PJM Generator Interconnection

Facility Study Report

Related to:

PJM Generation Interconnection Request Queue Position AD2-163

Broadview-Tangy 138 kV

June 2021

Table of Contents

Preface 3
A. Transmission Owner Facilities Study Summary 3
1. Description of Project 3
2. Amendments to the System Impact Study or System Impact Study Results 3
3. Interconnection Customer's Milestone Schedule 3
4. Customer's Scope of Work 4
5. Description of Facilities Included in the Facilities Study 5
6. Total Cost of Transmission Owner Facilities Included in the Facilities Study 6
B. Transmission Owner Facilities Study Results 7
1. Transmission Lines –New 7
2. Transmission Lines – Upgrade 7
3. New Substation/Switchyard Facilities 7
4. Substation/Switchyard Facility Upgrades 7
5. Telecommunications Facilities – Upgrades 10
6. Metering & Communications 10
7. Environmental, Real Estate and Permitting 11
8. Summary of Results of Study 12
9. Schedules and Assumptions 15
Attachment 1: Protection Scope 16
Attachment 2: Single Line Diagram 21
Attachment 3: Proposed Project Location 24
Attachment 4: Generation Connection Requirements 25

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 developer is responsible for the right-of-way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

A. Transmission Owner Facilities Study Summary

1. Description of Project

Madison Fields Solar Project, LLC (hereinafter referred to as "Interconnection Customer" or "IC") has proposed a solar generating facility located in Madison County, Ohio. The installed facilities for AD2-163 will have a total capability of 180 MW with 120.7 MW of this output being recognized by PJM as capacity. AD2-163 will have a point of interconnection on the Broadview - Tangy 138 kV Line. The generation facility will interconnect with ATSI, a First Energy Company (hereinafter referred to as "FE", "TO" or "Transmission Owner"), at a three-breaker ring bus substation south of the Broadview Tangy 138kV transmission line.

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

Subsequent to posting the System Impact Study Report February 2019, the Tangy- (with a tap at Mill Creek) (another tap at Bellepoint)– East Springfield line was reconfigured looping into Broadview as part of supplemental project S1210, which went in service in 2019.

Reinforcements due to Stability and Steady-state Voltage analysis results are not included in this report.

3. Interconnection Customer's Milestone Schedule

The Commercial Operation Date (COD) for the generation facility is **June 1, 2023**. Transmission Owner's proposed schedule does not match IC's requested Milestone Schedule. TO's schedule assumes that a Project Kickoff meeting will occur no later than **November 1, 2021** to meet the Milestone Schedule listed below.

Milestone Schedule:

04/01/2023	Initial Back-feed through Project Substation Date
06/01/2023	Project Commercial Operation Date

4. Customer's Scope of Work

Interconnection Customer 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) transformers, 138 kV (AD2-163) 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 where Interconnection Customer-owned 138 kV attachment line conductor will terminate on the insulators on the dead-end takeoff structure and will be defined as the POI.

The Broadview-Tangy 138 kV line will be intersected at the following GPS coordinates:

40.081794, -83.486403

Interconnection Customer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on line entrance and the breakers on the high-side of the GSU transformers with revenue metering equipment on the facility side of the line entrance breaker before the tap to the two GSU breakers. The protective relaying and metering design must comply with First Energy's applicable standards and can be found at https://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy as well as PJM requirements.

The easements and associated rights of way for the TO owned substation along with the 138kV 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:

- Interconnection Customer 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.
- Interconnection Customer will coordinate design and construction of proposed 138 kV Lead Line. For these areas, the Interconnection Customer 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, Interconnection Customer facilities should not encroach within 100 feet of Transmission line centerline at blowout conditions. If Interconnection Customer'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 Interconnection Customer, if final alignment of the 138 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities.
- Interconnection Customer is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule are included herein.
- All new generator only and new generator plus load facilities must be isolated from the FE Transmission System by a Power Transformer. The winding configurations of the transformer is shown in Attachment 2

5. Description of Facilities Included in the Facilities Study

Direct Connection

- AD2-163 138 kV (New Interconnection Substation)
    - Customer drawings and nameplates will be reviewed, and metering will be installed.

Non-Direct Connection

- Broadview-Tangy 138 kV Line
    - The Broadview-Tangy138 kV line will be cut and looped into the new interconnect substation. This cut will take place between structures 5382 and 5381. It is assumed that the new interconnection substation will be located within one span (approximately 300 feet) from the existing line.

