Generation Interconnection Feasibility Study Report (Web Version)

For

PJM Generation Interconnection Request Queue Position V3-057

Ironwood 230 kV Project

April, 2011

Feasibility Study Report

Ironwood 230 kV Generation Project

Introduction

This Feasibility Study report provides the documentation of a system assessment performed by PJM Interconnection, LLC (PJM) and FirstEnergy (FE) in response to a request made by Interconnection Customer for the interconnection of a 20 MW Ironwood Battery Storage project to the Met-Ed Transmission network. When discharging, the proposed Battery Storage project will have a capability to inject 20 MW into the Met-Ed system. When charging, it could withdraw up to 22 MW as a load. The assessment of the Ironwood 230 kV Project was accomplished by: 1. Evaluating the reliability impact of the proposed facilities and connection on the interconnected transmission system by the performance of a power flow study; 2. Ensuring compliance with the NERC, ReliabilityFirst, PJM and FE Reliability Standards by identifying the system reinforcements that will need to be installed for an interconnection of the proposed project; 3. Coordinating and cooperating with the PJM staff and Interconnection Customer by participating in project meetings and issuing this report as a part of the RTEP study process; 4. Performing a Steady State, Short-Circuit and Dynamics Study as necessary; 5. Conducting all studies in accordance with the PJM Manuals and the "FE Requirements for Transmission Connected Facilities" documents that assure the assessment performed incorporates study assumptions, follows the documented system performance procedures, considers alternative connection and reinforcement plans, and jointly coordinates the study recommendations.

PJM Network Analysis

The following is the result of the analysis of the transmission system performed by PJM.

Network Impacts

The queue V3-057 project was studied as a 20MW energy injection into Meted's system at the Ironwood 230kV substation. The project was studied on a combined feasibility-impact basis which utilizes an AC analysis, and incorporates all contingency types. Project V3-057 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. Potential network impacts were as follows:

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, Stuck breaker and Bus Fault contingencies for the full energy output)

No problems identified.

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)

No problems identified.

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.

Short Circuit

No breakers were over-dutied by the addition of this project.

Potential Congestion due to Local Energy Deliverability
(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 below. There is no guarantee of full deliverability 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 identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:

No problems identified.

FirstEnergy Network Analysis and Balance of Report

The following is the portion of this report was prepared by FirstEnergy. It identifies the necessary reinforcements to the transmission system, if any, as well as the details on the FIrstEnergy requirements and upgrades.

Power Flow Analysis

A Power Flow study was conducted to determine the reliability impact of the proposed Ironwood 230 kV Project on the FE Transmission System. This study was completed using a 2014 summer peak load power flow that contained a detailed representation of the Met-Ed transmission networks in the area of the proposed Ironwood 230 kV Project. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM or FE Planning Criteria and are attributable to this project.

The results of the FE analysis show that there are no network upgrades required for the deliverability of the Ironwood 230 kV Project generation to the Met-Ed transmission system. This includes a finding that the Ironwood 230 kV Project does not significantly contribute to the flow on the constraining facilities defined for any preceding project that submitted an application for service in accordance with the PJM RTEP process.

Short Circuit and Dynamics Analysis

A short circuit analysis was conducted by PJM in accordance with the RTEP process. This analysis showed that no FE circuit breaker will exceed its interrupting capability with the implementation of the Ironwood 230 kV Project. The FE Protection staff also conducted a short circuit review of the project connection to confirm the PJM results. An assumption of this study was that solar generation projects will contribute no appreciable fault current to the breakers on the FE transmission system. As defined by EPRI: "Inverters are generally designed to limit fault currents to 130% or less of rated current. Thus they can usually be disregarded when conducting fault studies."1. Based on this fact, the results of the FE analysis showed that no FE circuit breaker will exceed its interrupting capability with the implementation of the Ironwood 230 kV Project. Therefore no circuit breaker reinforcements will be required.

In accordance with the RTEP Impact Study process, the PJM staff is responsible for the performance of a dynamic analysis for the Ironwood 230 kV Project. The results of these studies will be included in the PJM Impact Study report if this project proceeds.

[1] EPRI Document TR-111490 "Integration of Distributed Resources in Electric Utility Distribution Systems:
Distribution System Behavior Analysis for Suburban Feeder", published November 1998, page 62

System Protection Analysis

An analysis was conducted to assess the impact of the Ironwood 230 kV Project on the system protection requirements in the area. The results of this review show that the following the system protection additions and upgrades will be required at the Ironwood 230 kV substation:

1. Swing the Current Transformer (CT) input for the 1001 line relaying from 100152 to the new 1001 line Circuit Breaker (CB).

