Transmission Interconnection Facilities Study Report

For

PJM Transmission Interconnection Request Queue Position AD2-009

"McConnellsburg 138 kV"

July 2021

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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 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

Great Cove Solar LLC, the Interconnection Customer (IC), has proposed a 70 MW solar generating facility to be built in Fulton County, Pennsylvania. PJM recognizes 48.1 MW as Capacity Interconnection Rights (CIR) for this project. The generation facility will interconnect with the West Penn Power Company, a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO), at a newly constructed 138 kV terminal connected to the McConnellsburg 138 kV bus.

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

The 138 kV capacitor bank installation at McConnellsburg referenced in the System Impact Study posted February 2019 has been removed from the scope of this project.

3. Interconnection Customer's Milestone Schedule

The planned in-service date, as requested by the IC is 12/06/2020. This date has passed.

Developer's Requested Milestone Schedule:

09/06/2020 Initial Back-feed through Project Substation Date
12/06/2020 Project Commercial Operation Date

Transmission Owner's Assumed Milestone Schedule:

10/31/2023 Initial Back-feed through Project Substation Date
12/31/2023 Project Commercial Operation Date

4. Customer's Scope of Work

Developer 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 (AD2-009) generator lead line and connection to the new 138 kV terminal position at the McConnellsburg Substation.

Point of Interconnection (POI): The POI will be located within the TO's existing McConnellsburg 138 kV substation, where the Developer-owned 138 kV attachment line conductor will terminate on the insulators on the dead-end takeoff structure and will be defined as the POI.

Developer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of the GSU transformer with revenue metering equipment between the collector bus and the incoming generator lead line. The protective relaying and metering design must comply with First Energy's applicable standards as well as PJM requirements.

Assumptions / Notes:

- Route selection, line design, and right-of-way acquisition for the Developer's facilities are not included in this report and are the responsibility of the Developer.
- Developer 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.
- Developer will coordinate design and construction of proposed 138 kV Lead Line. For these areas, the Developer 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 position. As a minimum, Developer facilities should not encroach within 100 feet of TO centerline at blowout conditions. If Developer'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 Developer if final alignment of the 138 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities.
- Developer is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule included herein.
- Grounded WYE HV windings, Ungrounded WYE LV windings and delta tertiary and no neutral grounding reactor will be acceptable for AD2-009.

5. Description of Facilities Included in the Facilities Study

Attachment Facilities

McConnellsburg Substation
Transmission Owner will design, furnish and construct the new 138 kV line terminal to connect AD2-009. This work will include, but not be limited to, installation of a 138 kV line exit take-off structure, 138 kV circuit breaker (with disconnect switches), a set of CVT's and associated foundations, structures, and equipment to accommodate the termination of the 138 kV generator lead line. This includes reviewing customer design drawings, nameplates and relay settings.

Engineering oversight of IC's specification and installation of revenue metering equipment at generation facility. Support set up of Power Producer - owned metering in FE's MV90 and other systems.

Direct Connection

Estimated SCADA work at McConnellsburg, Cherry Run & Guilford substations to support relay installations, wave trap installations and updated relay settings. Estimated in-sub fiber run from McConnellsburg control house to developer ran fiber for communications to AD2-009.

Non-Direct Connection

Cherry Run Substation
The existing wave trap and line tuner will be replaced along with the associated power line carrier equipment in order to accommodate the anti-islanding protection scheme.

Guilford Substation
The existing wave trap and line tuner will be replaced along with the associated power line carrier equipment in order to accommodate the anti-islanding protection scheme.

McConnellsburg
The existing wave traps and line tuners on the terminals to Cherry Run and Guilford will be replaced along with the associated power line carrier equipment in order to accommodate the anti-islanding protection scheme.

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

Description	Total (without Tax)
Attachment Facilities:	**$ 264,000**
Total Direct Connection (DC) Costs:	**$ 113,500**
Total Non-Direct Connection (NDC) Upgrade Costs:	**$ 2,630,700**

Network Upgrades	**$0**
TOTAL Costs (ALL Categories)	**$ 3,008,200**

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

Attachment Facility	*Timeframe*
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

None

3. New Substation/Switchyard Facilities

None

4. Substation/Switchyard Facility Upgrades

McConnellsburg upgrades will be installed in the southern portion of the substation on the No. 1 138 kV Bus. Structures will follow First Energy current standards and best practices.