- Tangy Substation
    - Replace one (1) wavetrap with two wavetraps and associated line tuners on the line towards AD2-163. Install a carrier cabinet for PLC relaying and anti-islanding equipment.

- Broadview Substation
    - Install two (2) wavetraps and associated line tuners on the line towards AD2-163 as well as a carrier cabinet consisting of PLC relaying and anti-islanding equipment.

- Bellpoint Substation
    - Install one (1) wavetrap and associated line tuners on the line towards Broadview-Tangy 138kV line as well as a carrier cabinet consisting of PLC relaying and anti-islanding equipment.

- Mill Creek Substation
    - Install two (2) wavetraps and associated line tuners on the line towards Broadview-Tangy 138kV line as well as a carrier cabinet consisting of PLC relaying and anti-islanding equipment.

Other Work

- AD2-163 Metering
    - Customer-owned revenue metering at interconnection customer substation.

- Option to Build Facilities
    - The IC has exercised their option-to-build these facilities, so they will design, furnish and construct the new 138 kV line terminal and take off structure in the new AD2-163 ring bus substation. 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. Transmission Owner will oversee the design and construction and perform testing and commissioning.
    - The IC has exercised their option-to-build these facilities, so they will design, furnish and construct a new three breaker ring bus substation, AD2-163 138 kV, along the Broadview-Tangy 138 kV transmission line to interconnect the AD2-163 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. Transmission Owner will oversee the design and construction and perform testing and commissioning.

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

Description	Total (w/o Tax)
Attachment Facilities:	**$ 0**
Total Direct Connection (DC) Costs:	**$ 604,700**
Total Non-Direct Connection (NDC) Costs:	**$ 2,069,700**
Total Other Charges:	**$ 454,200**

TOTAL Costs (ALL Categories):	**$ 3,128,600**

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

Broadview-Tangy 138kV Line

- Cut the Broadview-Tangy 138kV line and terminate the line inside the proposed AD2-163.
- The existing line is constructed on single circuit wood H-frame structures. Existing conductor is 336.4 kcmil ACSR, shielded with (2) 3/8" EHS shield wires.
- To create the loop install (2) single circuit wood 3-pole deadend structures (TR-138075)
- Install (2) spans of 795 kcmil 26/7 ACSR conductor shielded by (2) 7#8 Alumoweld (~.1 miles total).
- The existing conductors and shield wire are assumed to be in good condition and will be transferred to the new wood 3-pole deadend structures.
- Remove the existing conductor and shield wire between the new deadend structures.
- Siting/Licensing
    - A LON will be required to be filed with OPSB.
        - A LON is expected to take 1 month to develop and 4 months for agency review and approval.
    - Assume no local opposition to the project.
    - Assume minimal social and ecological impacts.
- Assumptions
    - The proposed ring bus location is between existing structures 5381 and 5382. Existing structures 5381 and 5382 are assumed to be in good condition and have adequate capacity for the new loading arrangement. An engineering analysis will be required to confirm.
    - Aground survey of the project site will be required.
    - Assume OPGW is not required.
    - Assume the Bellpoint, Mill Creek, Broadview, and Tangy substations will remain energized during construction. Temporary construction may be required.

3. New Substation/Switchyard Facilities

AD2-163 Interconnection Substation

- Below Grade
    - Foundations, conduit & cable trench, and ground grid as required for new 138-kV equipment
    - Conduit for fiber connection to customer substation
- Above Grade
    - Install (3) 138-kV SF6 circuit breakers

