

***Generation Interconnection
Facility Study Report***

For

***PJM Generation Interconnection Request
Queue Position Z1-036***

***Winfall – Mackeys 230kV
39MW Capacity / 300.3MW Energy***

Revised September / 2015

Introduction

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

General

IC has proposed a wind generating facility located in Perquimans County, NC. The installed facilities will have a total capability of 300.3 MW with 39 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June, 1, 2016. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

Z1-036 will interconnect with the ITO transmission system via a new three breaker ring bus switching station (Perquimans) that connects to the Windfall – Mackey’s 230kV line.

Cost Summary

The Z1-036 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 891,265
Direct Connection Network Upgrades	\$4,434,840
Non Direct Connection Network Upgrades	\$1,766,979
Allocation for New System Upgrades	\$ 0
Contribution for Previously Identified Upgrades	\$ 0
Total Cost	\$7,093,084

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue Z1-036 is a request to interconnect 300.3 MW (Capacity 39 MW) of energy from a new wind facility to be located on the Winfall to Mackeys line #2131 between the distribution substations, South Herford and Chowan. The new 230 kV substation is called Perquimans which is physically located near the Town of Edenton, North Carolina. The requested in-service date is June 2016. Attachment Facility and Direct Connection Network upgrade construction is estimated to be 18 months from the latter Effective Date of the Interconnection Service Agreement and Interconnection Construction Service Agreement. Facilities may require local zoning approval. Site plan was developed between the IC and ITO during IC Certificate of Public Convenience and Necessity (a/k/a CPCN) process with the North Carolina Public Utility Commission.

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

The Queue Project Z1-036 was studied as a 300.3 MW (Capacity 39.0 MW) injection tapping the Edenton – South Hertford 230 kV line in the ITO area. Project Z1-036 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners) for summer peak conditions in 2017. Project Z1-036 was studied with a commercial probability of 100%.

Light Load and Stability Analysis were deferred to the Facilities Study.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

Normal ITO criteria will allow for steady-state voltage on the transmission system under normal and contingency conditions to vary between 0.9 pu and 1.05 pu. Generators connected to the 230 kV System are usually expected to maintain a voltage schedule as defined in PJM Manual 03 “Transmission Operations”.

Stability and Reactive Power Requirement for Low Voltage Ride Through

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

None, for more details see Attachment 3.

Light Load Analysis

(Study to determine that the Transmission System is capable of delivering the system generating capacity at light load)

None

3. Interconnection Customer's Submitted Milestone Schedule

Description	Schedule
Permits	December 31, 2016
Substantial site work complete	June 1, 2017
Delivery of wind turbines	July 31, 2017
Commercial Operation	December 31, 2017

4. Scope of Customer's Work

IC will build a wind farm generating facility in Perquimans County, NC. The generating facility will be comprised of 91 Vestas 3.3MW wind turbines, two 51MVAR 34.5kV capacitor banks, and two 111MVA 230/34.5kV grounded wye – grounded wye generator step up transformers. The 230kV generator lead is 11.2 miles in length and will be 795 ACSR Drake.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new 230kV Perquimans switching station. This substation will be on the Winfall-Edenton Section of Line #2131. This project will involve looping existing line number 2131 in and out of the proposed Perquimans substation between existing structure number 122 and 123.

The islanding scheme has determined the need to include transfer trip equipment at a number of substations:

- Transfer trip transmitters will need to be installed in existing line panels at Winfall and Mackeys 230kV substations.
- A transfer trip transmitter will need to be installed at Earleys substation with a corresponding receiver at Trowbridge substation on the 2034 line.
- A transfer trip transmitter will need to be installed at Trowbridge substation with a corresponding receiver at Mackeys on the 2126 line.

All new transfer trip equipment can be installed in existing line panels. No work is required at the three distribution substations (South Hertford, Chowan, and Edenton) on the 2131 line nor is any work required at either of the distribution stations Plymouth and Cashie on the 2126 and 2034 lines respectively.

The single line is shown in Attachment 1 and the proposed layout of the transmission line loop and Perquimans Switching Station is shown in Attachment 2.

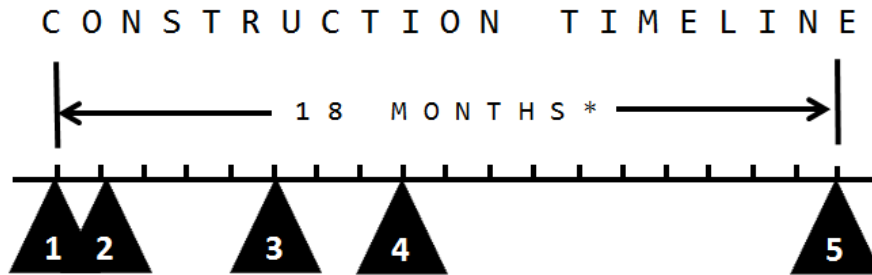
6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities	\$379,493	\$383,495	\$82,182	\$46,095	\$891,265
Total Attachment Facilities Cost	\$379,493	\$383,495	\$82,182	\$46,095	\$891,265
Perquimans Switching Station (n4265)	\$1,686,956	\$2,264,348	\$319,600	\$163,937	\$4,434,840
Loop Line #2131 into Perquimans Switching Station (n4476)	\$749,588	\$523,676	\$210,333	\$115,918	\$1,599,515
Winfall Substation (n4477)	\$11,193	\$11,657	\$3,030	\$1,673	\$27,553
Mackeys Substation (n4478)	\$17,599	\$23,122	\$4,903	\$3,318	\$48,942
Trowbridge Substation (n4557)	\$17,599	\$28,879	\$4,903	\$4,144	\$55,525
Earleys Substation (n4558)	\$11,193	\$18,557	\$3,030	\$2,664	\$35,444
Total Network Upgrades	\$2,494,128	\$2,870,238	\$545,799	\$291,654	\$6,201,819
Total Project Cost	\$2,873,621	\$3,253,733	\$627,981	\$337,749	\$7,093,084

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

These estimated project costs and time frame to construct are based on the IC providing the following:

- Suitable Access Road from Substation to a North Carolina State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Switching Station/Substation.



M I L E S T O N E S & A C T I V I T I E S

- 1 Latter Effective Date between the Interconnection Service Agreement and Interconnection Construction Service Agreement
- 2 Budgeting and Scoping
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 - B Detailed Schedule Development
 - C Budgetary Approval
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 - D Long Lead Time Material Ordered
- 5 Implementation Phase
 - A Site Development
 - B Facilities Constructed
 - C Test and Energize Facilities

* Contingency schedule duration is 30 months. Potential delays considered:
 budget approval (up to 1 month);
 land acquisition (up to 4 months);
 procurement (up to 1 month); and
 construction and test (up to 6 months)

B. Transmission Owner Facilities Study Results

1. Attachment Facilities – New

The attachment facilities include that portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities. The equipment associated with the Attachment Facilities includes the following. The work required is as follows:

1. One (1) 230kV, Light Duty Steel Backbone
2. One (1) 230kV, 3000A Vertical Break Switch.
3. Three (3) 230kV metering accuracy CCVT's.
4. Three (3) 230kV stand alone CT's.
5. Conductor, connectors, conduit, control cable, foundations, steel structures and grounding material as per engineering standards.

