Transmission Interconnection Facilities Study Report

For

PJM Transmission Interconnection Request Queue Position AE2-277

"McDowell 138 kV"

January 2022

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Preface

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

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

The Facility Study estimates attempt to identify the estimated time required to obtain property rights and permits for construction of the required facilities. The project IC is responsible for the right-of-way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

A. Transmission Owner Facilities Study Summary

1. Description of Project

Keystone State Renewables, LLC, (hereinafter referred to as "IC") has proposed a solar generating facility located in Mercer County, Pennsylvania. The installed facilities for AE2-277 will have a total capability of 38.2 MW with 16 MW of this output being recognized by PJM as capacity. The generation facility will interconnect with American Transmission System Inc. (ATSI) a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO) in the Penn Power operating region, by adding a line terminal position to the existing McDowell 138 kV Substation by extending the McDowell 138 kV bus and installing one circuit breaker and related equipment.

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

No amendments to the System Impact Study or System Impact Study Results posted on PJM's website dated February 2020 were identified.

3. Interconnection Customer's Milestone Schedule

The Commercial Operation Date (COD) for the generation facility is **December 31, 2023**. IC's requested COD does not match the TO's assumed milestone schedule. A Project Kickoff meeting must occur by **October 31, 2022** to meet Transmission Owner's Assumed Milestone Schedule listed below.

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

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 (AE2-277) generator lead line and connection to the new line termination at the interconnection substation.

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

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

Assumptions / Notes:

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

5. Description of Facilities Included in the Facilities Study

Attachment Facilities

- **AE2-277 Generator Lead Termination**
    - Transmission Owner will accommodate the attachment of the incoming generator lead line. This work will include, but not be limited to, foundations, motor-operated disconnect switch, jumpers, insulator assemblies, and associated equipment to accommodate the termination of the 138 kV generator lead line.

- **AE2-277 Customer Substation**
    - Drawings and nameplates will be reviewed.

Direct Connection

None

Non-Direct Connection

- **McDowell Substation**
    - To connect the AE2-277 solar project with the ATSI transmission system, a new line position will be established within the McDowell 138 kV Substation by adding a new circuit breaker and related equipment.
    - Estimated SCADA work at McDowell substation to support breaker, MOAB, meter, and relay installations. Estimated (1) in-sub fiber run from McDowell substation control house to developer built fiber run to support communications and control to generator site.

- **Sharon Substation**
    - Relay settings will be updated.

- **Campbell Substation**
    - Relay settings will be updated.

- **Maysville Substation**
    - Relay settings will be updated.

- **Crossland Substation**
    - Relay settings will be updated.

- **Cedar Street Substation**
    - Relay Settings will be updated.

- **Keisters Substation**
    - Relay settings will be updated.

- **Shenango Substation**
  - Relay settings will be updated.

- **Masury Substation**
  - Relay settings will be updated.

- **Boardman Substation**
  - Relay settings will be updated.

New System Upgrades

- **McDowell Substation**
  - A new relay panel will be installed and relay settings will be updated.

Other Work

- AE2-277 Metering
  - Customer-owned revenue metering at interconnection customer substation.

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

Description	Total
Attachment Facilities:	**$ 169,400**
Total Direct Connection (DC) Costs:	**$ 0**
Total Non-Direct Connection (NDC) Upgrade Costs:	**$ 2,260,700**
New System Upgrades	**$ 253,800**
Total Other Charges	**$ 2,500**

TOTAL Costs (ALL Categories)	**$ 2,686,400**

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

Attachment Facility	*Timeframe*
Engineering, Procurement, and Construction	12 months

B. Transmission Owner Facilities Study Results

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

1. Transmission Lines –New

None

2. Transmission Lines – Upgrade

None

3. New Substation/Switchyard Facilities

AE2-277 Customer Substation

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

4. Substation/Switchyard Facility Upgrades

McDowell

- Below Grade
  - Install Foundations, Grounding and Conduit for New Interconnection Breaker to AE2-277.
  - Foundations and Grounding for New Steel Structures.
  - Conduit to Control Building for Fiber.
- Above Grade
  - Install (1) 138 kV Dead-end Structure between the Existing Dead-end Structures.
  - Install (6) 138 kV Bus Supports.
  - Install (1) 138 kV, 3000 A, 40 kA, Circuit Breaker.