  - Install (6) 138-kV breaker disconnect switches
  - Install (3) 138-kV motor-operated line disconnect switches
  - Install (4) 138-kV wave traps
  - Install (4) line tuners
  - Install (9) 138-kV CVTs
  - Install (9) 138kV surge arresters
  - Install (1) 100kVA SSVT
  - Install (1) Lightning Mast
  - Install (1) physical security camera system
  - Install (1) pre-packaged control building
  - Install one lot of steel structures and insulators for bus supports as indicated in the attached proposed layout
  - Install one lot of steel and insulators for (3) H-Frame deadends as indicated in the attached proposed layout
  - Install one lot of steel for (6) switch stands as indicated in the attached proposed layout
  - Install one lot of rigid bus, wire, and fittings as indicated in the attached proposed layout
- R&C
  - Install (2) line relay panels to include dual (2) SEL-421 primary/backup relays with communication over PLC
  - Install (1) line relay panels to include dual (2) SEL-411L primary/backup relays with communication over fiber
  - Install (3) breaker control panels to include (1) SEL-501 and metering
  - Install (2) carrier panels to include (3) UPLC relays, (3) PCM5350s, and anti-islanding equipment
  - Install (1) SCADA RTU, HMI Panel, and other standard communication equipment
  - Install (1) Fiber Distribution Panel
- Additional Equipment to be Removed
  - None
- Assumptions
  - Outages can be obtained to complete work as estimated
  - Rough graded site and access road provided by developer
  - Backup station service feed will be from local distribution

AD2-163 Customer Sub

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

4. Substation/Switchyard Facility Upgrades

Tangy Substation

- Below Grade
  - Foundations, conduit, and grounding for new wavetraps
- Above Grade
  - Replace (1) 138kV, 800A wavetrap, line tuner, and coax with (2) 138kV, 2000A wavetraps, line tuners, and coax with steel supports
- R&C
  - Install (1) carrier panel to include (3) UPLC relays, (3) PCM5350s, and anti-islanding equipment.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Upgraded carrier equipment can fit on one panel

Broadview Substation

- Below Grade
  - Foundations, conduit, and grounding for new wavetraps.
- Above Grade
  - Install (2) 138kV, 2000A wavetraps, line tuners, and coax with steel supports.
- R&C
  - Install (1) carrier panel to include (3) UPLC relays, (3) PCM5350s, and anti-islanding equipment.
- Additional Equipment to be Removed
  - None
- Assumptions
  - Upgraded carrier equipment can fit on one panel

Bellepoint Substation

- Below Grade
  - Foundation & grounding for wavetrap installation
- Above Grade
  - Modify drawings and nameplates for line name change.
  - Install (1) additional 138kV 2000A wavetrap on the Broadview – Tangy 138kV Line exit
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Assumptions
  - Existing 138kV wavetrap is sufficient

Mill Creek Substation

- Below Grade
  - Foundations & grounding for wavetrap installations
- Above Grade

  - Modify drawings and nameplates for line name change.
  - Install (2) 138kV 2000A wavetraps on the Broadview – Tangy 138kV Line exit
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

5. Telecommunications Facilities – Upgrades

Interconnection Customer will design, provide, install, own and maintain a fiber-optic communications cable between the new **interconnection** substation, and Interconnection Customer'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).

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

6. Metering & Communications

Interconnection Customer shall install, own, operate, test and maintain the necessary revenue metering equipment. Interconnection Customer 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 Interconnection customer shall, at its own expense, install, operate, test, and maintain any communications equipment required to transmit data from the revenue metering at the IC's facility.

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

Communications for transmission line protection between the new **interconnection** substation, and Interconnection Customer'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:

- A Letter of Notification (LON) will be required by the Ohio Power Siting Board.
- 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 Interconnection Customer to purchase the property, a Phase 1 Environmental Assessment should be conducted for the entire site to avoid assumption of environmental liabilities by Interconnection Customer or Transmission Owner.
- The Transmission Owner interconnection substation may involve environmental surveys, permits, approvals and plans with federal, state, and/or local agencies.
- Assumed Interconnection Customer 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 Interconnection Customer, twelve (12)-to-eighteen (18)- months should be added to the Project Schedule to secure necessary permits, and additional costs would apply.
- Interconnection Customer will provide copies of the relative environmental permits and other necessary approvals to Transmission Owner before Transmission Owner accepts the interconnection facilities.
- Interconnection Customer 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. Interconnection Customer is responsible for maintaining the access road and ensuring unimpeded access for Transmission Owner at all times.
- Interconnection Customer is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- If Interconnection Customer 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. Interconnection Customer is

responsible for all costs, including but not limited to subdivision, associated with the property transfer.

