PJM Generator Interconnection Request
Queue # V4-52
West Reading Project
Feasibility/Impact Study Report
Web Version

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FirstEnergy Feasibility / Impact Study
West Reading (V4-052) Generation Project

Introduction

This Feasibility Study report provides the documentation of an assessment that has been performed by PJM Interconnection and FirstEnergy (FE) in response to a request made by Interconnection Customer for the connection of two Natural Gas generators with a total capacity of 10.0 MW to the Met-Ed Transmission and Distribution System. This assessment was accomplished by: 1. Evaluating the reliability impact of the proposed facilities and connection on the interconnected distribution and transmission systems 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 the Interconnection Customer by conducting 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, the "FE Requirements for Transmission Connected Facilities", and the "FE Study Guide". In addition, an assessment was made of the requirements to connect to the Met-Ed distribution system.

Connection Facilities

In compliance with the Regional Transmission Expansion Planning (RTEP) protocol, Interconnection Customer has submitted a "Form of Generation Interconnection Feasibility Study Agreement" to PJM that identifies its plan to construct a West Reading (V4-052) Generation Project that will be comprised of two 5 MW natural gas fired units totaling 10.0 MW at their facilities at Sixth Avenue and Spruce Street, West Reading, Berks County, Pennsylvania (shown on Attachment 1). This generation has a proposed in-service date of January 1, 2011. Interconnection Customer currently receives electric service on the General Primary rate at 13.2 kV from 527 line out of Met-Ed's West Reading Substation, with an automatic alternate feed from 504 line, also out of the West Reading Substation. Interconnection Customer has requested that the alternate feed from 504 line be eliminated.

Attachment 2 shows a conceptual one-line diagram of the Direct Connection facilities that will be required for the West Reading (V4-052) Project. As shown, the 13.2 kV interconnection point will require the installation of a breaker on the generator side of the interconnection and a GOAB switch (to be installed by Met-Ed at Interconnection Customer's cost) at or near the tap point of the existing 527 line. Interconnection Customer is also responsible for constructing all of the facilities on its side of the point of interconnection. In addition, Interconnection Customer will be responsible for obtaining any needed right-of-way between the plant site and the FirstEnergy facilities. A summary of the facilities required for the West Reading (V4-052) Project Direct Connection and their cost estimate is shown on Attachment 3.

Met-Ed Distribution System

Met-Ed's 527 line (13.2 kV nominal) is the main source to Interconnection Customer. The transformer at West Reading Substation sources 527 line as well as other 13.2 kV circuits. There are other Met-Ed customers served by 527 line and the other circuits out of the West Reading Substation. The source at the West Reading substation is a 67-13.8 kV transformer rated 28 MVA (top nameplate). This transformer does not have a Load Tap Changer (LTC). The Interconnection Customer site is approximately 0.57 miles (circuit miles) from West Reading Substation.

Met-Ed Transmission System (Vicinity of Interconnection Customer)

The nearest 69 kV transmission line is approximately 0.34 miles from the Interconnection Customer site.

Met-Ed Distribution System Analysis

The effects of the generation on the Met-Ed system at the hospital location and at the West Reading Substation 13.2 kV bus were analyzed.

The voltage at the West Reading Substation 13.2 kV bus has been up to 126 volts in the past. Adding generation at the hospital location could cause the voltages seen by our other customers to exceed our PUC limits. To prevent this, the hospital must not generate above 124 volts without absorbing vars to keep the voltage from going above 124 volts. The required vars are estimated to be up to 4,000 KVARs that the hospital would have to absorb. (This requirement is above and beyond the requirement to not exceed a lagging (absorbing) power factor of 0.95, discussed later in this report. The voltage at the West Reading bus has been at or above 124 volts approximately 1,534 hours per year.

If the full 10.0 MW of generation should trip off suddenly, the change in voltage could be as high as 4.2% which is above our limit of 3%.

Also, if the generators are on and the full hospital load trips off, the change in voltage could be as high as 3.7% which is above our limit of 3%.

The total load on the transformer at the West Reading Substation (which includes the hospital load) is occasionally below 10 MVA.

