PJM Generator Interconnection Request Queue X1-014 Peter's Mountain 34.5kV Feasibility Study Report

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#655748

Preface

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

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

X1-014 Peter's Mountain 34.5kV Feasibility Study

General

The Interconnection Customer (IC) has proposed a 20 MW wind project, utilizing 12 1.6 MW General Electric turbines, to be located on Little Mountain in Monroe County West Virginia. The in-service date for the project is 07/01/13

The customer will connect to the utility grid via one of three options described below:

1) An express 34.5 KV circuit from the wind farm to AEP's Peters Mountain substation with a dedicated 138/34.5 KV transformer.

2) An express 34.5 KV circuit from the wind farm to AEP's Peters Mountain substation with a dedicated breaker on AEP's existing 138/34.5 KV 30 MVA transformer sourced bus.

3) Tying into AEP's existing distribution system along Route 219 approximately 6.6 miles from Peters Mountain substation. Per an email from the customer dated 7/6/11, "The IC has decided that Option # 3 (Direct connection to AEP's existing 34.5kV distribution circuit) is not feasible. While this option is more economical from an interconnection stand point, it poses too much risk to revenue and power purchase agreement conditions due to the fact that there is extended vulnerability to line outages throughout the year. We would like to leave this option open for consideration at a later {date} with a smaller capacity but for your feasibility report to PJM please consider this {option} contractually unfeasible for the client, AWRE."

The wind turbine generator systems will operate 24 hours per day, seven days per week. Each unit is expected to be on line 98% of the year or approximately 8,580 hours per year. It is understood that some number of the wind turbine generators will be generating power 100% of the time.

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Direct Connection

Option #1 – Express circuit to Peter's Mountain with a dedicated 138/34.5kV transformer.

AEP work:

- Double circuit approximately 6.6 miles of existing 34.5 KV distribution with 4/0 AA primary. Construct a new 34.5 KV distribution line from Route 219 to the customer's breakers.

- Reconfigure the 138 KV transmission line at Peters Mountain substation, install a new 138/34.5 KV 30 MVA transformer and all necessary equipment such as regulators, breakers, and protection controls.
- Install primary metering at 138 KV.
- Install necessary communication equipment.

The approximate total estimated cost of improvements for option 1 is **$2,900,000,** contingent upon demonstration of compliance, by the applicant, with IEEE 1547 for clearing their generation from the AEP system for all fault types.

Option #2 – Express circuit to Peter's Mountain with a dedicated circuit breaker on AEP's existing 138/34.5 KV 30 MVA transformer sourced bus.

- Double circuit approximately 6.6 miles of existing 34.5 KV distribution with 4/0 AA primary. Construct a new 34.5 KV distribution line from Route 219 to the customer's breakers.
- Install a 34.5 KV breaker on the existing 34.5 KV bus at Peters Mountain substation.
- Reprogram the Beckwith M2001C transformer LTC control on the Peters Mountain transformer for reverse power flow.
- Install primary metering at 34.5 KV.
- Install necessary communication equipment.

The approximate total estimated cost of improvements for option 2 is **$1,200,000**, contingent upon demonstration of compliance, by the applicant, with IEEE 1547 for clearing their generation from the AEP system for all fault types.

Regardless of which option is chosen by the applicant, an operational agreement between the applicant and AEP will have to entered into, defining the roles and responsibilities by each party when responding to abnormal system conditions such as dispatching first responders, operating devices and making repairs on damaged equipment that is owned by the applicant either in Peters Mountain substation or attached to AEP poles.

Disclaimer

The results of this feasibility study apply only to the system described in the PJM X1-014 feasibility study data application. All modeling is based on a wind turbine generating system located on Little Mountain in Monroe County, West Virginia.

This review is limited to equipment affecting AEP system operations. The customer must take all necessary steps to assure compliance with all laws, ordinances, building codes and other applicable regulations. AEP granting approval of the requested connection is not an endorsement of a particular design nor does it assure fitness of the DG to accomplish an intended function.

Regarding compliance with IEEE 1547, the customer has stated "... it is our full intention to comply with IEEE Standards 1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems. We understand that the most current IEEE 1547 Standard is only applicable on loads 'with aggregate capacity of 10 MVA or less at the point of common coupling' as stated in the second paragraph of the abstract and we intend to generate more than 10 MVA. However, {we} will supply the system and configuration required to meet your precise fault time to trip off our wind park for safety of your technicians and the security of your system."

Modeling and Assumptions

This is a new customer with plans on installing their equipment on Little Mountain in Monroe County, West Virginia.

The DG system will consist of twelve GE 1.6 MW XLE wind turbine generator systems each rated 690 volts, 1600 KW/1778 KVA, 90% power factor. The DG system will contribute up to a maximum of 21.3 MVA at 90% power factor when all twelve wind turbine systems are operating. The DG system output voltage is 34.5 KV delta. The customer's facilities will be protected by two 34.5 KV breakers. The requested AEP service will connect to the customer through a primary metered point of common coupling (PCC) at 138 KV (option 1) or at 34.5 KV (option 2).