- If Interconnection Customer leases the project property, the Interconnection Customer 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 Interconnection Customer'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.
- Interconnection Customer will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- Interconnection Customer 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.
- Interconnection Customer will conduct all necessary wetlands and waterways studies and permits within their scope of work. IC will not be responsible for permitting of work that is in the TO's scope to complete.
- Interconnection Customer will conduct all necessary historical and archaeological studies within their scope of work. IC will not be responsible for studies for work that is in the TO's scope to complete.
- If the Interconnection Customer 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

Since the IC has exercised the option to build the direct connect and attachment facilities, only the TO's estimated costs to oversee engineering and construction and to perform any required testing and commissioning activities are included. All other costs in these categories will be determined by the IC.

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Total Attachment Facilities Cost	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
AD2-163 Customer: Review drawings and nameplates for FE standards.	$ 22,300	$ 0	$ 6,600	$ 0	$ 28,900

Work Description	Direct Labor	Direct Material	Indirect Labor	Indirect Material	Total Cost
SCADA/Fiber Communication: Estimated SCADA work at Tangy, Broadview, Bellepoint, and Mill Creek substations to support relay and wavetrap installations. Estimated installation of Cellular system to support RTU installation at AD2-163. Assumed SCADA work is included in this cost. Estimated (1) in-sub fiber run from AD2-163 substation control house to developer built fiber run to support communications and control to generator site.	$ 139,600	$ 10,600	$ 41,500	$ 900	$ 192,600
Project Management: Project Management, Environmental, Real Estate, and Right of Way.	$ 295,500	$ 0	$ 87,700	$ 0	$ 383,200
Total Direct Connection Cost	**$ 457,400**	**$ 10,600**	**$ 135,800**	**$ 900**	**$ 604,700**
Broadview Tangy 138 kV Line Loop: Cut the Broadview-Tangy 138kV line and terminate the line inside the proposed AD2-163.	$ 494,400	$ 122,400	$ 146,800	$ 10,400	$ 774,000
Tangy: Line terminal upgrade	$ 229,800	$ 90,000	$ 68,200	$ 7,700	$ 395,700
Bellepoint: Line terminal upgrade	$ 150,400	$ 20,000	$ 44,700	$ 1,700	$ 216,800
Millcreek: Line terminal upgrade	$ 196,400	$ 30,800	$ 58,300	$ 2,600	$ 288,100
Broadview: Line terminal upgrade	$ 228,700	$ 90,800	$ 67,900	$ 7,700	$ 395,100
Total Non-Direct Connection Cost	**$ 1,299,700**	**$ 354,000**	**$ 385,900**	**$ 30,100**	**$ 2,069,700**
AD2-163: OPTION TO BUILD: Attachment Facilities in Interconnection Substation	$ 3,855	$ 0	$ 1,145	$ 0	$ 5,000
AD2-163: OPTION TO BUILD: Install a 138kV three breaker ring bus on the East Springfield Broadview – Tangy line to provide interconnection facilities for 200MW of solar generation.	$ 344,445	$ 0	$ 102,255	$ 0	$ 446,700
Metering: Customer-owned revenue metering at AD2-163 generation facility.	$ 1,900	$ 0	$ 600	$ 0	$ 2,500
Total Other Work Costs	**$ 350,200**	**$ 0**	**$ 104,000**	**$ 0**	**$ 454,200**
Total Project Costs	**$ 2,107,300**	**$ 364,600**	**$ 625,700**	**$ 31,000**	**$ 3,128,600**

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 **seventeen (17) month** 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 all applicable permits and/or easements have been obtained.

17-month Schedule (Assume June 2021 Start)

Activity	Start Month	End Month
[redacted]		
Preliminary Engineering	1	3
Siting, Permits & Real Estate	3	10
Detailed Engineering	3	10
Equipment Delivery	10	11
Below Grade Construction – Substation	11	14
Below Grade Construction – T-Lines	13	15
Above Grade Construction – Substation	14	16
Above Grade Construction – T-Lines	15	16
Testing & Commissioning	17	17

Attachment 1: Protection Scope

Short Circuit Values

The 138 kV fault values for the AD2-163 interconnection location with all new generation out of service are:

Three phase = 6.2kA
Single line to ground = 4.3kA
Z1= (2.052+ j 6.51) %
Z0= (4.35 + j 14.91) %

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 AD2-163 generating substation and the new 138kV ring bus substation to be used for line protection, direct transfer trip (DTT) and other communication.

