Transmission Interconnection Facilities Study Report

For

PJM Transmission Interconnection Request Queue Position AD2-062

"Roxbury-Greene 138 kV"

June 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

Beaver Creek Solar LLC, (hereinafter referred to as "IC") has proposed a solar generating facility located in Franklin County, Pennsylvania. The installed facilities for AD2-062 will have a total capability of 80.3 MW with 53.4 MW of this output being recognized by PJM as capacity. The generation facility will interconnect with Mid-Atlantic Interstate Transmission (MAIT) a First Energy Company (FE), hereinafter referred to as "Transmission Owner" (TO), at a newly constructed 138 kV three-breaker ring bus substation tapped off of the Grand Point-Roxbury 138 kV transmission line.

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

No amendments to the retooled System Impact Study or System Impact Study Results posted on PJM's website dated October 2021 were identified, except that the IC has elected the Option to Build the interconnection substation.

3. Interconnection Customer's Milestone Schedule

IC's requested Commercial Operation Date (COD) for the generation facility is **December 30, 2022 (PJM website currently indicates a June 1, 2020 in-service date)**. A Project Kickoff meeting must occur by TBD to meet Transmission Owner's Assumed Milestone Schedule listed below.

IC's Requested Milestone Schedule:

10/03/2022	Initial Back-feed through Project Substation Date
12/30/2022	Project Commercial Operation Date

Transmission Owner's Assumed Milestone Schedule:

TBD	Initial Back-feed through Project Substation Date
TBD	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 the generation step-up (GSU) transformer, 138 kV (AD2-062) generator lead line and connection to the new 3 breaker ring bus interconnection substation.

Point of Interconnection (POI): The POI will be located within the new 138 kV ring bus interconnection substation where IC-owned 138 kV attachment line conductor will terminate on the insulators on the dead-end takeoff structure and will be defined as the POI.

The Grand Point - Roxbury 138 kV line will be intersected at the following GPS coordinates:

40° 5' 26.20" N, 77° 38' 49.77" W

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

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

Assumptions / Notes:

- IC will coordinate design and alignment of proposed 138 kV generator lead line with the Transmission Owner for review of any clearance, right-of-way or right-of-way encroachment issues with TO owned facilities.

- IC will coordinate design and construction of proposed 138 kV Lead Line. For these areas, the IC shall provide TO with proposed drawings prior to construction and as-built drawings, confirmed by as-built survey data post-construction.
- Transmission Owner's preference would be to limit interference and avoid transmission line crossings with new 138 kV terminal positions. As a minimum, IC facilities should not encroach within 100 feet of TO centerline at blowout conditions. If IC's line design does not comply with this requirement TO would need to review this area as a special exception.
- Additional costs will be incurred by the IC, if final alignment of the 138 kV generator lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities.
- IC is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule are included herein.
- The IC will be required to install a transformer with a delta low side winding and a wye grounded winding on the 138kV side.

5. Description of Facilities Included in the Facilities Study

Attachment 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 AD2-062 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.

Direct Connection

AD2-062 138 kV (new interconnection substation)

The IC has exercised their option-to-build these facilities, so they will design, furnish and construct a new three breaker ring bus substation, AD2-062 138 kV, along the Grand Point-Roxbury 138 kV transmission line to interconnect the AD2-062 solar project with the MAIT 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.

Non-Direct Connection

Grand Point to Roxbury 138 kV line

The Grand Point to Roxbury 138 kV line will be cut and looped into the new AD2-062 138 kV interconnect substation. This cut will take place at a location that is approximately 2.25 miles from the Roxbury substation and 6.28 miles from the Greene. It is assumed that the new interconnection substation will be located within one span (approximately 300 feet) from the existing line.

Grand Point Substation

A tuner pack and carrier panel will be installed.

Roxbury Substation

ADSS will be installed from the AD2-062 Interconnection Substation to Roxbury Substation. The wave trap and associated line tuner will be removed. An anti-islanding transmitter will be installed.

Greene Substation

Drawings and nameplates will be modified. An anti-islanding transmitter will be installed.

Letterkenny

Drawings and nameplates will be modified.

Other Costs

AD2-062 Customer Metering

Customer-owned revenue metering at AD2-062 generating facility will be installed.

Option to Build Oversight

Review and Oversight of the drawings, nameplates and customer constructed new 138 kV three breaker ring bus substation on the Grand Point-Roxbury 138kV transmission line to interconnect the AD2-062 project.

