PJM Generator Interconnection Request Queue #R60 Robison Park-Convoy 345kV Impact Study

504744
September 2008

© PJM Interconnection 2008. All rights reserved

R60 Robison Park-Convoy 345kV Impact Study

General

Iberdrola Renewable Energies USA, Ltd. (Interconnection Customer) proposes to install a 350 MW wind generating facility (PJM Project #R60), comprised of 175 2 MW wind turbines, to the American Electric Power (AEP) transmission system. The project is in Allen County, Indiana. These facilities will connect via a new 345 kV switching station in the Convoy-Robison Park 345 kV AEP line in 2009. The connection request specifies that 70 MW of the project is to be a Capacity Resource, with the balance to be an Energy Resource.

The intent of the Impact study is to determine system reinforcements and associated costs and construction time estimates required to facilitate the addition of the new generating plant to the transmission system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the transmission system.

Direct Connection

The attachment facilities will consist of a new in-line switching station located in Allen County, Indiana between AEP's Robison Park and Convoy stations. The new station would consist of three 345 kV circuit breakers configured in a ring-bus arrangement with 345 kV metering. AEP will retain ownership of the proposed in-line station facilities. A preliminary one-line diagram of these facilities is shown in Figure 2.1. It is understood that Iberdrola will be responsible for all costs associated with this construction, as well as facilities associated with connecting the generation facilities to the in-line facilities.

It is expected that any right-of-way for line extensions, as well as a 400' x 400' (minimum) substation site will be provided to AEP by Iberdrola. Note that the Iberdrola station facilities and any facilities outside the new station were not included in the cost estimate. These are assumed to be Iberdrola's responsibility.

The AEP construction scope for the attachment facilities:

- Construction of a new switching station connecting to the Convoy – Robison Park 345 kV line, including three 345 kV circuit breakers, relays, 345 kV metering, SCADA, and associated equipment.

  Estimated Cost:* ***$8,000,000***

- Construction of an assumed 0.25 miles of 345 kV line facilities to loop in and out of the new switching station from the Convoy – Robison Park 345 kV line.

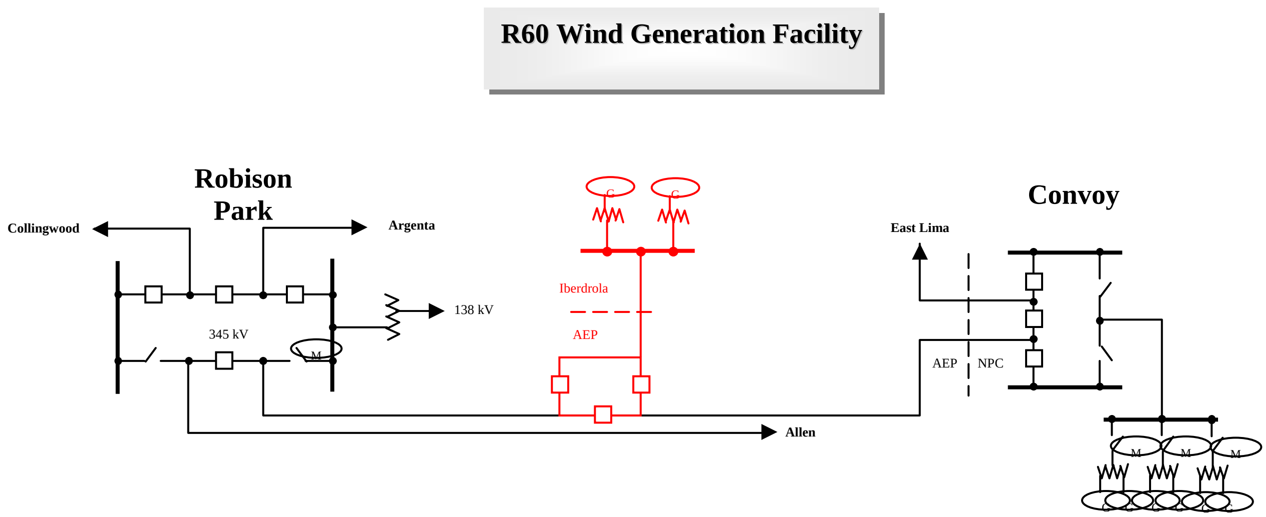
  Estimated Cost:* ***$500,000***

© PJM Interconnection 2008. All rights reserved.

Total Attachment Facilities Cost*: **$8,500,000**

**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.*

Figure 2.1: Preliminary One-line Diagram of Interconnection Facilities



Network Impacts

The Queue Project #R60 was studied as a(n) 350MW(70 MW of Capacity) interconnection at the Robinson Park – Convoy 345 kV line in the AEP system. Project #R60 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)
None

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)
None

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

None

© PJM Interconnection 2008. All rights reserved.