  - Install (2) 138 kV, 1200 A, Disconnect Switches for New Breaker
  - Install (1) 138 kV, 1200 A, Motor-Operated Line By-pass Switch.
  - Install conductor that exceeds SN: 304 MVA, SSTE: 373, WN: 352, WSTE 451 from the Breakers to Disconnect Switches and Line Drops.
  - Install (3) 138 kV Station Class Polymer Surge Arresters
  - 1 Lot of Rigid Bus, Strain Bus, Connectors, and Steel as Indicated on the Attached Layout.
- R&C
  - Install (1) FE Standard Transmission Line Relaying Panel Consisting of Dual SEL411L with SEL501 BFT and PM174 for Line Metering.
  - Modify Existing Primary and Backup Bus Protection Relays for New Breaker Connections.
- Additional Equipment to be Removed
  - None
- Assumptions
  - The AC/DC System are Adequate.
  - The SCADA System has Enough Available Points.
  - There is Room in the Existing Control House.
  - Interconnection Customer Owns the 138 kV Line.

Sharon

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Campbell

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Maysville

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed

- None
- Assumptions
  - None

Crossland

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Cedar Street

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Keisters

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Shenango

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Masury

- Below Grade

  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

Boardman

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Update relay settings
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

McDowell (Sharon line exit relaying upgrade)

- Below Grade
  - None
- Above Grade
  - None
- R&C
  - Upgrade relaying on the Sharon Y-300 exit to eliminate a relay thermal loadability concern
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

5. Telecommunications Facilities – Upgrades

IC will design, provide, install, own and maintain a fiber-optic communication cable between the McDowell 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 McDowell Substation control house.

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

6. Metering & Communications

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

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

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

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

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

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

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

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

7. Environmental, Real Estate and Permitting

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

- Environmental permitting, Real Estate acquisition, Pennsylvania Public Utility 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 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 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**	
AE2-277 Generator Lead Termination: Installation of foundations, disconnect switch and associated equipment to accommodate the termination of the 138 kV generator lead line.	$ 86,300	$ 26,300	$ 25,700	$ 2,200	$ 140,500
AE2-277 Customer Substation: Review drawings, nameplates, and relay settings.	$ 22,300	$ 0	$ 6,600	$ 0	$ 28,900
Total Attachment Facilities Cost	**$ 108,600**	**$ 26,300**	**$ 32,300**	**$ 2,200**	**$ 169,400**
None	-	-	-	-	-
Total Direct Connection Cost	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
McDowell: Extend 138 kV bus and Add a 138 kV Breaker.	$ 776,900	$ 236,600	$ 230,700	$ 92,400	$ 1,336,600
Estimated SCADA work at McDowell substation to support breaker, MOAB, meter, and relay installations. Estimated (1) in-sub fiber run from McDowell substation control house to developer built fiber run to support communications and control to generator site.	$ 38,900	$ 4,100	$ 11,600	$ 400	$ 55,000
Campbell: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Maysville: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700

Work Description	Direct		Indirect		Total Cost
	Labor	**Material**	**Labor**	**Material**	
Cedar Street: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Crossland: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Sharon: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Keisters: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Shenango: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Masury: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Boardman: Modify relay settings.	$ 68,400	$ 0	$ 20,300	$ 0	$ 88,700
Project Management: Project Management	$ 54,600	$ 0	$ 16,200	$ 0	$ 70,800
Total Non-Direct Connection Network Upgrades	**$ 1,486,000**	**$ 240,700**	**$ 441,200**	**$ 92,800**	**$ 2,260,700**
McDowell: Upgrade line relaying	$ 165,700	$ 35,800	$ 49,200	$ 3,100	$ 253,800
Total New System Upgrades	**$ 165,700**	**$ 35,800**	**$ 49,200**	**$ 3,100**	**$ 253,800**
Metering: Customer-owned revenue metering at generation facility.	$ 1,900	$ 0	$ 600	$ 0	$ 2,500
Total Other Charges	**$ 1,900**	**$ 0**	**$ 600**	**$ 0**	**$ 2,500**
Total Project Costs	**$ 1,762,200**	**$ 302,800**	**$ 523,300**	**$ 98,100**	**$ 2,686,400**

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

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

9. Schedules and Assumptions

A proposed **twelve (12) 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.