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

Description	Total
Attachment Facilities:	**$ 27,100**
Total Direct Connection (DC) Costs:	**$ 1,211,200**
Total Non-Direct Connection (NDC) Upgrade Costs:	**$ 1,144,300**
Other Costs:	**$ 1,094,700**
New System Upgrades	**$ 0**

TOTAL Costs (ALL Categories)	**$ 3,477,300**

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

For this project which the Interconnection Customer has elected Option to Build the Transmission Owner Attachment and Direct Connection facilities, a proposed twenty four (24) month schedule is estimated to complete the engineering, construction and the associated Non-direct Connection activities, from the later of the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting or upon TO's receipt of IC's locational data and design parameters for the deadend structure(s) for final tie-in connections. 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 or January through March) will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

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

B. Transmission Owner Facilities Study Results

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

1. Transmission Lines –New

None

2. Transmission Lines – Upgrade

Grand Point-Roxbury 138 kV Line

- Loop the Grand Point-Roxbury 138kV line into the proposed AD2-062 customer substation.
    - The existing line is constructed on single circuit wood H-frame structures. Existing conductor is 636 kcmil ACSR, shielded with (2) 3/8" EHS shieldwires.
    - Per the transmission checklist, the recommended conductor size is 556.5 ACSR. It is assumed new conductor will be 556.5 kcmil 26/7 ACSR "Dove" and new shield wire will be (2) 7#8 Alumoweld.
    - Per the proposed site plan, the line will be cut and looped into the proposed customer substation near existing tangent structure 15.
    - The line loop will be constructed per the following:
        - Install (2) wood 3-pole deadend structures, standard structure TR-138075
        - Transfer existing conductors and shield wires to (2) new structures
        - Install new conductors and shield wires in one span on each leg of the loop. Remove existing H-frame tangent structure 15
- Siting/Licensing
    - An LON will be required to be filed with the PaPUC.
    - Assume minimal ecological impacts.
- Assumptions
    - Assume OPGW is not required.
    - Assume existing adjacent structures to the newly installed structures are in good condition and have adequate capacity for the new loading arrangement. An engineering analysis will be required to confirm.
    - A ground survey of the project area will be required.

- Per the one line diagram, the new substation and loop is located 2.25 miles from Roxbury and 3.33 miles from the PN/WP interconnection. This location is approximately 0.7 miles south of the proposed substation location per the site plan. It is assumed the loop location will be as shown in the site plan, approximately 1.55 miles from Roxbury and approximately 4.03 miles from the PN/WP interconnection.

3. New Substation/Switchyard Facilities

AD2-062 Interconnect

- Below Grade
  - Foundations, conduit, and grounding for all new equipment.
  - Siting, surveying, grading, fencing for new substation.
- Above Grade
  - Install three (3) 138kV, SF6 circuit breakers
  - Install six (6) 138kV breaker disconnect switches
  - Install three (3) 138kV motor operated line disconnect switches
  - Install one (1) 138kV wideband wave trap, line tuner, and coax
  - Install nine (9) 138kV CCVTs
  - Install nine (9) 138kV surge arresters
  - Install one (1) pre-fabricated control building
  - Install one (1) SSVT
  - Install intercompany meter equipment on the Grand Point line terminal.
  - 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 three (3) H-Frame deadends as indicated in the attached proposed layout
  - Install one lot of steel for six (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 relaying for Grand Point, Roxbury, and AD2-062 Gen 138kV lines in the prefabricated control building with the following equipment:
    - Install (1) Standard Line Relaying Panels with: (2) SEL-411L and (1) SEL-2411 (Roxbury Line)
    - Install (1) Standard Line Relaying Panels with: (2) SEL-411L and (1) SD relay (Customer Line)
    - Install (1) Standard Line Relaying Panel with: (1) SEL-421 and (1) SEL-411L (Grand Point Line)
    - Install (3) Standard Breaker Control Panels each with: (1) SEL-501 BFT, (1) SATEC Meter
    - Install (1) Carrier Panel with: (1) UPLC, (1) RFL-9780, (1) PCM-5350, (1 lot) hybrids (Grand Point Line)
    - Install one (1) SCADA RTU, RTAC, GPS Clock, and HMI
- Additional Equipment to be Removed
  - None
- Assumptions
  - None

AD2-062 Customer

- Below Grade

- None
- Above Grade
  - Nameplates and drawing review
  - Add to HV circuit diagram.
- R&C
  - None
- Additional Equipment to be Removed
  - None
- Siting/Licensing
  - None
- Assumptions
  - None

4. Substation/Switchyard Facility Upgrades

Greene

- Below Grade
  - None
- Above Grade
  - Modify drawings and nameplates for new line name
- R&C
  - Replace (1) RFL-9785 with (1) UPLC.
- Additional Equipment to be Removed
  - None
- Siting/Licensing
  - None
- Assumptions
  - New equipment will fit in existing control building.