2. Transmission Line – Upgrades

PJM Upgrade n4476 – Loop Line #2131 into Perquimans Switching Station

This project will involve looping existing line number 2131 in and out of the proposed Perquimans substation between existing structure number 122 and 123. The estimate was completed with a maximum NESC heavy tension of 3500 lbs for the conductor and 1500 lbs for the shield wire in the spans to the backbones. Construction will include the following:

1. Install two 230kV single circuit double deadend steel poles with pipe pile foundations outside the proposed Perquimans substation to loop the line in and out of the proposed substation site. Transfer the existing conductor and shield wire to the poles.
2. Install two 230kV single circuit light-duty backbone structures with pipe pile foundations inside the proposed Perquimans substation.
3. Install one span (160') of single circuit 3-phase 1192.5 ACSR 45/7 conductor and two 3#6 alumoweld shield wires between the proposed steel pole and backbone. This will include the installation of dampers and risers.
4. Install one span (160') of single circuit 3-phase 1192.5 ACSR 45/7 conductor and two 3#6 alumoweld shield wires between the proposed steel pole and backbone. This will include the installation of dampers and risers.
5. Install three shield wire poles with pipe pile foundations inside the proposed substation.
6. Install five 3#6 alumoweld shield wire spans (approximately 816' total) between the proposed backbones and shield wire poles.
7. Renumber 121 structures and two backbones between Perquimans and Winfall.

3. New Substation/Switchyard Facilities

PJM Upgrade n4265 – Perquimans Switching Station

This project will involve building a new 230 kV Perquimans Switching Station on the Winfall-Edenton Section of Line #2131. These costs include ITO purchasing and installing the following:

1. Approximately 210' X 310' site preparation and grading as required for installation of the switching station.

2. Approximately 1040' of perimeter fence.
3. Two (2) 230 kV, Light Duty Steel Backbones.
4. Three (3) shield wire poles and five span of shield wire.
5. Three (3) 230 kV, 3000A, 63 kA SF6 Circuit Breakers.
6. Eight (8) 230 kV, 3000A, Center Break Gang Operated Switches.
7. Nine (9) 180 kV, Station Class Arresters.
8. Nine (9) 230 kV CCVTs, Relay Accuracy.
9. Two (2), 230 kV, 3000 Amps Waves Trap and Line Tuners.
10. One (1) 24' X 40' Control Enclosure.
11. One (1) 125 VDC, 150 AH Station Battery.
12. One (1) 125 VDC, 25 A Battery Charger.
13. Cable Trough, concrete w/cover, 2' 6'' wide, approximately 100 FT.
14. Four (4) Station Service Transformers, 100 KVA.
15. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports.
16. Foundations as required including control house, equipment and bus support stands.
17. Install conduit, control cable, cable trough, conductor, connectors and grounding as per engineering standards.
18. One (1), Dual SEL 587Z Bus Pnl
19. One (1), Bus CT MU Box
20. Three (3), 3 PH CCVT MU Box (2-Line, 1-Bus)
21. Three (3), SEL-351 Breaker Panels w/ reclosing
22. Three (3), SEL-2411 Breaker Annunciators
23. Two (2), Dual SEL-421 Line Panel
24. One (1), Metering Panel
25. One (1), Metering CT MU Box
26. One (1), Metering 3 PH CCVT Pot. MU Box
27. Two (2) 800A Power Pot Disconnect Switches
28. Two (2) Station Service Potential MU Boxes
29. Two (2) 800A Station Service AC Distributional Panels
30. One (1) 225A Outdoor AC Transmission AC NQOD
31. Three (3) 225A, 3PH Throwover Switches
32. One (1) Station Ambient Temperature Monitor
33. One (1) Wall Mounted Battery Monitor
34. One (1) SEL-3354 Comm Panel
35. One (1) ASE SAM-900 Station Annunciator
36. One (1) SEL-2411 RTU
37. One (1), Station Fiber Management Panel
38. Three (3), CB Fiber MU Box
39. One (1) Digital Fault Recorder (Single Cab., 32 channels)
40. One (1) Power Quality Meter - Rack
41. One (1) Network Rack
42. One (1) Telecomm Fiber Rack (Misc.) – for Telecomm F/O Patch Panels
43. One (1) Security Rack
44. One (1) Transmission Islanding Panel

45. One (1) Indoor AC NQOD
46. One (1), Customer Interface Box
47. One (1) Telecommunications Network
48. One (1) High Voltage Protection
49. One (1) High Dielectric Cable
50. One (1) Telephone interface Box

4. Upgrades to Substation / Switchyard Facilities

PJM Upgrade n4477 – Winfall 230 kV Substation

1. Purchase and install transfer trip transmitter to existing line panel

PJM Upgrade n4478 – Mackeys 230 kV Substation

1. Purchase and install transfer trip transmitter to existing line panel
2. Purchase and install a transfer trip receiver to existing line panel

PJM Upgrade n4557 – Trowbridge 230 kV Substation

1. Purchase and install transfer trip transmitter (Trench) to existing line panel
2. Purchase and install a transfer trip receiver (UPLC) to existing line panel

PJM Upgrade n4558 – Earleys 230 kV Substation

1. Purchase and install transfer trip transmitter (UPLC) to existing line panel

5. Metering & Communications

PJM Requirements

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

ITO Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

6. Environmental, Real Estate and Permitting Issues

The ITO plans to acquire the necessary Rail Road Crossing permits. These take time and as the ITO has established relationships that should aid in acquiring these permits. The IC may opt to acquire the Rail Road Crossing permits if desired.

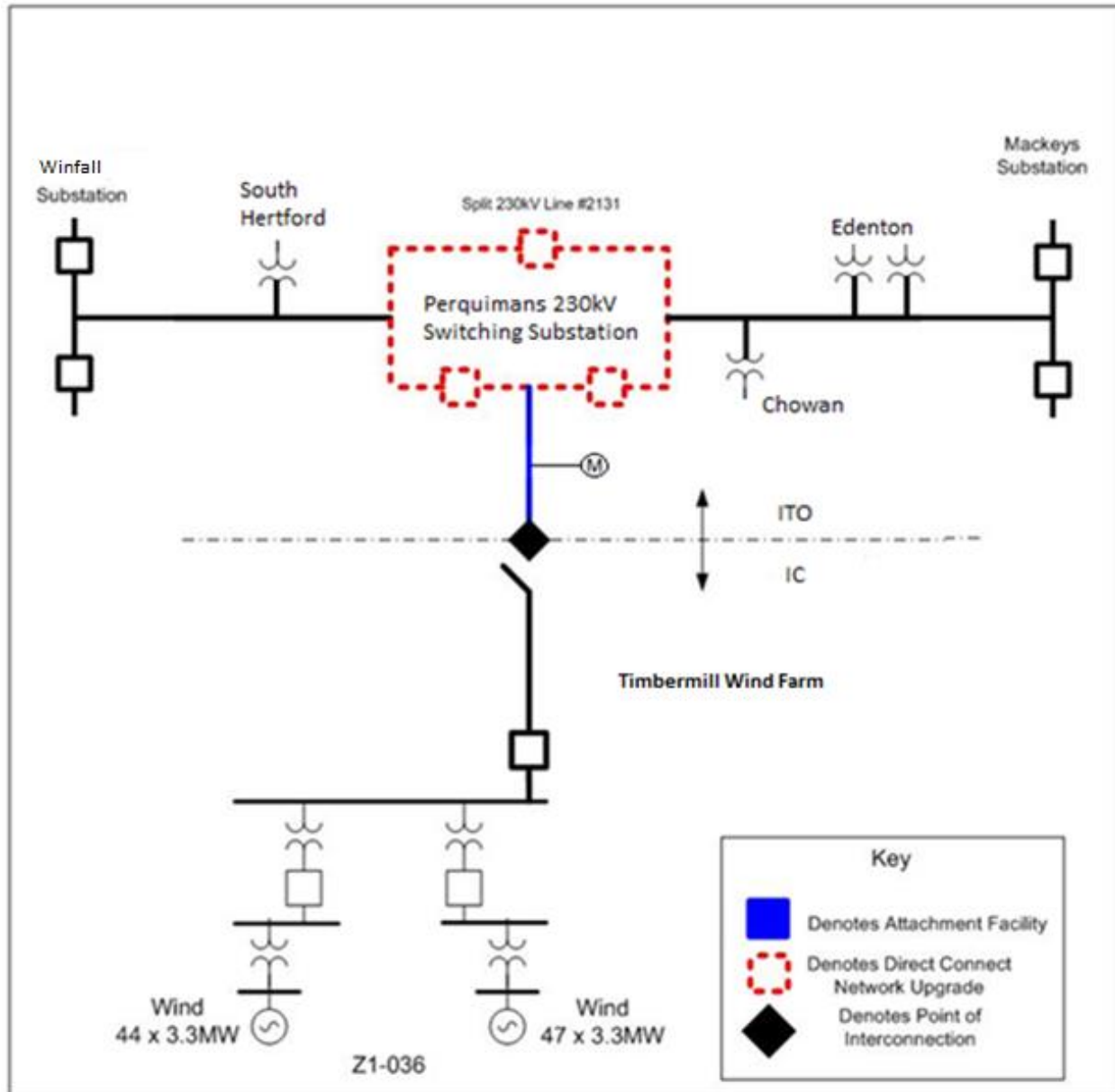
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a North Carolina State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.