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

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None

Stability

Stability analysis was performed at 2011 summer peak load condition and for maximum gross generation output of 350 MW for the proposed R60 project. See Attachment #1 for the fault cases evaluated. The range of contingencies evaluated was limited to that necessary to assess expected compliance with MAAC Stability criteria.

The Study shows with the turbines specified: GAMESA 2.0 MW (175 units) and operating in power factor control mode it will be transiently stable and meet the voltage ride through requirement when the **controlled power factor at 34.5 KV collector bus is 0.985 lagging (turbines supplying VARS) and with the following voltage trip levels and times :**

Voltage at the terminal of the generator:

- 0.85 pu or lower for 10 seconds
- 0.75 pu or lower for 1 second
- 0.70 pu or lower for 0.35 second
- 0.30 pu or lower for 0.15 second
- 1.10 pu or higher for 1.1 second
- 1.15 pu or higher for 0.2 second
- 1.3 pu or higher for 0.02 second

Whenever R60 wind farm plant was 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 different level of generator MW and/or MVAR output at different load levels and operating conditions would disclose unforeseen stability problems. The

© PJM Interconnection 2008. All rights reserved.

regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in this or other operating or planning studies will need to be resolved.

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

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)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

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

Coordination with MISO

PJM evaluation has shown that there are no impacts to MISO facilities due to the interconnection of this project. Those results have been communicated to MISO.

© PJM Interconnection 2008. All rights reserved.

<u>Attachment #1</u>

R60

2011 Summer Light/Peak Load Case Stability Faults

BREAKER CLEARING TIMES (CYCLES)

Station		Primary (3ph/slg)	Stuck Breaker (total)	Zone 2 (total)
Generating	345 kV	4	15	15
Non-generating	345 kV	4	15	15

All cases are stable.

1a. 3ph @ R61 – Hiple 345 KV line
1c. slg @ R61 – Hiple 345 KV line, 80% from R61, Zone 2 clearing

2a. 3ph @ Hiple – Leesburg 345 KV line
2c. slg @ Hiple – Leesburg 345 KV line, 80% from Hiple, Zone 2 clearing

3a. 3ph @ Robison Park – Argenta 138 KV line
$3b_{1\text{-}K1}$. slg @ Robison Park – Argenta 138KV line, BF @ Hiple
$3b_{1\text{-}KM}$. slg @ Robison Park – Argenta 138KV line, BF @ Hiple

4a. 3ph @ Hiple – Cook 345 KV line
$4b_{1\text{-}24\text{-}25}$. slg @ Hiple – Cook 138 KV line, BF @ Hiple
$4b_{1\text{-}25\text{-}26}$. slg @ Hiple – Cook 138 KV line, BF @ Hiple
4c. slg @ Hiple – Cook 345 KV line, 80% from Hiple, Zone 2 clearing

5a. 3ph @ R61 – Collingwood 345 KV line
5c. slg @ R61 - Collingwood 345 KV line, 80% from R61, Zone 2 clearing

6a. 3ph @ R60 – Robison Park 345 KV line
6c. slg @ R60 – Robison Park 345 KV line, 80% from R60, Zone 2 clearing

7a. 3ph @ Robison Park - Collingwood345 KV line
$7b_{1\text{-}KM}$. slg @ Robison Park – Collingwood 138 KV line, BF @ Robison Park
$7b_{1\text{-}K2}$. slg @ Robison Park – Collingwood 138 KV line, BF @ Robison Park
7c. slg @ Robison Park – Collingwood 345 KV line, 80% from Robison Park, Zone 2 clearing

8a. 3ph @ R60 – Convoy 345 KV line
8c. slg @ R60 – Convoy 345 KV line, 80% from Robert P. Mone, Zone 2 clearing

9a. 3ph @ Convoy – East Lima 345 KV line

© PJM Interconnection 2008. All rights reserved.

9c. slg @ Convoy – East Lima 345 KV line, 80% from Robert P. Mone, Zone 2 clearing

10a. 3ph @ East Lima – Fostoria Central 345 KV line
$10b_{1-M2}$. slg @ East Lima – Fostoria Central 138 KV line, BF @ East Lima
$10b_{1-P2}$. slg @ East Lima – Fostoria Central 138 KV line, BF @ East Lima

11a. 3ph @ East Lima – Southwest Lima 345 KV line
$11b_{1P}$. slg @ East Lima – Southwest Lima 138 KV line, BF @ East Lima
$11b_{1P1}$. slg @ East Lima – Southwest Lima 138 KV line, BF @ East Lima
11c. slg @ East Lima – Southwest Lima 345 KV line, 80% from East Lima, Zone 2 clearing

