PJM Generator Interconnection Request Queue #R49 Haviland-Milan(Ohio West Wind) 138kV Impact Study

(Revised per R Queue Retool and Horizon Choice of Option to Build the Interconnection Station)

539216
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V2 August 2010

R49 Haviland-Milan 138kV Impact Study Report

General

Horizon Wind Energy, LLC (Horizon) proposes to install a 150 MW generating facility comprised of 83-1.8 MW wind turbine generators connecting to the American Electric Power (AEP) Haviland - Milan 138 kV circuit. This project is number R49 in the PJM Generator Interconnection queue. The proposed location of the generating facilities and switching station is approximately four miles south of Payne, OH (See Exhibit 1). The projected in-service date is scheduled for June 1, 2011 for 99MW and October 31, 2011 for 50.4MW.

Attachment Facilities

The proposed generation project will be connected to the AEP Haviland - Milan 138 kV circuit via a new in-line switching station. The new station will consist of three (3) 138 kV circuit breakers configured in a ring-bus arrangement with 138 kV metering (See Exhibit 2). AEP will retain ownership of the proposed in-line station facilities. In addition, remote terminal relaying will need to be upgraded to coordinate with the new relays to be installed at the new station. It is understood that Horizon will be responsible for the all costs associated with this construction, as well as facilities associated with connecting their 150 MW generation to the in-line facilities.

It is expected that any right-of-way for line extensions, as well as a 250' x 250' (minimum) station site will be provided to AEP by Horizon. Note that the Horizon station facilities and any facilities outside the new station were not included in the cost estimate. These are assumed to be Horizon's responsibility.

The AEP construction scope includes:

Horizon Wind Energy, LLC has chosen the "Option to Build" for the R49 interconnection station.

- Provide inspection and oversite services for the new switching station connecting to the Haviland - Milan 138 kV circuit between Haviland and Tillman stations, including three (3) 138 kV circuit breakers, relays, 138 kV metering, SCADA, and associated equipment. (Network Upgrade #n1222)

  PJM estimated cost: $400,000

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Milan station. (Network Upgrade #n1223)

  Estimated Cost (2009 Dollars): **$682,500**

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Haviland station. (Network Upgrade #n1224)

  Estimated Cost (2009 Dollars): **$721,000**

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Tillman station. (Network Upgrade #n1225)

  Estimated Cost (2009 Dollars): **$370,100**

- Cut-in and terminate the Haviland-Tillman 138kV circuit in the new interconnection station for the R49 project. (Network Upgrade #n2041)

  Estimated Cost: $600,000

Total Attachment Facilities Cost*: **$2,773,600**

*The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately fourteen (14) to eighteen (18) months after obtaining an executed ISA and CSA to construct the facilities as outlined above.

Local Impacts

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet single contingency performance criteria in accordance with the AEP FERC Form 715. Therefore, this criterion was used to assess the impact of the proposed facility on the AEP System. The Horizon project was studied as a 150 MW net capacity consistent with the interconnection application. The results are summarized below.

Normal System (2009 Summer Conditions)

- No problems identified.

Single Contingency (2009 Summer Conditions)

- Outage of the Haviland - R49 Ohio West 138 kV circuit overloads the Tillman 138/34.5 kV transformer to 101% of its summer rating.

Short Circuit Analysis

- No problems identified.

Stability Analysis

- Instability occurs for an outage of the Robison Park - R49 and East Lima – Haviland 138 kV lines (double-contingency scenario). In this scenario, both 138 kV outlets are outaged, and R49 is connected only to the underlying 69 kV network via the Haviland 138/69 kV Station. **Generation curtailment will be required following the first contingency (loss of either the Robison Park – R49 or East Lima – Haviland 138 kV circuit).**

Local Upgrades

To maintain appropriate levels of reliability and mitigate the single contingency problems resulting from the additional generation identified in this study, the following system improvements are required:

- To alleviate the overload on the Tillman 138/34.5kV transformer the existing transformer will be replaced with a 30 MVA unit that will require installation of a high-side circuit switcher and associated equipment. (Network Upgrade #n1226)

  Estimated Cost (2009 Dollars): **$1,856,600***

*The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately one year after obtaining the authorization to construct the facilities as outlined above.

Reactive Requirements

PJM requires a power factor correction to 95 lead-0.99 lag at the point of interconnection for wind generating facilities. It is expected that Horizon will adhere to this standard.

Network Impacts

The Queue Project #R49 was studied as a(n) 150 MW(Capacity=30 MW) injection into the Haviland – Milan 138 kV line in the AEP area. Project #R49 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

Generator Deliverability

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

No problems were identified

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

No problems were identified

Short Circuit
No problems identified

Re-Tool Result

The retool analysis has shown that two 138kV circuit breakers at East Lima are overdutied due to the installation of the R49 project. The results are summarized in the table below.

BUS_NO	BUS	BREAKER	Rating Type	Duty Percent With r049	Duty Percent Without r049	Duty Percent Difference	Note
0	05E LIMA 138.kV	E2	T	100.70%	99.70%	1.00%	New Over duty
0	05E LIMA 138.kV	C	T	100.30%	99.40%	0.90%	New Over duty

Stability and Reactive Power Requirement
Background

This study concerns the stability assessment for the PJM generator interconnection request – Queue #R49 (Havilland-Milan 138 kV Tap). The R49 project consists on a new 150 MW wind farm facility. The developer specified the use of 72 units Suzlon 2.1 MW wound rotor induction generator.

The objective of the study was to determine the system stability for the contingencies around the R49 project as shown in Attachment #1.

All units and its control systems were updated according to the developer's specification; these updates are shown in Attachment #2 and Attachment #3 (Dynamic data format).

The topology of the system is shown in Attachment #4

Stability (AEP Stability Criteria)

Stability analysis was performed at 2013 summer peak load condition. The maximum generation output is considered. The range of contingencies evaluated was limited to that necessary to assess expected compliance with AEP criteria.

This study includes 74 contingencies conditions that includes 3-phase permanent fault with unsuccessful High-Speed-Recloser (HSR) for normal clearing time contingencies and single line to ground for delayed clearing time due to stuck breaker condition and line tripping without fault.

Result and Analysis

No stability problem was identified with the new transmission line upgrade. The swing angles do not exceed the transient stability criteria and the transient voltage and low voltage ride through criteria were also satisfactory for all contingencies scenarios.

Table-1 in Attachment #1 tabulates the clearing times for the all contingencies scenarios, also a brief description of the scenario is provided.

Whenever R49 wind farm plant is islanded with a load, we recommend the following values for trip settings at the interconnection point:

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

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 plant specific dynamics data for the plant 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.

Retool Results

This study evaluates the stability and low voltage ride-through (LVRT) capability for PJM queue project R49. The R49 project consists of 83 Vestas V100 1.8 MW wind turbines for a total of

149.4 MW. This wind farm will interconnect to the AEP system by tapping on the Havilland-Milan 138 kV line.

The stability and LVRT study for R49 was performed at 2013 summer peak conditions. The range of contingencies evaluated was limited to those necessary to assess compliance with the NERC criteria. Simulation time was 10 seconds for all faults.

This study includes 74 contingencies conditions that includes 3-phase permanent fault with unsuccessful High-Speed-Recloser (HSR) for normal clearing time contingencies and single line to ground for delayed clearing time due to stuck breaker condition and line tripping without fault.

Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A. Generation equipment data is shown in Appendix B.

Results

The R49 project was tested using the following conditions:

	R49
Gross power output (MW)	149.4
Reactive power output (MVARS)	0
Auxiliary load (MW/MVARS)	0
Net real power injection	149.4

All facilities in service:

1. Low Voltage Ride Through: For the cases studied, the R49 queue project rides through the 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 R49 queue project recovers to an acceptable steady state voltage within 10 seconds.