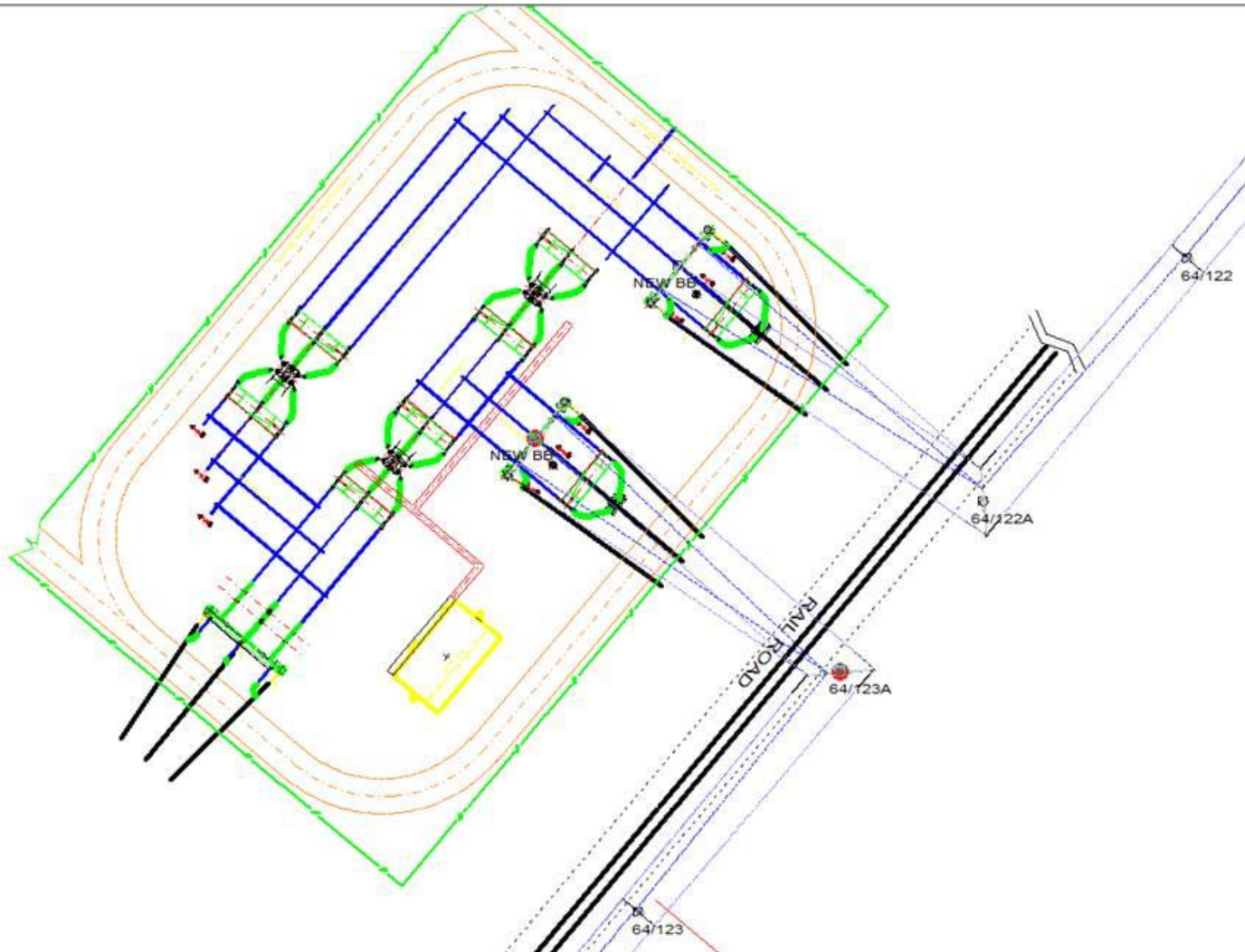
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.
- ITO would prefer to own the Substation in fee simple but would accept a perpetual easement.

The expected substation property would be 320' x 320'.

Attachment 1. Z1-036
One line Diagram



Attachment 2.
Perquimans Layout



Attachment 3.

Stability and Low Voltage Ride Through (LVRT) Study Report

Introduction

The stability analysis and LVRT study for the interconnection project Z1-036 was performed at 2017 light load as well as 2017 summer peak conditions required by ITO Planning Criteria. The maximum generation output (155.1+145.2) 300.3 MW was considered for the queue project under study.

For the summer peak case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -45.8 Mvar to 0.69 kV collection buses and collection bus voltage at 1.037 p.u. The 230 kV POI bus was maintained at 1.025 p.u.

For the light Load case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -16.0 Mvar to 0.69 kV collection buses and collection bus voltage at 1.043 p.u. The 230 kV POI bus was maintained at 1.014 p.u.

The range of contingencies evaluated was limited to that necessary to assess expected compliance with ITO and PJM criteria. The simulation time period was 20 seconds for each contingency.

This study involves transient simulations of approximately 31 contingencies that include:

- (a) 3-phase faults with normal clearing
- (b) Single line to ground (SLG) for delayed clearing time due to stuck breaker condition
- (c) Single line to ground (SLG) for delayed clearing time due to protection failure

The simulation time period was 20 seconds for each contingency.

Results

	Project Z1-036			
	2017 SP Case		2017 LL case	
	G1	G2	G1	G2
Gross power output (MW) @ 0.69 kV bus	155.1	145.2	155.1	145.2
Reactive power output (Mvars) @ 0.69 kV bus	-22.9	-22.9	-8.0	-8.0
Net real power injection @ 0.69 kV bus	300.3 MW, 45.8 Mvar		300.3 MW, -16.0 Mvar	
Net real power injection @ 230 kV bus	296.1 MW, -3.6 Mvar		296.1 MW, -33.4 Mvar	
Total Auxiliary load	0 MW, 0 Mvar			

All facilities in service:

1. Low Voltage Ride Through: For the cases studied, the Z1-036 queue project rides through faults shown in Appendix A thus meeting the LVRT test specified in FERC order 661 and 661A.

2. Voltage Recovery: For all cases studied, the Z1-036 queue Project recovers to an acceptable steady state voltage within 20 seconds.
3. Transient Stability: For all cases studied, transient stability is maintained with all oscillations stabilized in less than 20 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance.

Note: While the stability analysis has been performed at 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 may 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 plant specific dynamic data for the plant and its controls are available, it must be forwarded to PJM. 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. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

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Point of Interconnection

Z1-036 will interconnect with the ITO transmission system via a new three breaker ring bus switching station (Perquimans) that connects to the Windfall – Mackey’s 230kV line.