McConnellsburg Line Terminal

- Below Grade
  - Grading, grounding, fence and stoning to expand the finished substation on FE owned property
  - Foundations, conduit, and grounding for 138 kV deadend structure, breaker, support structures & fiber from AD2-009
- Above Grade
  - Install (1) 138 kV SF6 circuit breaker.
  - Install (2) 138 kV, 2000A disconnect switches
  - Install (3) 138 kV CVTS
  - Install (3) 138 kV surge arresters
  - Install (1) 138 kV dead end structure.
  - Install (1) lot of rigid bus, strain bus, connectors, and steel supports
  - Replace (2) 1200A wavetraps and line tuners with (2) 2000A wideband wavetraps and line tuners for Cherry Run and Guilford line terminals.
- R&C
  - Install (1) prewired relaying panel consisting of dual SEL411L over fiber with SEL501 BFT

  - Install (1) Fiber termination rack
  - Install (2) RFL9780 receivers for Cherry Run and Guilford line terminals.
- Additional Equipment to be Removed
  - None
- Assumptions
  - AC&DC station service, SCADA RTU and relay house space are all adequate.

WP-S-871: Cherry Run

- Below Grade
  - None
- Above Grade
  - Replace (1) 1200A wavetrap and line tuner with (1) 2000A wideband wavetrap and line tuner.
- R&C
  - Install (1) RFL 9780 transmitter with balanced hybrid for anti-islanding.
- Additional Equipment to be Removed
  - None
- Assumptions
  - RFL 9780 will fit in an existing panel.

WP-S-872 : Guilford

- Below Grade
  - None
- Above Grade
  - Replace (1) 1200A wavetrap and line tuner with (1) 2000A wideband wavetrap and line tuner.
- R&C
  - Install (1) RFL 9780 transmitter with balanced hybrid for anti-islanding.
- Additional Equipment to be Removed
  - None
- Assumptions
  - RFL 9780 will fit in an existing panel.

WP-S-873: AD2-009 Customer Sub

  - Review nameplates, drawings, and relay settings.

5. Telecommunications Facilities – Upgrades

Developer will design, provide, install, own and maintain a fiber-optic communications cable between the new McConnellsburg line terminal and Developer'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 McConnellsburg Substation control house. Developer is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber cable.

6. Metering & Communications

Required at AD2-009 Generation

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

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

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

7. Environmental, Real Estate and Permitting

First Energy will be responsible for the expansion of the McConnellsburg substation.

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

- Environmental permitting, Real Estate acquisition, and Pennsylvania Public Utilities Commission (PAPUC) 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, on IC's property, or on the TO'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 for the scope of work they are performing.
- IC will obtain all necessary permits for the scope of work they are performing.
- IC will conduct all necessary wetlands and waterways studies and permits for the scope of work they are performing.
- IC will conduct all necessary historical and archaeological studies for the scope of work they are performing.
- 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	
AD2-009 Generator Lead Termination: Install a 138 kV line terminal at McConnellsburg for service to AD2-009 Generation **AD2-009 Customer Substation:** Review customer design drawings, nameplates, and relay settings.	$ 162,400	$ 38,000	$ 47,800	$ 11,900	$ 260,100
Engineering oversight of IC's specification and installation of revenue metering equipment at generation facility. Support set up of Power Producer-owned metering in FE's MV90 and other systems.	$ 3,000	$ 0	$ 900	$ 0	$ 3,900

Total Attachment Facilities Cost	**$ 165,400**	**$ 38,000**	**$ 48,700**	**$ 11,900**	**$ 264,000**
Estimated SCADA work at McConnellsburg, Cherry Run, & Guildford substations to support relay installations, wave trap installations, and updated relay settings. Estimated in-sub fiber run to from McConnellsburg control house to developer ran fiber for communications to AD2-009.	$ 83,300	$ 4,100	$ 24,600	$ 1,500	$ 113,500
Total Direct Connection Cost	**$ 83,300**	**$ 4,100**	**$ 24,600**	**$ 1,500**	**$ 113,500**
McConnellsburg: Install a 138 kV breaker for the AD2-009 generation interconnection. Including Project Management & Environmental	$ 1,180,300	$ 350,100	$ 347,600	$ 110,500	$ 1,988,500
Cherry Run: Replace (1) 1200A wavetrap and line tuner with (1) 2000A wideband wavetrap and line tuner.	$ 216,400	$ 30,100	$ 63,700	$ 10,900	$ 321,100
Guilford: Replace (1) 1200A wavetrap and line tuner with (1) 2000A wideband wavetrap and line tuner.	$ 216,400	$ 30,100	$ 63,700	$ 10,900	$ 321,100
Total Non-Direct Connection Network Upgrades	**$ 1,613,100**	**$ 410,300**	**$ 475,000**	**$ 132,300**	**$ 2,630,700**
Total Project Costs	**$ 1,861,800**	**$ 452,400**	**$ 548,300**	**$ 145,700**	**$ 3,008,200**

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 as stated in Schedule E of the Interconnection Service Agreement.