12 month Schedule

Activity	Start Month	End Month
[redacted]		
Preliminary Engineering	1	2
Permits & Real Estate	2	7
Detailed Engineering	2	7
Equipment Delivery	7	8
Below Grade Construction – Substation	8	11
Above Grade Construction – Substation	9	11
Testing & Commissioning	11	12

Attachment #1: Protection Study

PROTECTION SCOPE

Short Circuit Analysis

Short Circuit Values

The preliminary 138kV fault values at the AE2-277 interconnection location (McDowell 138kV) are:

Three phase = 10kA
Single line to ground =9kA
Z1= (0.8 + j 4.0)%
Z0= (0.8 + j 5.2)%

These values are provided for bolted, symmetrical faults under anticipated normal system conditions and are provided on a 138kV, 100MVA base. 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.

Protection Requirements

The AE2-277 facility shall consist of inverter-based PV with battery storage connecting directly to the McDowell substation 138kV bus via a dedicated line. It is understood that the customer will be using a single 138-34.5kV transformer rated 25/33.5/42 MVA.

AE2-277 138kV Station

Main 138/34.5kV Transformer

- The interconnecting 138-34.5kV transformer shall be connected wye grounded on the transmission (138kV) side and delta connected on the low (34.5kV) side.
- One 138kV, three-phase circuit breaker will be required on the FE side of the customer's main 138/34.5kV wye grounded/delta transformer.
- The circuit breaker shall be fully rated to interrupt available fault current when calculated according to the latest ANSI standard.
    - Bypass switches shall NOT be installed across the breaker. If the customer desired the added reliability benefit of being able to keep the substation energized while performing breaker maintenance, a ring bus or dedicated sparing circuit breaker is required.
    - If the circuit breaker uses gas as an interrupting medium, the device shall be equipped with a low gas pressure alarming/tripping/lockout scheme (as appropriate for the particular device) in order to minimize the possibility of a transmission fault resulting from a loss of insulating gas.
- The interconnecting transformer and all 138kV facilities at the customer substation shall have redundant, high-speed protection inclusive of the 138kV breaker and high-side metering and shall trip, at minimum, this breaker. Separate CTs and tripping paths are required between the primary and backup relaying.
    - Primary Transformer Differential Protective Relay – minimum functions: 87TP. (FE standard device is SEL-587 or SEL-487E)
        - The 138kV source for primary transformer differential protection shall be CTs on the utility source side of the transformer breaker. The low side source for primary differential protection shall be CTs on the bus side of the low side transformer breaker

  - Backup Transformer Differential Protective Relay - minimum functions: 87TB. (FE standard device is SEL-587 or SEL-487E)
    - The 138kV source for backup transformer differential protection shall be CTs on the utility source side of the transformer breaker separate from the primary differential relay. The low side source for backup differential protection shall be CTs on the bus side of the low side transformer breaker separate from the primary differential relay
  - Breaker Failure (BF) Relay – Dedicated breaker failure relay with associated hand-reset lock out relay (LOR). Will be wired to transfer trip the breakers at McDowell to isolate from the transmission system if there is a failure to trip operation. (FE standard device is SEL-501 or SEL-451-5).
    - Direct transfer trip for breaker failure, anti-islanding, and other functions as needed shall be communicated via fiber using the associated SEL-411L primary and backup relays. Trip on loss of channel to both the primary and backup schemes.
- CTs used for the zones of protection covering the high voltage portion of the customer's system shall use C800 relay accuracy CTs. These CTs should not saturate for the maximum through-fault current that can be experienced by the relay for the tap ratio in use.
- The relaying system shall have a reliable source of power independent from or immune to disturbances/loss of the AC system (e.g. DC battery and charger) to ensure proper operation of the protection schemes and tripping of the circuit breakers.
- The customer will be required to coordinate with upstream protection. It is solely the customer's responsibility to install and design their relaying to ensure adequate protection of their equipment.
- Detailed one-line diagrams with proposed protection should be provided well in advance of design and engineering to allow for approval of the protection scheme and preliminarily validate coordination with FE system.
- The low-side of the transformer shall have a dedicated circuit breaker with CTs adequate for use with, at minimum, the transformer differential relaying.