Cost Summary

The Z1-036 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 631,333
Direct Connection Network Upgrades	\$4,696,495
Non Direct Connection Network Upgrades	\$1,855,247
Allocation for New System Upgrades	\$ 0
Contribution for Previously Identified Upgrades	\$ 0
Total Cost	\$7,183,075

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

None, for more details see Attachment 3.

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(Study to determine that the Transmission System is capable of delivering the system generating capacity at light load)

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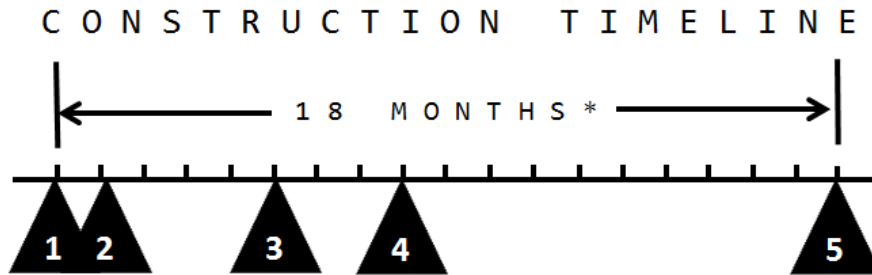
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Total Attachment Facilities Cost	\$276,326	\$252,999	\$72,065	\$29,943	\$631,333
Perquimans Switching Station (n4265)	\$1,686,956	\$2,264,348	\$437,986	\$307,205	\$4,696,495
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Trowbridge Substation (n4557)	\$17,599	\$28,279	\$5,899	\$5,608	\$57,985
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Total Network Upgrades	\$2,560,591	\$2,855,650	\$688,002	\$447,499	\$6,551,742
Total Project Cost	\$2,836,917	\$3,108,649	\$760,067	\$477,442	\$7,183,075

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

These estimated project costs and time frame to construct are based on the IC providing the following:

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7. Renumber 121 structures and two backbones between Perquimans and Winfall.

3. New Substation/Switchyard Facilities

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4. Three (3) shield wire poles and five span of shield wire.
5. Three (3) 230 kV, 3000A, 63 kA SF6 Circuit Breakers.
6. Eight (8) 230 kV, 3000A, Center Break Gang Operated Switches.
7. Nine (9) 180 kV, Station Class Arresters.
8. Nine (9) 230 kV CCVTs, Relay Accuracy.
9. Two (2), 230 kV, 3000 Amps Waves Trap and Line Tuners.
10. One (1) 24' X 40' Control Enclosure.
11. One (1) 125 VDC, 150 AH Station Battery.
12. One (1) 125 VDC, 25 A Battery Charger.
13. Cable Trough, concrete w/cover, 2' 6'' wide, approximately 100 FT.
14. Four (4) Station Service Transformers, 100 KVA.
15. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports.
16. Foundations as required including control house, equipment and bus support stands.
17. Install conduit, control cable, cable trough, conductor, connectors and grounding as per engineering standards.
18. One (1), Dual SEL 587Z Bus Pnl
19. One (1), Bus CT MU Box
20. Three (3), 3 PH CCVT MU Box (2-Line, 1-Bus)
21. Three (3), SEL-351 Breaker Panels w/ reclosing
22. Three (3), SEL-2411 Breaker Annunciators
23. Two (2), Dual SEL-421 Line Panel
24. One (1), Metering Panel
25. One (1), Metering CT MU Box
26. One (1), Metering 3 PH CCVT Pot. MU Box
27. Two (2) 800A Power Pot Disconnect Switches
28. Two (2) Station Service Potential MU Boxes
29. Two (2) 800A Station Service AC Distributional Panels
30. One (1) 225A Outdoor AC Transmission AC NQOD
31. Three (3) 225A, 3PH Throwover Switches
32. One (1) Station Ambient Temperature Monitor
33. One (1) Wall Mounted Battery Monitor
34. One (1) SEL-3354 Comm Panel
35. One (1) ASE SAM-900 Station Annunciator
36. One (1) SEL-2411 RTU
37. One (1), Station Fiber Management Panel
38. Three (3), CB Fiber MU Box
39. One (1) Digital Fault Recorder (Single Cab., 32 channels)
40. One (1) Power Quality Meter - Rack
41. One (1) Network Rack
42. One (1) Telecomm Fiber Rack (Misc.) – for Telecomm F/O Patch Panels
43. One (1) Security Rack
44. One (1) Transmission Islanding Panel

45. One (1) Indoor AC NQOD
46. One (1), Customer Interface Box
47. One (1) Telecommunications Network
48. One (1) High Voltage Protection
49. One (1) High Dielectric Cable
50. One (1) Telephone interface Box

4. Upgrades to Substation / Switchyard Facilities

PJM Upgrade n4477 – Winfall 230 kV Substation

1. Purchase and install transfer trip transmitter to existing line panel

PJM Upgrade n4478 – Mackeys 230 kV Substation

1. Purchase and install transfer trip transmitter to existing line panel
2. Purchase and install a transfer trip receiver to existing line panel

PJM Upgrade n4557 – Trowbridge 230 kV Substation

1. Purchase and install transfer trip transmitter (Trench) to existing line panel
2. Purchase and install a transfer trip receiver (UPLC) to existing line panel

PJM Upgrade n4558 – Earleys 230 kV Substation

1. Purchase and install transfer trip transmitter (UPLC) to existing line panel

5. Metering & Communications

PJM Requirements

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

ITO Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

6. Environmental, Real Estate and Permitting Issues

The ITO plans to acquire the necessary Rail Road Crossing permits. These take time and as the ITO has established relationships that should aid in acquiring these permits. The IC may opt to acquire the Rail Road Crossing permits if desired.