AD2-163 Connecting Party Generator Owner fiber requirements:

New 138 kV Ring Bus (FE) – AD2-163 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 AD2-163 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 Broadview, Tangy 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:

Broadview-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)

Tangy -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

AD2-163 Generating Station 138 kV

138 kV Transmission Line Protection @ AD2-163 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 breakers, located on the 138 kV transformer side of the breaker, and CCVTs or PTs on the line side of the 138 kV line breakers. 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 all the high side 138 KV circuit breakers. Any protective trip of these breakers 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 @ AD2-163 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 bus or 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

AD2-163 138 kV Interconnecting Substation

For this project, the existing Broadview – Tangy 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 Broadview, Tangy and AD2-163 generation facility line 138 kV exits.

For the AD2-163 generator station exit, the primary and backup relays shall be SEL-411Ls.

For both the Broadview & Tangy 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).

Broadview Substation

Modifications are required to Transmission Owner's Broadview 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.

Tangy Substation

Modifications are required to Transmission Owner's Tangy 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.

Bellepoint Substation

Transmission Owner shall provide the design, procurement, installation of one additional power line carrier wave trap as part of the cost of the project.

Mill Creek Substation

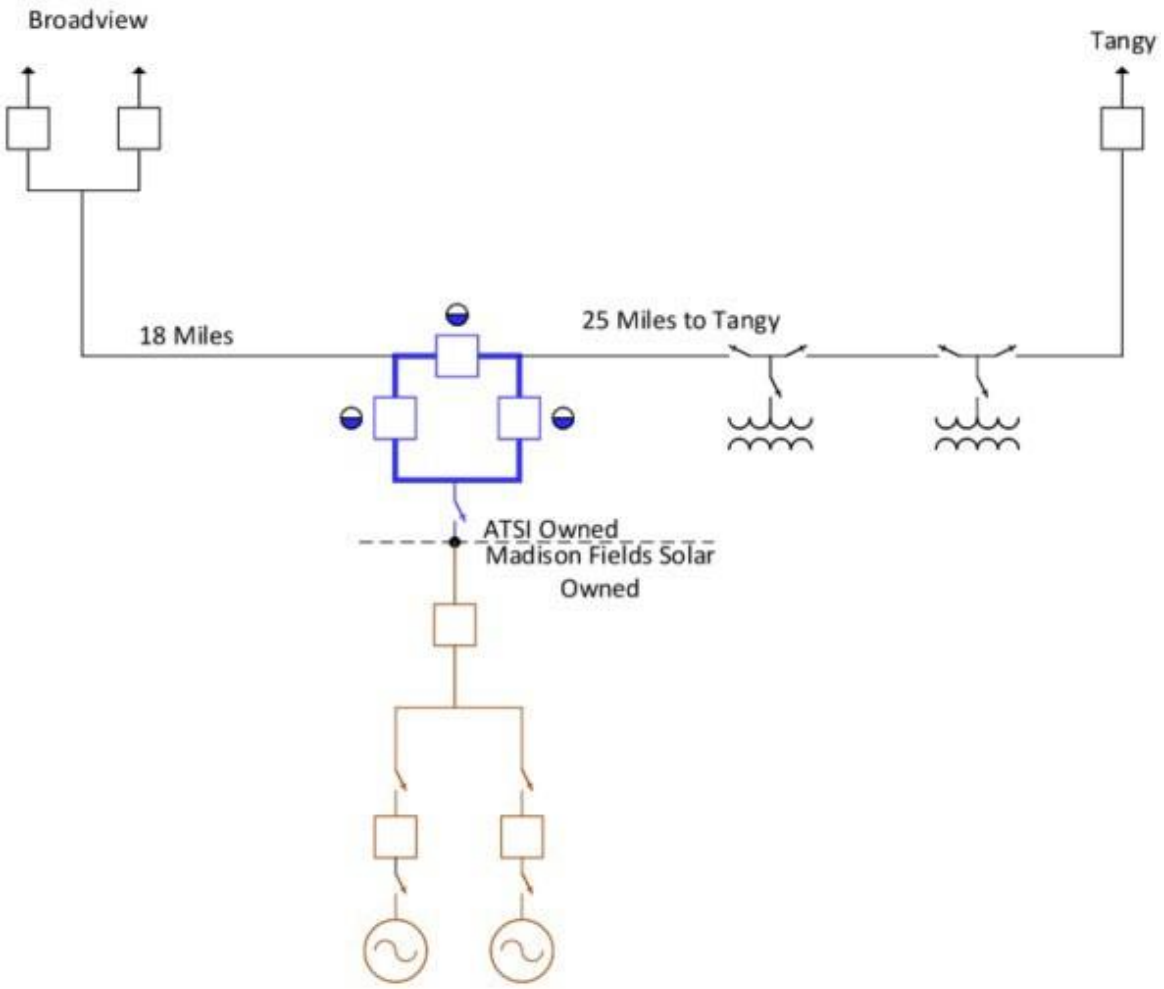
Transmission Owner shall provide the design, procurement, installation of two new power line carrier wave traps as part of the cost of the project.