3. Transient Stability: For all cases studied, transient stability is maintained with all oscillations stabilized in less than 10 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance.

Maintenance outage: Maintenance outage conditions were not studied during the impact study phase since the project equipment data provided by the project developer is preliminary in nature. The stability and LVRT study including the maintenance outage test will be re-evaluated during the facility study phase (or at later stage), when more accurate dynamic data becomes available. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

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.

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

New System Reinforcements

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

None

Retool Result

1. The overdutied condition of the E2 138kV circuit breaker at East Lima can be alleviated by replacing the circuit breaker with a a 3000 A, 63 kA circuit breaker. The estimated time to replace is 14-18 months and cost for the circuit breaker replacement is $278,450. (Network Upgrade #n1545)

2. The overdutied condition of the C 138kV circuit breaker at East Lima can be alleviated by replacing the circuit breaker with a a 3000 A, 63 kA circuit breaker. The estimated time to replace is 14-18 months and cost for the circuit breaker replacement is $278,450. (Network Upgrade #n1546)

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

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.
As a result of the aggregate energy resources in the area, the following violations were identified:)

None

Cost Allocation

The R49 project is responsible for 100% of the costs for the network upgrades listed under the Attachment Facilities section of the report estimated to cost **$2,773,600**. The R49 project is also 100% responsible for the upgrade listed under Local Upgrades estimated to cost **$1,856,600**.

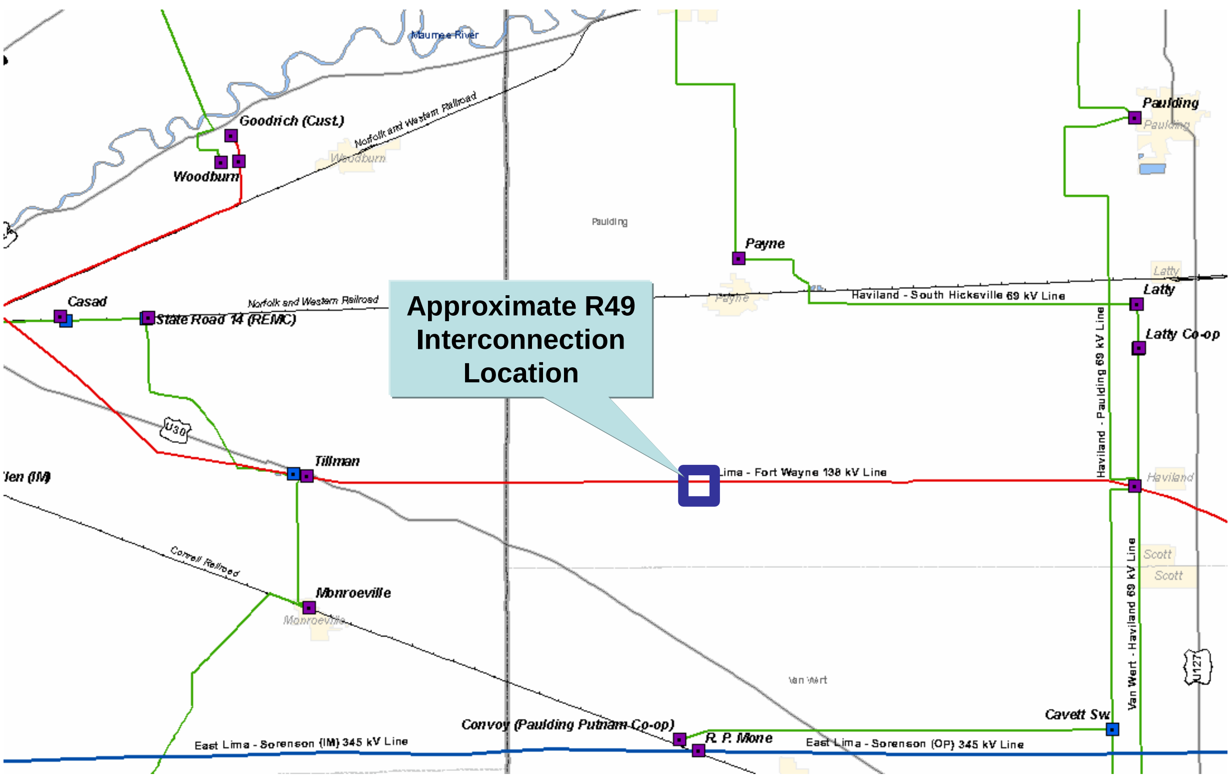

Exhibit 1: Approximate interconnection location of the proposed facilities.

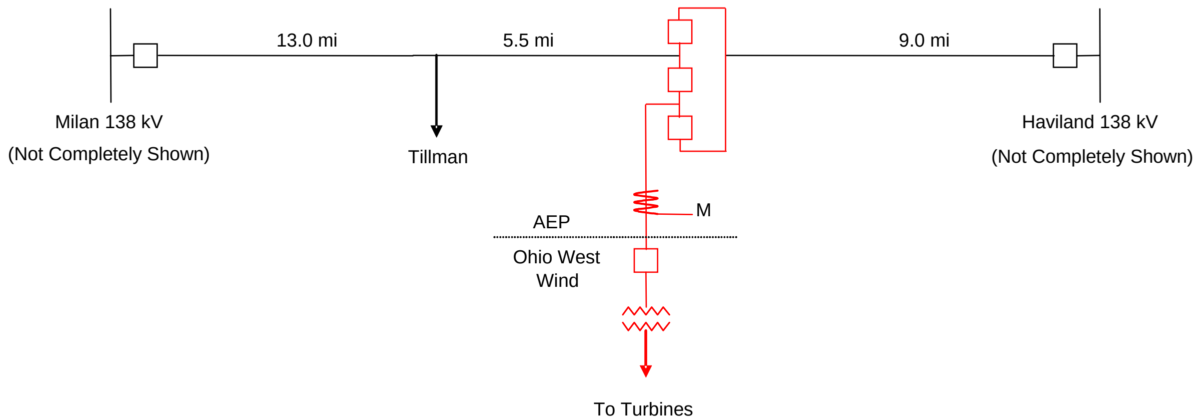

Exhibit 2: Simplified diagram of proposed 138 kV in-line switching substation.

Attachment #1

R49

2013 Light Load Stability Faults

BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Line Open w/o Fault
345kV	4	25	
138kV	5	20	
69kV	63	93	

Table-1: Summary of the recommended maximum clearing time for the different case scenarios.

All cases stable

1a. 3ph @ R49 – Milan 138 kV line
1c. line-trip @ R49 – Milan 138 kV line

2a. 3ph @ Milan – Robison Park 138 kV line
2b. slg @ Milan – Robison Park 138 kV line, BF @ Milan
2c. line-trip @ Milan – Robison Park 138 kV line

3a. 3ph @ Robison Park – Lincoln 138 kV line 1
3b. slg @ Robison Park – Lincoln 138 kV line 1, BF @ Robison Park
Loss of: Robison_Park-Guardian and Robison_Park-Albion.
3c. line-trip @ Robison Park – Lincoln 138 kV line 1

4a. 3ph @ Robison Park – Lincoln 138 kV line 2 through Reed
4b. slg @ Robison Park – Lincoln 138 kV line 2 through Reed, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison_Park-Auburn, Robison_Park-Lockwood.
4c. line-trip @ Robison Park – Lincoln 138 kV line 2 through Reed

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5a. 3ph @ Robison Park – Industrial Park 138 kV line through Summit
5b. slg @ Robison Park – Industrial Park 138 kV line through Summit, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Albion
5c. line-trip @ Robison Park – Industrial Park 138 kV line through Summit

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6a. 3ph @ Robison Park – Albion 138 kV line through Huntertown
6b. slg @ Robison Park – Albion 138 kV line through Huntertown, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Industrial Park
6c. line-trip @ Robison Park – Albion 138 kV line through Huntertown