Grand Point

- Below Grade
  - None
- Above Grade
  - Install an additional tuning pack on existing wide band wave trap
- R&C
  - Install (1) Carrier Panel with: (1) RFL-9780, (1) PCM-5350, and (1) balanced hybrid
- Additional Equipment to be Removed
  - None
- Siting/Licensing
  - None
- Assumptions
  - Assumes relaying equipment to Roxbury (AD2-062) has been upgraded.
  - CVTs, Wave Trap and Line Tuner are adequate for reuse.
  - Control room has adequate space for new panel.
  - AC/DC system is adequate for new equipment

Roxbury

- Below Grade

    - Conduit for new fiber run
- Above Grade
    - Remove (1) 138kV wave trap
    - Remove (1) line tuner
    - Remove/retire existing intercompany metering equipment
- R&C
    - Remove (1) RFL-9785
    - Install (1) SEL-2411
- Additional Equipment to be Removed
    - Remove RFL-9785 relay
- Assumptions
    - Assumes relaying and terminal equipment to Grand Point (AD2-062) has been upgraded.
    - Fiber patch panel exists

Letterkenny

- Below Grade
    - None
- Above Grade
    - Modify drawings and nameplates for new line name
- R&C
    - None
- Additional Equipment to be Removed
    - None
- Siting/Licensing
    - None
- Assumptions
    - None

5. Telecommunications Facilities – Upgrades

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

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

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

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.

Transmission Owner will provide the telecommunication circuits for the SCADA RTU and the telephone in the Transmission Owner interconnection substation.

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

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

7. Environmental, Real Estate and Permitting

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

- Environmental permitting, Real Estate acquisition, and Pennsylvania Public Utility Commission (PAPUC) notifications vary, some up to twelve (12) months after preliminary engineering is completed to secure the required approvals.
- Prior to agreement by IC to purchase the property, a Phase 1 Environmental Assessment should be conducted for the entire site to avoid assumption of environmental liabilities by IC or Transmission Owner.
- The Transmission Owner interconnection substation may involve environmental surveys, permits, approvals and plans with federal, state, and/or local agencies.
- Assumed IC is to provide all access rights, easements, ROW and permits necessary to complete the Project to the satisfaction of Transmission Owner. Environmental permitting shall encompass all federal, state and local requirements, consultations and agency coordination. Confirmation of meeting all permitting requirements shall be provided to Transmission Owner, prior to start of construction. Following construction and energization, confirmation of permit closeout shall be provided to the satisfaction of Transmission Owner, prior to transfer of ownership. If any of these

elements are not included in the final agreement between Transmission Owner and IC, twelve (12)-to-eighteen (18) months should be added to the Project Schedule to secure necessary permits, and additional costs would apply.

- IC will provide copies of all of the relative environmental permits and other necessary approvals to Transmission Owner before Transmission Owner accepts the interconnection facilities.
- IC is required to install an access road from the new interconnection substation to the nearest public road (must be approved by Transmission Owner), and obtain access rights for Transmission Owner. IC is responsible to maintain access road and ensure unimpeded access for Transmission Owner at all times.
- IC is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.
- If IC owns the project property, in fee title, Transmission Owner will require a fee property transfer for the interconnection substation site which may require subdivision approval, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation. IC is responsible for all costs, including but not limited to subdivision, associated with the property transfer.
- If IC leases the project property, the IC will be required to obtain fee property from the underlying fee property owner, on behalf of Transmission Owner, for the interconnection substation site, together with permanent access rights to and from the substation, as well as a perpetual easement for any transmission lines to the substation.
- All property rights must be surveyed and metes and bounds descriptions prepared for incorporation into Transmission Owner's document forms, for transfer of title.
- The Transmission Owner interconnection substation and transmission line loop will involve Pennsylvania Public Utility Commission (PAPUC) notification/approval.
- All work occurs within an existing transmission line right-of-way or on IC's property with access to all existing structures possible via that property and the right-of- way following established access routes that do not cross wetlands or streams.
- IC will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits included in the IC's scope of work.
- IC will obtain all necessary permits included in the IC's scope of work.
- IC will conduct all necessary wetlands and waterways studies and permits included in the IC's scope of work.
- IC will conduct all necessary historical and archaeological studies included in the IC's scope of work.
- 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