PJM Analysis

Network Impacts

The queue V4-052 project was studied as a 10MW (6 MW capacity) injection into ME's system at the West Reading 69kV substation. The project was studied on a combined feasibility-impact basis which utilizes an AC analysis, and incorporates all contingency types. Project V4-052 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.

Transmission Owner Analysis

Power Flow Analysis -Transmission

A Power Flow study was conducted to determine the reliability impact of the proposed Interconnection Customer (V4-052) 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 Interconnection Customer (V4-052). The findings and the recommendations from this study are based on a contingency analysis 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 Interconnection Customer (V4-052) project generation to the PJM system.

Short Circuit and Dynamics Analysis - Transmission

PJM did not perform a Short Circuit analysis for this project based upon the interconnection voltage level.

Note that stability studies will be conducted by the PJM staff should this project proceed to the Facilities Study stage of the RTEP process.

Short Circuit Analysis – Distribution

A short circuit analysis was performed on the distribution system by the MetEd Planning and Protection staff. This analysis showed that there are three locations with a total of five transformers that now require the installation of current limiting fuses (CLF's), because the Interconnection Customer Generator project increases the fault duty above 10,000 amps at these locations.

Another analysis was performed to determine if the Interconnection Customer Generator project, (with resistance generator grounding), would cause temporary, transient over-voltages on the 527 line during single phase to ground faults. This analysis showed that there will be a problem with TOV, and 42 distribution lightning arresters must be changed to MOV type.

System Protection Analysis

An analysis was conducted to assess the impact of the Interconnection Customer (V4-052) project on the system protection requirements in the area. The results of this review have identified the following minimum requirements:

Direct Transfer Trip (DTT) using a developer provided communications channel is required from the 527 line breaker, the B7-02 high side bank breaker, and the 7B2 low side bank breaker at the West Reading Substation. The type of communication

channel shall be specified and/or approved by FirstEnergy. The FirstEnergy standard communications channel is a fiber optic cable. The generator will be fed from the West Reading substation and the cost estimates provided have the DTT signal coming from the West Reading substation. The DTT equipment at West Reading will be owned by FE. The generator must be disconnected from the 13.2 kV system while 527 line is fed from an alternate source.

If, in the future, upstream line protection is modified or added by First Energy, the Interconnection Customer will be responsible for the cost to add Direct Transfer Trip on any new device.

The 527 line over-current relays at the West Reading substation must be changed to directional overcurrent relays.

The cost estimate for the required FE facilities is included on Attachment 3.

Metering

Met-Ed will replace the existing interval meter with a meter that has bidirectional capabilities. The instrument transformers will require replacement and will result in an outage on the 13.2kV service. Met-Ed will provide the Customer access to bidirectional kWh and kVARh pulses from the revenue meter if requested. The customer shall install, at its expense, separate metering and telemetry equipment to provide the real-time MW, MVAR, volts and amps data required by the Met-Ed Data Center.

Compliance Issues

The 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 between .95 leading (absorbing MVARs) and .90 lagging (producing MVARs). However, the Hospital will be required to operate as shown above under **Met-Ed Distribution System Analysis. (In this section, it states that the Interconnection Customer will at times be required to absorb 4 MVAR of reactive load).**

The 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 shows that no planning criteria violations are attributable to the addition of the Interconnection Customer (V4-052) Project for the conditions studied. Therefore the conclusion is that no transmission or distribution reinforcements, (beyond those listed in the **Short Circuit Analysis – Distribution** sections and the **System Protection Analysis** section), will be required to provide the requested service.

Interconnection Customer Requirements

In addition to the FE facilities, Interconnection Customer will also be responsible for 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 execution of a co-gen back-up service agreement to serve the customer load supplied from the West Reading 13.2 kV substation when the units are out-of-service.
3. 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 must communicate with the FirstEnergy EMS via DNP 3.0 protocol. The RTU, the communications channel and all related equipment will be furnished and maintained by the generator owner.

4. 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.
    d. Indication that a transfer trip has occurred.

5. The installation must comply with the attached Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System (Attachment 7).

6. A direct transfer trip scheme using a developer provided fiber communications channel will be required from the 527 line breaker, the B7-02 high side bank breaker and the 7B2 breaker at the West Reading substation. If one of these FE breakers trips, both Interconnection Customer generator breakers would open.

7. The above requirements are in addition to any metering or other requirements imposed by PJM. It is the responsibility of the Interconnection Customer to provide appropriate metering and communications channels to submit to PJM required generation data.

8. The point of interconnection will be the existing customer owned pad mount switchgear at FE location 50226-36827 on Fifth Avenue. FE will own the UG 500 copper wire and terminators coming into the gear from the 527 line. The conductor leaving the gear will be the responsibility of the Interconnection Customer.

Additional Operating Requirements

1. Met-Ed will not allow any scheme where the full 10 MW of generation could trip off with one protective device (except that Met-Ed will allow a single breaker for the entire hospital facility which will trip off both the generation and the hospital load). Therefore the initial one-line diagram provided has been revised to indicate that each generator is to be connected to a separate breaker at the main 13.2 kV bus.

2. Also, if the generators are on and the full hospital load trips off, this exceeds the Met-Ed limit. Therefore, the amount of hospital load which can be behind a single internal protective device (other than the main interconnection breaker to Met-Ed) must be limited. Essentially the hospital load must be sourced from at least two circuit breakers.

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

4. The number of generator starts per day must be limited to help prevent flicker complaints. The hospital has indicated they only expect the two 5 MW generators will be started a maximum of once each per day. The number of starts and stops can not exceed one per day.

5. It is recommended that the generators ramp up and down as slowly as possible to prevent rapid voltage swings.

6. The hospital must not generate above 124 volts without absorbing VARS to keep the voltage from going above 124 volts. This is a calculated value and may require some adjustment after operation begins. This could also result in low power factor readings for the hospital which would result in higher demand billing for the hospital.

7. Under emergency conditions on the Met-Ed system (e.g. a substation transformer outage or a 527 line outage) or during equipment maintenance, the hospital may not be allowed to export to the Met-Ed system, with no penalty to Met-Ed.

8. The underground cable at the hospital site has a thermal limit of approximately 10 MVA (475 Amps). This would limit the amount of generation that Met-Ed could accept. In addition, the thermal limit of the 527 line egress cable at West Reading substation is also approximately 10

MVA (475 Amps). Since there are other customers also served by this circuit, the maximum load at the hospital is also limited by this rating.

9. Unacceptable levels of harmonics, generated by the Interconnection Customer project (V4-052), must not flow back onto the Met-Ed distribution system. Any and all impacts of such current injection, (typically but not limited to voltage waveform distortion), will be the sole responsibility of the Interconnection Customer to correct. Typical standards and limitations concerning harmonic currents and their impacts are found in the latest version of IEEE Standard 519 - Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

10. The Interconnection Customer is responsible for ensuring that the design of their generator and generator project takes into consideration the BIL of the Met-Ed distribution system, which is 95 kV. The Interconnection Customer should also be aware that the 527 line is an overhead line and, as such, it may at times see typical over-voltages due to lightning.

11. Presently, the Interconnection Customer takes a back up service from the Met-Ed 00504-1 circuit out of West Reading. After the completion of this project the 504 circuit will not be needed by the Interconnection Customer, and the Interconnection Customer will be disconnected from the 504 line.,

12. The installation must comply with the attached **Technical Requirements for the Interconnection of Parallel-Operated Generation to the FirstEnergy Distribution System.**

Summary

The connection of the Interconnection Customer project (V4-052) to the FE distribution system will require minor network upgrades, including the installation of several current limiting fuses, and lightning arresters. There will also be relay upgrades and direct transfer trip upgrades. As shown on Attachment 3, their estimated cost is $294,580.

Based on the extent of the FE direct connection and system upgrades required to support this project, it is estimated that it will take one (1) year from the date of a fully executed Interconnection Connection Service Agreement to complete the upgrades required for the Interconnection Customer project (V4-052). This includes the requirement for the 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. It further assumes that the Interconnection Customer will provide the property for the 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 will allow all transmission system 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 Facilities Study. Further note that the cost estimate data contained in this document should also be considered conceptual for budgetary purposes since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FirstEnergy 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.

Because of the large level of generation, (10 MW) being injected into the Met-Ed 527 West Reading line, the operating guidelines listed previously in this report must be followed. Failure to adhere to these operating guidelines may result in complaints from Met-Ed customers. It will be the sole responsibility of the Interconnection Customer to change operation of their facilities to mitigate the complaints. Met-Ed reserves the right to disconnect the Interconnection Customer from the Met-Ed system if the hospital fails to mitigate the complaints

Fault Information

Projected fault currents at the Interconnection Customer point of attachment to Met-Ed's 527 line are:

With the generation off:

Currents are at 13.2 kV.

Three Phase Fault	6,616 amperes
Single Line to Ground Fault	5,024 amperes
X1/R1 ratio	5.43
X0/R0 ratio	5.59

The fault values provided are bolted, symmetrical values for present, normal FE system conditions. Future increases in fault currents are possible and it is the customer's responsibility to upgrade his equipment and/or protective equipment coordination when necessary.

1. Applicability

This document defines the technical requirements for the interconnection of parallel-operated generation and related equipment to the FirstEnergy distribution system. For purposes of this document the term "generation" includes rotating and inverter-derived generating sources.

These requirements apply to customer-owned generation used to offset energy usage and to distributed generation exporting energy on a wholesale basis.

This document also applies to standby generator schemes with a make-before-break transition provided that the duration of parallel operation is 100 milliseconds or more.

These requirements apply to new generator interconnections as well as existing facilities being upgraded or expanded.

2. Purpose

The purpose of these technical requirements are to ensure the safety of FirstEnergy employees and the public, to protect FirstEnergy equipment from damage and to ensure the reliability of service to FirstEnergy customers.

3. Applicable Standards

3.1 Generator facilities must comply with all requirements of the latest version of the IEEE 1547, "Standard for Interconnecting Distributed Resources with Electric Power Systems[1]."

3.2 Inverter systems must comply with all requirements of the latest version of the UL1741, "Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources[2]."

3.3 Generator facilities and equipment must comply with all applicable national, state, and local construction codes and all operation and maintenance-related safety codes, such as the National Electrical Code (NEC), the National Electrical Safety Code (NESC), and the Occupational Safety and Health Administration (OSHA) regulations.

3.4 Generator interconnections are subject to applicable Federal or State interconnection rules and regulations depending upon interconnection type.

4. Relaying and Protection

[1] IEEE Standard 1547-2003, "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems," July 28, 2003.
[2] Underwriters Laboratory U.L. 1741, "Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources," May 7, 1999.

4.1.1 The generator owner is responsible for providing adequate protection to FirstEnergy facilities for conditions arising from the operation of generation under all FirstEnergy distribution system operating conditions.

4.1.2 The generator owner is responsible for providing adequate protection to their facility under any distribution system operating condition whether or not their generator is in operation. Conditions may include but are not limited to:

- Loss of a single phase of supply
- Distribution system faults
- Equipment failures
- Abnormal voltage or frequency
- Lightning and switching surges
- Excessive harmonic voltages
- Excessive negative sequence voltages
- Separation from supply
- Synchronizing generator to the distribution system
- Re-synchronizing the generation after electric restoration of the supply.
- Loss of transfer trip communication channel where applicable.

4.2 The generator must trip within the specified time for voltage excursions outside of the allowable operating ranges specified in the IEEE 1547 Standard. By agreement of both the generator owner and FirstEnergy, different settings may be used for the under/over voltage trip levels or time delays.

4.3 The generator must trip within the specified time for frequency excursions outside of the ranges specified in the IEEE 1547 standard. By agreement of both the generator owner and FirstEnergy, different settings may be used for the under/over frequency trip levels or time delays.

4.4 The generator shall cease to energize the FirstEnergy Distribution System for faults on the circuit to which it is connected.

4.5 The generator unit protection and controls must be designed to coordinate with the reclosing practices of FirstEnergy line protective devices.

4.6 The generator shall be designed to prevent it from being connected to a de-energized FirstEnergy circuit. The generator shall not be reconnected to the FirstEnergy system after a trip from a system protection device, until the FirstEnergy system has been re-energized for a minimum of five minutes.

4.7 Generator equipment must have adequate fault interruption and withstand capacity, and adequate continuous current and voltage rating to operate properly[3] with the FirstEnergy system. Where three-phase generators are used, a three-phase interrupting device shall be used so that all three phases are interrupted simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the FirstEnergy distribution system

[3] Properly, in this context, means within the acceptable utility or applicable industry established practices.

connection.

4.8 Utility grade relays are required for non-certified inverter-based generators and rotating machines rated 300kW or larger. Where multiple generators are connected to the distribution system through a single point of interconnection and the aggregate generation exceeds 2 MW, utility-grade relays must be applied at the point of interconnection which satisfy the protection requirements of par. 4.1.1

For purposes of this policy, utility-grade relays are defined as follows:

- Relays meet the latest IEEE Standard, C37.90, "Relays and Relay Systems Associated with Electric Power Apparatus."
- Have relay test facilities to allow testing without unwiring or disassembling the relay.
- Have appropriate test plugs/switches for testing the operation of the relay.
- Have targets to indicate relay operation.

5. Anti-Islanding Protection

5.1 The generator must be equipped with adequate protection to detect an island condition and disconnect from the FirstEnergy distribution system within two seconds of the formation of an island (per IEEE 1547).

5.2 The anti-islanding requirement can be met by any one of the following :

- Direct Transfer Trip Scheme. (see par 3.3 for requirements)
- Use of frequency relays (par 3.1.3) and voltage relays (par 3.1.4)
- The generator or inverter is certified to pass an anti-islanding test.
- Use of reverse power relaying. (for non-exporting customers)

6. Direct Transfer Trip

6.1 FirstEnergy will make the determination if a DTT scheme is required on a case-by-case basis. A DTT scheme will typically be required when both of the following are true:

a) The generator is a synchronous machine, a non-certified or self-commutating inverter, or a self-excited induction generator capable of sustaining a load when separated from the utility system, and:

b) The aggregate generator capacity is greater than one-third of the feeder's minimum load connected to the generator(s) after operation of any automatic line sectionalizing devices.[4]

6.2 The DTT scheme design, equipment and type of communication channel shall be proposed by the generator owner and submitted to FirstEnergy for review and acceptance.

6.3 The DTT scheme must be designed to automatically trip and separate the generator from the FirstEnergy distribution system upon loss of communication channel. The generator shall not reconnect to the system until the communication channel is proven to functioning normally.

[4] For further guidance see IEEE 1547.2-2008, "IEEE Application Guide for IEEE Std. 1547™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems" dated April 15, 2009.

6.4 Responsibilities for purchase, installation and ownership of DTT equipment will be as follows:

6.4.1 The generator owner shall own and bear the costs to purchase, install, and maintain a direct-transfer trip receiver(s) at their facility to receive tripping signals originating from a FirstEnergy location(s).

6.4.2 The generator owner shall bear the costs to purchase and install the required DTT transmitting and associated relaying equipment at the required FirstEnergy location(s). FirstEnergy will perform or coordinate the installation of the equipment at the cost of the generator owner. FirstEnergy will own and be responsible to maintain and perform periodic maintenance and testing of this equipment.

6.4.3 The generator owner is responsible for the design, installation and maintenance of a dedicated communication channel(s) between the FirstEnergy location(s) and the generation owner's facility, including any rental, license and attachment fees for the communications channel.

6.5 If the generator owner wishes to install communications cables or equipment on FirstEnergy Operating Company poles, the generator owner will be responsible to secure a license agreement or pole attachment agreement for those attachments, and assume typical licensed attachment responsibilities in terms of make-ready work costs and annual attachment fees. Cable attachment will be in the communications space on the poles.

6.6 When a DTT tripping signal originates from a FirstEnergy substation breaker, the preferred location for DTT transmitter and associated equipment is within the FirstEnergy substation control room or approved outdoor enclosure within the substation perimeter if a control room is not available.

6.7 FirstEnergy will establish a demarcation point for any DTT communication cables leaving the substation property. FirstEnergy will perform or coordinate the installation of the cable and conduit up to the demarcation point including the box enclosure. FirstEnergy will determine the enclosure location. All material and installation costs will be borne by the generator owner. The generator owner will be responsible to install cable and conduit originating from their end up to the demarcation point. Details of the planned installation including any trenching must be approved by FirstEnergy.

6.8 The generator owner may be responsible to compensate FirstEnergy for any labor expenses involved with troubleshooting or testing of the DTT communications or protection system. This requirement is to be contractually addressed in the Interconnection Agreement with the generator owner.

7. Operational Requirements

7.1 The generator equipment must be capable of interconnecting to the distribution system

with minimum voltage and current disturbances to other FirstEnergy customers.

7.2 Generator synchronizing equipment must comply with the synchronization parameter limits established in the IEEE 1547 standard.

7.3 The generator equipment shall not be a source of excessive harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including inductive telephone influence factors) will be as published in the latest issues of IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems[5]." Flicker occurring at the point of common coupling shall remain below the Border Line of Visibility curve on the IEEE/GE curve. When there is reasonable cause for concern due to the nature of the generation and its location, FirstEnergy may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the generator owner's expense. Situations where high harmonic voltages and/or currents originate from the distribution system are to be addressed in the Interconnection Agreement.

7.4 If high-voltage, low-voltage, or objectionable voltage flicker arises due to the operation, frequent tripping, and/or frequent starting and stopping of the generator, the generator owner may be required to disconnect its generation equipment from the FirstEnergy system until the problem has been fully investigated and resolved.

7.5 The operation of the generator equipment must not result in harmonic currents or voltages at the point of common coupling that will interfere with FirstEnergy's metering accuracy and/or proper operation of facilities and/or with the loads of other FirstEnergy customers. Such adverse effects may include, but are not limited to heating of wiring and equipment, overvoltage, communication interference, harmonic resonance, etc.

7.6 DC injection from inverters shall be maintained at or below 0.5% of full rated inverter output current into the point of common coupling. This is an IEEE 1547 requirement.

7.7 The generated voltage shall follow, not attempt to oppose or regulate, changes in the prevailing voltage level provided by FirstEnergy at the point of common coupling, unless otherwise mutually agreed to by the generator owner and FirstEnergy.

7.8 The generator must not interfere with the operation of FirstEnergy voltage regulating equipment including voltage regulators and line capacitors such that the service voltage to other FirstEnergy customers falls outside the limits specified in ANSI C84.1[6], Range A.

7.9 Voltage unbalance at the point of common coupling caused by the generator equipment under any condition shall not exceed 3% (ratio of maximum deviation from average

[5] IEEE Standard 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems," Second printing June 15, 2004.
[6] ANSI C84.1-2006, American National Standard for Electrical Power Systems and Equipment—Voltage Ratings (60 Hertz)

voltage to the average voltage).[7]

7.10 A generator connected to an area network system shall not cause tripping of network protectors due to reversal of power flow.

8. Disconnect Switch Requirements

8.1 FirstEnergy requires that a disconnect device with a visibly open means be provided, installed, and paid for by the generator owner, which is readily accessible to and lockable by FirstEnergy personnel, in order to safely disconnect the generator from the FirstEnergy system.[8]

8.2 The disconnect device may be installed either at the primary voltage level or secondary voltage level at the discretion of FirstEnergy. The generator disconnect device must be clearly labeled to show its intended function.

9. Interconnection Transformer Requirements

9.1 Note: The choice of winding configuration and grounding for the interconnection transformer involves a tradeoff and therefore needs careful consideration. Each interconnection will need careful engineering review to determine the best solution. The IEEE 1547.2 Application Guide[9] gives further guidance on interconnection transformer selection.

9.2 All three-phase generation must be isolated from other FirstEnergy customers by a power transformer in order to properly integrate the grounding scheme of the generator to the distribution system.

9.3 The grounding scheme of the interconnection transformer shall not cause overvoltages on the un-faulted phases during ground-fault conditions that exceed the rating of equipment connected to the FirstEnergy distribution system.

9.4 The ground source contribution current of the interconnection transformer shall not disrupt the coordination of the overcurrent devices of the feeder whether or not the generator is in operation.

9.5 IEEE/ANSI C62.92 -1987 shall be method of choice for determining effective transformer grounding.

10. Maintenance Requirements

[7] ANSI C84.1-2006, Annex C, Polyphase Voltage Unbalance, Paragraph C.2

[8] Exception: In New Jersey, an outdoor disconnect switch is not a requirement for level 1 interconnections per NJ Net metering regulations. See NJ Administrative Code, NJAC 14:8-4.1 et seq.(2008)

[9] IEEE Standard 1547.2-2008, "IEEE Application Guide for IEEE Std 1547™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems" April 15, 2009.