2. Add dual bus differential relaying to the newly created bus section between breakers 100115, the new 1001 line CB, and the new V3-057 Generator CB.
   - SEL 587Z
   - SEL 387

3. Move the 3 phase Capacitor Coupled Voltage Transformer (CCVT) from between the 100152 to the line side of the new 1001 Line CB for line relaying

4. Add a single phase CCVT to the newly created bus section for synchronization purposes

5. Add an SEL 352 relay to the new 1001 line CB for breaker failure and synchronization check (Moved line 3ph CCVT and New 1ph CCVT as voltage inputs) Add LOR
6. Voltage inputs to T-52 CB synchronization check relay will remain after the 3 phase CCVT has been moved

7. Add an SEL 352 to the 105452 CB for synchronization check (this will replace existing breaker failure relay)

8. Change tripping contacts of 100152 breaker failure to
   - Include New 1001 Line CB
   - Include New V3-057 Gen breaker
   - Remove T-52

9. Change tripping contacts of T-52 breaker failure to
   - Include New 1001 Line CB
   - Remove 100152 CB

10. Connect the new relaying to the existing 2020 Communication processor

The cost estimate for the required FE system protection facilities is included in the tabulation on Attachment 4. A more detailed system protection analysis will be included as a part of the Impact and Facilities Study.

Metering

Interconnection Customer will be required to comply with all "FirstEnergy Revenue Metering Requirements for Generation Interconnection Customers" for facilities connected to the FE 69

kV and higher transmission system. These FE requirements are detailed on Attachment 5 of this report.

As defined, Interconnection Customer shall install, own, operate, test and maintain all of the necessary revenue metering equipment. Interconnection Customer shall also provide Met-Ed with dial-up communication to a revenue meter. The following are additional requirements:

- The Customer's revenue meter will typically have a DNP 3.0 port (or a similar protocol port) connected to the Customer's SCADA RTU for communication of any real-time meter data required by PJM and FE.

- The FE billing data collection system (MV-90) collects kWH/kVARH interval data from the Customer's revenue meter via a Customer-provided analog telephone line. It is assumed that the interval data collected by FE may be used for station power billing and/or operations settlement purposes as directed by PJM.

- The revenue metering is to be tested by the Customer every two years per PJM requirements.

- FE may apply another metering practice to these facilities for engineering design or other reasons.

FE will provide the telecommunication circuits for the SCADA RTU and the telephone in the FE Interconnection Substation.

Interconnection Customer will be responsible for designing, furnishing and installing a SCADA RTU in their generation substation and obtaining the telecommunication circuits from the RTU to the Met-Ed Data Center. These requirements are in addition to any metering required by PJM, including those defined in Manual 01.

Compliance Issues

Interconnection Customer will be responsible for meeting all FE criteria as defined in the FE Requirements for Transmission Connected Facilities document. This includes the provision of a reactive power capability sufficient to maintain a composite power delivery for the facility at the interconnection point at a power factor from .95 leading (absorbing 6.6 MVARs) to .90 lagging (producing 9.7 MVARs). If this capability cannot be provided, a STATCOM or SVC device must be installed at the Ironwood 230 kV substation at Interconnection Customer cost.

Interconnection Customer will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, the Developer will need to properly locate and report the over and under-voltage and over and under-frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

FE Facility Upgrades and Costs

The results of the FE analysis show that no planning criteria violations are attributable to the addition of the Ironwood 230 kV Project for the conditions studied. Therefore the conclusion is that no transmission or distribution reinforcements will be required to provide the requested service.

Interconnection Customer Requirements for Ironwood 230 kV Project

In addition to the FE facilities, Interconnection Customer will be responsible for meeting all criteria as specified in the applicable sections of the "FE Requirements for Transmission Connected Facilities" document. This includes but is not limited to the following:

1. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

2. The purchase and installation of the standard voice grade (analog) telephone line and associated conduit between the telephone company source and the meter socket or enclosure.

3. A compliance with the FE and PJM generator power factor and voltage control requirements.

4. The execution of a back-up service agreement to serve the customer load supplied from the Ironwood 230 kV substation when the Ironwood 230 kV Project units are out-of-service. This assumes the intent of Interconnection Customer is to net the generation with the load.

5. Any complaints from other customers (e.g. flicker complaints) will have to be corrected by Interconnection Customer. Correction may include changing operation, reducing generation, disconnecting the project from the Met-Ed system, or other measures.

6. The purchase and installation of supervisory control and data acquisition (SCADA) equipment to provide information in a compatible format to the FE Transmission System Control Center. The RTU, the communications channel and all related equipment will be furnished and maintained by the Interconnection Customer. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.

7. The following status and metering points will be required:
   a. Interconnection breaker position.
   b. Generator real and reactive power output measured at the high-side of the generator step-up transformer.
   c. Generator voltage at the point of interconnection.

8. An installation of two independent high-speed zones of protection to sense and clear faults on the interconnection transformer.

9. A compliance with the inverter standard UL1741 and IEEE 1547, "Standard for Interconnecting Distributed resources with Electrical Power Systems", in addition to the power quality standards defined by ReliabilityFirst and PJM.