Relay Settings Changes

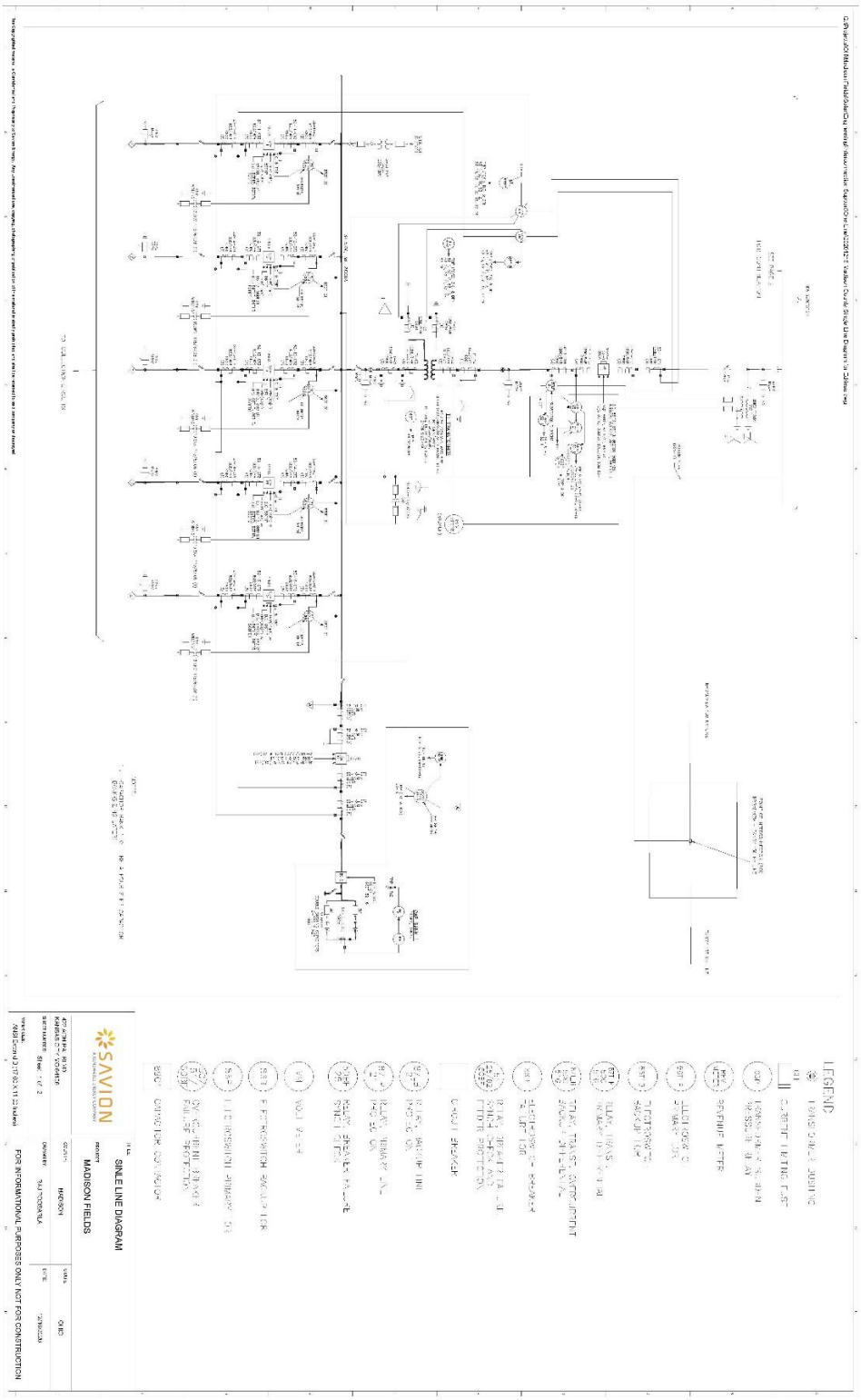
Relay setting changes will potentially be required at remote stations affected by the project.