10.1 The generator owner shall maintain all equipment associated with the generator system, including DTT communications equipment, according to good utility practices and according to equipment manufacturer's recommendations and keep it in proper working condition. The generator owner shall keep a written log and test records showing the periodic testing of such equipment. These records must be available to FirstEnergy upon request.

11. Acceptance Testing

11.1 Acceptance testing of the protective schemes must be completed on new or modified installations.

11.2 Test results or equipment pre-certification shall be supplied by the generator owner, that verify, to the satisfaction of FirstEnergy, compliance with the IEEE 1547 Standard, Section 5 "Interconnection Test Specifications and Requirements."

11.3 IEEE 1547.1 Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems contains the detailed requirements of acceptance testing.

11.4 The generator owner must provide FirstEnergy the opportunity to perform an inspection prior to interconnection to verify correct protective settings and wiring connections.

11.5 Conformance tests shall be performed on all generators and generating equipment not pre-certified by a Nationally Recognized Testing Laboratory as suitable for utility interconnection meeting the intent of these technical requirements. A qualified third party testing organization shall perform these tests at the expense of the generator owner.

12. Communications and Control

12.1 FirstEnergy may require the generator owner to provide a listing of two or more persons and their telephone numbers such that the FirstEnergy dispatching office can contact the generator owner for emergency switching operations 24-hour a day. This is a necessary safety requirement.

12.2 For generators rated 2000 kVA or larger, individually or in aggregate, who are exporting energy on a wholesale basis, will require the generator owner to furnish a SCADA RTU which will interface with the FirstEnergy EMS system. The RTU, the communications channel and all related equipment will be furnished and maintained by the generator owner. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol.

The following status and metering points will be required:

- Control of generator or interconnection breaker at FirstEnergy's discretion.
- Interconnection breaker position.

- Generator real and reactive power output measured at the high-side of the generator step-up transformer.
- Generator voltage at the point of interconnection.
- Indication that a direct-transfer trip operation has occurred where applicable

13. Revenue Metering Requirements

13.1 Metering instrument transformers are to be protected from the distribution system by a fuse or other protective device such that failure of an instrument transformer does not cause a distribution protection device to open.

13.2 In the case of an existing retail customer that is adding generation their facility, the retail billing meter will need to be replaced with a bi-directional meter. A review of the wiring and current transformers may need to be performed to verify the ampacity ratings are sufficient for the size of the generator.

13.3 Revenue-producing generators which are selling energy to the market must comply with the metering requirements of the appropriate RTO. The metering point shall be located on the high voltage side of the interconnection transformer.

13.4 Cost responsibilities associated with the purchase, installation, and testing and of revenue metering equipment will be determined on a case-by-case basis under the direction of the FirstEnergy Corporate Metering Department and in accordance with the rules found in filed tariffs. These details are to be addressed in the facilities study.

13.5 Metering equipment must meet the specifications of FirstEnergy and the appropriate RTO.

13.6 Generators 1000kVA or larger may require the generator owner to provide at their cost a dedicated phone line and metering equipment for interval metering. Interval metering data will be collected by FirstEnergy MV-90 system.

Definitions

Area Network System - A type of electric distribution system served by multiple transformers interconnected in an electrical network circuit, which is generally used in large metropolitan areas that are densely populated, in order to provide highly reliable service. Area network has the same meaning as the term “distribution secondary grid network” found in institute of electrical and electronics engineers (IEEE) standard 1547.

Flicker – A variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity.

Harmonic Distortion – Continuous distortion of the normal sine wave; typically caused by nonlinear loads or by inverters.

Point of Common Coupling – The point at which the generator facility is connected to the shared portion, or potentially shared portion of the FirstEnergy system. The IEEE 1547 standard establishes this point as the location where voltage and harmonic limits are measured and applied.

Single Phasing Condition – Occurs when one or two phases of the three phase supply line are disconnected.

Unintentional Island - An unplanned condition where one or more generator’s and a portion of the FirstEnergy system remain energized solely through the point of interconnection.