9. Schedules and Assumptions

A proposed **twenty-four (24) 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 after all applicable permits and/or easements have been obtained.

24 month Schedule (assume December 2020 start)

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
Above Grade Construction – Substation	18	23
Testing & Commissioning	24	24

Attachment #1: Protection Study

Protection Requirements

Non-Direct Connect Protection Requirements

Cherry Run Substation

Install one RFL-9780 FSK Tx unit with balanced hybrid to combine DCB carrier signal and new breaker status relaying carrier signal to McConnellsburg. The anti-islanding carrier transmit scheme shall couple to Y-phase, and operate at a frequency yet to be determined. The anti-islanding scheme will utilize the local breaker 'b' breaker contacts to key the new transmitter to communicate the proper network connection status to McConnellsburg via the Frequency Shift Keyed power line carrier signal.

Replace the existing McConnellsburg line terminal single frequency line tuner and line trap with a wide band line tuner and a 2000A wide band line trap.

Transmission Owner will perform an area coordination study of the existing protective relay settings for equipment at Cherry Run and adjacent substations to determine if relay settings are affected by the change in short circuit current due to the addition of the AD2-009 solar generation.

Guilford Substation

Install one RFL-9780 FSK Tx unit with balanced hybrid to combine DCB carrier signal and new breaker status relaying carrier signal to McConnellsburg. The anti-islanding carrier transmit scheme shall couple to Y-phase, and operate at a frequency yet to be determined. The anti-islanding scheme will utilize the local breaker 'b' breaker contacts to key the new transmitter to communicate the proper network connection status to McConnellsburg via the Frequency Shift Keyed power line carrier signal.

Replace the existing McConnellsburg line terminal single frequency line tuner and line trap with a wide band line tuner and a 2000A wide band line trap.

Transmission Owner will perform an area coordination study of the existing protective relay settings for equipment at Guilford and the adjacent substations to determine if relay settings are affected by the change in short circuit current due to the addition of the AD2-009 solar generation.

Short Circuit Values (Existing Conditions)

Fault values for the AD2-009 Interconnection Substation location:

Three phase = 5,993 A

Single line to ground = 3,777 A
Zl= 0.00949 + j0.06916 p.u.
Z0= 0.05269 + j0.1855 p.u.

Note: These fault values were obtained using the FirstEnergy short circuit model without AD2-009 solar generation in the fault case.

Impedances are given on 100 MVA and 138 kV bases. The faults provided are bolted, symmetrical values for normal system conditions with a flat 1.0 p.u. voltage profile. Future increases in fault currents are possible and it is Developer's responsibility to upgrade its equipment and/or protective equipment coordination when necessary.

AD2-009 Interconnection Substation (138 kV existing McConnellsburg Substation) Protection Requirements

One new 145kV rated, 3000A continuous, 40kA interrupting, nominal 138 kV breaker is required to connect to the McConnellsburg 138 kV bus. The 138 kV breaker will be equipped with four sets (12 total) 2000:5 A multi-ratio C800 relay accuracy CTs with a thermal rating factor of 2.0, and one set (3 total) 1500:5 A, single-ratio 0.3B1.8 meter accuracy CTs with a thermal factor of 2.0, for direct connect tie line operational metering. One set of (3) CCVTs, one per phase, is required on the 138 kV line exit. The CCVTs shall have dual secondary windings with each winding capable of being connected at either a 1200:1 or 700:1 ratio.

Anti-islanding scheme - utilize breaker status from the remote substations as communicated via Frequency Shift Keyed power line carrier, to determine when the local direct connect tie line breaker should be tripped. This is when both 138 kV network connections at McConnellsburg are open, either locally or at the adjacent substations or beyond. Tripping of the local direct connect tie line breaker takes the generation offline.