138kV Line and Intertie Relaying

- The line between McDowell and AE2-277 station will require redundant fiber optic based communications channels to be installed and maintained between the facilities for use with high-speed line current differential protection.
  - Separate primary and backup SEL-411L relays at the AE2-277 station will be required. Separate primary and backup SEL-411L relays will also be required at McDowell.
  - Intertie relay functionality (e.g. overfrequency, underfrequency, phase and ground overvoltage, directional overcurrent, and directional power) will be incorporated into the SEL-411L line relaying as necessary
  - The source CTs for the line current differential relays at the customer station shall be separate sets of 1200:5 CTs (C800 or better). These shall be located in the transformer-side bushings of the customer's high-side breakers
    - Line and transformer zones of protection overlap through the breaker.
  - The primary SEL-411L relays shall be sourced from an inner set of CTs and the backup SEL-411L relays sourced from an outer set of CTs on the transformer side of the customer's high-side breaker such that the backup SEL-411L scheme encompasses the primary.
  - PTs with separate secondary windings on the high/transmission-side of the interconnecting transformer with separate tripping paths are required for the line/intertie relays.

- Any sync check for manual/SCADA close on the interconnecting line is to be done at the AE2-277 generating station.

Generator Owner's System Protection

- The generator owner (GO) is to design their protective system to clear any fault within their zones of protection with one or more of their local breakers.

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.

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

FE System Modifications

System modifications may be required to make settings changes and/or replace existing relays at FirstEnergy remote substation. Customer relaying will be required to coordinate with upstream transmission system protection.

McDowell Substation

- Add a 138kV breaker for new line to AE2-277. Breakers shall be rated 40kAIC, 3000A continuous and each have dedicated breaker failure relaying. Incorporate into the existing McDowell 138kV primary and backup bus protection.
- Upgrade relaying on the Sharon Y-300 exit to eliminate a relay thermal loadability concern

Circuit Breaker Adequacy

- PJM does not identify any new breakers as overdutied by this project

Settings Changes

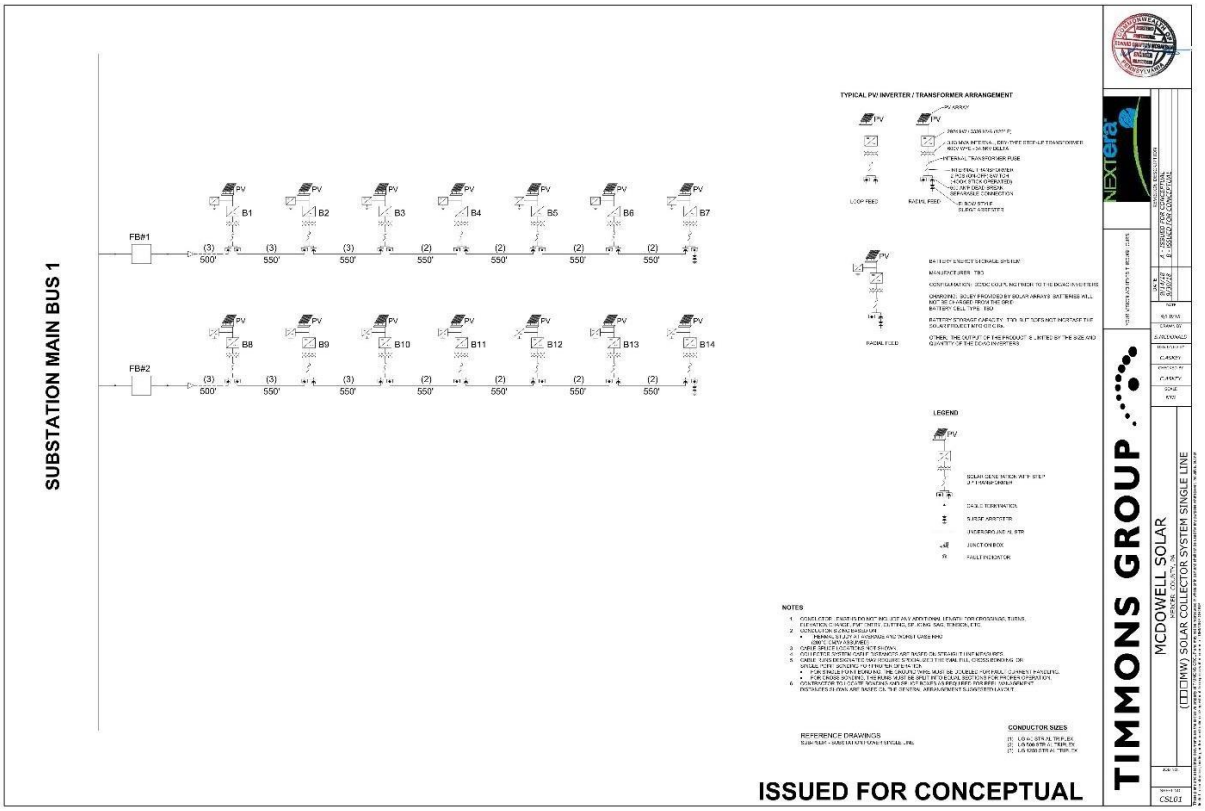
Settings changes are possible at, but not limited to, the following stations:

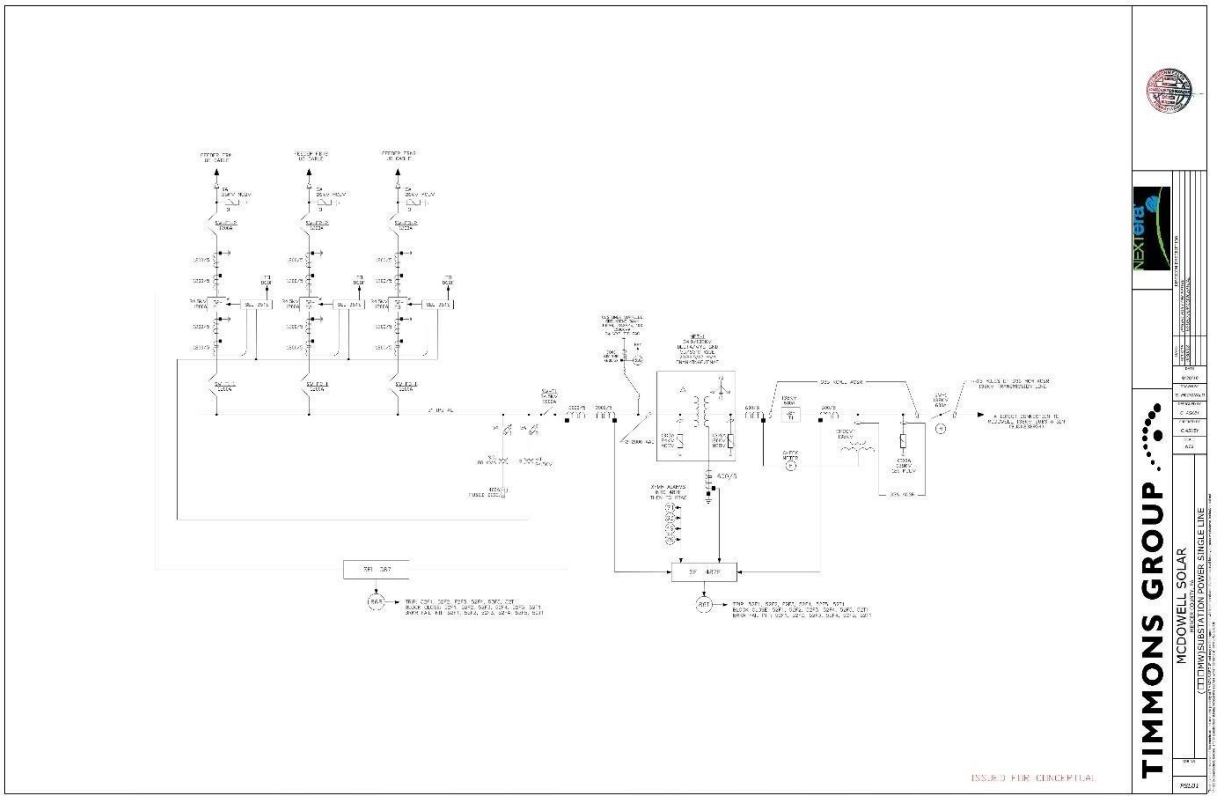
- Boardman

- Campbell
- Cedar Street
- Crossland
- Keisters
- Masury
- Maysville
- McDowell
- Sharon
- Shenango