The customer owned 34,500/690 volt step up transformers will be configured Delta-Grounded Wye and with each transformer having an impedance of 5.75% at 1.75 MVA. Each wind generator system will have its own step up transformer and be connected together at 34.5 KV using 3-3/0 AL TRXLPE underground distribution cable manufactured by General Cable. The customer will build an overhead line using 3-4/0 AA conductor from their 34.5 KV breakers down to Route 219 where they will attach to AEP on an existing distribution pole line. The customer will attach as a joint user on AEP's existing distribution poles for approximately 6.6 miles back to AEP's Peters Mountain substation.

The DG system is assumed to be equipped with appropriate voltage regulation, system protection, and power factor controls. As previously stated, the DG system will be operated in parallel with the AEP system and the customer intends to export power to the utility grid.

Analysis

The system conditions of concern are:

1. Wind turbine generator system location.
2. Wind turbine generator system fault contribution.
3. Wind turbine generator system effect on system steady state voltage at peak load.
4. Wind turbine generator system effect on system steady state voltage at light load.

5. Wind turbine generator system effect on power flow for the existing Peters Mountain substation transformer (option 2) during light load conditions.
6. Wind turbine generator system effect on power flow for the Peters Mountain substation transformer LTC (option 2).
7. Wind turbine generator system effect on the existing138 KV transmission protection scheme

DG Location

The center of the DG system was modeled at approximately 2000 feet southeast of AEP distribution pole 37810091C00037 along a 2.2 mile ridge on Little Mountain in Monroe County, West Virginia.

Fault Contribution

Maximum available fault at PCC

The total maximum available three-phase bolted fault (LLL) current at the customer PCC is 15,147 amps symmetrical at 138 KV (option 1) and 3,854 amps symmetrical at 34.5 KV (option 2) when the DG system is connected. The maximum available AEP contribution to a three-phase bolted fault (LLL) at the customer PCC is 14,958 amps symmetrical at 138 KV (option 1) and 3,057 amps symmetrical at 34.5 KV (option 2).

The total maximum available single-phase bolted fault (LG) current at the customer PCC is zero amps at 138 KV (option 1) and 4,038 amps symmetrical at 34.5 KV (option 2) when the DG system is connected. The maximum available AEP contribution to a single-phase bolted fault (LG) at the customer PCC is zero amps at 138 KV (option 1) and 3,076 amps symmetrical at 34.5 KV (option 2).

When the DG system is connected to the AEP utility grid via option 1, the increase in fault currents is negligible at 138 KV. When the DG system is connected to the AEP utility grid via option 2, this results in a 26.1% increase in available three-phase bolted fault (LLL) current and a 31.3% increase in available (LG) fault current. These increases in fault current are not expected to significantly impact the operation of the AEP protection system at Peters Mountain substation. It is important to note that these values are subject to change if AEP distribution system enhancements and/or substation enhancements are made in the future. These values are also subject to change if the customer changes their equipment.

System Protection

The customer's responsibilities include providing adequate protection to AEP facilities due to events arising from the operation of the DG under all AEP system operating conditions. The customer is responsible for protecting their own facilities under all AEP system operating conditions whether the DG is connected to the AEP system or not, including but not limited to:

1. Abnormal voltage or frequency
2. Loss of a single phase of supply
3. Equipment failure
4. Distribution system faults
5. Lightning
6. Excessive harmonic voltages
7. Excessive negative sequence voltages
8. Separation from supply
9. Loss of synchronization

Ground Current Sources – Protective relays must be utilized to detect line-to-ground faults. The customer shall provide adequate protection to comply with IEEE 1547 to clear generation source for all types of faults on the AEP system including any breaker failure events. Adequate protection requires that all fault types are cleared before equipment damage occurs to AEP facilities. If the customer fails to provide adequate protection for faults on the AEP system, then the customer will pay all costs associated with AEP facility damage.

Automatic Reclosing – The transmission line feeding Peters Mountain substation is protected by automatic high speed pilot wire relaying. These relays can detect and clear faults within 5 cycles or 0.083 seconds. When the AEP source breakers trip isolating the customer's generation source so that they are no longer in synchronization with the AEP system, the customer shall ensure that their generation equipment is disconnected from AEP facilities in accordance with requirements established in IEEE 1547 prior to automatic reclosure by AEP. Automatic reclosing out-of-phase with customer's generation equipment may cause damage to customer's equipment. The customer is solely responsible for the protection of their equipment from automatic reclosing by AEP.

AEP will require communication at the PCC in order to monitor connection status, real power output, reactive power output and voltage at the point of DG system interconnection as stated in section 4.1.6 of IEEE 1547.

Voltage Regulation

Generator effect on power flow for the Peters Mountain transformer during light load

During fall and spring months, the #1 transformer at Peters Mountain substation is lightly loaded. If option 2 is utilized, the generated load of the DG system could be more than the load on the 34.5 KV bus, thus resulting in a back flow of power through the transformer. Given this, the Beckwith M2001C transformer LTC control will have to be reprogrammed to respond to reverse power flow.

Network Impacts

Queue project X1-014 was studied as a(n) 20.0 MW (2.6 MW of which was Capacity) injection into AEP's system at the Peter’s Mountain 138.0 kV substation. Project X1-014 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

Generator Deliverability

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

No problems identified

Multiple Facility Contingency

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

No problems identified

Short Circuit

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

No problems identified

System Reinforcements

None required

Energy Portion of Interconnection Request

(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection request.
Note: Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.)

No problems identified.