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7a. 3ph @ Robison Park – Auburn 138 kV line through County
7b. slg @ Robison Park – Auburn 138 kV line through County, BF @ Robison Park

Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Lockwood
7c. line-trip @ Robison Park – Auburn 138 kV line through County

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8a. 3ph @ Robison Park – Lockwood 138 kV line through Grabill
8b. slg @ Robison Park – Lockwood 138 kV line through Grabill, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Auburn
8c. line-trip @ Robison Park – Lockwood 138 kV line through Grabill

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9a. 3ph @ R49 – Haviland 138 kV line
9c. line-trip @ R49 – Haviland 138 kV line

10a. 3ph @ Haviland - East Lima 138kV
10b. slg @ Haviland – East Lima 138 kV line, BF @ Haviland
Loss of: Haviland substation.
10c. line-trip @ Haviland – East Lima 138kV line,

11a. 3ph @ Haviland Transformer 138/69 kV line

12a. 3ph @ East Lima – West Lima 138 KV line
$12b_{B}$. slg @ East Lima – West Lima 138 kV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (2A&2B).
$12b_{B2.}$ slg @ East Lima – West Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling.
12c. line-trip @ East Lima – West Lima 138 KV line

13a. 3ph @ East Lima – Thayer Road 138 KV line
$13b_{E2}$. slg @ East Lima – Thayer Road 138 kV line, BF @ East Lima
Loss of: East Lima-East_Leipsic.
13c. line-trip @ East Lima – Thayer Road 138 KV line

14a. 3ph @ East Lima – South Kenton 138 KV line
$14b_{E1}$. slg @ East Lima – South Kenton 138 kV line, BF @ East Lima
14c. line-trip @ East Lima – South Kenton 138 KV line

15a. 3ph @ East Lima – RockHill 138 KV line
$15b_{D.}$ slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Liberty
$15b_{D2}$. slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
15c. line-trip @ East Lima – RockHill 138 KV line

16a. 3ph @ East Lima – Ford Lima 138 KV line
$16b_{C.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (1).
$16b_{C2.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
16c. line-trip @ East Lima – Ford Lima 138 KV line

17a. 3ph @ East Lima – East Leipsic 138 KV line
17c. line-trip @ East Lima – East Leipsic 138 KV line

18a. 3ph @ East Lima – North Findlay 138 KV line
18b$_{A.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-Haviland
18b$_{A1.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
18c. line-trip @ East Lima – North Findlay 138 KV line

19a. 3ph @ East Lima – New Liberty 138 KV line,
19b$_{D.}$ slg @ East Lima –New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-RockHill
19$_{D1.}$ slg @ East Lima – New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
19c. line-trip @ East Lima – New Liberty 138 KV line

20a. 3ph @ East Lima – Fostoria Central 345 KV line
20c. line-trip @ East Lima – Fostoria Central 345 KV line

21a. 3ph @ East Lima – South West Lima 345 KV line
21c. line-trip @ East Lima – South West Lima 345 KV line

22a. 3ph @ East Lima – Marysville 345 KV line
22c. line-trip @ East Lima – Marysville 345 KV line

23a. 3ph @ East Lima – R.P Mone 345 KV line
23c. line-trip @ East Lima – Marysville 345 KV line

24a. 3ph @ Robison Park – Argent 345 kV line
24c. line-trip @ Robison Park – Argent 345 kV line

25a. 3ph @ Robison Park – Collingwood 345 kV line
25c. line-trip @ Robison Park – Collingwood 345 kV line

26a. 3ph @ Robison Park – Allen 345 kV line
26c. line-trip @ Robison Park – Allen 345 kV line

27a. 3ph @ Robison Park – Convoy 345 kV line
27c. line-trip @ Robison Park – Convoy 345 kV line

28a. 3ph @ Robison Park Transformer 345/138 kV

APPENDIX A
R49

A.1) POWER FLOW CONDITIONS

2013 Summer Peak Base Case

A.2) BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Line Open w/o Fault
345kV	4	25	
138kV	5	20	
69kV	63	93	

Table-1: Summary of the recommended maximum clearing time for the different case scenarios.

A.3) FAULTS CONSIDERED (All facilities in service)

1a. 3ph @ R49 – Milan 138 kV line
1c. line-trip @ R49 – Milan 138 kV line

2a. 3ph @ Milan – Robison Park 138 kV line
2b. slg @ Milan – Robison Park 138 kV line, BF @ Milan
2c. line-trip @ Milan – Robison Park 138 kV line

3a. 3ph @ Robison Park – Lincoln 138 kV line 1
3b. slg @ Robison Park – Lincoln 138 kV line 1, BF @ Robison Park
Loss of: Robison_Park-Guardian and Robison_Park-Albion.
3c. line-trip @ Robison Park – Lincoln 138 kV line 1

4a. 3ph @ Robison Park – Lincoln 138 kV line 2 through Reed
4b. slg @ Robison Park – Lincoln 138 kV line 2 through Reed, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison_Park-Auburn, Robison_Park-Lockwood.
4c. line-trip @ Robison Park – Lincoln 138 kV line 2 through Reed

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5a. 3ph @ Robison Park – Industrial Park 138 kV line through Summit
5b. slg @ Robison Park – Industrial Park 138 kV line through Summit, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Albion
5c. line-trip @ Robison Park – Industrial Park 138 kV line through Summit

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6a. 3ph @ Robison Park – Albion 138 kV line through Huntertown
6b. slg @ Robison Park – Albion 138 kV line through Huntertown, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Industrial Park
6c. line-trip @ Robison Park – Albion 138 kV line through Huntertown

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7a. 3ph @ Robison Park – Auburn 138 kV line through County
7b. slg @ Robison Park – Auburn 138 kV line through County, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Lockwood
7c. line-trip @ Robison Park – Auburn 138 kV line through County

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8a. 3ph @ Robison Park – Lockwood 138 kV line through Grabill
8b. slg @ Robison Park – Lockwood 138 kV line through Grabill, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Auburn
8c. line-trip @ Robison Park – Lockwood 138 kV line through Grabill

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9a. 3ph @ R49 – Haviland 138 kV line
9c. line-trip @ R49 – Haviland 138 kV line

10a. 3ph @ Haviland - East Lima 138kV
10b. slg @ Haviland – East Lima 138 kV line, BF @ Haviland
Loss of: Haviland substation.
10c. line-trip @ Haviland – East Lima 138kV line,

11a. 3ph @ Haviland Transformer 138/69 kV line

12a. 3ph @ East Lima – West Lima 138 KV line
$12b_{B}$. slg @ East Lima – West Lima 138 kV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (2A&2B).
$12b_{B2.}$ slg @ East Lima – West Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling.
12c. line-trip @ East Lima – West Lima 138 KV line

13a. 3ph @ East Lima – Thayer Road 138 KV line
$13b_{E2}$. slg @ East Lima – Thayer Road 138 kV line, BF @ East Lima
Loss of: East Lima-East_Leipsic.
13c. line-trip @ East Lima – Thayer Road 138 KV line

14a. 3ph @ East Lima – South Kenton 138 KV line
$14b_{E1}$. slg @ East Lima – South Kenton 138 kV line, BF @ East Lima
14c. line-trip @ East Lima – South Kenton 138 KV line

15a. 3ph @ East Lima – RockHill 138 KV line
$15b_{D.}$ slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Liberty
$15b_{D2}$. slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
15c. line-trip @ East Lima – RockHill 138 KV line

16a. 3ph @ East Lima – Ford Lima 138 KV line
$16b_{C.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (1).