Cherry Run 138 kV line terminal

Install one RFL-9780 FSK RX unit with balanced hybrid to decouple DCB carrier signal and new breaker status relaying carrier signal from Cherry Run Substation. The anti-islanding carrier scheme shall couple to Y-phase, and operate at a frequency yet to be determined. The anti-islanding scheme will utilize the local breaker 'b' contacts and receive the status of the remote breaker 'b' contacts to determine the proper network connection status at McConnellsburg via the Frequency Shift Keyed power line carrier signal.

Replace the existing Cherry Run line terminal single frequency line tuner and line trap with a wide band line tuner and a 2000A wide band line trap.
Transmission Owner will perform an area coordination study of the existing protective relay settings for equipment at Cherry Run and adjacent substations to determine if relay settings are affected by the change in short circuit current due to the addition of the AD2-009 solar generation.

Guilford 138 kV line terminal

Install one RFL-9780 FSK RX unit with balanced hybrid to decouple DCB carrier signal and new breaker status relaying carrier signal from Guilford Substation. The anti-islanding carrier scheme shall couple to Y-phase, and operate at a frequency yet to be determined. The anti-islanding scheme will utilize the local breaker 'b' contacts and receive the status of the remote breaker 'b' contacts to determine the proper network connection status at McConnellsburg via the Frequency Shift Keyed power line carrier signal.

Replace the existing Guilford line terminal single frequency line tuner and line trap with a wide band line tuner and a 2000A wide band line trap.

Transmission Owner will perform an area coordination study of the existing protective relay settings for equipment at Guilford and the adjacent substations to determine if relay settings are affected by the change in short circuit current due to the addition of the AD2-009 solar generation.

AD2-009 Direct Connect Tie Line Protection

The zone of protection for this scheme consists of the direct connect tie line between the CTs supplying the relays at AD2-009 Interconnection (McConnellsburg) Substation and the CTs on the direct connect tie line circuit breaker at the AD2-009 Generation substation. The line protection system will consist of dual, high speed clearing pilot protection schemes. The AD2-009 direct connect tie line primary protection shall be an SEL-411L current differential scheme communicating over a dedicated fiber-optic channel via a direct, relay to relay fiber cable, with direct tripping, non-pilot step distance and directional ground overcurrent backup elements. The AD2-009 direct connect tie line backup protection shall be an SEL-411L current differential scheme utilizing a second dedicated fiber-optic channel over a direct, relay-to-relay fiber cable, with direct tripping, non-pilot, step distance and directional ground overcurrent backup elements. Direct Transfer Trip (DTT) for breaker failure to trip will also utilize both SEL-411L relays and their respective fiber optic communication channels between the AD2-009 Interconnection Substation and the AD2-009 Generation Substation. Redundancy for primary and backup line protection schemes is required including independent DC supply on separate breakers from a DC panelboard, separate tripping paths energizing separate trip coils in the breakers, independent current transformers, and independent secondary windings of the same voltage transformer for primary and backup relaying. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes, the primary and backup relay fiber optic communication channels must be in separately routed cable paths. No automatic reclosing will be applied at the AD2-009 Interconnection Substation for faults on the 138 kV direct connect tie line.

Breaker Failure Relaying

A breaker failure relay (SEL-501) shall be utilized on the new 138 kV circuit breaker. The source for the breaker failure relay shall be the same CTs as used on the backup relaying. Any

protective trip of this breaker shall initiate the breaker failure to trip scheme. The re-trip feature of the SEL-501 breaker failure relay shall be utilized to re-trip the 138 kV circuit breaker. DC supplied to power the breaker failure schemes shall be independent DC breakers from either the primary or backup relaying scheme DC.

This 138 kV breaker failure scheme shall trip and block closing of the Warfordsburg and Guilford 138 kV Breakers at the AD2-009 Interconnection (McConnellsburg) Substation. Tripping shall be done via a hand-reset LOR lockout relay. Breaker failure should key direct transfer trip (DTT) to the AD2-009 Generation Substation main breaker.

DC Power

The relaying system shall have a reliable source of DC power independent from the AC system that is immune to AC system disturbance or loss (for example - DC battery and charger) to assure proper operation of the protection scheme. Primary and backup relaying schemes shall be powered from different DC distribution panel circuit breakers.

Operational Metering Requirements

Meter accuracy operational metering is required by PJM for the direct connect tie lines and will be provided using a Satec meter, and meter accuracy CTs and CCVTs at the direct connect tie line exits at the AD2-009 Interconnection Substation.