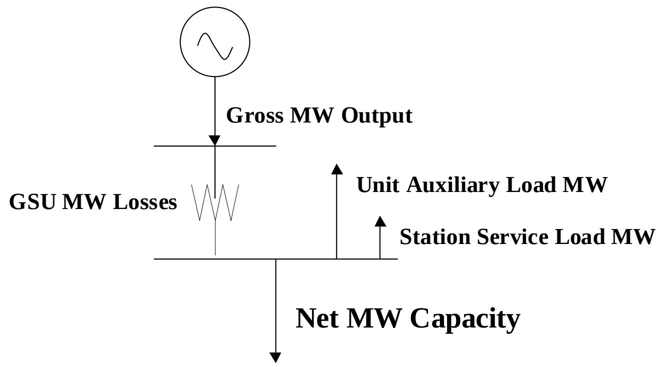
12a. 3ph @ East Lima – Marysville 345 KV line
$12b_{1-M1}$. slg @ East Lima – Marysville 138 KV line, BF @ East Lima
$12b_{1-P1}$. slg @ East Lima – Marysville 138 KV line, BF @ East Lima
12c. slg @ East Lima – Marysville 345 KV line, 80% from East Lima, Zone 2 clearing

13a. 3ph @ Robison Park – Allen 345 KV line
13b. slg @ Robison Park – Allen 345 KV line, BF @ Robison Park
13c. slg @ Robison Park – Allen 345 KV line, 80% from Robison Park, Zone 2 clearing

© PJM Interconnection 2008. All rights reserved.

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: ____ R60

Primary Fuel Type: ____Wind /Gamesa G87

Maximum Summer (92º F ambient air temp.) Net MW Output**: _________ 350/2.0 per turbine

Maximum Summer (92º F ambient air temp.) Gross MW Output: _________ 350/2.0 per turbine

Minimum Summer (92º F ambient air temp.) Gross MW Output:________________________0

Maximum Winter (30º F ambient air temp.) Gross MW Output:___________ 350/2.0 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): _______ 0.24

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

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): ________ 0.48

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

Station Service Load (MW/MVAR): ____ 0.1125

* 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.

© PJM Interconnection 2008. All rights reserved.

Unit Generator Dynamics Data

Queue Letter/Position/Unit ID: ____ R60

MVA Base (upon which all reactances, resistance and inertia are calculated): _____2.197

Nominal Power Factor: ____1.0

Terminal Voltage (kV): ____0.69

Unsaturated Reactances (on MVA Base)

- Direct Axis Synchronous Reactance, $X_{d(i)}$: ________________________________ 4.63
- Direct Axis Transient Reactance, X'd(i): ________________________________ 0.214
- Direct Axis Sub-transient Reactance, X"d(i): _____________________________ 0.152
- Quadrature Axis Synchronous Reactance, Xq(i): ___________________________ 4.63
- Quadrature Axis Transient Reactance, X'q(i): _____________________________ 0.214
- Quadrature Axis Sub-transient Reactance, X"q(i): __________________________ 0.152
- Stator Leakage Reactance, Xl: ____ 1.07
- Negative Sequence Reactance, X2(i): ____________________________________ 0.212
- Zero Sequence Reactance, X0: ____ 0.410

Saturated Sub-transient Reactance, X"d(v) (on MVA Base): ____________________0.152

Armature Resistance, Ra (on MVA Base): ___________________________________ 0.015

Time Constants (seconds)

- Direct Axis Transient Open Circuit, T'_{do}: ___________________________________ 1.4
- Direct Axis Sub-transient Open Circuit, T''_{do}:_ ____________________________ 0.0025
- Quadrature Axis Transient Open Circuit, T'_{qo}:_ ____________________________ 1.4
- Quadrature Axis Sub-transient Open Circuit, T''_{qo}: __________________________ 0.0025
- Inertia, H (kW-sec/kVA, on KVA Base): __________________________________ 3.25

Speed Damping, D: ____N/A

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

Units utilize a Generator model

© PJM Interconnection 2008. All rights reserved.

Unit GSU Data

Queue Letter/Position/Unit ID:____R60
Generator Step-up Transformer MVA Base: ___________________________________2.1
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): ___ 8.8%
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________N/A
Generator Step-up Transformer Rating (MVA):_________________________________2.1
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: _______+/- 2.5%, +/- 5%

Main Transformer Data

Queue Letter/Position/Unit ID:____R60
Generator Step-up Transformer MVA Base: _______________________________ 3 x 110
Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): __ 12.5%
Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ___________N/A
Generator Step-up Transformer Rating (MVA):_____________________________ 3 x 110
Generator Step-up Transformer H-side Voltage (kV): ___________________________ 345
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: _______ +/-2.5% 4 steps

© PJM Interconnection 2008. All rights reserved.