerset
7c slg @ 80% of Somerset – Pride 115 kV, zone 2 clearing from Somerset

With Rockwood – Penn Mar 115 kV line out of service (pre-disturbance outage p):

5a 3ph @ Somerset 115 kV on Somerset – Hooversville 115 kV
6a 3ph @ Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV
7a 3ph @ Somerset 115 kV on Somerset – Allegheny 115 kV

ATTACHMENT #2

Unit Capability Data



Net MW Capacity = (Gross MW Output - GSU MW Losses* – Unit Auxiliary Load MW - Station Service Load MW)

Queue Letter/Position/Unit ID: _____ O48&R40

Primary Fuel Type: _____ Wind /Suzlon S88 2.1 MW

Maximum Summer (92º F ambient air temp.) Net MW Output**: _____ N/A

Maximum Summer (92º F ambient air temp.) Gross MW Output: _____ 37.8

Minimum Summer (92º F ambient air temp.) Gross MW Output: _____ 37.8

Maximum Winter (30º F ambient air temp.) Gross MW Output: _____ 37.8

Minimum Winter (30º F ambient air temp.) Gross MW Output: _____ 37.8

Gross Reactive Power Capability at Maximum Gross MW Output – Please include Reactive Capability Curve (Leading and Lagging): ___ 0.99 Leading to 0.95 Lagging

Individual Unit Auxiliary Load at Maximum Summer MW Output (MW/MVAR): 0.022

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR): _0.022

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): __0.022

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR): __0.040

Station Service Load (MW/MVAR): _____ 0.025

* GSU losses are expected to be minimal.

** Your project's declared MW, as first submitted in Attachment N, and later confirmed or modified by the Impact Study Agreement, should be based on either the 92º F Ambient Air Temperature rating of the unit(s) or, if less, the declared Capacity rating of your project.

Unit Generator Dynamics Data

Queue Letter/Position/Unit ID: _____ O48&R40

MVA Base (upon which all reactances, resistance and inertia are calculated): _____2.183

Nominal Power Factor: _____ 0.92 uncompensated-1.00 compensated

Terminal Voltage (kV): _____0.60

Unsaturated Reactances **(on MVA Base)**

Direct Axis Synchronous Reactance, $X_{d(i)}$: _____5.4 p.u.

Direct Axis Transient Reactance, X'd(i): _____0.198 p.u.

Direct Axis Sub-transient Reactance, X"d(i):_____0.110 p.u.

Quadrature Axis Synchronous Reactance, Xq(i):_____ N/A

Quadrature Axis Transient Reactance, X'q(i): _____ N/A

Quadrature Axis Sub-transient Reactance, X"q(i):_____ N/A

Stator Leakage Reactance, Xl: _____0.325 p.u.

Negative Sequence Reactance, X2(i):_____ N/A

Zero Sequence Reactance, X0: _____ N/A

Saturated Sub-transient Reactance, X"d(v) (on MVA Base):_____N/A

Armature Resistance, Ra (on MVA Base):_____ N/A

Time Constants (seconds)

Direct Axis Transient Open Circuit, T'_{do}: _____ N/A

Direct Axis Sub-transient Open Circuit, T''_{do}:_ _____ N/A

Quadrature Axis Transient Open Circuit, T'_{qo}:_ _____ N/A

Quadrature Axis Sub-transient Open Circuit, T''_{qo}: _____ N/A

Inertia, H (kW-sec/kVA, on KVA Base):_____ 4.7

Speed Damping, D:_____ N/A

Saturation Values at Per-Unit Voltage [S(1,0), S(1,15)]:_____ N/A

Units utilize a *Generator model*

Unit GSU Data

Queue Letter/Position/Unit ID: O48&R40

Generator Step-up Transformer MVA Base: 2.5

Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): 6%

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): 60

Generator Step-up Transformer Rating (MVA): 2.5

Generator Step-up Transformer Low-side Voltage (kV): 0.60

Generator Step-up Transformer High-side Voltage (kV): 24.9

Generator Step-up Transformer Off-nominal Turns Ratio: N/A

Generator Step-up Transformer Number of Taps and Step Size: N/A

Main Transformer Data

Queue Letter/Position/Unit ID: O48&R40

Generator Step-up Transformer MVA Base: 42

Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): 0.4%+j8.98%

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): 33

Generator Step-up Transformer Rating (MVA): 33/44/55

Generator Step-up Transformer Low-side Voltage (kV): 24.9(wye)

Generator Step-up Transformer High-side Voltage (kV): 115(delta)

Generator Step-up Transformer Off-nominal Turns Ratio: N/A

Generator Step-up Transformer Number of Taps and Step Size: +/- 2.5%, +/- 5%

Figure 1: