Transmission Interconnection Facilities Study Report

For

PJM Transmission Interconnection Request Queue Position AE2-217

"East Springfield-London 138 kV"

January 2022

Table of Contents

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

Invenergy Solar Development North America LLC, (hereinafter referred to as "IC") has proposed a solar generating facility located in Clark County, Ohio. The installed facilities for AE2-217 will have a total capability of 180 MW with 108 MW of this output being recognized by PJM as capacity. The generation facility will interconnect with American Transmission Systems Inc (ATSI), a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO), at a newly constructed 138 kV three-breaker ring bus substation tapped off of the East Springfield-London 138 kV transmission line.

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

This report is based on the System Impact Study Report posted February 2020. Amendments were identified.

In addition to the scope of work in that report, additional scope on the London – North Titus line which shares towers with the East Springfield—London line and additional communications requirements were identified as a result of this study phase.

The results of the stability analysis and reactive power assessment were not available for this report.

3. Interconnection Customer's Milestone Schedule

The Commercial Operation Date (COD) for the generation facility is **September 30, 2024**. A Project Kickoff meeting must occur by 05/01/2022 to meet Transmission Owner's Assumed Milestone Schedule listed below.

Milestone Schedule:

06/01/2024	Initial Back-feed through Project Substation Date
09/30/2024	Project Commercial Operation Date

1. 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 (AE2-217) generator lead line and connection to the new 3 breaker ring bus interconnection substation.

Point of Interconnection (POI): The POI will be located within the new 138 kV ring bus interconnection 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.

The easements and associated rights of way for the TO owned substation along with the 138 kV line taps to the substation will be acquired by the IC and transferred to the TO at no cost. Site preparation for the TO owned substation, including clearing, grading and an access road, as necessary, is assumed to be by the IC. The access road design must be approved by First Energy to ensure it provides adequate access to the substation to support construction and maintenance activities. Route selection, line design, and right-of-way acquisition for the IC's facilities are not included in this report and are the responsibility of the IC.

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 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.
- IC is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule are included herein.

2. Description of Facilities Included in the Facilities Study

Attachment Facilities

- AE2-217 Customer Substation:
    - Transmission Owner will design, furnish and construct the new 138 kV line terminal and take off structure. This work will include, but not be limited to, installation of a 138 kV line exit take-off structure, foundations, disconnect switch and associated equipment to accommodate the termination of the 138 kV generator lead line.
    - Drawings, nameplates, relay settings, and high voltage circuit diagram will be modified.

Direct Connection

- AE2-217 Interconnection Substation
    - A new 138 kV three breaker ring bus substation will be constructed along the East Springfield-London 138 kV transmission line to interconnect the AE2-217 solar project with the ATSI transmission system. The POI will be at the TO-owned deadend structure inside the substation yard where the generator lead line terminates.
    - Design, install, and test/commission MPLS Equipment for SCADA transport.

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

- East Springfield and London Substations
    - Estimated SCADA work at East Springfield & London substation to support relay installations, updated relay settings, and wave trap installations. Estimated in-sub fiber run to customer built fiber to support communications to AE2-217 substation.

- AE2-217 to North Titus 138 kV
    - Install fiber from AE2-217 to North Titus for communication transport.

Non-Direct Connection

- East Springfield to London 138kV line
    - The East Springfield to London 138 kV line will be cut and looped into the interconnection substation. This cut will take place at a location that is approximately 9.4 miles from the East Springfield substation and 9 miles from the London Substation. It is assumed that the new interconnection substation will be located within one span (approximately 300 feet) from the existing line.

- East Springfield Substation
    - A new carrier relay will be installed in the existing protection panel for the line section between the East Springfield and AE2-217 interconnect substations. 2 new wavetraps, 2 tuners and 3 UPLC sets will be installed. An anti-islanding transmitter will be installed.

- London Substation
    - The existing East Springfield relaying and controls will be replaced with a pre-wired relaying panel to be used for AE2-217 interconnection. A new carrier relay will be installed in the existing protection panel for the line section between the London and AE2-217 interconnect substations. 2 new wavetraps, 2 tuners, and 3 UPLC sets will be installed. An anti-islanding transmitter will be installed.

- London – North Titus 138 kV line
    - Deadend hardware assemblies will be installed on a new 3-pole structure. The existing conductors (6) and shield wires (2) will be transferred from the existing double circuit lattice towers to the new 3-pole structure.

Other Work

- AE2-217 Metering
    - Customer-owned revenue metering at interconnection customer substation.

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

Description	Total (w/o Tax)
Attachment Facilities:	**$ 679,800**
Total Direct Connection (DC) Costs:	**$ 7,036,700**
Total Non-Direct Connection (NDC) Costs:	**$ 3,246,600**
Total Other Charges:	**$ 2,500**
New System Upgrades:	**$ 0**

TOTAL Costs (ALL Categories):	**$ 10,965,600**

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

Attachment Facility	*Duration*
Engineering, Procurement, and Construction	24 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

East Springfield – London No. 1 138kV line

- Loop the East Springfield – London No. 1 138kV line into the new AE2-217 substation between existing structures #5762 and #5763, approximately 8.44 miles from the London substation.
- Existing line is currently constructed on double circuit lattice towers shared with the London – North Titus 138kV line. Existing conductor is 477 kcmil 26/7 ACSR shielded with 134.6 12/7 ACSR.
- The proposed loop will consist of the following:
    - (1) 138kV double circuit 3-pole custom steel loop structure on drilled shaft foundations. Drawing TZ2862B1_C is attached as a reference.
    - See Estimate OE-T-1007A below for the hardware costs associated with the London – North Titus 138kV Line.
    - Install 795 kcmil 26/7 ACSR conductor, shielded with 7#8 Alumoweld, approximately (0.1) miles.
    - Transfer the existing conductor onto the new structure. (6) wires total. Transfer the existing shield wire onto the new structure. (2) wires total.
- Construction Considerations:
- Siting/Licensing
    - A LON will be required to be filed with the OPSB.
    - Assume no public opposition
- Assumptions
    - It is assumed the adjacent structures are adequate to support the new loading. An engineering analysis is required to confirm.
    - Assume existing conductor and shield wire are in good condition and can be transferred to new structure.
    - For proposed T-line site layout, refer to attached KMZ.
    - Proposed shield wire is assumed, to be confirmed in detailed engineering.
    - Assume the London and East Springfield substations will remain energized during construction.
    - New ground survey is to be required.

London – North Titus 138kV line

- Install deadend hardware assemblies on the new 3-pole structure listed in the OE-T-1006A estimate.

- Existing line is currently constructed on double circuit lattice towers shared with the East Springfield – London No. 1 138kV line. Existing conductor is 477 kcmil 26/7 ACSR shielded with 134.6 12/7 ACSR.
- Perform the following:
    - Install (6) 138kV deadend hardware assemblies.
    - Transfer the existing conductor onto the new structure. (6) wires total.
    - Transfer the existing shield wire onto the new structure. (2) wires total.
- Siting/Licensing
    - Siting Costs will be captured in Estimate OE-T-1006A above.
    - Assume no public opposition
- Assumptions
    - It is assumed the adjacent structures are adequate to support the new loading. An engineering analysis is required to confirm.
    - Assume existing conductor and shield wire are in good condition and can be transferred to new structure.
    - For proposed T-line site layout, refer to attached KMZ.
    - Ground survey costs will be captured in Estimate OE-T-1006A above.
    - Assume the London and East Springfield substations will remain energized during construction.

3. New Substation/Switchyard Facilities

AE2-217 Interconnection

- Below Grade
    - Install foundations, conduit and grounding for all new equipment.
    - Install ground grid, fence, cable trench and stone.
- Above Grade
    - Install (3) 138 kV circuit breakers.
    - Install (6) 138 kV, 2000 A, GOAB breaker disconnect switches.
    - Install (3) 138 kV, 1200 A, MOAB line disconnect switches.
    - Install (4) 138 kV, 1200 A, wave-traps, line tuners and associated coax.
    - Install (9) 138 kV surge arresters.
    - Install (9) 138 kV CVTs.
    - Install (1) prefabricated control building.
    - Install (2) 138 kV SSVTs.
    - Install (3) 138 kV dead-end structures.
    - Install (1) lot of conductor, fittings, insulators, steel and bus.
- R&C
    - Install (2) standard line relaying panels to include (2) SEL-421s for East Springfield and London line terminals.
    - Install (3) standard breaker control panels to include (1) SEL-501 & metering
    - Install (1) standard line relaying panel to include (2) SEL-411Ls for generator interconnection.
    - Install (2) carrier panels to include (3) UPLC relays, (3) PCM-5350s, and associated anti-islanding equipment.
    - Install (1) SCADA RTU including operational and non-operational RTAC.
    - Install (1) HMI panel and standard communication equipment.
- Additional Equipment to be Removed
    - None
- Assumptions

- None

AE2-217 Customer Substation

- Below Grade
  - None
- Above Grade
  - Review drawings, nameplates, relay settings and add substation to high voltage circuit diagram.
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

4. Substation/Switchyard Facility Upgrades

East Springfield

- Below Grade
  - Foundations, conduit, and grounding for new wave trap/line tuner.
- Above Grade
  - Revise drawings, nameplates and relay settings.
  - Install (2) 138kV, 1200 A, wave traps, line tuner, coax, and steel supports.
- R&C
  - Install (3) UPLC relays for DTT and Anti-Islanding, and (3) PCM-5350s
- Additional Equipment to be Removed
  - None
- Assumptions
  - Control building has sufficient space for new panel
  - Dual SEL421 and SEL501 BFT Line Panel Exists at the Station.

London

- Below Grade
  - Foundations, conduit, and grounding for new wave trap/line tuner.
- Above Grade
  - Install (2) 138kV, 1200 A, wave traps, line tuners, coax and steel supports.
- R&C
  - Replace existing East Springfield relaying and controls with (1) standard pre-wired relaying panel to include (2) SEL-421s, (1) SEL-501 BFT, and metering to be used for AE2-217 interconnection.
  - Install (1) carrier panel with: (3) UPLC relays for DTT and Anti-Islanding, and (3) PCM-5350s
- Additional Equipment to be Removed
  - None
- Assumptions
  - Control building has sufficient space for new panels

5. Telecommunications Facilities – Upgrades

IC will design, provide, install, own and maintain a fiber-optic communications cable between the new **interconnection** 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 IC's substation control house.

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

Approximately one mile of ADSS fiber will be ran from AE2-217 to North Titus for SCADA communication.

6. Metering & Communications

IC shall install, own, operate, test and maintain the necessary revenue metering equipment.

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.

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, and Ohio Power Siting Board (OPSB) notifications vary, some up to twelve (12) months after preliminary engineering is completed to secure the required approvals.
- Prior to agreement by IC to purchase the property, a Phase 1 Environmental Assessment should be conducted for the entire site to avoid assumption of environmental liabilities by IC or Transmission Owner.
- The Transmission Owner interconnection substation may involve environmental surveys, permits, approvals and plans with federal, state, and/or local agencies.
- Assumed IC is to provide all access rights, easements, ROW and permits necessary to complete the Project to the satisfaction of Transmission Owner. Environmental permitting shall encompass all federal, state and local requirements, consultations and agency coordination. Confirmation of meeting all permitting requirements shall be provided to Transmission Owner, prior to start of construction. Following construction and energization, confirmation of permit closeout shall be provided to the satisfaction of Transmission Owner, prior to transfer of ownership. If any of these elements are not included in the final agreement between Transmission Owner and IC, twelve (12)-to-eighteen (18) months should be added to the Project Schedule to secure necessary permits, and additional costs would apply.
- IC will provide copies of all of the relative environmental permits and other necessary approvals to Transmission Owner before Transmission Owner accepts the interconnection facilities.
- IC is required to install an access road from the new interconnection substation to the nearest public road (must be approved by Transmission Owner), and obtain access rights for Transmission Owner. IC is responsible to maintain access road and ensure unimpeded access for Transmission Owner at all times.
- IC is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- If IC owns the project property, in fee title, Transmission Owner will require a fee property transfer for the interconnection substation site which may require subdivision approval, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation. IC is responsible for all costs, including but not limited to subdivision, associated with the property transfer.
- If IC leases the project property, the IC will be required to obtain fee property from the underlying fee property owner, on behalf of Transmission Owner, for the interconnection substation site, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation.
- All property rights must be surveyed and metes and bounds descriptions prepared for incorporation into Transmission Owner's document forms, for transfer of title.
- The Transmission Owner interconnection substation and transmission line loop will involve Ohio Power Siting Board (OPSB) notification/approval.
- 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 within their scope of work.
- IC will obtain all necessary permits within their scope of work. IC will not be responsible for permitting of work that is in the TO's scope to complete.

- IC will conduct all necessary wetlands and waterways studies and permits within their scope of work. IC will not be responsible for studies and permits of work that is in the TO's scope to complete.
- IC will conduct all necessary historical and archaeological studies within their scope of work. IC will not be responsible for historical and archaeological studies of work that is in the TO's scope to complete.
- 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		Indirect		Total Cost
	Labor	**Material**	**Labor**	**Material**	
AE2-217 Generator Lead Termination: Installation of a 138 kV line exit take-off structure, foundations, disconnect switch and associated equipment to accommodate the termination of the 138 kV generator lead line.	$ 300,000	$ 213,600	$ 89,100	$ 18,200	$ 620,900
AE2-217 Customer: Modify drawings and nameplates for FE standards.	$ 45,400	$ 0	$ 13,500	$ 0	$ 58,900
Total Attachment Facilities Cost	**$ 345,400**	**$ 213,600**	**$ 102,600**	**$ 18,200**	**$ 679,800**
AE2-217: Construct a new 3-breaker Ring Bus on the 138 kV East Springfield-London line. (Network Upgrade n7339)	$ 2,699,800	$ 1,922,200	$ 801,600	$ 163,800	$ 5,587,400
SCADA/Fiber Communication: Design, install, and test/commission MPLS Equipment for SCADA transport. (Network Upgrade n7340)	$ 89,900	$ 59,800	$ 26,700	$ 5,100	$ 181,500
Project Management: Project Management, Environmental, Real Estate, and Right of Way. (Network Upgrade n7339)	$ 234,300	$ 0	$ 69,600	$ 0	$ 303,900

Estimated SCADA work at East Springfield & London substation to support relay installations, updated relay settings, and wave trap installations. Estimated in-sub fiber run to customer built fiber to support communications to AE2-217 substation. (Network Upgrade n7341)	$ 61,100	$ 4,100	$ 18,100	$ 400	$ 83,700
Install fiber from AE2-217 to North Titus for communication transport. @AE2-217 to North Titus (Network Upgrade n7342)	$ 624,100	$ 65,200	$ 185,300	$ 5,600	$ 880,200
Total Direct Connection Cost	**$ 3,709,200**	**$ 2,051,300**	**$ 1,101,300**	**$ 174,900**	**$ 7,036,700**
East Springfield – London No. 1 138 kV Line Loop: Loop the East Springfield – London No. 1 138kV line into the new AE2-217 substation between existing structures #5762 and #5763, approximately 8.44 miles from the London substation. (Network Upgrade n7343)	$ 572,200	$ 564,700	$ 169,900	$ 48,200	$ 1,355,000
London – North Titus 138kV Line Loop: Transfer conductor and install deadend hardware assemblies on the new 3-pole Structure (Network Upgrade n7344)	$ 64,700	$ 3,300	$ 19,200	$ 300	$ 87,500
East Springfield: Line Terminal Upgrade (Network Upgrade n7345)	$ 463,900	$ 180,300	$ 137,800	$ 15,300	$ 797,300
London: Line Terminal Upgrade (Network Upgrade n7346)	$ 593,300	$ 218,800	$ 176,100	$ 18,600	$ 1,006,800
Total Non-Direct Connection Cost	**$ 1,694,100**	**$ 967,100**	**$ 503,000**	**$ 82,400**	**$ 3,246,600**
Metering: Customer-owned revenue metering at AE2-217 Sloopy Solar generation facility.	$ 1,900	$ 0	$ 600	$ 0	$ 2,500
Total Other Charges	**$ 1,900**	**$ 0**	**$ 600**	**$ 0**	**$2,500**
Total Project Costs	**$ 5,750,600**	**$ 3,232,000**	**$ 1,707,500**	**$ 275,500**	**$ 10,965,600**

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.

9. Schedules and Assumptions

A proposed **twenty-four (24) 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.

24 month Schedule

Activity	Start Month	End Month
[redacted]		
Preliminary Engineering	1	3
Siting, Permits & Real Estate	2	12
Detailed Engineering	2	12
Equipment Delivery	14	15
Below Grade Construction – Substation	15	18
Below Grade Construction – T-Lines	21	22
Above Grade Construction – Substation	18	23
Above Grade Construction – T-Lines	22	23
Testing & Commissioning	24	24

FE will need to conduct an environmental survey for the loop and proposed interconnect substation. If permits are necessary to complete the project, approximately 3-6 months will be needed to draft and receive agency approvals.

Attachment #1: Protection Study

PROTECTION SCOPE

General Connection Requirements

All proposed generation interconnection points and load-serving delivery points must comply with the technical requirements detailed in Transmission Owner's "Requirements for Transmission Connected Facilities" document. Procedures for gaining access to these standards can be found at the link below.

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

The AE2-217 delivery point substation (DPS) is a new 138 kV three-breaker ring bus on the East Springfield - London 138 kV line.

Line protection between East Springfield and AE2-217 and between London and AE2-217 shall consist of two independent SEL-421 line schemes with pilot protection over PLC for each 138 kV line, at each terminal.

At the AE2-217 DPS, each 138 kV breaker shall have breaker failure-to-trip protection.

Protection of the 138 kV Generator Lead Line of approximately 0.1 miles shall consist of two SEL-411L line current differential schemes with pilot communication over fiber optic cable, at each terminal.

Detailed Protection Requirements

Short Circuit Analysis

Short Circuit Values

The 138 kV fault values for the AE2-217 interconnection location with all new generation out of service are:

Three phase = 8.0kA
Single line to ground = 7.2kA
Z1= (1.20+ j 5.09) %
Z0= (1.74 + j 6.88) %

Impedances are given on 100 MVA and 138 kV 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.

Fiber Optic Communication Channels

Connecting Party will design, install, own and maintain fiber optic communications between the AE2-217 generating substation and the new 138kV ring bus substation to be used for line protection, direct transfer trip (DTT) and other communication.

AE2-217 Connecting Party Generator Owner fiber requirements:

New 138 kV Ring Bus (FE) – AE2-217 Generating Station 138 kV – fiber provided by Connecting Party generator owner

- Eight (8) fibers (4 pairs) total [minimum number required for protection purposes only]
- Two (2) independent (**diverse route**) cables (4 pairs per cable) [i.e. one (1) cable for primary path and one (1) cable for backup path to cover schemes for both lines]

Connecting party will design, provide, install, own and maintain fiber optic communication channels between the 138KV delivery point substation and the AE2-217 generation substation. Connecting party is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber cable.

Power Line Carrier Communication Channels

Transmission Owner will design, install, own and maintain power line carrier communications between the East Springfield, London and the new 138 kV ring bus substation to be used for line protection, direct transfer trip (DTT) and anti-islanding.

Transmission Owner power line carrier requirements:

East Springfield-New 138 kV Ring Bus:

(1) ON/OFF Carrier frequency for DCB scheme
(3) FSK frequencies, one for DTT send, one for DTT receive/backup DUTT relay schemes, one for anti-islanding (52b contacts)

London -New 138 kV Ring Bus:

(1) ON/OFF Carrier frequency for DCB scheme
(3) FSK frequencies, one for DTT send, one for DTT receive/backup DUTT relay schemes, one for anti-islanding (52b contacts)

Protection Requirements

AE2-217 Generating Station 138 kV

138 kV Transmission Line Protection @ AE2-217 generating station

For the 138 kV line exit to the new 138 kV ring bus, primary and backup line protection relays are required. The primary and backup relays shall be SEL-411Ls (two (2) relays) (usage of this particular model is required). Specific style numbers shall be provided by Transmission Owner at a later date. AC sources for these schemes shall be CTs on the 138kV breaker, located on the 138 kV transformer side of the breaker, and CCVTs or PTs on the line side of the 138 kV line breaker. A separate tripping path energizing separate breaker trip coils is required for primary and backup relaying. The line relays shall communicate via dedicated multi-fiber, fiber optic communication channels with the new ring bus

terminal line relays. The line relays will send/receive DTT and receive an anti-islanding trip from the existing ring bus station. The primary & backup schemes must utilize independent (diverse) fiber routes. Transmission Owner shall provide relay settings for these line relays at the cost of Connecting party.

138 kV Breaker Failure to Trip Protection

A breaker failure relay (SEL-501 or SEL-451) shall be utilized on the high side 138 KV circuit breaker. Any protective trip of this breaker shall initiate the failure to trip scheme. The re-trip feature for the BFT scheme shall be utilized and trip the high side breaker it protects. The high side breaker failure scheme shall initiate trip & block close of all adjacent breakers. The line breaker at each station will also initiate direct transfer trip via line relaying to the corresponding remote ring bus substation. Local tripping shall be accomplished via hand-reset lockout relays.

138 kV Bus & GSU Transformer Protection @ AE2-217 generating station (minimum protection to meet FE requirements)

The transformer windings for each GSU shall be wye ground–delta (HV-LV).

For each GSU, the minimum protective relaying requirements for this installation include primary and backup transformer differential (87T) relays, a transformer neutral time overcurrent relay (51G), and a breaker failure relay for the dedicated high side breaker. Acceptable relay models for each of the schemes are identified below, the use of any other relays will require prior approval from Transmission Owner.

SEL-587, SEL-387 and/or SEL-487E relays are acceptable for both applications of the required 87T functions. The 87T schemes shall trip the high side GSU transformer breaker and the transformer low side breakers to remove the transformer from service. A separate tripping path energizing separate breaker trip coils is required for primary and backup relaying.

The AC current source for the 87T relays shall be CTs on the line side of the high side GSU circuit breakers and CTs from the bus side of the GSU low side breakers.

An SEL-551, SEL351 or SEL451 relay is acceptable for the transformer 51G function(s). The 51G scheme shall trip the transformer breaker and the transformer low side breakers to remove the transformer from service with a dedicated tripping path.

The relaying systems shall have a reliable source of DC power independent from the AC system or immune to AC system disturbance or loss (for example - DC battery and charger) to assure proper operation of the protection scheme.

The Connecting Party shall provide utility-grade relays for protection of the FE Transmission System. FE shall approve all relays specified for the protection of the FE Transmission System, including time delay and auxiliary relays. Relay operation for any of the listed functions that are required shall initiate immediate separation of the parallel generation from the FE Transmission System:

Relay	**Function**
Frequency	To detect underfrequency and overfrequency operation.
Overvoltage	To detect overvoltage operation.
Undervoltage	To detect undervoltage operation.
Ground Fault Detector	To detect a circuit ground on the FE Transmission System.
Phase Fault Detector	To detect phase to phase faults on the FE Transmission System.

Transfer Trip Receiver	To provide tripping logic to the generation owner for isolation of the generation upon opening of the FE supply circuits.
Directional Power	To detect, under all system conditions, a loss of FE primary source. The relay shall be sensitive enough to detect transformer magnetizing current supplied by the generation.
Breaker Failure	To detect a stuck breaker condition at the generation station and send a trip signal to the remote end of the connected line via transfer trip.

The Interconnection Customer will be required to comply with all FE Generation Protection Requirements for Generation Interconnection Customers. The Generation Protection Requirements may be found within the "FirstEnergy 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

All relays, relay schemes and relay settings that include bulk electric system 138 kV voltages or currents, or trip any 138 kV circuit breakers shall require the review and approval of Transmission Owner. It is required that Transmission Owner review and approve all one-line diagrams and AC and DC schematics showing these relays and their respective inputs, outputs and tripping paths. It is required that these documents be sent electronically to Transmission Owner at least ninety (90) days prior to the planned in-service date.

Transmission Owner will complete detailed relay coordination studies to identify off-site relay setting changes required due to this generation interconnection. This may result in additional individual relay replacements being required (most likely an electromechanical ground relay due to a range issue). These relay replacements will be done at the cost of Connecting party.

Connecting party is solely responsible for protecting its own equipment in such a manner that electrical faults or other disturbances on the Transmission Owner system do not damage its equipment.

FE System Modifications

AE2-217 138 kV Interconnecting Substation

For this project, the existing East Springfield – London 138 kV line is to be sectionalized by a new substation in a ring bus configuration.

The new ring bus substation shall consist of three (3) 138 kV breakers with four (4) sets of CT's per breaker (12 total) and three (3) line side 138 kV MOABs [one located on each line exit].

Three sets (3) of three 138 kV line side CCVTs (one on each phase) are to be installed on the three new line exits on the new ring bus.

Each new breaker shall have a dedicated SEL-501 relay for breaker failure protection with associated hand-reset lockout auxiliary schemes.

Primary and backup line protective relays are required on the East Springfield, London and AE2-217 generation facility line 138 kV exits.

For the AE2-217 generator station exit, the primary and backup relays shall be SEL-411Ls.

For both the East Springfield & London 138 kV line exits, the primary and backup relays shall be SEL-421s (four (4) relays total), with three (3) UPLC carrier set transceivers (six (6) total), two (2) wave traps (four (4) total) and two (2) line tuners (four (4) total).

East Springfield Substation

Modifications are required to Transmission Owner's East Springfield substation.

For power line carrier communication channels, the following new equipment is required:
three UPLC carrier sets, two wave traps and two line tuners

The existing primary and backup SEL-421 line relays will require setting changes,

Transmission Owner shall provide the design, procurement, installation of new equipment and relay settings for these relays, as part of the cost of the project.

London Substation

Modifications are required to Transmission Owner's London substation.

For power line carrier communication channels, the following new equipment is required:
three UPLC carrier sets, two wave traps and two line tuners

Replace the existing line relays with new primary and Backup SEL-421 line relays.

Transmission Owner shall provide the design, procurement, installation of new equipment and relay settings for these relays, as part of the cost of the project.

Relay Settings Changes

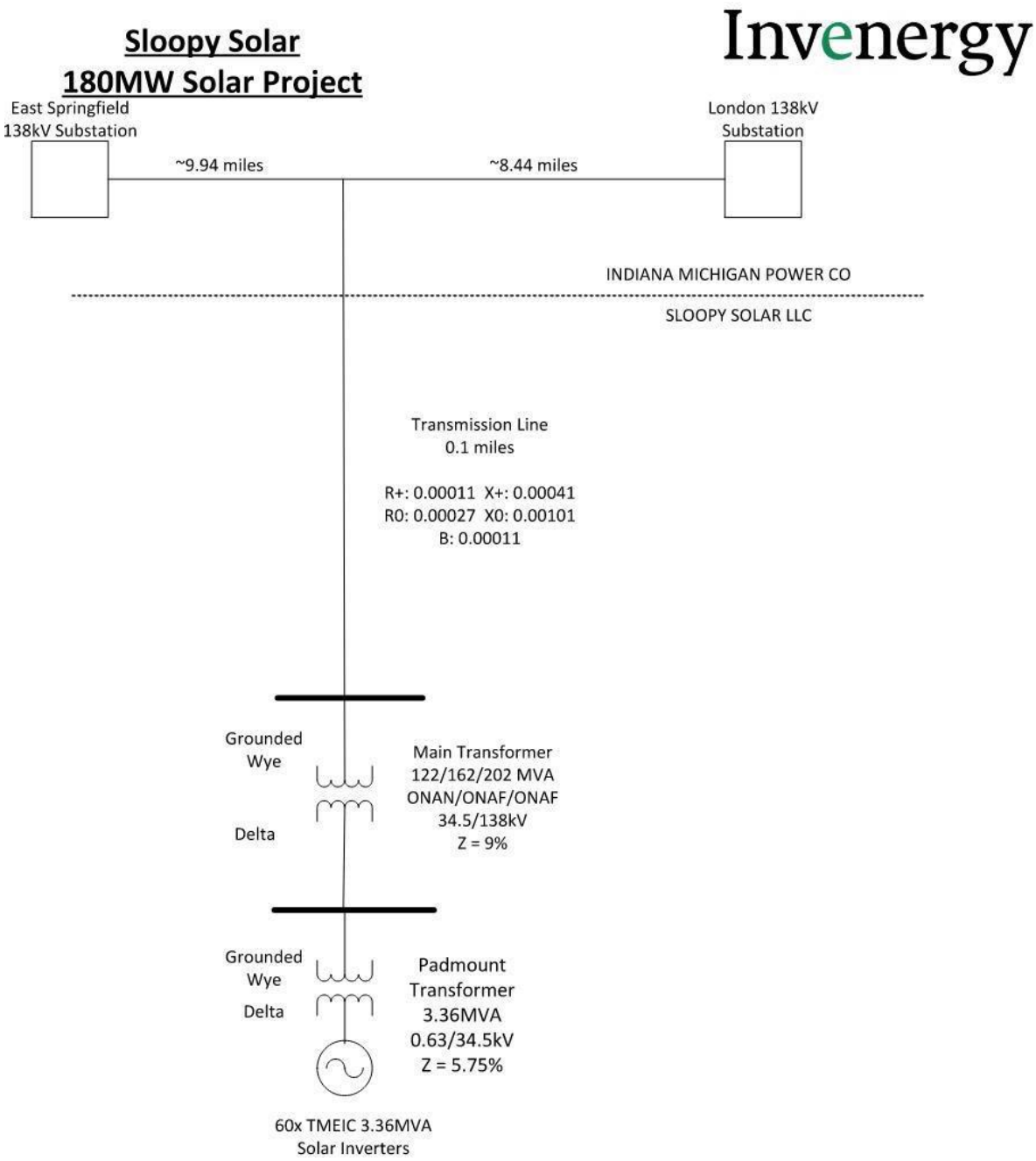
Relay setting changes will potentially be required at remote stations affected by the project.

Attachment #2: One-Line Diagrams

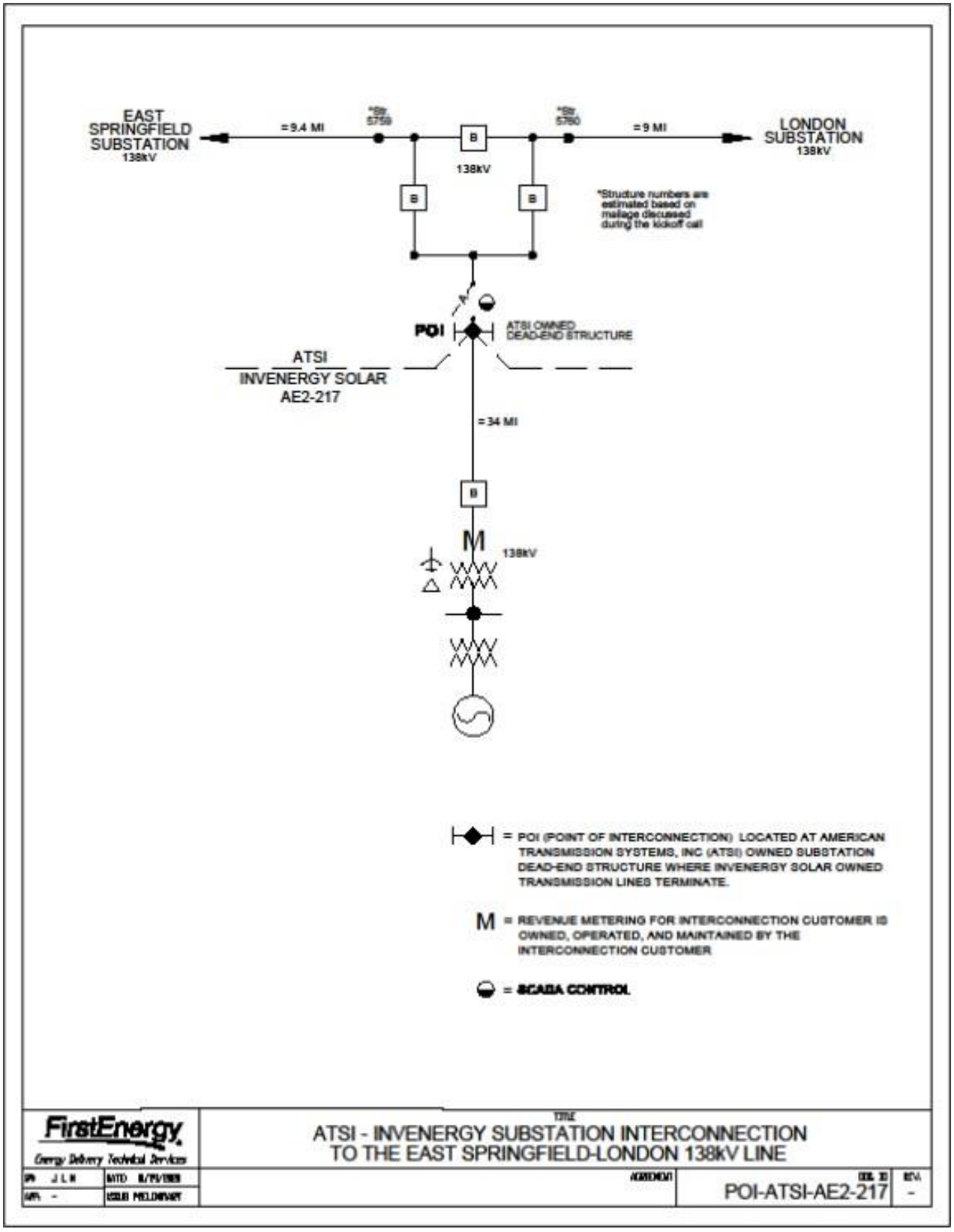
IC One-Line

(NOT APPROVED FOR CONSTRUCTION)

Required disconnect switches and breakers not shown.

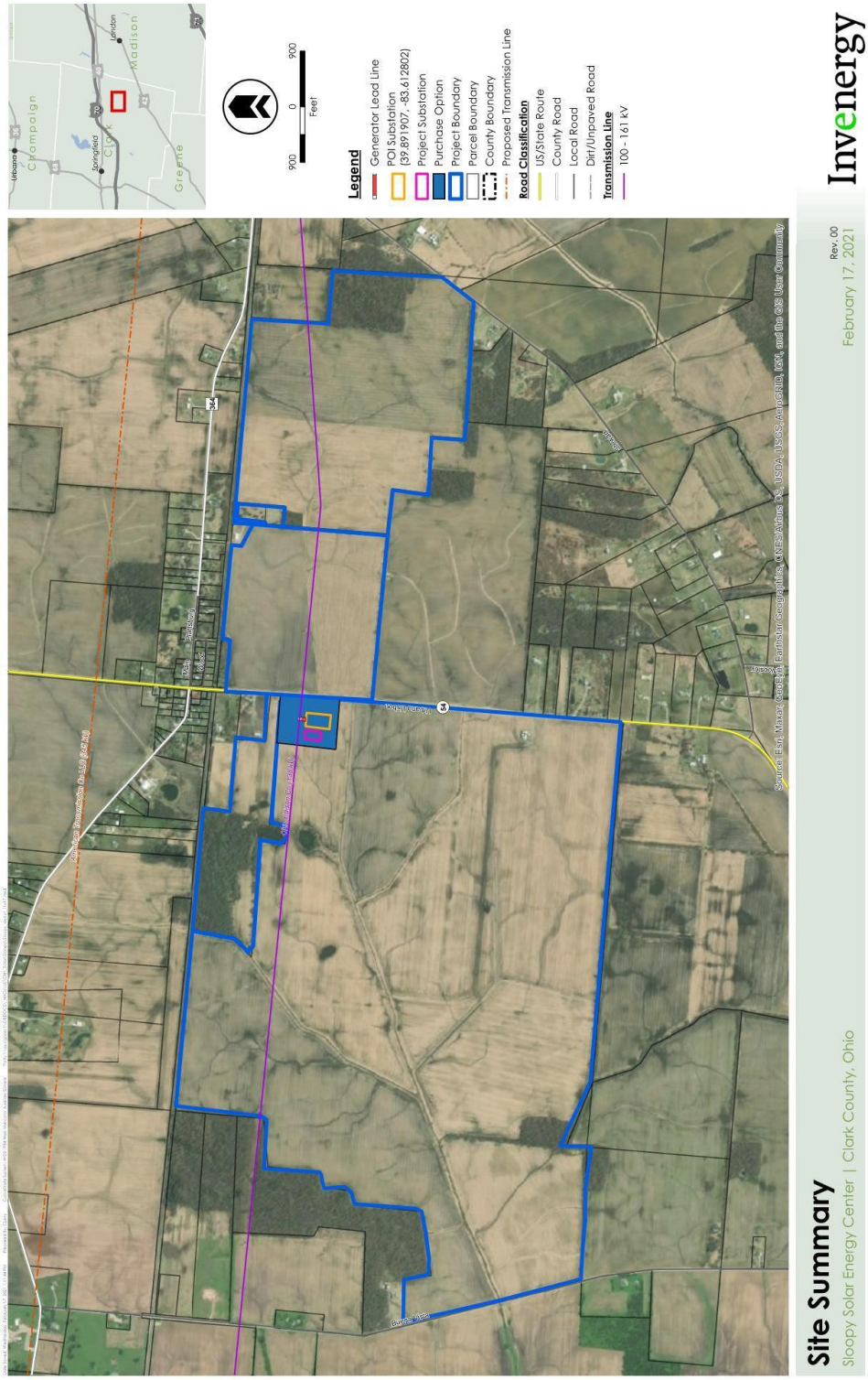


First Energy One-Line



Attachment #3: IC Site Plan and Substation Attachment Facilities

IC Site Plan



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
Wind or Non-Synchronous	New	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: 40 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”