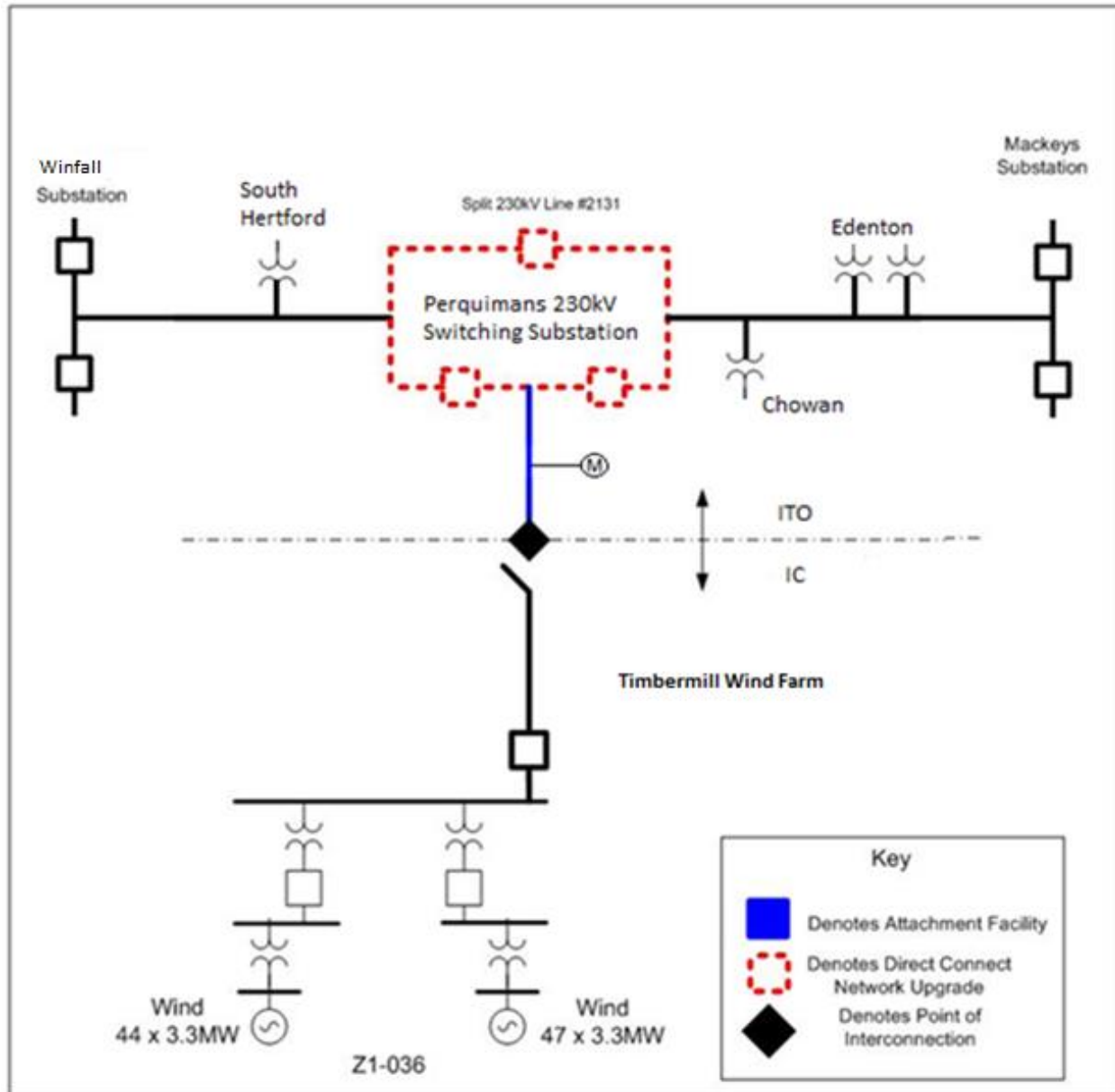
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a North Carolina State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.

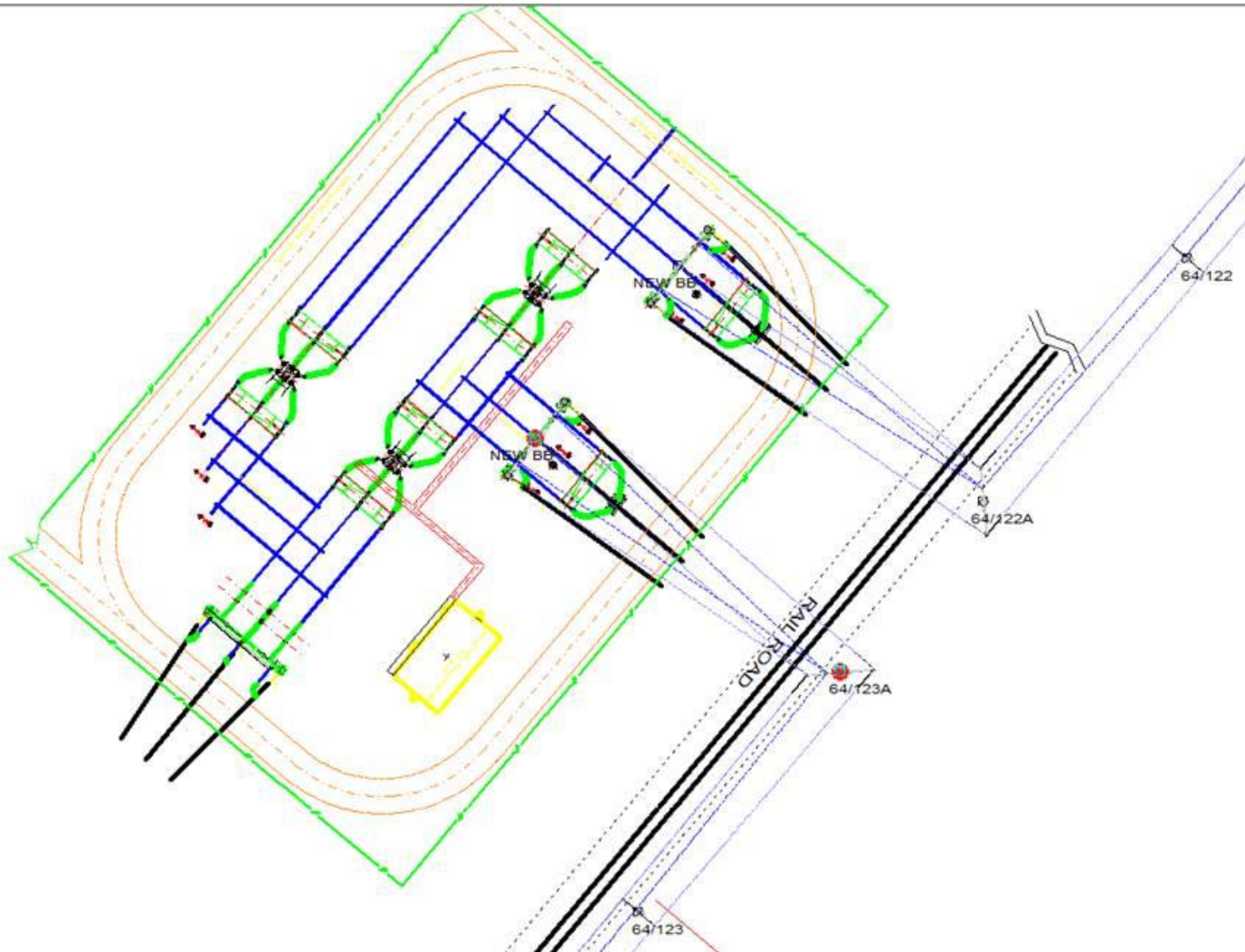
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.
- ITO would prefer to own the Substation in fee simple but would accept a perpetual easement.

The expected substation property would be 320' x 320'.

Attachment 1. Z1-036
One line Diagram



Attachment 2.
Perquimans Layout



Attachment 3.

Stability and Low Voltage Ride Through (LVRT) Study Report

Introduction

The stability analysis and LVRT study for the interconnection project Z1-036 was performed at 2017 light load as well as 2017 summer peak conditions required by ITO Planning Criteria. The maximum generation output (155.1+145.2) 300.3 MW was considered for the queue project under study.

For the summer peak case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -45.8 Mvar to 0.69 kV collection buses and collection bus voltage at 1.037 p.u. The 230 kV POI bus was maintained at 1.025 p.u.

For the light Load case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -16.0 Mvar to 0.69 kV collection buses and collection bus voltage at 1.043 p.u. The 230 kV POI bus was maintained at 1.014 p.u.

The range of contingencies evaluated was limited to that necessary to assess expected compliance with ITO and PJM criteria. The simulation time period was 20 seconds for each contingency.

This study involves transient simulations of approximately 31 contingencies that include:

- (a) 3-phase faults with normal clearing
- (b) Single line to ground (SLG) for delayed clearing time due to stuck breaker condition
- (c) Single line to ground (SLG) for delayed clearing time due to protection failure

The simulation time period was 20 seconds for each contingency.

Results

	Project Z1-036			
	2017 SP Case		2017 LL case	
	G1	G2	G1	G2
Gross power output (MW) @ 0.69 kV bus	155.1	145.2	155.1	145.2
Reactive power output (Mvars) @ 0.69 kV bus	-22.9	-22.9	-8.0	-8.0
Net real power injection @ 0.69 kV bus	300.3 MW, 45.8 Mvar		300.3 MW, -16.0 Mvar	
Net real power injection @ 230 kV bus	296.1 MW, -3.6 Mvar		296.1 MW, -33.4 Mvar	
Total Auxiliary load	0 MW, 0 Mvar			

All facilities in service:

1. Low Voltage Ride Through: For the cases studied, the Z1-036 queue project rides through faults shown in Appendix A thus meeting the LVRT test specified in FERC order 661 and 661A.