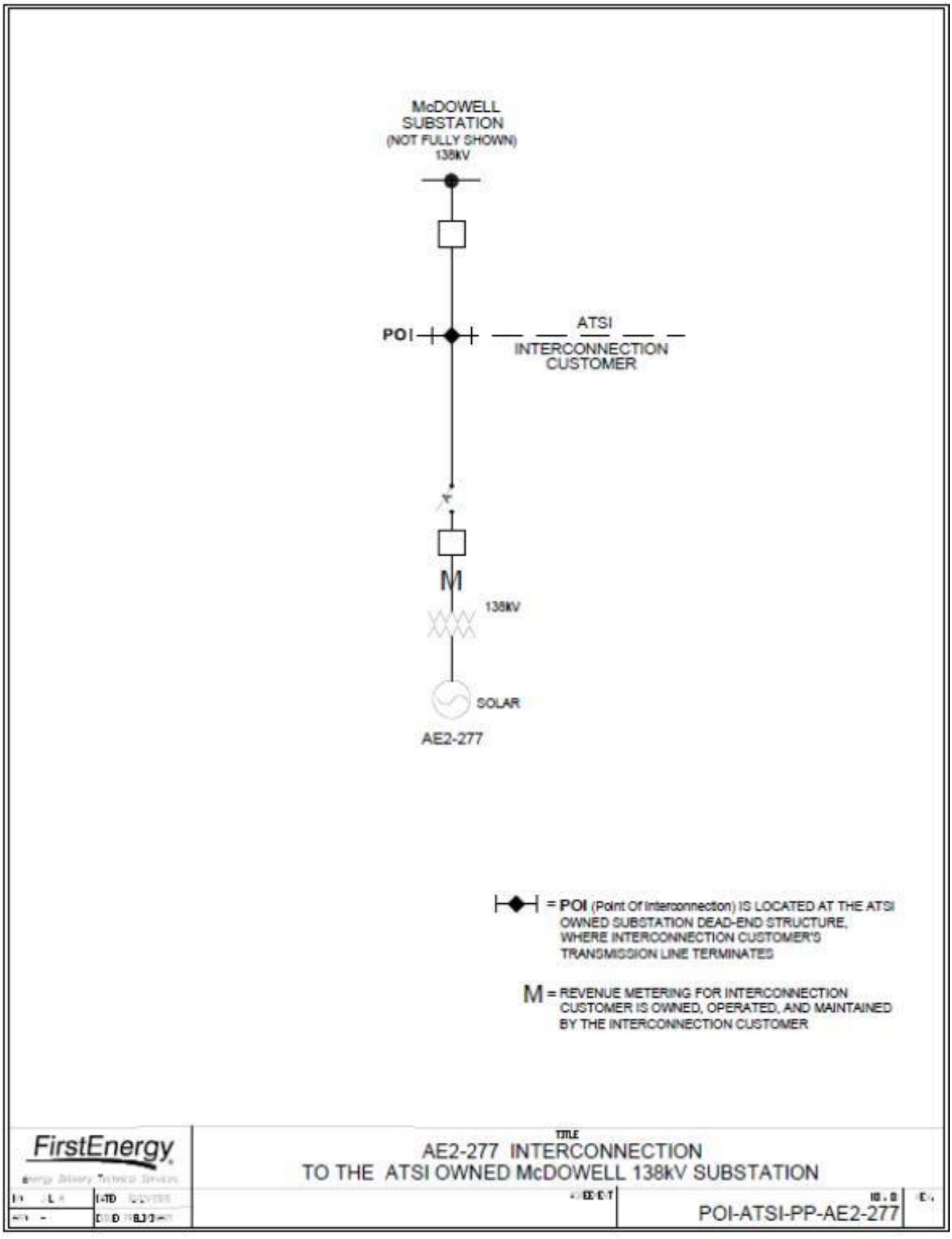
Attachment #2: One-Line Diagrams

IC One-Lines
(Not For Construction)



