Transmission Interconnection Facilities Study Report

For

PJM Transmission Interconnection Request Queue Position AE2-333

"Bedington 138 kV"

April 2022

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Preface

The intent of the Facility Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances, an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement.

The Facility Study estimates attempt to identify the estimated time required to obtain property rights and permits for construction of the required facilities. The project IC 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.

A. Transmission Owner Facilities Study Summary

1. Description of Project

Bedington Energy Facility, LLC, (hereinafter referred to as "IC") has proposed a solar generating facility located in Berkeley County, West Virginia. The installed facilities for AE2-333 will have a total capability of 100 MW with 60 MW of this output being recognized by PJM as capacity. The generation facility will interconnect with The Potomac Edison Company (PE) a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO), by adding a line terminal position to the existing Bedington 138 kV Substation. This will be accomplished by adding a breaker and related equipment into the existing breaker-and-a-half scheme. The POI is located on an existing Potomac Edison-owned deadend structure inside the Potomac Edison-owned substation.

2. Amendments to the System Impact Study or System Impact Study Results

No amendments to the System Impact Study or System Impact Study Results were identified.

3. Interconnection Customer's Milestone Schedule

The Commercial Operation Date (COD) for the generation facility is **May 1, 2024**. A Project Kickoff meeting must occur by July 31, 2022 to meet Transmission Owner's Assumed Milestone Schedule listed below.

Milestone Schedule:

3/01/2024	Initial Back-feed through Project Substation Date
5/01/2024	Project Commercial Operation Date

4. Customer's Scope of Work

IC is responsible for all design and construction related to activities on their side of the Point of Interconnection (POI). This includes, but is not limited to the generation step-up (GSU) transformer, 138 kV (AE2-333) generator lead line and connection to the new line termination at the interconnection substation.

Point of Interconnection (POI): The POI will be located within the existing Bedington 138 kV breaker-and-a-half substation where IC-owned 138 kV attachment line conductor will terminate on the insulators on the dead-end takeoff structure and will be defined as the POI.

IC is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of the GSU transformer, as well as the necessary revenue metering equipment. The revenue metering current and voltage transformers shall be installed on the high voltage side of the GSU, on the generation side of the fault-interrupting device, and within the local zone of fault protection for the facility. The protective relaying and metering design must comply with First Energy's applicable standards as well as with PJM requirements.

Assumptions / Notes:

- IC will coordinate design and alignment of proposed 138 kV generator lead line with the Transmission Owner for review of any clearance, right-of-way or right-of-way encroachment issues with TO owned facilities.
- IC will coordinate design and construction of proposed 138 kV Lead Line. For these areas, the IC shall provide TO with proposed plan and profile or PLS-CADD drawings prior to construction and as-built drawings, confirmed by as-built survey data post-construction.
- Transmission Owner's preference would be to limit interference and avoid transmission line crossings with new 138 kV terminal positions. As a minimum, IC facilities should not encroach within 100 feet of TO centerline at blowout conditions. If IC's line design does not comply with this requirement TO would need to review this area as a special exception.
- Additional costs will be incurred by the IC, if final alignment of the 138 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities. See Section 7 of this report for additional information.

5. Description of Facilities Included in the Facilities Study

Attachment Facilities

- AE2-333 Customer Substation
    - Transmission Owner will accommodate the attachment of the incoming generator lead line. This work will include, but not be limited to, foundations, motor-operated disconnect switch, jumpers, insulator assemblies, and associated equipment to accommodate the termination of the 138 kV generator lead line.
    - Drawings and nameplates will be reviewed.

Direct Connection

None

Non-Direct Connection

- Bedington Substation
    - To connect the AE2-333 solar project with the Potomac Edison transmission system, a new line position will be established within the Bedington 138 kV Substation by adding a new circuit breaker and related equipment to the breaker-and-a-half scheme. A circuit breaker, 3 CCVTs, 3 slip-over bushing CTs, and a prewired relaying panel will be installed to accommodate the new line terminal.
    - Estimated (1) in-sub fiber run from Bedington control house to developer built fiber run to support communications to AE2-333. SCADA work at Bedington to support breaker and relay installations.

- Project Management
    - Review of scope regarding Project Management, Commissioning, Environmental, Forestry, Real Estate, and Right of Way.

Other Work

- AE2-333 Metering
    - Customer-owned revenue metering at interconnection customer substation.

6. Total Cost of Transmission Owner Facilities Included in the Facilities Study

Description	Total
Attachment Facilities:	**$ 139,900**
Total Direct Connection (DC) Costs:	**$ 0**
Total Non-Direct Connection (NDC) Upgrade Costs:	**$ 1,129,300**
Total Other Charges:	**4,400**
New System Upgrades	**$ 0**

TOTAL Costs (ALL Categories)	**$ 1,273,600**

7. Summary of the Schedule for Completion of Work for the Facilities Study

Attachment Facility	*Timeframe*
Engineering, Procurement, and Construction	18 months

B. Transmission Owner Facilities Study Results

This section describes facilities identified to be installed (attachment facilities), replaced, and/or upgraded (upgrade facilities) by First Energy to accommodate the project. During detailed design and analysis other components may be identified for installation or replacement due to this interconnection.

1. Transmission Lines –New

None

2. Transmission Lines – Upgrade

None

3. New Substation/Switchyard Facilities

AE2-333 Customer Substation

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Review of customer drawings & nameplates.
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

4. Substation/Switchyard Facility Upgrades

Bedington Substation

- Below Grade
  - Install new foundations, conduit, and grounding for new equipment.
- Above Grade
  - Install (3) new 138kV CCVT's on the new AE2-333 terminal.
  - Install (1) new 138kV Motor Operated Line Disconnect switch, rated 2000A cont.
  - Install (1) new 138kV Circuit Breaker, rated 2000A cont., minimum 63 kA interrupting
  - Replace (2) existing 138kV Circuit Breaker Disconnects with (2) new 138kV Circuit Breaker Disconnects, rated 2000A cont.
  - Install (3) slip-over CT's on 138kV Circuit Breaker BD14, per protection specs attached.

- R&C
  - Install (1) standard prewired Line Relaying Panel, utilizing dual SEL-411L transmission line protection and differential over fiber w/ step distance backup. Include SEL-501 BFT and SATEC meter on this panel.
  - Install (1) new GPS Clock.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Control house has adequate space for new equipment.
  - SEL RTAC/RTU to be replaced in 2022.

5. Telecommunications Facilities – Upgrades

IC will design, provide, install, own and maintain a fiber-optic communication cable between the Bedington Substation and IC's **generation** (collector) substation. Two (2) fiber-optic channels are required for each generator protection scheme to obtain high-speed tripping capability for any fault within the zone of protection. Should subsequent/additional PJM studies indicate that stability issues exist, the primary and backup relay fiber-optic communication channels must be in separately-routed cable paths and additional fiber-optic connection costs would apply (not included herein).

The IC will make the fiber-optic cable termination connections for its cable(s) at the Bedington Substation control house.

Transmission Owner will make the fiber termination connections for its cable(s) at the Bedington Substation control house. IC is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber cable.

6. Metering & Communications

IC shall install, own, operate, test and maintain the necessary revenue metering equipment. IC shall provide Transmission Owner with dial-up communication to the revenue meter.

The revenue metering system (particularly the revenue metering current transformers) shall be designed to accurately meter the light loads that will occur when the facility is not generating power and only back-feeding station service from the Transmission Owner. This may require the use of high accuracy extended range current transformers.

Transmission Owner's Revenue Metering Requirements may be found in the *Requirements for Transmission Connected Facilities* document located at the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

These requirements are in addition to any metering required by PJM.

The existing Bedington telecommunication circuits will be used for SCADA and telephone.

Transmission Owner will obtain real-time, site-specific, generation data from PJM, via the required communication link from IC to PJM. Transmission Owner will work with PJM and IC to ensure the generation data provided to PJM meets Transmission Owner's requirements.

Communications for transmission line protection between the new **interconnection** substation, and IC's **generation** (collector) substation, will be via fiber optics (see "Telecommunication Facilities" section above).

7. Environmental, Real Estate and Permitting

The following are possible environmental, real estate and permitting issues:

- Environmental permitting, Real Estate acquisition, Public Service Commission of West Virginia (PSCWV) notifications vary, some up to twelve (12) months after preliminary engineering is completed to secure the required approvals.
- IC is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- All work occurs within an existing transmission line right-of-way or on IC's property with access to all existing structures possible via that property and the right-of- way following established access routes that do not cross wetlands or streams.
- IC will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- IC will obtain all necessary permits.
- IC will conduct all necessary wetlands and waterways studies and permits.
- IC will conduct all necessary historical and archaeological studies.
- All substation upgrades will take place within the current substation fencing. No expansion of the Bedington substation is required.
- If the IC plans to cross the transmission line right of way with facilities or access roads, please refer to the Transmission Rights-of-Way Restrictions information located at: https://www.firstenergycorp.com/help/safety/real-estate-power-lines/transmission-right-of-way.html#ROWform

8. Summary of Results of Study

Work Description	Direct Labor	Direct Material	Indirect Labor	Indirect Material	Total Cost
AE2-333 Generator Lead Termination: Installation of foundations, disconnect switch and associated equipment to accommodate the termination of the 138 kV generator lead line.	$ 57,100	$ 28,600	$ 20,700	$ 2,200	$ 108,600
AE2-333 Customer: Review drawings and nameplates.	$ 23,000	$ 0	$ 8,300	$ 0	$ 31,300
Total Attachment Facilities Cost	**$ 80,100**	**$ 28,600**	**$ 29,000**	**$ 2,200**	**$ 139,900**
None	-	-	-	-	-
Total Direct Connection Cost	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
Bedington: Direct injection into Bedington substation to interconnect queue project AE2-333	$ 514,100	$ 257,500	$ 185,900	$ 19,600	$ 977,100
Estimated (1) in-sub fiber run from Bedington control house to developer built fiber run to support communications to AE2-333. SCADA work at Bedington to support breaker and relay installations.	$ 38,900	$ 4,100	$ 14,100	$ 300	$ 57,400
Project Management: Project Management	$ 66,100	$ 4,500	$ 23,900	$ 300	$ 94,800
Total Non-Direct Connection Network Upgrades	**$ 619,100**	**$ 266,100**	**$ 223,900**	**$ 20,200**	**$ 1,129,300**
Metering: Customer-owned revenue metering at interconnection customer substation.	$ 3,200	$ 0	$ 1,200	$ 0	$ 4,400
Total Other Charges	**$ 3,200**	**$ 0**	**$ 1,200**	**$ 0**	**$ 4,400**
Total Project Costs	**$ 702,400**	**$ 294,700**	**$ 254,100**	**$ 22,400**	**$ 1,273,600**

Generation projects meeting IRS "Safe Harbor" provisions generally do not incur "CIAC" (Contribution in Aid to Construction), a tax collected by the utility for the state or federal government. First Energy does not expect to collect CIAC for this project. If for any reason, "CIAC" would be required for this project, it would be the responsibility of the party owning the generator to pay this cost.

First Energy reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering facilities, owned by First Energy. This must be included in Schedule E of the Interconnection Service Agreement.

9. Schedules and Assumptions

A proposed **eighteen (18) month Direct Connection** schedule is estimated to complete the engineering, construction and the associated activities, from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" section of this document are resolved, and outages (typically not granted from June through September) will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

18 month Schedule

Activity	Start Month	End Month
[redacted]		
Preliminary Engineering	1	3
Permits & Real Estate	2	12
Detailed Engineering	2	12
Equipment Delivery	13	14
Below Grade Construction – Substation	14	17
Above Grade Construction – Substation	15	17
Testing & Commissioning	17	18

Attachment #1: Protection Study

PROTECTION SCOPE

SHORT CIRCUIT DATA for a fault at the proposed location of the connection of AE2-333 on the 138kV bus at Bedington Substation (Symmetrical Values Only)

Initial conditions (percent on 100 MVA base)

	138kV
Z1 =	0.077 + j 1.197%
Z0 =	0.440 + j 2.198%

3 phase fault – 35,166A
Single line to ground fault – 27,308A 3I0

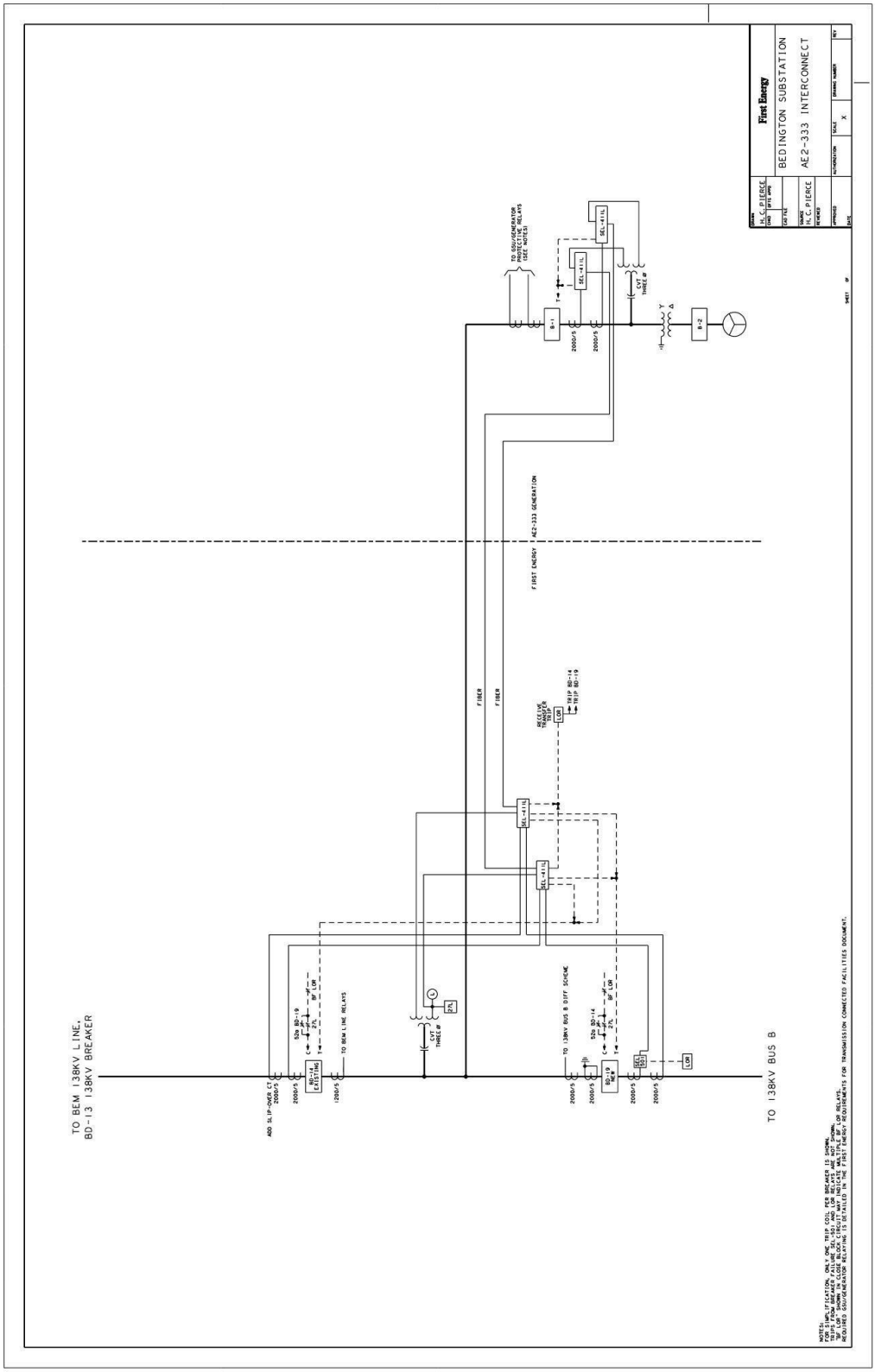
Note: These fault values do not include the AE2-333 Generator or GSU step up transformer as being modeled in the calculations.

Impedances are given on a 100 MVA and 138kV bases. The faults provided are bolted, symmetrical values for normal system conditions. Future increases in fault currents are possible and it is the customer's responsibility to upgrade their equipment and/or protective equipment coordination when necessary.

All proposed generation interconnection points and load-serving delivery points must comply with the technical requirements detailed in FE's "Requirements for Transmission Connected Facilities" document.

The attached relay sketch provides details of relay requirements for AE2-333 Generation interconnection and is considered part of the Facilities Study Report.

AE2-333 Interconnection at Bedington substation



MAJOR EQUIPMENT SPECIFICATIONS

Install the following:

- New, for position BD-19, 138kV circuit breaker nominal, rated 145kV, 2000A minimum continuous, 63kA or higher interrupting, with 4 sets (2 per bushing) of CTs, 2000/5 MR, C800 @ 2000:5, thermal factor of 2.0.
    - Include 2 sets of 3, Metering CTs, 1000/5 MR, C800 @ 1000:5, thermal factor of 3.0, metering accuracy of 0.3B1.8. – For revenue metering and operational (SCADA) metering.

- New, set of 3, nominal 138kV system - 1200/700:1 capacitor voltage transformers, with three secondary windings, 0.3MWXYZ. Each secondary winding shall be wye connected. X, Y, and Z winding taps shall be wired to independent test switches. The Z secondary winding shall be used exclusively for metering and be rated for 0.3% accuracy at Z or ZZ burden. 115 and 66 volt secondary voltages from each winding shall be run to the control building. No carrier accessories are required.

RELAY AND COMMUNICATION EQUIPMENT SCOPE

138kV Line Exit to Generator – Customer SS

Install the following:

- Three single-phase dual winding capacitor voltage transformer, dual ratio = 1200/700/1 (carrier facilities are not required)
- OPGW fiber optic cable to customer substation for relaying digital communication channel

The protective relaying for the 138kV line to the generator shall contain the following:

- SEL-411L relay for the primary line protection, which shall utilize a line differential scheme with step distance backup
- SEL-411L relay for the backup line protection, which shall utilize a line differential scheme with step distance backup
- SEL-501 relay for Bkr BD-19 breaker failure
- LOR relay for Bkr BD-19 breaker failure tripping
- LOR relay for generation station breaker failure tripping (operate from transfer trip receive)
- SATEC digital multimeter
- SD relay (“27L”) for line potential monitoring (blocks all closing of Bkrs BD-14 and BD-19 if line from generator is hot)

AE2-333 will only close into this line if it is dead. All synchronizing is to be performed at the Generator Substation. No automatic reclosing will be applied.

Additional items

- GPS Clock, Arbiter 1094B, with antenna, 50 feet of cable, and antenna mounting kit (if not already at Bedington SS)
- SCADA and annunciator, details to be determined by Real Time Operations
- SEL RATC for remote access to SEL protective relays (if not already at Bedington SS)

- Test switches, fuses, and terminal blocks as deemed necessary

Changes to existing relaying at Bedington:
- Bus B Differential CT inputs removed from Breaker BD14 and moved to Breaker BD19
- Remove Bus B Differential trip, lockout, and breaker failure initiate from BD14
- Remove Breaker BD14 breaker failure trips and lockouts from BD3, BD6, BD9, BD12 and BD17

Generation Substation Protection Requirements

It is the responsibility of the Generator Owner (GO) to assure protection, coordination and equipment adequacy within their facility for conditions including but not limited to:

- Single phasing of supply
- System faults
- Equipment failures
- Deviations from nominal voltage or frequency
- Lightning and switching surges
- Harmonic voltages
- Negative sequence voltages
- Separation from FE supply
- Synchronizing generation
- Synchronizing facilities between independent transmission system and FE
- Transmission System

The generator owner (GO) is to design their protective system to clear any faults within their zones of protection with one or more of their local breakers. Each zone of protection covering the 138kV portion of the GO system (including the GSU(s)) is to be protected by two fully independent relay schemes that each provides high speed fault protection. The terminal breaker at the GO end of the direct connection line is to be included in one of these zones of protection. Two SEL-411L relays shall be used for protection of the interconnect line, to match the companion relays at Bedington Substation.

The customer is solely responsible for protecting its own equipment in such a manner that electrical faults or other disturbances on the FE system do not damage its equipment.

Metering Requirements

A revenue metering installation is required for this installation. Requirements are outlined in FirstEnergy's "Requirements for Transmission Connected Facilities" document.

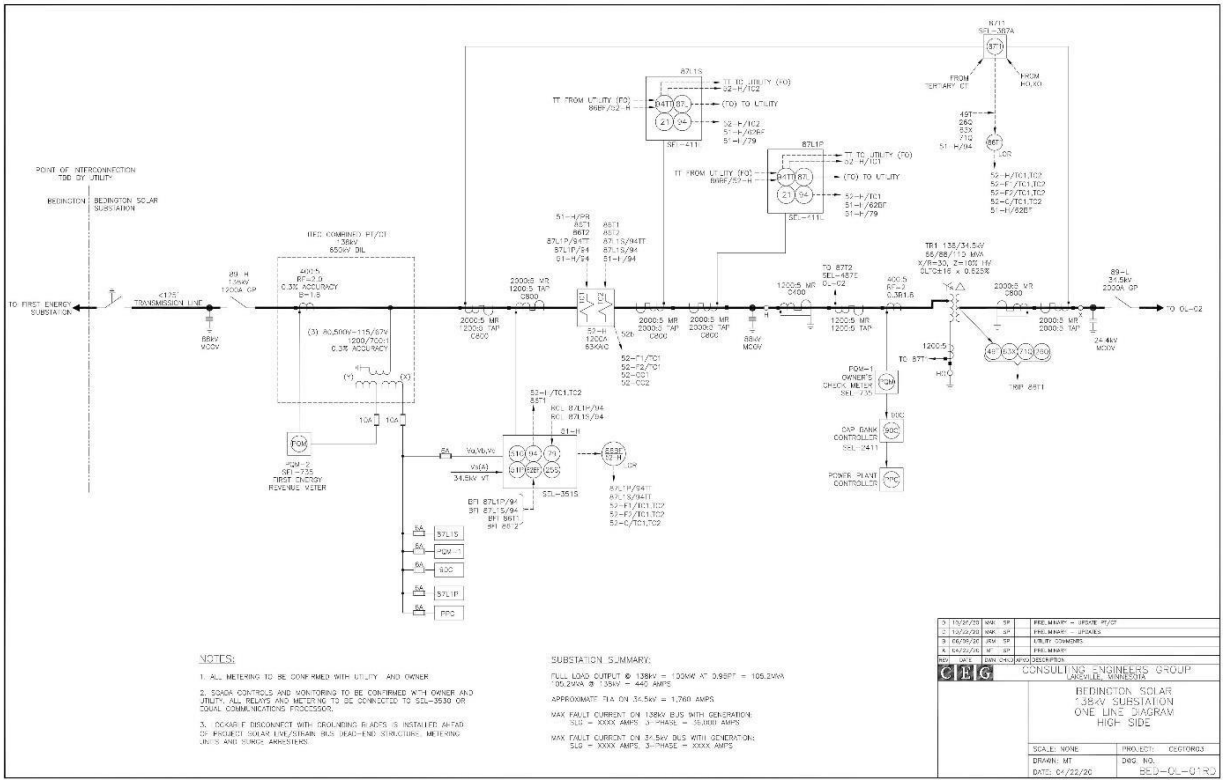
Operational metering is also required for this generation connection. These requirements are also outlined in FirstEnergy's "Requirements for Transmission Connected Facilities" document. These requirements are in addition to any metering required by PJM.

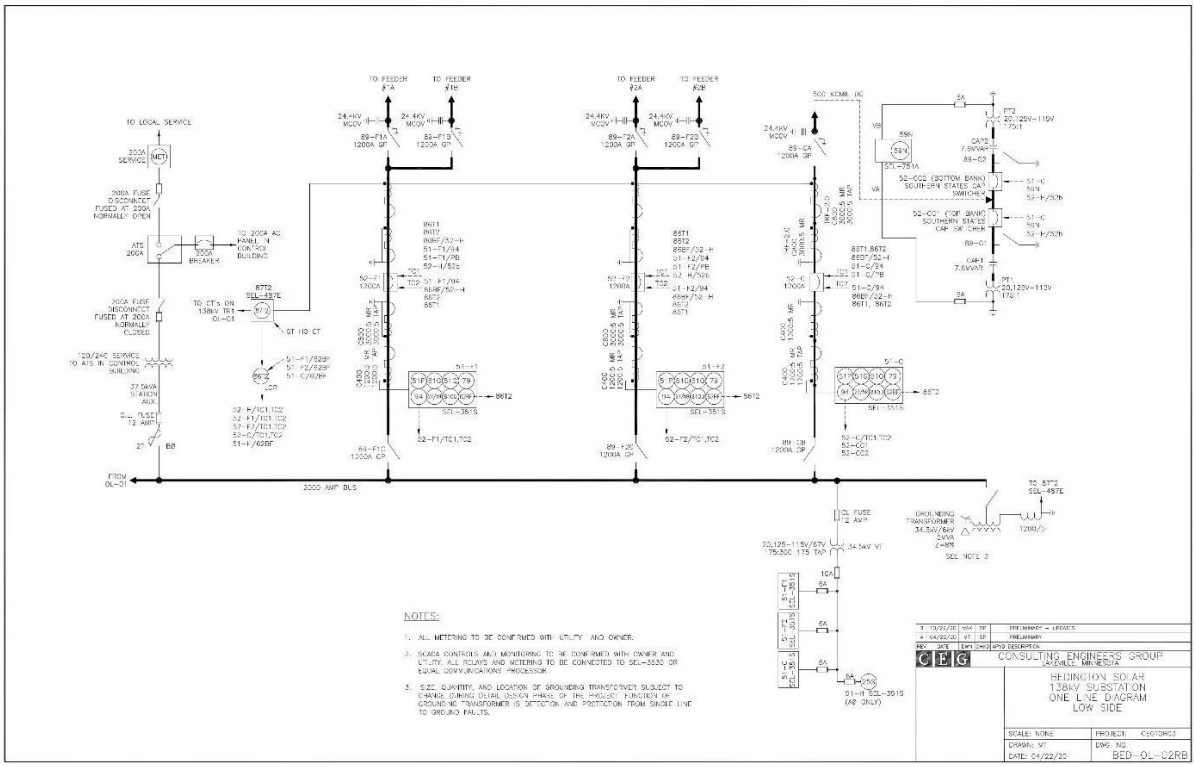
Generator Step-Up Transformer Requirements

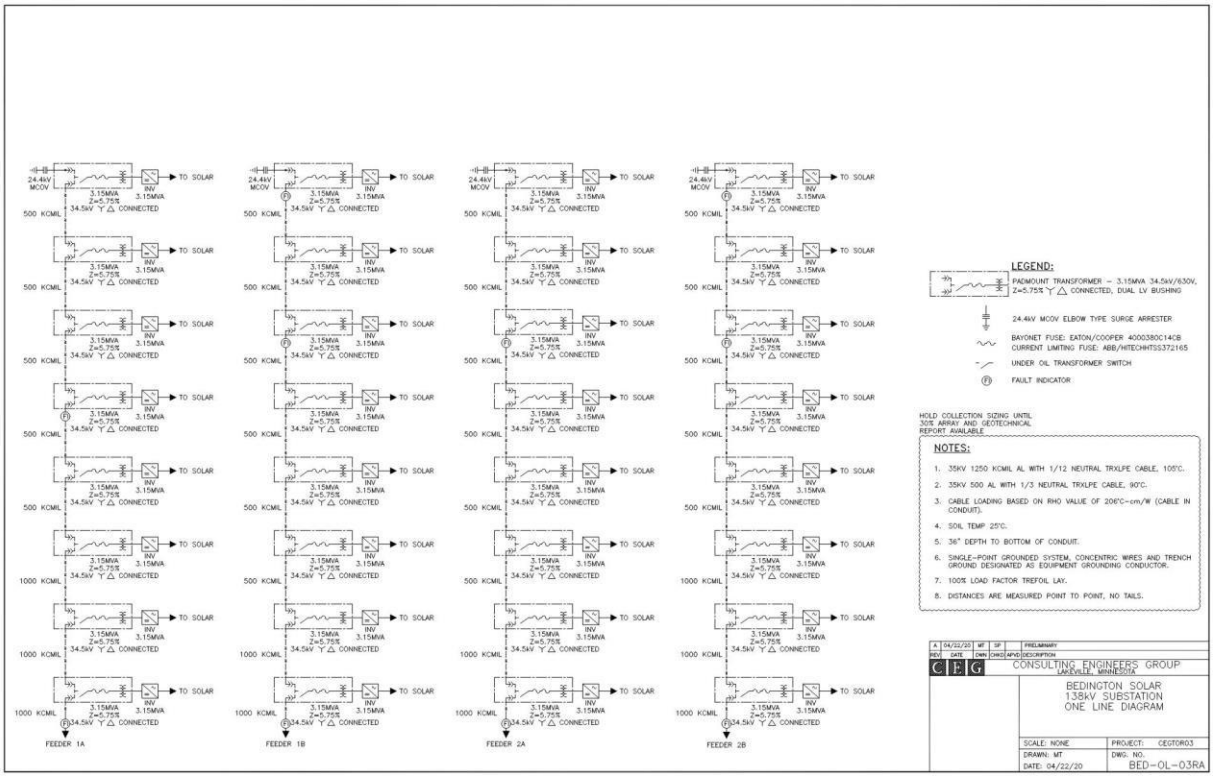
As per section 14.2.6 of the First Energy Requirements for Transmission Connected Facilities document, because this area of the system is effectively grounded, the transformer shall have a wye grounded winding on the high (transmission system) side and have a delta connected winding on the low side. This is required to maintain proper ground relay coordination on the First Energy system. No exceptions to this standard shall be granted.

Attachment #2: One-Line Diagrams

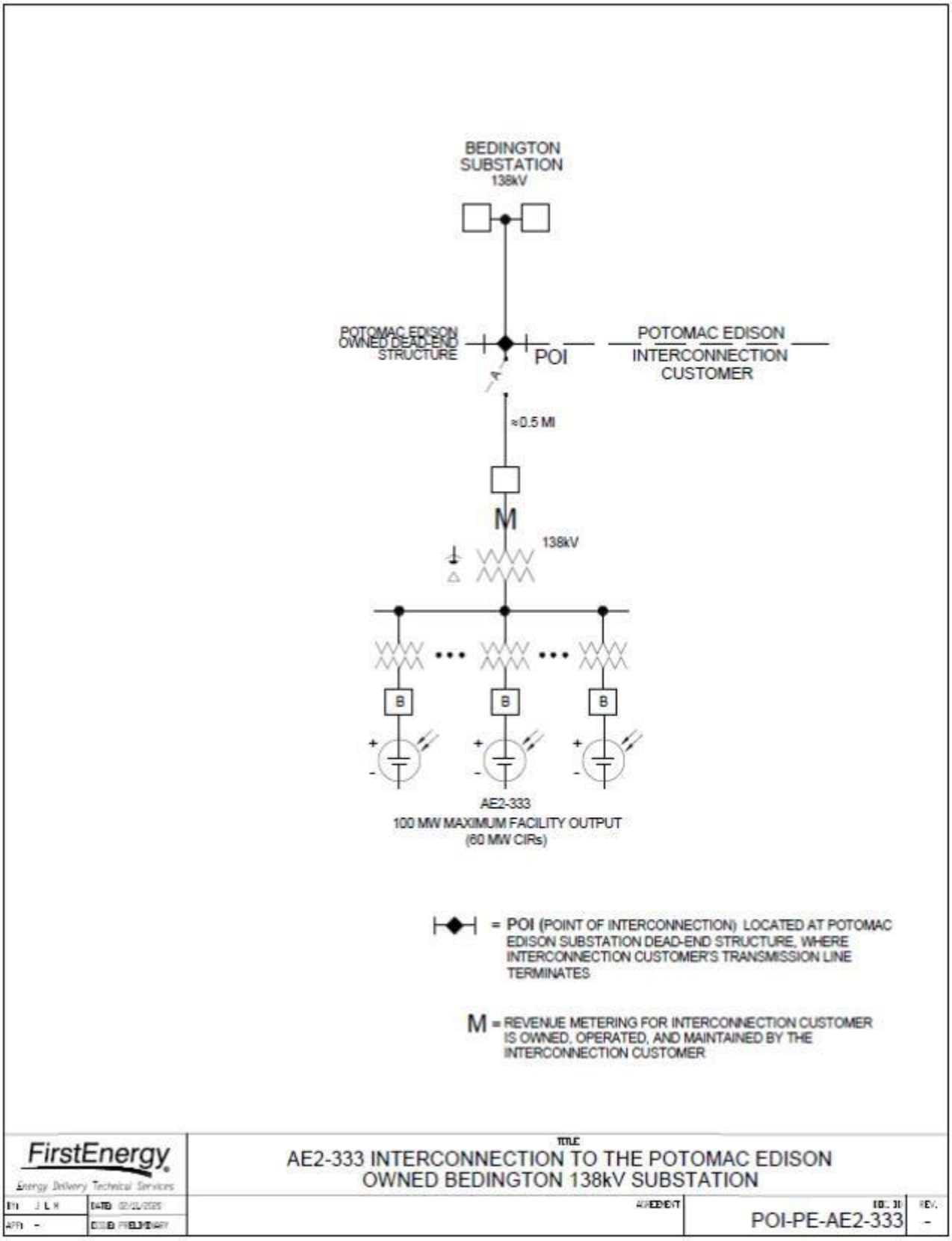
IC One-Lines





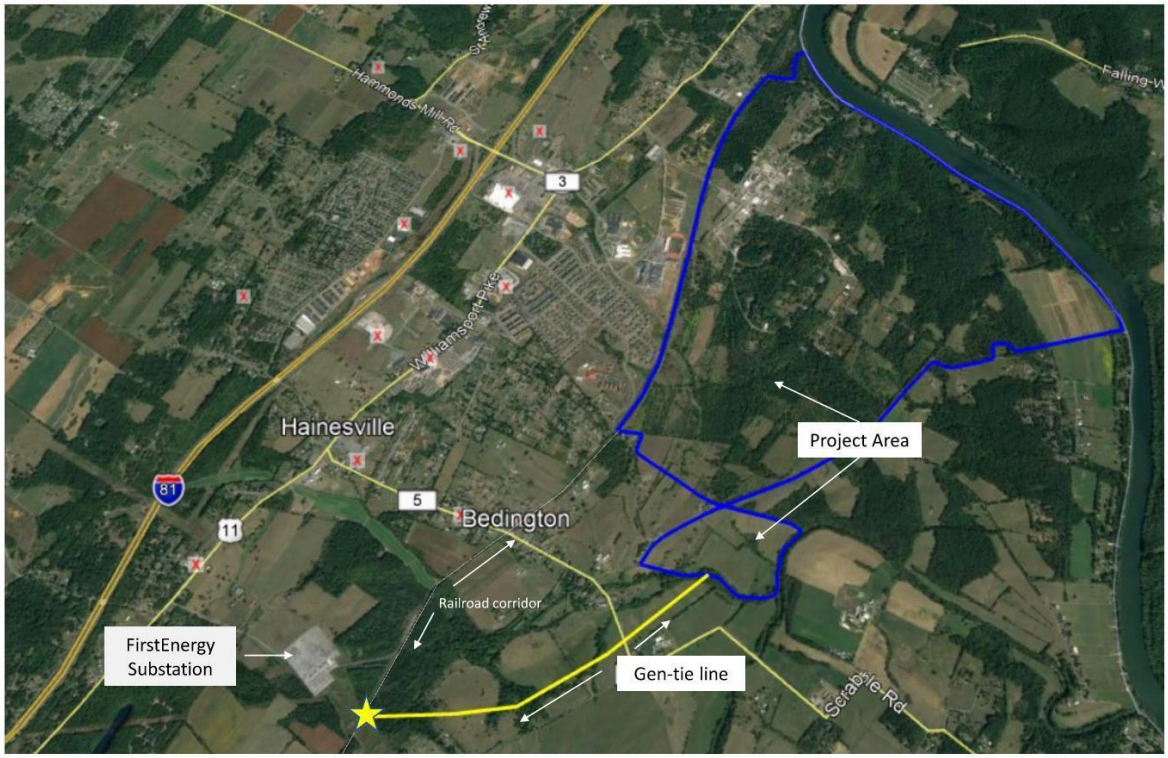

FEEDER 1A
FEEDER 1B
FEEDER 2A
FEEDER 2B
TO SOLAR
INV
3.15MVA
LEGEND:
PADMOUNT TRANSFORMER – 3.15MVA 34.5kV/630V, Z=5.75% Y △ CONNECTED, DUAL LV BUSHING
24.4kV MCOV ELBOW TYPE SURGE ARRESTER
BAYONET FUSE: EATON/COOPER 4000380C14CB
CURRENT LIMITING FUSE: ABB/HITECHHTS5372165
UNDER OIL TRANSFORMER SWITCH
FAULT INDICATOR
HOLD COLLECTION SIZING UNTIL 30% ARRAY AND GEOTECHNICAL REPORT AVAILABLE
NOTES:
1. 35KV 1250 KCMIL AL WITH 1/12 NEUTRAL TRXLPE CABLE, 105°C.
2. 35KV 500 AL WITH 1/3 NEUTRAL TRXLPE CABLE, 90°C.
3. CABLE LOADING BASED ON RHO VALUE OF 206°C-cm/W (CABLE IN CONDUIT).
4. SOIL TEMP 25°C.
5. 36" DEPTH TO BOTTOM OF CONDUIT.
6. SINGLE-POINT GROUNDED SYSTEM, CONCENTRIC WIRES AND TRENCH GROUND DESIGNATED AS EQUIPMENT GROUNDING CONDUCTOR.
7. 100% LOAD FACTOR TREFOIL LAY.
8. DISTANCES ARE MEASURED POINT TO POINT, NO TAILS.
A 04/22/20 MT SP PRELIMINARY
REV. DATE. DWN CHKD APVD DESCRIPTION
CEG CONSULTING ENGINEERS GROUP
LAKEVILLE, MINNESOTA
BEDINGTON SOLAR
138kV SUBSTATION
ONE LINE DIAGRAM
SCALE: NONE
PROJECT: CEGTOR03
DRAWN: MT
DWG. NO.
DATE: 04/22/20
BED-OL-03RA

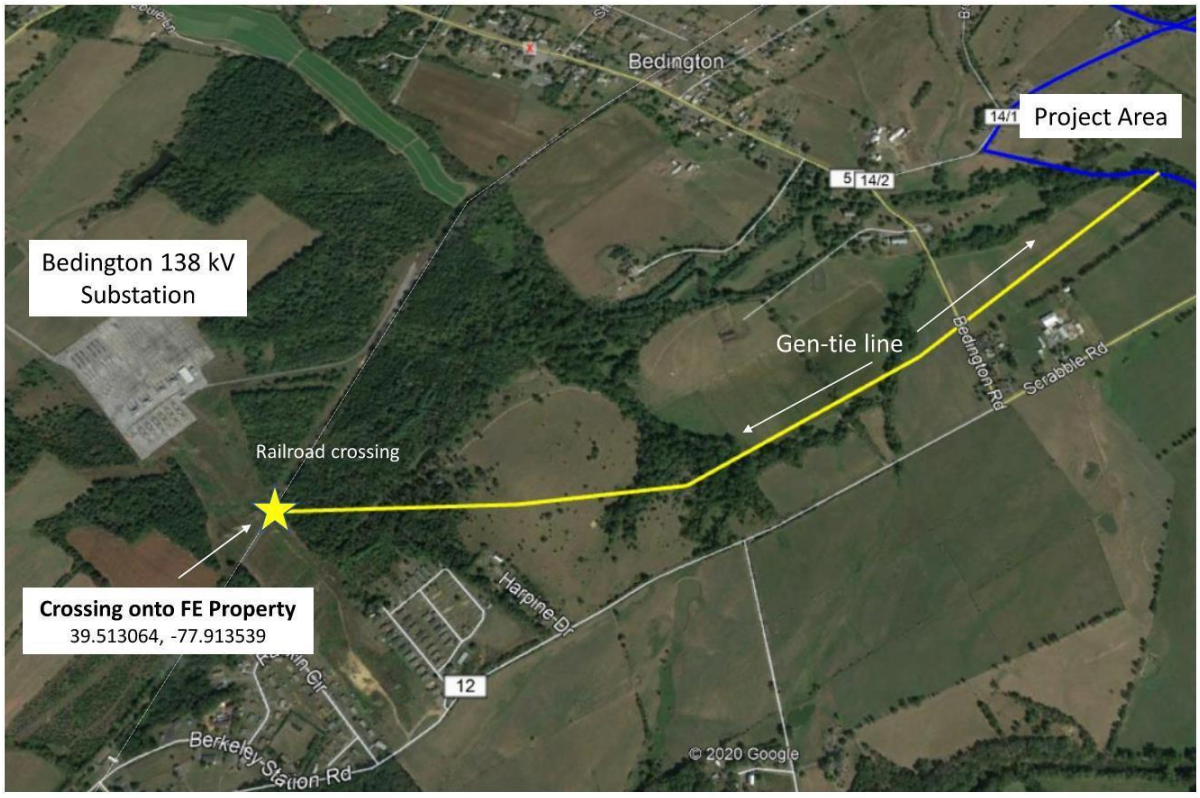
First Energy One-Line



Attachment #3: IC Site Plan and Substation Attachment Facilities

IC Site Plans






Privat Dr
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X = 2415188.9007
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Using WV83-NF coordinate system code
PRELIMINARY - NOT FOR CONSTRUCTION
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Attachment #4: Generation Connection Requirements

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* documents located at either of the following links:

www.firstenergycorp.com/feconnect

www.pjm.com/planning/design-engineering/to-tech-standards.aspx

The following is an excerpt taken from Transmission Owner's *Requirements for Transmission Connected Facilities* document:

> *For all generation facilities, other than wind-powered and other non-synchronous generating facilities, the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at continuous rated power output at a power factor as defined in the table below. This requirement will be measured at either the POI or generator terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when demanded.*
>
> *For all wind-powered or other non-synchronous generating facilities the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at a power factor as defined in the table. This requirement will be measured at either the POI or generator's terminals as specified in the table below. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when needed.*

For projects that entered PJM's New Service Queue after November 1, 2016, the power factor requirement will be as follows:

Generation Type	New / Increase	Size	Power Factor Requirement	Measurement Location
Synchronous	New	> 20 MW	0.95 leading to 0.90 lagging	Generator's Terminals
Synchronous	New	<= 20 MW	0.95 leading to 0.90 lagging	Point of Interconnection

Wind or Non-Synchronous	New	All	0.95 leading to 0.95 lagging	High Side of the Facility Substation Transformers
Synchronous	Increase	> 20 MW	1.0 (unity) to 0.90 lagging	Generator's Terminals
Synchronous	Increase	<= 20 MW	1.0 (unity) to 0.90 lagging	Point of Interconnection
Wind or Non-Synchronous	Increase	All	0.95 leading to 0.95 lagging	High Side of the Facility Substation Transformers

Any different reactive power requirements that FE and/or PJM determines to be appropriate for wind-powered or other non-synchronous generation facilities will be stated in the applicable interconnection agreement(s).

Induction generators and other generators with no inherent VAR (reactive power) control capability, or those that have a restricted VAR capability less than the defined requirements, must provide dynamic supplementary reactive support located at the generation facility with electrical characteristics equivalent to that provided by a similar-sized synchronous generator.

Design Requirements

IC is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with Transmission Owner's Transmission System. IC is also responsible for meeting any applicable federal, state, and local codes.

Transmission Design Requirements

Design Criteria

Facilities owned and operated by Transmission Owner shall comply with the applicable Transmission Owner technical requirements and standards posted on the PJM website per the PJM Tariff, and the following criteria. Where there are different requirements for the same criterion, the more restrictive shall apply. IC must abide by any PJM, RFC or NERC criteria imposed that is more restrictive than those of Transmission Owner.

General Design Requirements

- System phasing (counter clockwise) X-Y-Z
- System frequency: 60 hertz
- Elevation, AMSL: Less than 1000 meters
- Isokeraunic level: 40
- Maximum ambient temperature: 40 degrees C
- Minimum ambient temperature: -40 degrees C
- Maximum conductor operating temperature: Contact Transmission Owner
- Wind Loading (round shapes): Per ASCE 7-98, per Fig. 6-1 depending on location

- Ice loading – Substations (no wind): 25 mm
- Seismic zone: Per ASCE 7-98, per Fig. 9.4.1.1(a) and (b). Equipment qualification per IEEE 693-97

Voltage and Current Ratings

- Nominal phase-to-phase: 138 kV
- Maximum phase-to-phase: 145 kV
- Basic impulse level (BIL): 650 kV
- Maximum continuous current carrying capacity: 2000 A
- Design fault current: 63 kA
- Single Contingency (breaker failure) clearing time: 60 cycles

Clearances and Spacing

- Recommended rigid bus center-to-center phase spacing: 96”
- Minimum phase-to-phase, metal-to-metal distance: 63”
- Recommended phase-to-ground: 52.5”
- Minimum phase-to-ground: 50”
- Low bus height above top of foundations (match existing): 16’-0”
- High bus height above top of foundations (match existing): 24’-0”
- Minimum vertical clearance from live parts to grade: 12’-2”
- Minimum horizontal clearance from live parts: 6’-8”
- Minimum conductor clearance above roads in switchyard: 25’-0”
- Minimum bottom of insulator to top of foundation: 8’-6”