10. A provision of the necessary generator protection, synchronization controls, and fault detection to initiate a trip to protect the Locktown Road (W3-150) Project equipment from faults on the Jersey Central System.

11. A compliance with the PJM Manuals and Operating instructions to have a plant operator on call 24/7 to respond within a minute to reduce the output of Ironwood 230 kV Project when network constraints occur.

The above requirements are in addition to any metering required by PJM.

Summary

The connection of the Ironwood 230 kV Project to the FE transmission system will require no network upgrades. Therefore Interconnection Customer will only have a cost responsibility for the Direct Connection of the Ironwood 230 kV Project to the Met-Ed transmission system. As shown on Attachment 4, the estimated cost of these facilities is $2,686,200. In addition, the customer has requested a cost to transfer its Ironwood 230 kV substation facilities to FE. This cost has been determined to be $635,100. Therefore, the total cost attributable to the Ironwood 230 kV Project is $3,321,300.

Based on the extent of the FE Direct Connection facilities required to support this project and the action required to transfer an ownership of the facilities to FE, it is estimated that it will take 18 months (1.5 years) from the date of a fully executed Interconnection Construction Service Agreement to complete the upgrades required for the Ironwood 230 kV Project. This includes the requirement for Interconnection Customer to make a preliminary payment to FE that funds the first three months of engineering design that is related to the construction of the Direct Connection facilities and transfer of ownership of the substation equipment. It further assumes that Interconnection Customer will provide the property for the attachment facilities needed and any right-of-way properties needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined direct connection and network upgrades, and that PJM and the customer will allow all transmission system and substation outages when requested.

Note that the FE findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in the System Impact Study. Further note that the cost estimate data contained in this document should be considered as only ballpark since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any connections to the transmission system.

Attachment 4
Ironwood 230 kV Project
Ironwood 230 kV Substation Direct Connection Facilities

Connection Facilities	Cost
Expand Ironwood 230 kV substation to a four breaker ring bus configuration	
- Expand existing substation footprint	
- Extend tubular bus work for new attachment position	
- Add one (1) new circuit breakers (3000 amp with 60 kA interrupting capability)	
- Add two (2) new breaker disconnect switches (3000 amp)	
- Install a fence to separate the FE and AEC Battery Storage facilities	
Add new termination structure for generator attachment	
All substation conductor to be bundled 1590 ACSR (2) wire	
Install/Replace system protection facilities	
Install metering and reroute fiber communications as necessary	
Attachment Protection, Metering, SCADA etc.	
	$2,686,200

Attachment 5

FirstEnergy Revenue Metering Requirements
For Generation Facilities Connected 69 kV and Higher

This document addresses the revenue metering requirements for new generation-only facilities connected to FirstEnergy (FE) system voltages 69 kV and higher. This document is not intended for existing retail or wholesale load facilities where behind-the-meter generation is being installed.

The Interconnection Customer (IC) shall install, own, operate, test, and maintain the necessary revenue metering equipment. This includes current transformers, voltage transformers, mounting structures, wiring, meters, communication circuits, and associated devices. The metering equipment must meet the specifications listed in the FE and PJM connection documents.

The revenue metering equipment shall be located at the generation facility on the high voltage side of the generator step-up transformers or facility main step-up transformer and/or station service power transformers. Power flows to and from the facility shall be compensated to the Point of Interconnection.

FE will provide revenue metering equipment for a station service power supply at a generation facility if the supply is from the local FE distribution system.

The revenue metering equipment shall be capable of collecting and storing bidirectional billing data. The billing data shall be stored in intervals specified by FE, typically fifteen minutes or thirty minutes. The IC must provide FE with remote access to the billing data in the revenue meter via a dedicated voice-grade analog telephone circuit. The IC shall provide FE with contact information for the person or persons responsible for meter programming and metering equipment maintenance.

The IC shall consult with FE regarding the revenue metering system design and provide the following information:

- Facility one line and revenue metering installation drawings (schematics, wiring diagrams, etc.)
- Estimated power flows to and from the facility at all revenue metering points
- Current transformer and voltage transformer specifications, including manufacturer, type, nameplate drawings, and certified accuracy test reports
- Revenue meter specifications including manufacturer, type, model number, and accuracy
- Revenue meter program information including but not limited to billing data recorder channel assignments, recorder pulse weights (Ke), and read-only password for access to interval data by the FE billing data collection system (MV-90)
- Revenue meter telephone number
- Revenue meter loss compensation data (if applicable)

The IC shall provide FE with prior notification of any modifications at the facility that will affect the revenue meter measurements, including substation reconfigurations and meter program changes.

The revenue metering system at each location shall be tested for accuracy by the IC once every two years. The IC shall give reasonable notice to FE of the time when the testing is scheduled so that FE may have representatives present. FE and PJM shall have the right to audit the revenue metering equipment and/or related documents. The IC shall be given a reasonable period of time to comply with any requests associated with an audit.