2. Voltage Recovery: For all cases studied, the Z1-036 queue Project recovers to an acceptable steady state voltage within 20 seconds.
3. Transient Stability: For all cases studied, transient stability is maintained with all oscillations stabilized in less than 20 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance.

Note: While the stability analysis has been performed at 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 may 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 plant specific dynamic data for the plant and its controls are available, it must be forwarded to PJM. 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. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

***Generation Interconnection
Facility Study Report***

For

***PJM Generation Interconnection Request
Queue Position Z1-036***

***Winfall – Mackeys 230kV
39MW Capacity / 300.3MW Energy***

April / 2015

Introduction

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

General

IC has proposed a wind generating facility located in Perquimans County, NC. The installed facilities will have a total capability of 300.3 MW with 39 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June, 1, 2016. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

Z1-036 will interconnect with the ITO transmission system via a new three breaker ring bus switching station (Perquimans) that connects to the Windfall – Mackey’s 230kV line.

Cost Summary

The Z1-036 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	\$ 565,382
Direct Connection Network Upgrades	\$4,696,495
Non Direct Connection Network Upgrades	\$1,737,912
Allocation for New System Upgrades	\$ 0
Contribution for Previously Identified Upgrades	\$ 0
Total Cost	\$6,999,789

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue Z1-036 is a request to interconnect 300.3 MW (Capacity 39 MW) of energy from a new wind facility to be located on the Winfall to Mackeys line #2131 between the distribution substations, South Herford and Chowan. The new 230 kV substation is called Perquimans which is physically located near the Town of Edenton, North Carolina. The requested in-service date is June 2016. Attachment Facility and Direct Connection Network upgrade construction is estimated to be 18 months from the latter Effective Date of the Interconnection Service Agreement and Interconnection Construction Service Agreement. Facilities may require local zoning approval. Site plan was developed between the IC and ITO during IC Certificate of Public Convenience and Necessity (a/k/a CPCN) process with the North Carolina Public Utility Commission.

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

The Queue Project Z1-036 was studied as a 300.3 MW (Capacity 39.0 MW) injection tapping the Edenton – South Hertford 230 kV line in the ITO area. Project Z1-036 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners) for summer peak conditions in 2017. Project Z1-036 was studied with a commercial probability of 100%.

Light Load and Stability Analysis were deferred to the Facilities Study.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

Normal ITO criteria will allow for steady-state voltage on the transmission system under normal and contingency conditions to vary between 0.9 pu and 1.05 pu. Generators connected to the 230 kV System are usually expected to maintain a voltage schedule as defined in PJM Manual 03 “Transmission Operations”.

Stability and Reactive Power Requirement for Low Voltage Ride Through

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

None, for more details see Attachment 3.

Light Load Analysis

(Study to determine that the Transmission System is capable of delivering the system generating capacity at light load)

None

3. Interconnection Customer’s Submitted Milestone Schedule

Description	Schedule
Permits	December 31, 2016
Substantial site work complete	June 1, 2017
Delivery of wind turbines	July 31, 2017
Commercial Operation	December 31, 2017

4. Scope of Customer's Work

IC will build a wind farm generating facility in Perquimans County, NC. The generating facility will be comprised of 91 Vestas 3.3MW wind turbines, two 51MVAR 34.5kV capacitor banks, and two 111MVA 230/34.5kV grounded wye – grounded wye generator step up transformers. The 230kV generator lead is 11.2 miles in length and will be 795 ACSR Drake.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new 230kV Perquimans switching station. This substation will be on the Winfall-Edenton Section of Line #2131. This project will involve looping existing line number 2131 in and out of the proposed Perquimans substation between existing structure number 122 and 123. Transfer trip transmitters will need to be installed in existing line panels at Winfall and Mackeys 230kV substations. No work is required at the three distribution substations (South Hertford, Chowan, and Edenton) on this line. The single line is shown in Attachment 1 and the proposed layout of the transmission line loop and Perquimans Switching Station is shown in Attachment 2.

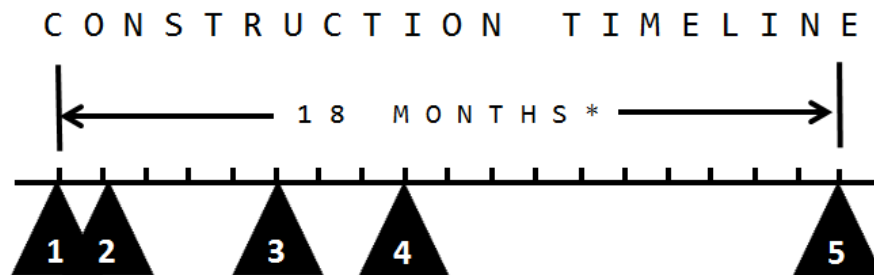
6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Attachment Facilities	\$242,800	\$228,127	\$62,653	\$31,802	\$565,382
Total Attachment Facilities Cost	\$242,800	\$228,127	\$62,653	\$31,802	\$565,382
Perquimans Switching Station (n4265)	\$1,686,956	\$2,264,348	\$437,986	\$307,205	\$4,696,495
Loop Line #2131 into Perquimans Switching Station (n4476)	\$816,052	\$509,087	\$230,897	\$124,330	\$1,680,366
Winfall Substation (n4477)	\$11,192	\$11,657	\$3,661	\$2,263	\$28,773
Mackeys Substation (n4478)	\$11,192	\$11,657	\$3,661	\$2,263	\$28,773
Total Network Upgrades	\$2,525,392	\$2,796,749	\$676,205	\$436,061	\$6,434,407
Total Project Cost	\$2,768,192	\$3,024,876	\$738,858	\$467,863	\$6,999,789

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

These estimated project costs and time frame to construct are based on the IC providing the following:

- Suitable Access Road from Substation to a North Carolina State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Switching Station/Substation.



M I L E S T O N E S & A C T I V I T I E S

- 1 Latter Effective Date between the Interconnection Service Agreement and Interconnection Construction Service Agreement
- 2 Budgeting and Scoping
 - A Project Team Kick-off Meeting
 - B Detailed Schedule Development
 - C Budgetary Approval
- 3 Permitting and Land Acquisition
 - A Local Approvals
 - B Community Meetings
 - C Land Acquisition
 - D Site Plans
- 4 Engineering Design
 - A Detailed Engineering
 - B Outage Scheduling
 - C Bill Materials
 - D Long Lead Time Material Ordered
- 5 Implementation Phase
 - A Site Development
 - B Facilities Constructed
 - C Test and Energize Facilities

* Contingency schedule duration is 30 months. Potential delays considered:
budget approval (up to 1 month);
land acquisition (up to 4 months);
procurement (up to 1 month); and
construction and test (up to 6 months)

B. Transmission Owner Facilities Study Results

1. Attachment Facilities – New

The attachment facilities include that portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities. The equipment associated with the Attachment Facilities includes the following. The work required is as follows:

1. One (1) 230kV, 3000A Vertical Break Switch.
2. Three (3) 230kV metering accuracy CCVT's.
3. Three (3) 230kV stand alone CT's.
4. Conductor, connectors, conduit, control cable, foundations, steel structures and grounding material as per engineering standards.