16b$_{C2.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
16c. line-trip @ East Lima – Ford Lima 138 KV line

17a. 3ph @ East Lima – East Leipsic 138 KV line
17c. line-trip @ East Lima – East Leipsic 138 KV line

18a. 3ph @ East Lima – North Findlay 138 KV line
18b$_{A.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-Haviland
18b$_{A1.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
18c. line-trip @ East Lima – North Findlay 138 KV line

19a. 3ph @ East Lima – New Liberty 138 KV line,
19b$_{D.}$ slg @ East Lima –New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-RockHill
19$_{D1.}$ slg @ East Lima – New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
19c. line-trip @ East Lima – New Liberty 138 KV line

20a. 3ph @ East Lima – Fostoria Central 345 KV line
20c. line-trip @ East Lima – Fostoria Central 345 KV line

21a. 3ph @ East Lima – South West Lima 345 KV line
21c. line-trip @ East Lima – South West Lima 345 KV line

22a. 3ph @ East Lima – Marysville 345 KV line
22c. line-trip @ East Lima – Marysville 345 KV line

23a. 3ph @ East Lima – R.P Mone 345 KV line
23c. line-trip @ East Lima – Marysville 345 KV line

24a. 3ph @ Robison Park – Argent 345 kV line
24c. line-trip @ Robison Park – Argent 345 kV line

25a. 3ph @ Robison Park – Collingwood 345 kV line
25c. line-trip @ Robison Park – Collingwood 345 kV line

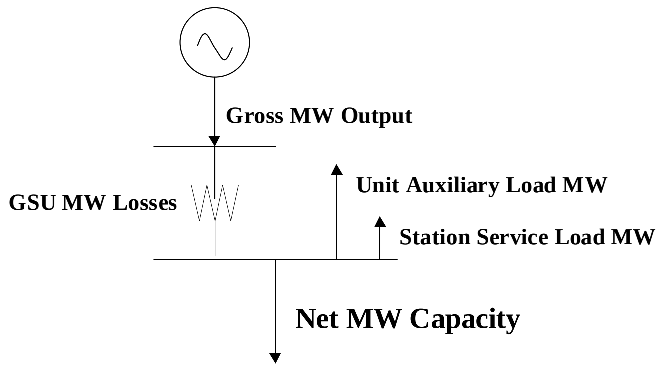
26a. 3ph @ Robison Park – Allen 345 kV line
26c. line-trip @ Robison Park – Allen 345 kV line

27a. 3ph @ Robison Park – Convoy 345 kV line
27c. line-trip @ Robison Park – Convoy 345 kV line

28a. 3ph @ Robison Park Transformer 345/138 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: ____ R49

Primary Fuel Type: _______________________________ Wind /Suzlon S88 2.1 MW

Maximum Summer (92º F ambient air temp.) Net MW Output**: ___ 151/2.1 per turbine

Maximum Summer (92º F ambient air temp.) Gross MW Output:____ 151/2.1 per turbine

Minimum Summer (92º F ambient air temp.) Gross MW Output: _________________ 0

Maximum Winter (30º F ambient air temp.) Gross MW Output:_____ 151/2.1 per turbine

Minimum Winter (30º F ambient air temp.) Gross MW Output: __________________ 0

Gross Reactive Power Capability at Maximum Gross MW Output – Please include Reactive Capability Curve (Leading and Lagging): _______________________N/A

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

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR): __N/A

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): ___N/A

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR): ___N/A

Station Service Load (MW/MVAR): ____________________________________N/A

* 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: ____ R49

MVA Base (upon which all reactances, resistance and inertia are calculated): _____2.283

Nominal Power Factor: ____ N/A

Terminal Voltage (kV): ____ 0.6

Unsaturated Reactances (on MVA Base)

Direct Axis Synchronous Reactance, $X_{d(i)}$: __________________________________ N/A

Direct Axis Transient Reactance, X'd(i): _________________________________ N/A

Direct Axis Sub-transient Reactance, X"d(i): ______________________________ N/A

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: ____ N/A

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): ____________________________________ N/A

Speed Damping, D: ____ N/A

Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]: ____________________________ N/A

Units utilize a   Generator model

Unit GSU Data

Queue Letter/Position/Unit ID:__________________________________ R49 (72 GSU)

Generator Step-up Transformer MVA Base: _________________________________2.5

Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): _ j0.0319

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________10/1

Generator Step-up Transformer Rating (MVA):________________________________2.5

Generator Step-up Transformer Low-side Voltage (kV):________________________0.6

Generator Step-up Transformer High-side Voltage (kV):_______________________34.5

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:_________________________R49 (1 Main Transformer)

Generator Step-up Transformer MVA Base: _________________________________ 100

Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): __ 9.89%

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________40/1

Generator Step-up Transformer Rating (MVA):_______________________________ 160

Generator Step-up Transformer H-side Voltage (kV): __________________________ 138

Generator Step-up Transformer X-side Voltage (kV): __________________________34.5

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

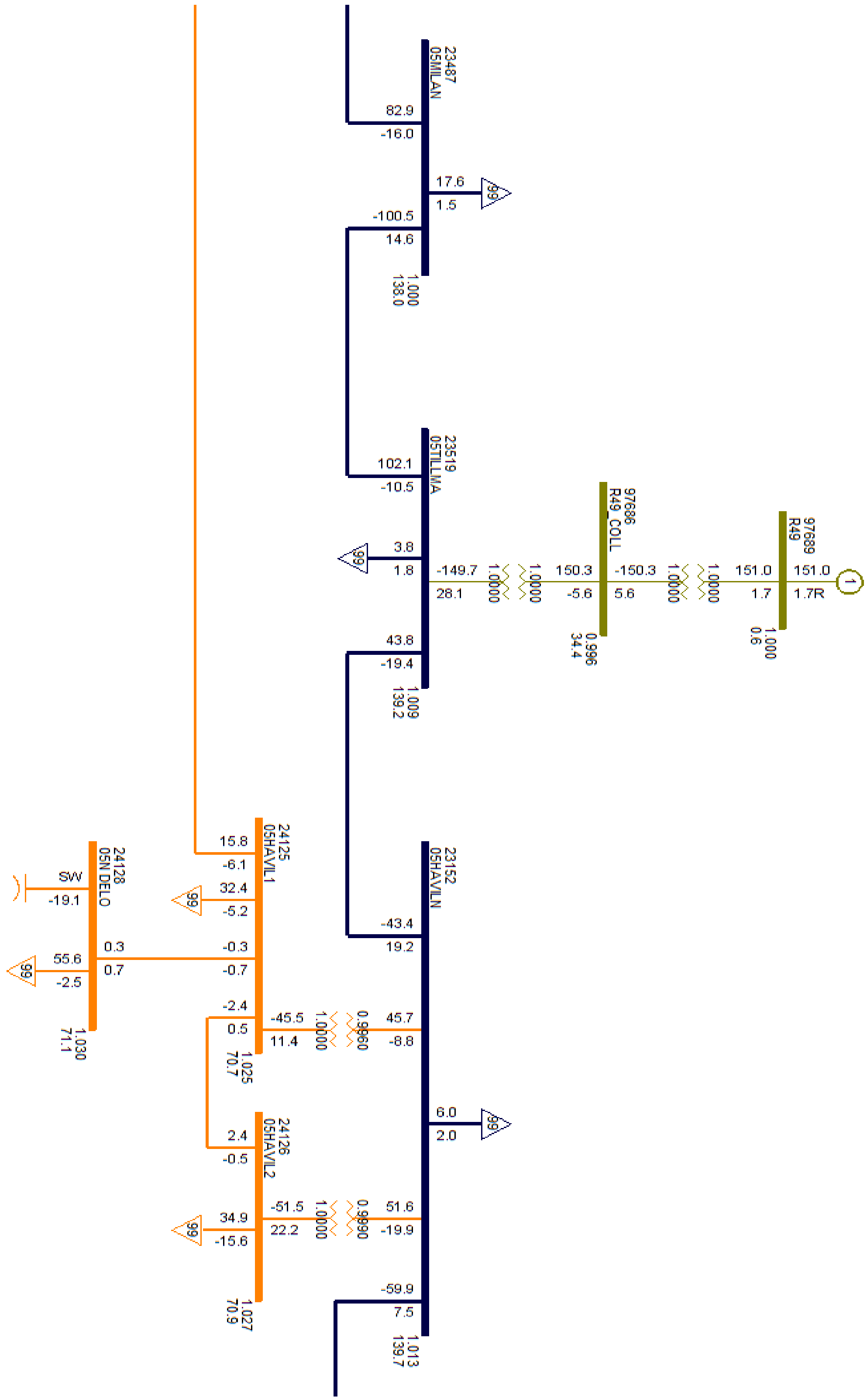
Generator Step-up Transformer Number of Taps and Step Size: _________________N/A

Attachment #3

All the control systems were updated according to the developer's specification; these updates are shown in Dynamic Data Format.