Attachment 2: Single Line Diagram

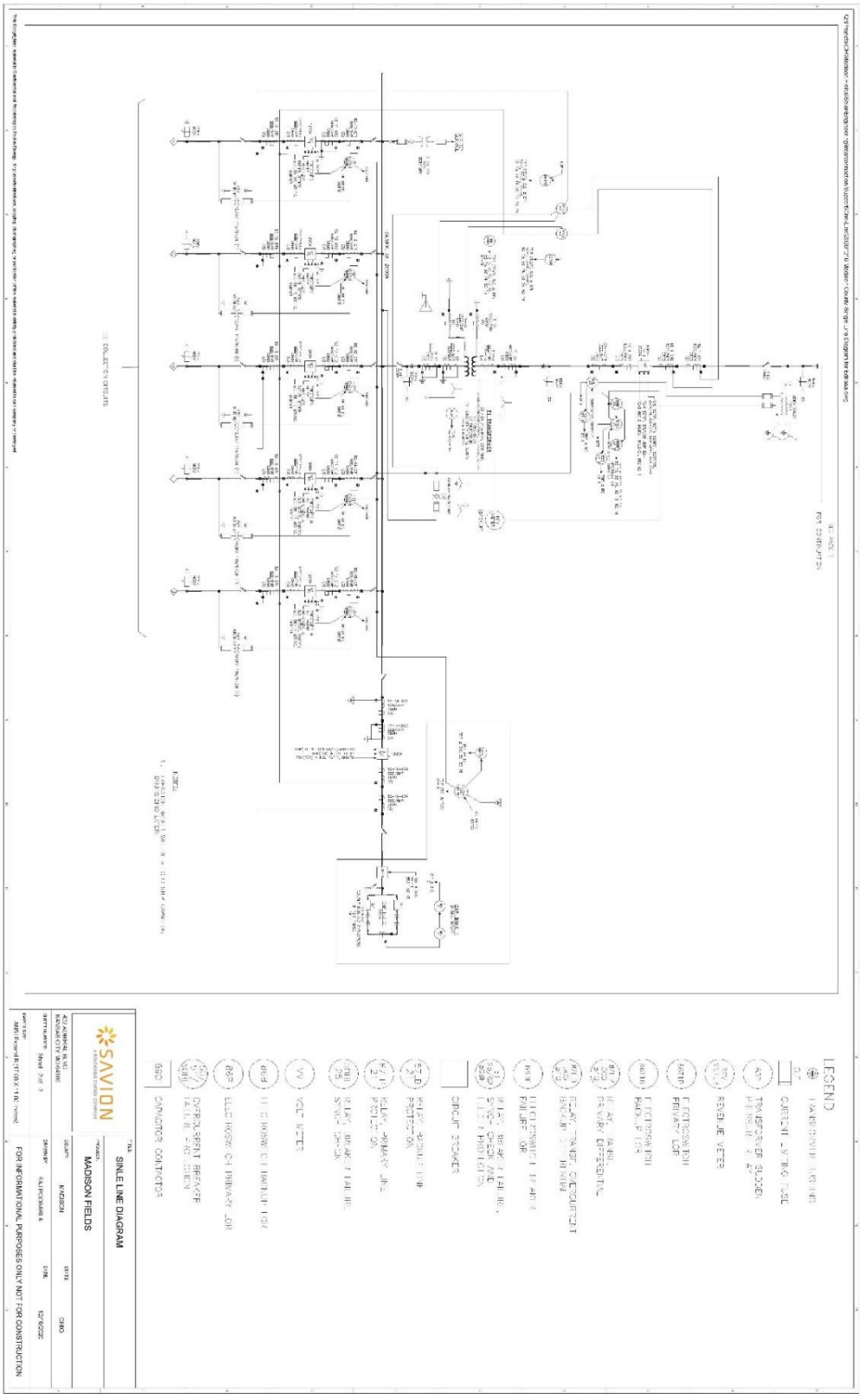
FirstEnergy Single Line



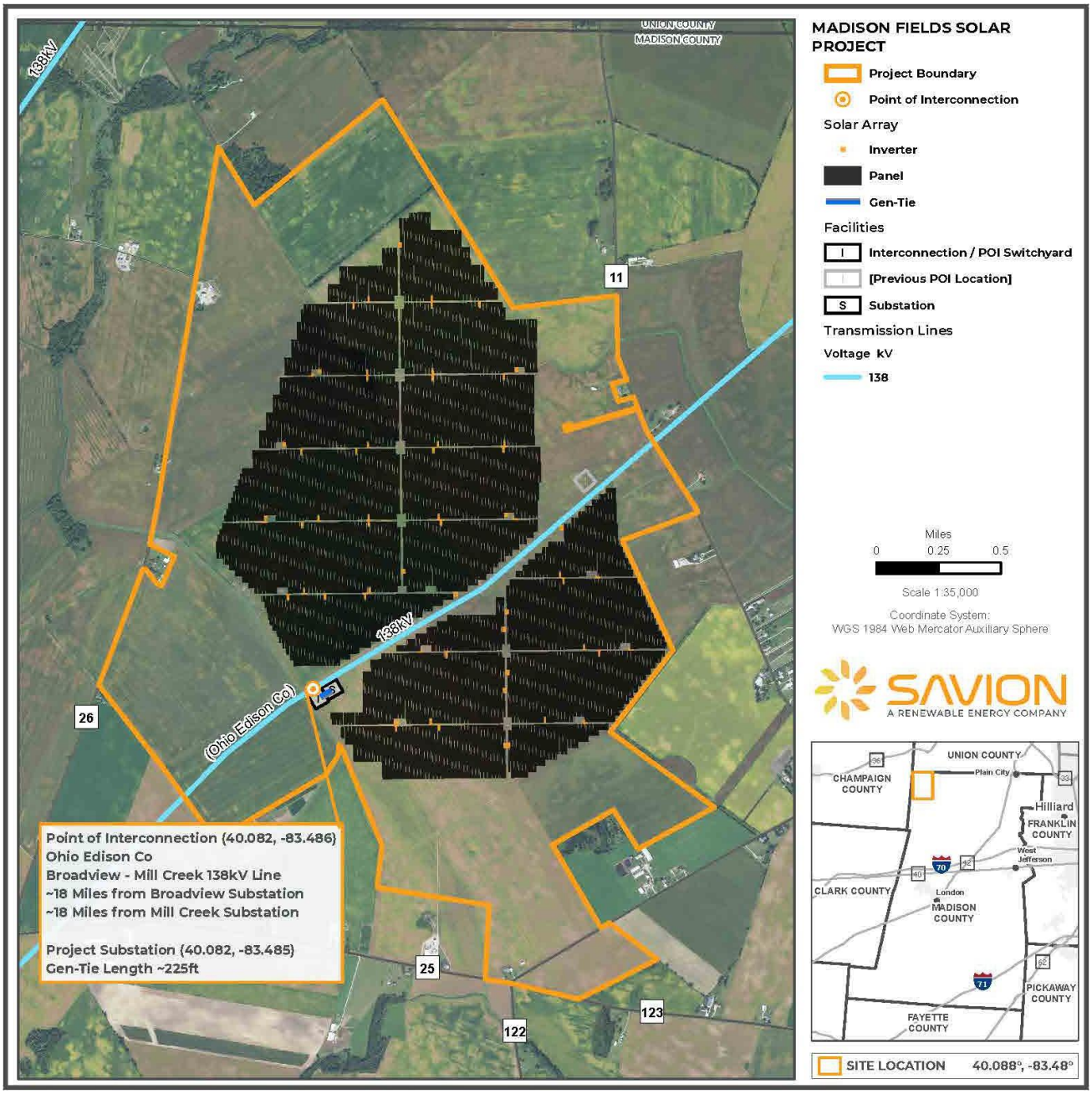
IC Single Lines
(ILLUSTRATIVE PURPOSES ONLY NOT APPROVED FOR CONSTRUCTION)



(ILLUSTRATIVE PURPOSES ONLY NOT APPROVED FOR CONSTRUCTION)



Attachment 3: Proposed Project Location



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

Interconnection Customer is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with Transmission Owner's Transmission System. Interconnection Customer 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. Interconnection Customer 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”