2. Transmission Line – Upgrades

PJM Upgrade n4476 – Loop Line #2131 into Perquimans Switching Station

This project will involve looping existing line number 2131 in and out of the proposed Perquimans substation between existing structure number 122 and 123. The estimate was completed with a maximum NESC heavy tension of 3500 lbs for the conductor and 1500 lbs for the shield wire in the spans to the backbones. Construction will include the following:

1. Install two 230kV single circuit double deadend steel poles with pipe pile foundations outside the proposed Perquimans substation to loop the line in and out of the proposed substation site. Transfer the existing conductor and shield wire to the poles.
2. Install two 230kV single circuit light-duty backbone structures with pipe pile foundations inside the proposed Perquimans substation.
3. Install one span (160') of single circuit 3-phase 1192.5 ACSR 45/7 conductor and two 3#6 alumoweld shield wires between the proposed steel pole and backbone. This will include the installation of dampers and risers.
4. Install one span (160') of single circuit 3-phase 1192.5 ACSR 45/7 conductor and two 3#6 alumoweld shield wires between the proposed steel pole and backbone. This will include the installation of dampers and risers.
5. Install three shield wire poles with pipe pile foundations inside the proposed substation.
6. Install five 3#6 alumoweld shield wire spans (approximately 816' total) between the proposed backbones and shield wire poles.
7. Renumber 121 structures and two backbones between Perquimans and Winfall.

3. New Substation/Switchyard Facilities

PJM Upgrade n4265 – Perquimans Switching Station

This project will involve building a new 230 kV Perquimans Switching Station on the Winfall-Edenton Section of Line #2131. These costs include ITO purchasing and installing the following:

1. Approximately 210' X 310' site preparation and grading as required for installation of the switching station.
2. Approximately 1040' of perimeter fence.

3. Two (2) 230 kV, Light Duty Steel Backbones.
4. Three (3) shield wire poles and five span of shield wire.
5. Three (3) 230 kV, 3000A, 63 kA SF6 Circuit Breakers.
6. Eight (8) 230 kV, 3000A, Center Break Gang Operated Switches.
7. Nine (9) 180 kV, Station Class Arresters.
8. Nine (9) 230 kV CCVTs, Relay Accuracy.
9. Two (2), 230 kV, 3000 Amps Waves Trap and Line Tuners.
10. One (1) 24' X 40' Control Enclosure.
11. One (1) 125 VDC, 150 AH Station Battery.
12. One (1) 125 VDC, 25 A Battery Charger.
13. Cable Trough, concrete w/cover, 2' 6'' wide, approximately 100 FT.
14. Four (4) Station Service Transformers, 100 KVA.
15. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports.
16. Foundations as required including control house, equipment and bus support stands.
17. Install conduit, control cable, cable trough, conductor, connectors and grounding as per engineering standards.
18. One (1), Dual SEL 587Z Bus Pnl
19. One (1), Bus CT MU Box
20. Three (3), 3 PH CCVT MU Box (2-Line, 1-Bus)
21. Three (3), SEL-351 Breaker Panels w/ reclosing
22. Three (3), SEL-2411 Breaker Annunciators
23. Two (2), Dual SEL-421 Line Panel
24. One (1), Metering Panel
25. One (1), Metering CT MU Box
26. One (1), Metering 3 PH CCVT Pot. MU Box
27. Two (2) 800A Power Pot Disconnect Switches
28. Two (2) Station Service Potential MU Boxes
29. Two (2) 800A Station Service AC Distributional Panels
30. One (1) 225A Outdoor AC Transmission AC NQOD
31. Three (3) 225A, 3PH Throwover Switches
32. One (1) Station Ambient Temperature Monitor
33. One (1) Wall Mounted Battery Monitor
34. One (1) SEL-3354 Comm Panel
35. One (1) ASE SAM-900 Station Annunciator
36. One (1) SEL-2411 RTU
37. One (1), Station Fiber Management Panel
38. Three (3), CB Fiber MU Box
39. One (1) Digital Fault Recorder (Single Cab., 32 channels)
40. One (1) Power Quality Meter - Rack
41. One (1) Network Rack
42. One (1) Telecomm Fiber Rack (Misc.) – for Telecomm F/O Patch Panels
43. One (1) Security Rack
44. One (1) Transmission Islanding Panel
45. One (1) Indoor AC NQOD

- 46. One (1), Customer Interface Box
- 47. One (1) Telecommunications Network
- 48. One (1) High Voltage Protection
- 49. One (1) High Dielectric Cable
- 50. One (1) Telephone interface Box

4. Upgrades to Substation / Switchyard Facilities

PJM Upgrade n4477 – Winfall 230 kV Substation

- 1. Purchase and install transfer trip transmitter to existing line panel

PJM Upgrade n4478 – Mackeys 230 kV Substation

- 1. Purchase and install transfer trip transmitter to existing line panel

5. Metering & Communications

PJM Requirements

The IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

ITO Requirements

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at www.dom.com.

6. Environmental, Real Estate and Permitting Issues

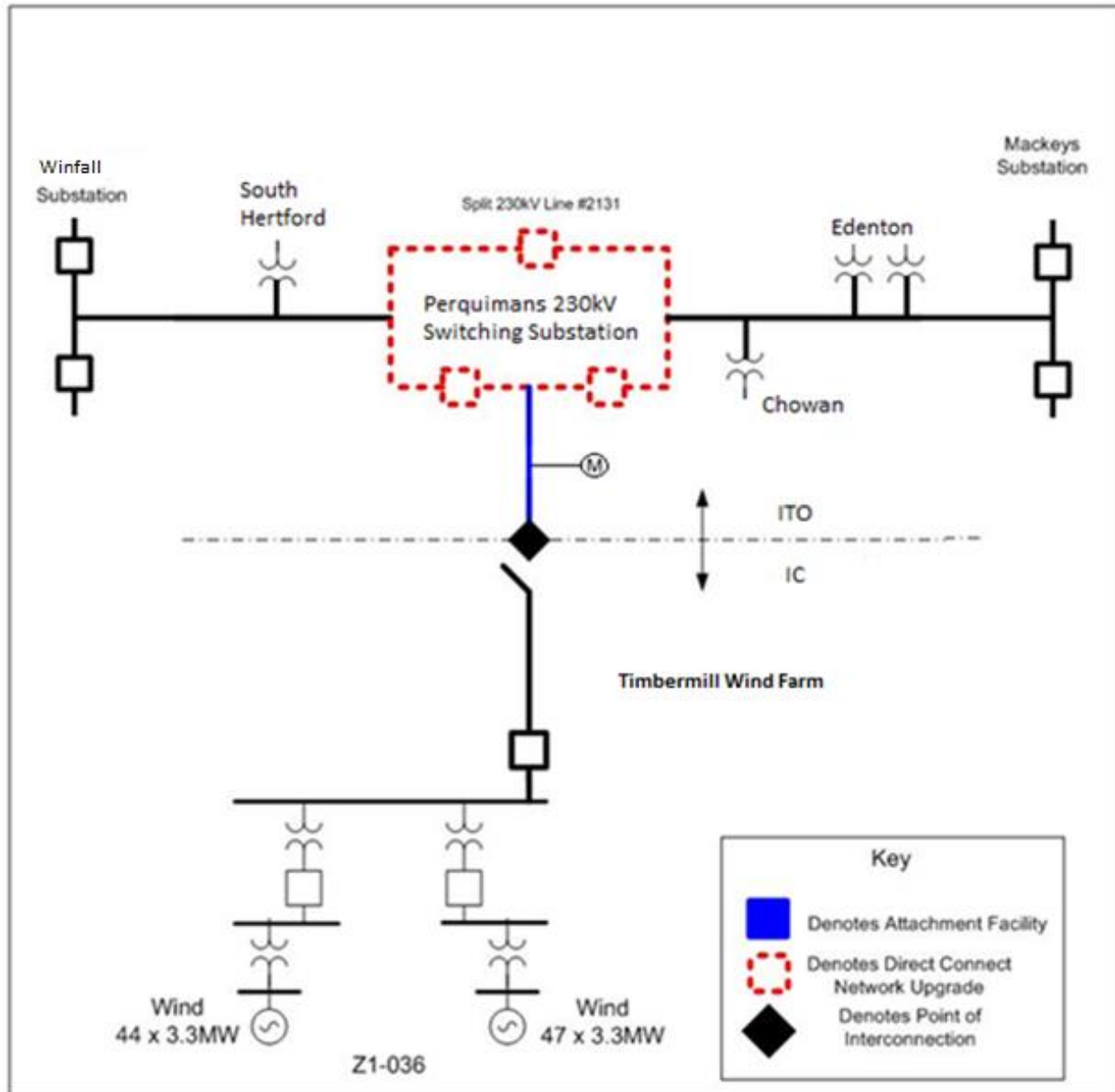
The ITO plans to acquire the necessary Rail Road Crossing permits. These take time and as the ITO has established relationships that should aid in acquiring these permits. The IC may opt to acquire the Rail Road Crossing permits if desired.