97689 'USRMDL' 1 'S88001' 1 1 11 79 4 32
20 0 1 1 1 1 1 1 1 1 1 0.0053 0.1042 5.0556 0.0066 0.1097 2.8763 4.1622 5.6849
71.3826 0.3 0.476 0.03 0.1697 0.0135 1.36 1.22 0.15 150.0 25.0 1850 150.0 25.0
1820 37.0 -2.0 88.0 0.10 10.0 -10.0 18.0 1.225 9999 9999 0 9999 9999 0
0.90 60.00 0.80 2.80 0.60 1.60 0.40 0.70 0.15 0.08 1.15 60.00 1.20 0.08 0.95 0.20
1.05 0.20 0.90 1.10 0.00 1.00 0.00 1.00 0.10 1.00 0.20 1.00 0.30 1.00 0.40 1.00
0.50 1.00 0.60 0.75 0.70 0.50 0.80 0.25 0.90 0.00 /R49_Suzlon

Attachment #4



APPENDIX B
Project Data

B.1) Wind farm and wind turbine data for R49

Queue Letter /Position/Unit ID: ______ R49

Wind farm data

Primary Fuel Type: ______ Wind

Maximum Net MW Output: ______ 149.4

Maximum Gross MW Output: ______ 149.4

Station Service Load in MW/MVAR: ______ N/A

Wind turbine data

Wind Turbine Type: ______ Vestas V100 1.8

MW Size: ______ 1.8

MVA Base: ______ 1.8

Nominal Power Factor: ______ N/A

Terminal Voltage (kV): ______ 0.69

Control Mode: ______

Number of Turbines (total): ______ 83

Wind farm capacitors

Queue Letter/Position/Unit ID: ______ R49

Additional Capacitor: ______ N/A

Location of Additional Capacitor: ______ N/A

Type of Additional Capacitor: ______ N/A

Steps of Switching Shunt: ______ N/A

Unit GSU data

Queue Letter /Position/Unit ID: ______ R49

Generator Step-up Transformer MVA Base: ______ 1.85

Generator Step-up Transformer Impedance (R+jX, on MVA Base):___________________ 7.8%

Generator Step-up Transformer Reactance-to-Resistance Ratio (X/R):___________________ 10.4

Generator Step-up Transformer Rating (MVA): ___________________________________ 1.85

Generator Step-up Transformer Low-side Voltage (kV):_____________________________ 0.69

Generator Step-up Transformer High-side Voltage (kV): ____________________________ 34.5

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: ____ R49

Generator Step-up Transformer MVA Base: ____96

Generator Step-up Transformer Impedance (R+jX, in p.u, on Xfmr MVA Base): _________95%

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R):___________________40

Generator Step-up Transformer Rating (MVA): ____________________________________160

Generator Step-up Transformer Low-side Voltage (kV):_____________________________ 34.5

Generator Step-up Transformer High-side Voltage (kV): _____________________________138

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

Transmission line data:

Queue Letter/ ID: ____ R49

Transmission Line MVA Base: ____ N/A

Transmission Line kV Base:____ N/A

Transmission Line length (mi):____ N/A

Conductor Type: ____ N/A

Transmission Line Positive Seq. Impedance (R+jX, p.u. on **MVA Base**): _______________ N/A

Transmission Line Positive Seq. Charging Admittance (B, p.u. on **MVA Base**): __________ N/A

APPENDIX C
PSSE MODEL

C.1) Load flow model:

```
rdch
1
 97686,'R49_COLL    ',  34.5000,1,     0.000,     5.000, 205, 252,0.99225, -14.6625,   1
 97689,'R49         ',   0.6000,2,     0.000,     0.000, 205, 252,0.99667, -10.3739,   1
0 / END OF BUS DATA, BEGIN LOAD DATA
0 / END OF LOAD DATA, BEGIN GENERATOR DATA
 97689,'1 ',   149.400,     0.000,     0.000,     0.000,1.00000,     0,   149.400,   0.00000,   1.00000,   0.00000,   0.00000,1.00000,1,  100.0,   149.400,
0.000,   1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
 97686, 23519,     0,'1 ',1,1,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.00247,   0.09890,   100.00
1.00000,   0.000,   0.000,   160.00,     0.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,  33, 0, 0.00000, 0.00000
1.00000,   0.000
 97689, 97686,     0,'1 ',1,1,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.00480,   0.04950,   100.00
1.00000,   0.000,   0.000,   157.70,     0.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,  33, 0, 0.00000, 0.00000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
 205, 22987,  5711.000,     5.000,'AEP         '
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN SWITCHED SHUNT DATA
0 / END OF SWITCHED SHUNT DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
 252,'AEP-IM      '
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
   1,'CENT HUD    '
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA
```

C.2) Dynamic model:

```
/ Vestas V90

97689 'USRMDL' '1'  'VWCORE' 1 1 2 20 3 23 1 0
 1800.0000 692.8203 899.6269 700.0000 2.6200 0.7620 0.0188
 6.0050 8.3264 6.0050 8.3264 100.0000 0.4000 1.2000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWVARS' 8 0 2 0 0 18 97689 '1' /
0 'USRMDL' 0 'VWLVRT' 8 0 3 21 0 10 97689 '1' 1
 0.85 0.001 0.2 12.5 50.0000 0.0000 0.0000
 0.5 0.0000 2.6200 0.8079 1.2 0.5 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWRC' 8 0 3 21 2 5 97689 '1' 0
 1.0000 0.0000 0.0000 1.000 1.000 1.000 1.0000
 1.0000 1.0000 1.0000 0.0000 0 0 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMECH' 8 0 2 7 3 0 97689 '1'
  1800.0000 351.8584 5684.1051 427.0000 65.0000 6358.0000 36.2900 /
0 'USRMDL' 0 'VWMEAS' 8 0 2 3 3 0 97689 '1'
 0.1000 0.1000 0.2000 /
0 'USRMDL' 0 'VWVPRT' 0 2 7 20 0 11 97689 '1'  1 1 0 0 0
 0.7500 0.0001 0.8500 0.4000 0.9000 60.0000 1.1000
 60.0000 1.1350 0.2000 1.2000 0.0800 0.0000 0.2000
 0.7000 2.6500 0.8000 11.0000 0.9000 60.0000 /
0 'USRMDL' 0 'VWFPRT' 0 2 3 4 0 1 97689 '1'  0
 56.4000 0.2000 61.2000 0.2000 /
```

C.3) Single-line diagram:

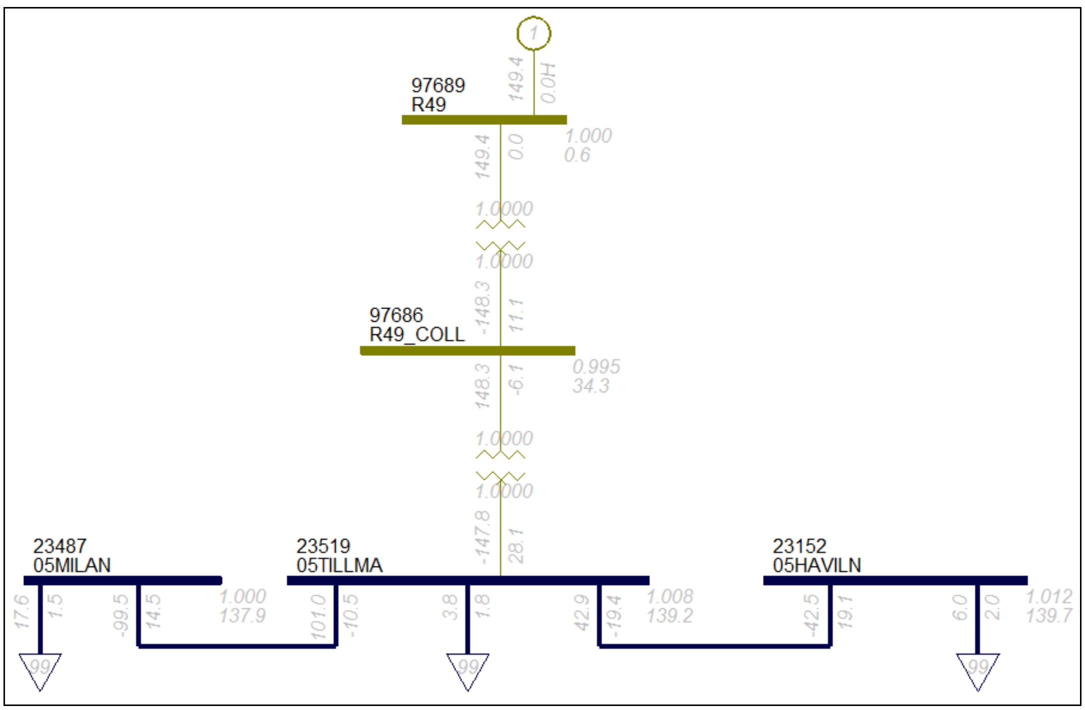


Figure C.1. Single-line diagram for R49. Breaker information not shown.

C.4) Base Case Reinforcements:

None

PJM Generator Interconnection Request Queue #R49 Haviland-Milan(Ohio West Wind) 138kV Impact Study

539216
June 2009

R49 Haviland-Milan 138kV Impact Study Report

General

Horizon Wind Energy, LLC (Horizon) proposes to install a 150 MW generating facility comprised of 75-2.1 MW wind turbine generators connecting to the American Electric Power (AEP) Haviland - Milan 138 kV circuit. This project is number R49 in the PJM Generator Interconnection queue. The proposed location of the generating facilities and switching station is approximately four miles south of Payne, OH (See Exhibit 1). The projected in-service date is scheduled for October 31, 2010.

Attachment Facilities

The proposed generation project will be connected to the AEP Haviland - Milan 138 kV circuit via a new in-line switching station. The new station will consist of three (3) 138 kV circuit breakers configured in a ring-bus arrangement with 138 kV metering (See Exhibit 2). AEP will retain ownership of the proposed in-line station facilities. In addition, remote terminal relaying will need to be upgraded to coordinate with the new relays to be installed at the new station. It is understood that Horizon will be responsible for the all costs associated with this construction, as well as facilities associated with connecting their 150 MW generation to the in-line facilities.

It is expected that any right-of-way for line extensions, as well as a 250' x 250' (minimum) station site will be provided to AEP by Horizon. Note that the Horizon station facilities and any facilities outside the new station were not included in the cost estimate. These are assumed to be Horizon's responsibility.

The AEP construction scope includes:

- Construction of a new switching station connecting to the Haviland - Milan 138 kV circuit between Haviland and Tillman stations, including three (3) 138 kV circuit breakers, relays, 138 kV metering, SCADA, and associated equipment. (Network Upgrade #n1222)

  Estimated Cost (2009 Dollars): **$4,485,300**

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Milan station. (Network Upgrade #n1223)

  Estimated Cost (2009 Dollars): **$682,500**

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Haviland station. (Network Upgrade #n1224)

  Estimated Cost (2009 Dollars): **$721,000**

- Replace line relaying with AEP standard package and upgrade the station remote terminal unit (RTU) at Tillman station. (Network Upgrade #n1225)

  Estimated Cost (2009 Dollars): **$370,100**

Total Attachment Facilities Cost*: **$6,258,900**

*The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately fourteen (14) to eighteen (18) months after obtaining an executed ISA and CSA to construct the facilities as outlined above.

Local Impacts

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet single contingency performance criteria in accordance with the AEP FERC Form 715. Therefore, this criterion was used to assess the impact of the proposed facility on the AEP System. The Horizon project was studied as a 150 MW net capacity consistent with the interconnection application. The results are summarized below.

Normal System (2009 Summer Conditions)

- No problems identified.

Single Contingency (2009 Summer Conditions)

- Outage of the Haviland - R49 Ohio West 138 kV circuit overloads the Tillman 138/34.5 kV transformer to 101% of its summer rating.

Short Circuit Analysis

- No problems identified.

Stability Analysis

- Instability occurs for an outage of the Robison Park - R49 and East Lima – Haviland 138 kV lines (double-contingency scenario). In this scenario, both 138 kV outlets are outaged, and R49 is connected only to the underlying 69 kV network via the Haviland

138/69 kV Station. **Generation curtailment will be required following the first contingency (loss of either the Robison Park – R49 or East Lima – Haviland 138 kV circuit).**

Local Upgrades

To maintain appropriate levels of reliability and mitigate the single contingency problems resulting from the additional generation identified in this study, the following system improvements are required:

- To alleviate the overload on the Tillman 138/34.5kV transformer the existing transformer will be replaced with a 30 MVA unit that will require installation of a high-side circuit switcher and associated equipment. (Network Upgrade #n1226)

  Estimated Cost (2009 Dollars): **$1,856,600***

*The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately one year after obtaining the authorization to construct the facilities as outlined above.

Reactive Requirements

PJM requires a power factor correction to 95% lead/lag at the point of interconnection for wind generating facilities. It is expected that Horizon will adhere to this standard.

Network Impacts

The Queue Project #R49 was studied as a(n) 150 MW(Capacity=30 MW) injection into the Haviland – Milan 138 kV line in the AEP area. Project #R49 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

Generator Deliverability

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

No problems were identified

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

No problems were identified

Short Circuit
No problems identified

Stability and Reactive Power Requirement
Background

This study concerns the stability assessment for the PJM generator interconnection request – Queue #R49 (Havilland-Milan 138 kV Tap). The R49 project consists on a new 150 MW wind farm facility. The developer specified the use of 72 units Suzlon 2.1 MW wound rotor induction generator.

The objective of the study was to determine the system stability for the contingencies around the R49 project as shown in Attachment #1.

All units and its control systems were updated according to the developer's specification; these updates are shown in Attachment #2 and Attachment #3 (Dynamic data format).

The topology of the system is shown in Attachment #4

Stability (AEP Stability Criteria)

Stability analysis was performed at 2013 summer peak load condition. The maximum generation output is considered. The range of contingencies evaluated was limited to that necessary to assess expected compliance with AEP criteria.

This study includes 74 contingencies conditions that includes 3-phase permanent fault with unsuccessful High-Speed-Recloser (HSR) for normal clearing time contingencies and single line to ground for delayed clearing time due to stuck breaker condition and line tripping without fault.

Result and Analysis

No stability problem was identified with the new transmission line upgrade. The swing angles do not exceed the transient stability criteria and the transient voltage and low voltage ride through criteria were also satisfactory for all contingencies scenarios.

Table-1 in Attachment #1 tabulates the clearing times for the all contingencies scenarios, also a brief description of the scenario is provided.