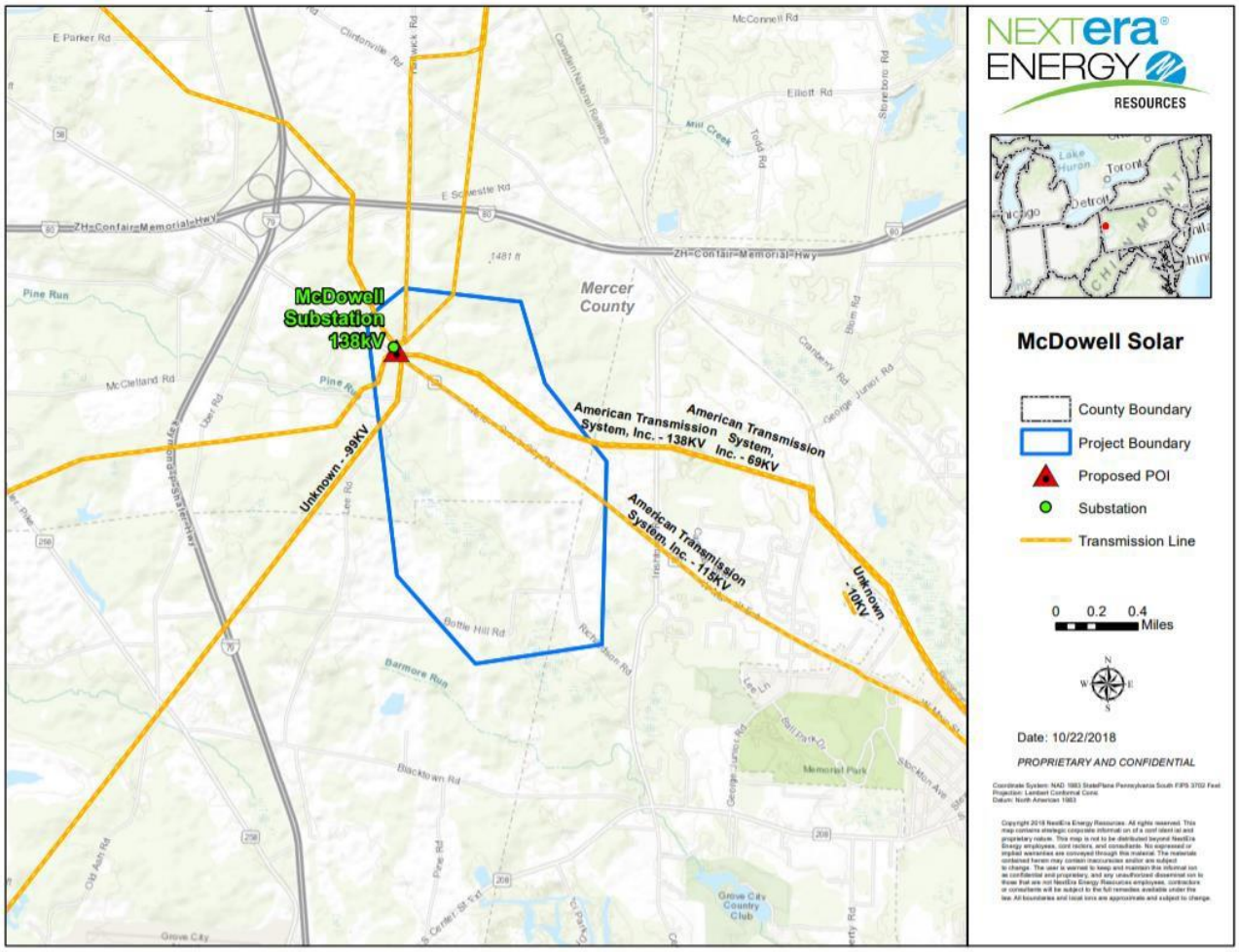

TIMMONS GROUP
MCDOWELL SOLAR
ISSUED FOR CONCEPTUAL

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
Synchronous	New	> 20 MW	0.95 leading to 0.90 lagging	Generator's Terminals
Synchronous	New	<= 20 MW	0.95 leading to 0.90 lagging	Point of Interconnection

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

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

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

Design Requirements

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

Transmission Design Requirements

Design Criteria

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

General Design Requirements

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

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

Voltage and Current Ratings

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

Clearances and Spacing

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