AD2-009 Generation Substation Protection Requirements

It is the responsibility of the Developer to assure protection, coordination and equipment adequacy within its 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

Developer is to design its protective system to clear any faults within their zones of protection with one or more of their local circuit breakers. Each zone of protection covering the 138 kV

portion of the interconnection system, including the GSU transformer, is to be protected by two independent relay schemes that each provide high speed fault clearing. The terminal breaker at the generation end of the direct connect tie line is to be included in the 138 kV over-lapping zones of protection. The CTs used for the zones of protection covering the 138 kV portion of the system shall use C800 relay accuracy CTs and the CTs should not saturate for the maximum through-fault current that can be experienced by the relay system for the tap ratio in use. Each 138 kV breaker is to have breaker failure to trip protection. The AD2-009 Generation substation will contain at least one 138 kV direct connect tie line/high-side GSU circuit breaker. The GSU transformer windings shall be Grounded wye HV windings, ungrounded wye LV windings and delta tertiary. The 138 kV interconnection line circuit breaker shall be purchased with four sets (12 total) of 2000:5 A MR C800. A 138 kV three phase potential source (CCVT or equivalent) is required for line terminal relaying. The AD2-009 Generation Substation shall not close into the direct connect tie line if it is dead, so that all synchronizing is performed at the AD2-009 Generation Substation. All communications between AD2-009 Interconnection Substation and the AD2-009 Generation Substation, including relay trip signals, shall utilize fiber optic communications paths so that no copper cables shall be run between these substations for the purpose of carrying currents, trip signals, or communications of any sort. No automatic reclosing will be applied at the AD2-009 Interconnection Substation for faults on the 138 kV direct connect tie line.

AD2-009 Direct Connect Tie Line Protection

The zone of protection for this scheme consists of the direct connect tie line between the CTs supplying the relays at AD2-009 Interconnection Substation and the CTs on the direct connect tie line circuit breaker at the AD2-009 Generation Substation. The line protection system will consist of dual, high speed clearing pilot protection schemes. The AD2-009 direct connect tie line primary protection shall be an SEL-411L current differential scheme communicating over a dedicated fiber-optic channel via a direct, relay to relay fiber cable, with direct tripping, non-pilot step distance and directional ground overcurrent backup elements. The AD2-009 direct connect tie line backup protection shall be an SEL-411L current differential scheme utilizing a second dedicated fiber-optic channel over a direct, relay-to-relay fiber cable, with direct tripping, non-pilot, step distance and directional ground overcurrent backup elements. Direct Transfer Trip (DTT) for breaker failure to trip will also utilize both SEL-411L relays and their respective fiber optic communication channels between the AD2-009 Interconnection Substation and the AD2-009 Generation Substation. Redundancy for primary and backup line protection schemes is required including independent DC supply on separate breakers from a DC panelboard, separate tripping paths energizing separate trip coils in the breakers, independent current transformers, and independent secondary windings of the same voltage transformer for primary and backup relaying. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes, the primary and backup relay fiber optic communication channels must be in separately routed cable paths. Developer may propose additional schemes or relays to protect its facility such as DTT transmitters/receivers, etc. Transmission Owner must review and agree to

any additional protection. No automatic reclosing will be applied at the AD2-009 Generation Substation for faults on the 138 kV direct connect tie line.

Breaker Failure Relaying

Each breaker on the high side portion of the AD2-009 Generation Substation is to have breaker failure to trip protection. The breaker failure to trip protection must include current sensing Or'd with the breaker status to identify a closed breaker. The breaker failure to trip protection shall trip all breakers electrically adjacent to the failed breaker at the AD2-009 Generation substation and the breaker failure to trip protection on the direct connect tie line breaker shall send DTT through both fiber channels to the Transmission Owner AD2-009 Interconnection Substation.

Inter-tie Relaying

In addition to the two fully independent high-speed relay schemes for the 138 kV portion of the AD2-009 Generation Substation, an inter-tie relay is also required. The inter-tie relay shall be an SEL-351 or equivalent, including 27, 59, 81, 67V and 67N elements. The current source for the intertie relay shall be CTs on the direct connect tie line breaker and the protection elements listed shall trip the 138 kV interconnection line main breaker.

The relaying system 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.