Whenever R49 wind farm plant is islanded with a load, we recommend the following values for trip settings at the interconnection point:

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

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 plant specific dynamics data for the plant 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.

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

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

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.
As a result of the aggregate energy resources in the area, the following violations were identified:)

None

Cost Allocation
The R49 project is responsible for 100% of the costs for the network upgrades listed under the Attachment Facilities section of the report estimated to cost **$6,258,900**. The R49 project is also 100% responsible for the upgrade listed under Local Upgrades estimated to cost **$1,856,600**.

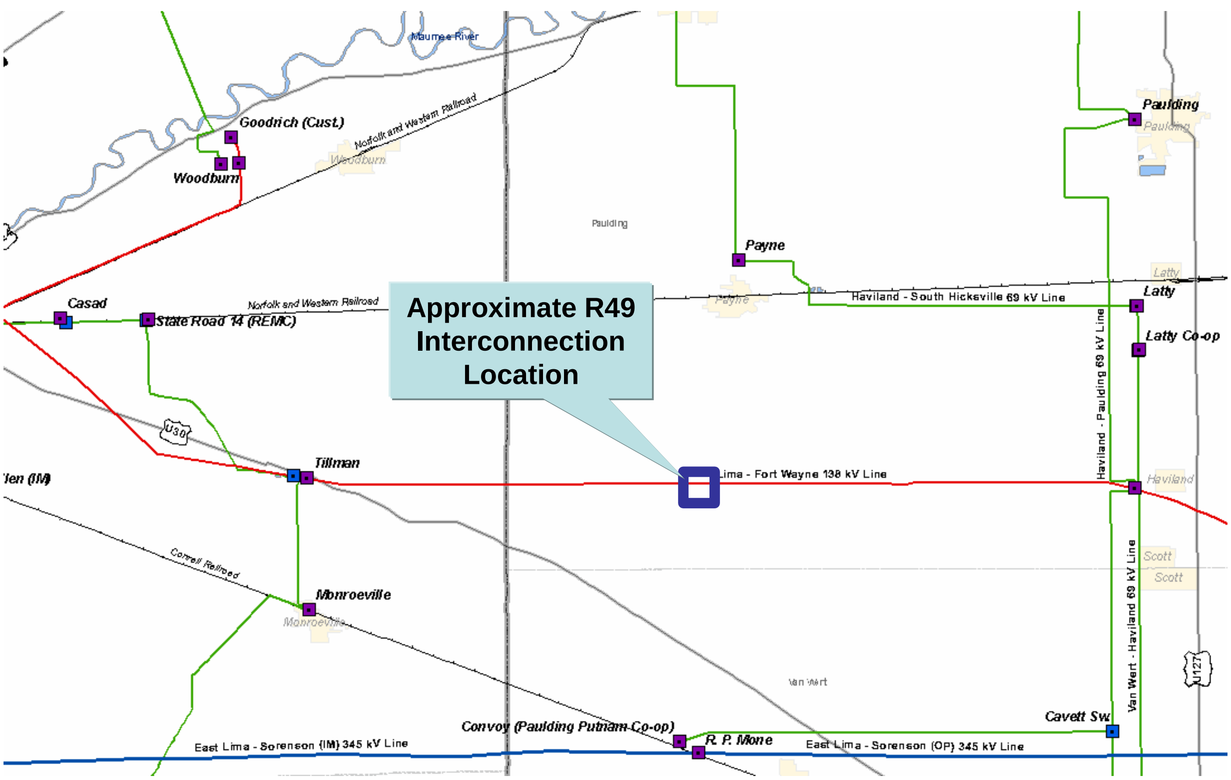


Exhibit 1: Approximate interconnection location of the proposed facilities.

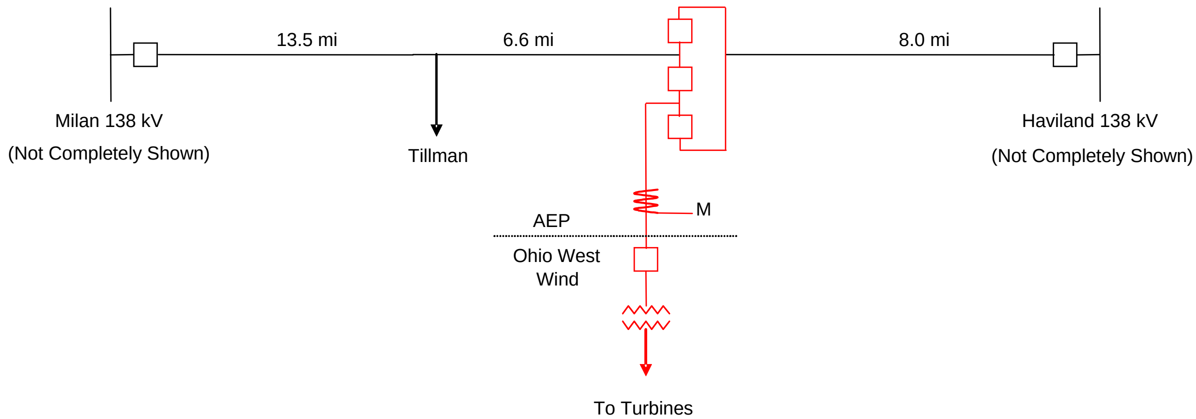


Exhibit 2: Simplified diagram of proposed 138 kV in-line switching substation.

Attachment #1

R49

2013 Light Load Stability Faults

BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Line Open w/o Fault
345kV	4	25	
138kV	5	20	
69kV	63	93	

Table-1: Summary of the recommended maximum clearing time for the different case scenarios.

All cases stable

1a. 3ph @ R49 – Milan 138 kV line
1c. line-trip @ R49 – Milan 138 kV line

2a. 3ph @ Milan – Robison Park 138 kV line
2b. slg @ Milan – Robison Park 138 kV line, BF @ Milan
2c. line-trip @ Milan – Robison Park 138 kV line

3a. 3ph @ Robison Park – Lincoln 138 kV line 1
3b. slg @ Robison Park – Lincoln 138 kV line 1, BF @ Robison Park
Loss of: Robison_Park-Guardian and Robison_Park-Albion.
3c. line-trip @ Robison Park – Lincoln 138 kV line 1

4a. 3ph @ Robison Park – Lincoln 138 kV line 2 through Reed
4b. slg @ Robison Park – Lincoln 138 kV line 2 through Reed, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison_Park-Auburn, Robison_Park-Lockwood.
4c. line-trip @ Robison Park – Lincoln 138 kV line 2 through Reed

---

5a. 3ph @ Robison Park – Industrial Park 138 kV line through Summit
5b. slg @ Robison Park – Industrial Park 138 kV line through Summit, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Albion
5c. line-trip @ Robison Park – Industrial Park 138 kV line through Summit

---

6a. 3ph @ Robison Park – Albion 138 kV line through Huntertown
6b. slg @ Robison Park – Albion 138 kV line through Huntertown, BF @ Robison Park
Loss of: Robison_Park-Lincoln, Robison_Park-Guardian, Robison_Park-Industrial Park
6c. line-trip @ Robison Park – Albion 138 kV line through Huntertown

---

7a. 3ph @ Robison Park – Auburn 138 kV line through County
7b. slg @ Robison Park – Auburn 138 kV line through County, BF @ Robison Park

Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Lockwood
7c. line-trip @ Robison Park – Auburn 138 kV line through County

---

8a. 3ph @ Robison Park – Lockwood 138 kV line through Grabill
8b. slg @ Robison Park – Lockwood 138 kV line through Grabill, BF @ Robison Park
Loss of: Robison_Park-Milan, Robison Park-Lincoln_2, Robison_Park-Auburn
8c. line-trip @ Robison Park – Lockwood 138 kV line through Grabill