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

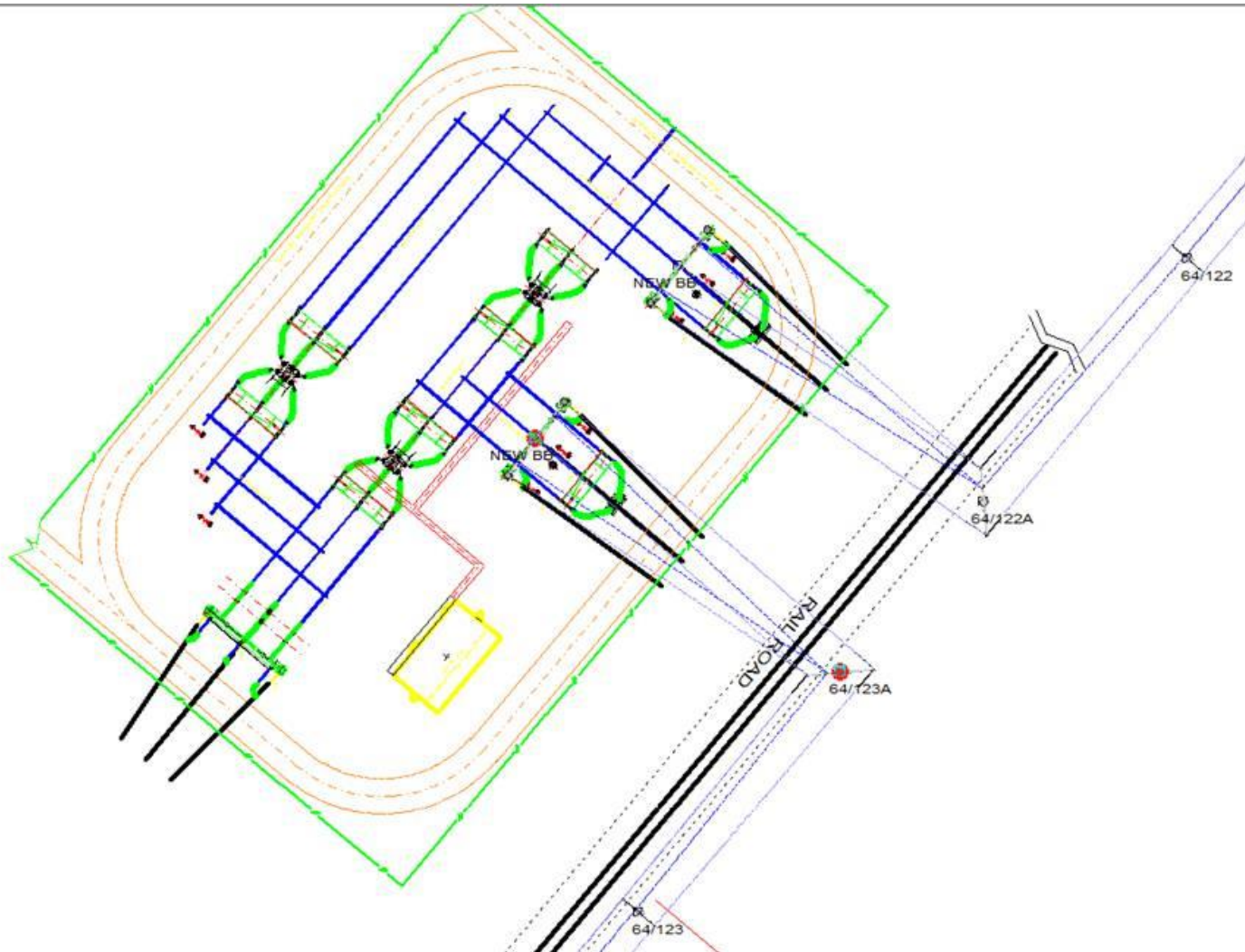
- Suitable Access Road from Substation to a North Carolina State Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.
- ITO would prefer to own the Substation in fee simple but would accept a perpetual easement.

The expected substation property would be 320' x 320'.

Attachment 1. Z1-036
One line Diagram



Attachment 2.
Perquimans Layout



Attachment 3.

Stability and Low Voltage Ride Through (LVRT) Study Report

Introduction

The stability analysis and LVRT study for the interconnection project Z1-036 was performed at 2017 light load as well as 2017 summer peak conditions required by ITO Planning Criteria. The maximum generation output (155.1+145.2) 300.3 MW was considered for the queue project under study.

For the summer peak case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -45.8 Mvar to 0.69 kV collection buses and collection bus voltage at 1.037 p.u. The 230 kV POI bus was maintained at 1.025 p.u.

For the light Load case, throughout the study, the Z1-036 wind turbines plant had an initial net output of 300.3 MW, -16.0 Mvar to 0.69 kV collection buses and collection bus voltage at 1.043 p.u. The 230 kV POI bus was maintained at 1.014 p.u.

The range of contingencies evaluated was limited to that necessary to assess expected compliance with ITO and PJM criteria. The simulation time period was 20 seconds for each contingency.

This study involves transient simulations of approximately 31 contingencies that include:

- (a) 3-phase faults with normal clearing
- (b) Single line to ground (SLG) for delayed clearing time due to stuck breaker condition
- (c) Single line to ground (SLG) for delayed clearing time due to protection failure

The simulation time period was 20 seconds for each contingency.

Results

	Project Z1-036			
	2017 SP Case		2017 LL case	
	G1	G2	G1	G2
Gross power output (MW) @ 0.69 kV bus	155.1	145.2	155.1	145.2
Reactive power output (Mvars) @ 0.69 kV bus	-22.9	-22.9	-8.0	-8.0
Net real power injection @ 0.69 kV bus	300.3 MW, 45.8 Mvar		300.3 MW, -16.0 Mvar	
Net real power injection @ 230 kV bus	296.1 MW, -3.6 Mvar		296.1 MW, -33.4 Mvar	
Total Auxiliary load	0 MW, 0 Mvar			

All facilities in service:

1. Low Voltage Ride Through: For the cases studied, the Z1-036 queue project rides through faults shown in Appendix A thus meeting the LVRT test specified in FERC order 661 and 661A.

2. Voltage Recovery: For all cases studied, the Z1-036 queue Project recovers to an acceptable steady state voltage within 20 seconds.
3. Transient Stability: For all cases studied, transient stability is maintained with all oscillations stabilized in less than 20 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance.

Note: While the stability analysis has been performed at 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 may 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 plant specific dynamic data for the plant and its controls are available, it must be forwarded to PJM. 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. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.