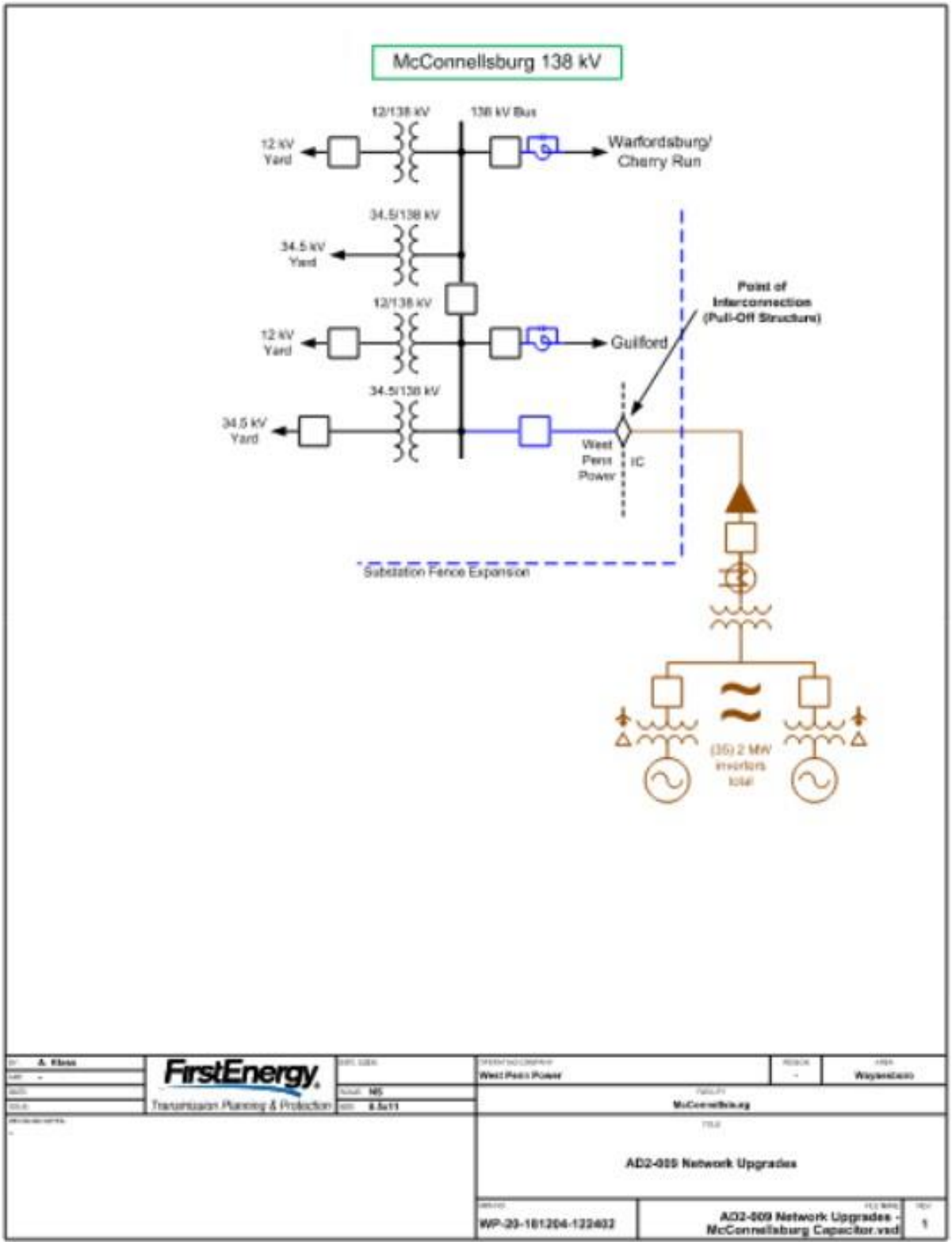
Developer is solely responsible for protecting its own equipment in such a manner that electrical faults or other disturbances on the Transmission Owner system do not damage its equipment.

Approvals

All relays, relay schemes and relay settings that include 138 kV voltages or currents, or trip any 138 kV circuit breakers, shall require the review and approval of Transmission Owner. 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. The cost of these relay replacements will be borne by Developer.

Attachment #2: One-Line Diagrams

First Energy One-Line



Attachment #3: Developer Site Plan and Substation Attachment Facilities

Developer Site Plan

Project Substation GPS: 39°55'26.09"N, 78° 0'3.34"W

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. Developer 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”