---

9a. 3ph @ R49 – Haviland 138 kV line
9c. line-trip @ R49 – Haviland 138 kV line

10a. 3ph @ Haviland - East Lima 138kV
10b. slg @ Haviland – East Lima 138 kV line, BF @ Haviland
Loss of: Haviland substation.
10c. line-trip @ Haviland – East Lima 138kV line,

11a. 3ph @ Haviland Transformer 138/69 kV line

12a. 3ph @ East Lima – West Lima 138 KV line
$12b_{B}$. slg @ East Lima – West Lima 138 kV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (2A&2B).
$12b_{B2.}$ slg @ East Lima – West Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling.
12c. line-trip @ East Lima – West Lima 138 KV line

13a. 3ph @ East Lima – Thayer Road 138 KV line
$13b_{E2}$. slg @ East Lima – Thayer Road 138 kV line, BF @ East Lima
Loss of: East Lima-East_Leipsic.
13c. line-trip @ East Lima – Thayer Road 138 KV line

14a. 3ph @ East Lima – South Kenton 138 KV line
$14b_{E1}$. slg @ East Lima – South Kenton 138 kV line, BF @ East Lima
14c. line-trip @ East Lima – South Kenton 138 KV line

15a. 3ph @ East Lima – RockHill 138 KV line
$15b_{D.}$ slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Liberty
$15b_{D2}$. slg @ East Lima – RockHill 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
15c. line-trip @ East Lima – RockHill 138 KV line

16a. 3ph @ East Lima – Ford Lima 138 KV line
$16b_{C.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima 345/138kV transformer (1).
$16b_{C2.}$ slg @ East Lima – Ford Lima 138 KV line, BF @ East Lima
Loss of: East Lima-Sterling
16c. line-trip @ East Lima – Ford Lima 138 KV line

17a. 3ph @ East Lima – East Leipsic 138 KV line
17c. line-trip @ East Lima – East Leipsic 138 KV line

18a. 3ph @ East Lima – North Findlay 138 KV line
18b$_{A.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-Haviland
18b$_{A1.}$ slg @ East Lima – North Findlay 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
18c. line-trip @ East Lima – North Findlay 138 KV line

19a. 3ph @ East Lima – New Liberty 138 KV line,
19b$_{D.}$ slg @ East Lima –New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-RockHill
19$_{D1.}$ slg @ East Lima – New Liberty 138 KV line, BF @ East Lima
Loss of: East Lima-South Kenton
19c. line-trip @ East Lima – New Liberty 138 KV line

20a. 3ph @ East Lima – Fostoria Central 345 KV line
20c. line-trip @ East Lima – Fostoria Central 345 KV line

21a. 3ph @ East Lima – South West Lima 345 KV line
21c. line-trip @ East Lima – South West Lima 345 KV line

22a. 3ph @ East Lima – Marysville 345 KV line
22c. line-trip @ East Lima – Marysville 345 KV line

23a. 3ph @ East Lima – R.P Mone 345 KV line
23c. line-trip @ East Lima – Marysville 345 KV line

24a. 3ph @ Robison Park – Argent 345 kV line
24c. line-trip @ Robison Park – Argent 345 kV line

25a. 3ph @ Robison Park – Collingwood 345 kV line
25c. line-trip @ Robison Park – Collingwood 345 kV line

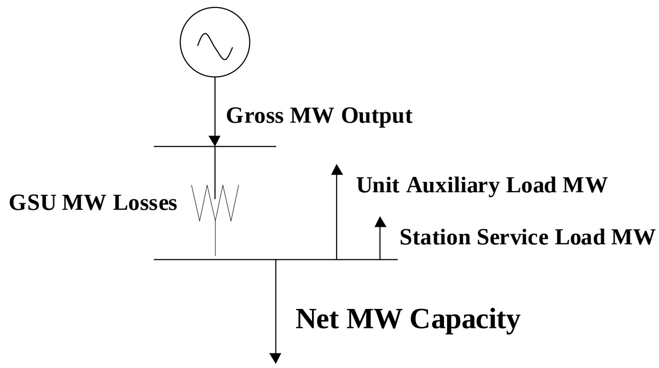
26a. 3ph @ Robison Park – Allen 345 kV line
26c. line-trip @ Robison Park – Allen 345 kV line

27a. 3ph @ Robison Park – Convoy 345 kV line
27c. line-trip @ Robison Park – Convoy 345 kV line

28a. 3ph @ Robison Park Transformer 345/138 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: ____R49

Primary Fuel Type: __________________________________ Wind /Suzlon S88 2.1 MW

Maximum Summer (92º F ambient air temp.) Net MW Output**: ___ 151/2.1 per turbine

Maximum Summer (92º F ambient air temp.) Gross MW Output:____ 151/2.1 per turbine

Minimum Summer (92º F ambient air temp.) Gross MW Output: ___________________ 0

Maximum Winter (30º F ambient air temp.) Gross MW Output:_____ 151/2.1 per turbine

Minimum Winter (30º F ambient air temp.) Gross MW Output: ____________________ 0

Gross Reactive Power Capability at Maximum Gross MW Output – Please include Reactive Capability Curve (Leading and Lagging): _________________________N/A

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

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR): __N/A

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): ___N/A

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR): ___N/A

Station Service Load (MW/MVAR): ____N/A

* 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: ____ R49

MVA Base (upon which all reactances, resistance and inertia are calculated): _____2.283

Nominal Power Factor: ____ N/A

Terminal Voltage (kV): ____ 0.6

Unsaturated Reactances (on MVA Base)

Direct Axis Synchronous Reactance, $X_{d(i)}$: ____________________________ N/A

Direct Axis Transient Reactance, X'd(i): ____________________________ N/A

Direct Axis Sub-transient Reactance, X"d(i): ____________________________ N/A

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: ____________________________ N/A

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): ____________________________ N/A

Speed Damping, D: ____________________________ N/A

Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]: ____________________________ N/A

Units utilize a   Generator model

Unit GSU Data

Queue Letter/Position/Unit ID:___________________________________ R49 (72 GSU)
Generator Step-up Transformer MVA Base: __________________________________2.5
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): _ j0.0319
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________10/1
Generator Step-up Transformer Rating (MVA):________________________________2.5
Generator Step-up Transformer Low-side Voltage (kV): _________________________0.6
Generator Step-up Transformer High-side Voltage (kV):________________________34.5
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:__________________________R49 (1 Main Transformer)
Generator Step-up Transformer MVA Base: _________________________________ 100
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): __ 9.89%
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________40/1
Generator Step-up Transformer Rating (MVA):_______________________________ 160
Generator Step-up Transformer H-side Voltage (kV): __________________________ 138
Generator Step-up Transformer X-side Voltage (kV): __________________________34.5
Generator Step-up Transformer Off-nominal Turns Ratio:_______________________N/A
Generator Step-up Transformer Number of Taps and Step Size: _________________N/A

Attachment #3

All the control systems were updated according to the developer's specification; these updates are shown in Dynamic Data Format.

97689 'USRMDL' 1 'S88001' 1 1 11 79 4 32
20 0 1 1 1 1 1 1 1 1 1 0.0053 0.1042 5.0556 0.0066 0.1097 2.8763 4.1622 5.6849
71.3826 0.3 0.476 0.03 0.1697 0.0135 1.36 1.22 0.15 150.0 25.0 1850 150.0 25.0
1820 37.0 -2.0 88.0 0.10 10.0 -10.0 18.0 1.225 9999 9999 0 9999 9999 0
0.90 60.00 0.80 2.80 0.60 1.60 0.40 0.70 0.15 0.08 1.15 60.00 1.20 0.08 0.95 0.20
1.05 0.20 0.90 1.10 0.00 1.00 0.00 1.00 0.10 1.00 0.20 1.00 0.30 1.00 0.40 1.00
0.50 1.00 0.60 0.75 0.70 0.50 0.80 0.25 0.90 0.00 /R49_Suzlon

Attachment #4