The following table provides a breakdown of the costs according to the description of work required to accommodate the requested interconnection. The estimated costs are in 2021 dollars. This cost excludes a Federal Income Tax Gross Up charges (CIAC (Contribution in Aid of Construction)). This tax may or may not be charged based on whether this project meets all qualifications and requirements as set forth in Section 118(a) and 118(b) of the Internal Revenue Code of 1986, as amended and interpreted by Notice 2016-36, 2016-25 I.R.B. (6/20/2016) (the "IRS Notice"). If at a future date it is determined that the Federal Income

Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

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.

Work Description	Direct		Indirect		Total Cost without Tax
	Labor	Material	Labor	Material	
AD2-062 Customer: Review drawings and nameplates for FE standards.	$ 22,300	$ 0	$ 4,800	$ 0	$ 27,100
Total Attachment Facilities Cost	**$ 22,300**	**$ 0**	**$ 4,800**	**$ 0**	**$ 27,100**
SCADA/Fiber Communication: Design, install, and test/commission MPLS Equipment for SCADA transport.	$ 96,700	$ 67,600	$ 21,000	$ 1,800	$ 187,100
Install fiber from AD2-062 interconnect substation to Roxbury for communication transport.	$ 253,400	$ 26,500	$ 54,900	$ 700	$ 335,500
Estimated (1) in-sub fiber run from AD2-062 substation control house to IC built fiber run to support communications and control to generator site. Estimated SCADA work at Roxbury substation to support wavetrap and relay installations.	$ 38,900	$ 4,100	$ 8,400	$ 100	$ 51,500
Project Management: Project Management, Environmental, Forestry, Real Estate, and Right of Way.	$ 505,100	$ 22,000	$ 109,400	$ 600	$ 637,100
Total Direct Connection Cost	**$ 894,100**	**$ 253,400**	**$ 38,900**	**$ 505,100**	**$ 1,211,200**

Grand Point-Roxbury 138kV Line Loop: Loop the Grand Point-Roxbury 138kV line into the new AD2-062 substation.	$ 376,000	$ 51,300	$ 81,400	$ 1,400	$ 510,100
Estimated SCADA work at Greene and Grand Point substations to support breaker and relay installations.	$ 44,000	$ 0	$ 9,500	$ 0	$ 53,500
Installation of meter equipment on the Grand Point line terminal. The meter at Roxbury Sub will be retired, and a new meter installation on the ring bus for AD2-062.	$ 10,100	$ 9,300	$ 2,200	$ 300	$ 21,900
Grand Point: Install carrier equipment	$ 163,000	$ 48,600	$ 56,500	$ 3,700	$ 271,800
Greene: Modify drawings and nameplates for new line name.	$ 72,400	$ 13,400	$ 15,700	$ 300	$ 101,800
Roxbury: Install SEL-2411.	$ 126,700	$ 2,400	$ 27,400	$ 100	$ 156,600
Letterkenny: Modify drawings and nameplates for new line name.	$ 23,500	$ 0	$ 5,100	$ 0	$ 28,600
Total Non-Direct Connection Network Upgrades	**$ 815,700**	**$ 125,000**	**$ 197,800**	**$ 5,800**	**$ 1,144,300**
Metering: Customer-owned revenue metering at Customer Facility	$ 2,800	$ 0	$ 600	$ 0	$ 3,400
AD2-062: Customer has selected the Option-to-Build. Construct a new 138kV ring bus on the Grand Point – Roxbury 138kV line.	$ 521,000	$ 337,600	$ 112,900	$ 119,800	$ 1,091,300
Total Other Costs	**$ 523,800**	**$ 337,600**	**$ 113,500**	**$ 119,800**	**$ 1,091,300**
Total Project Costs	**$ 2,255,900**	**$ 582,800**	**$ 509,800**	**$ 128,800**	**$ 3,477,300**

9. Schedules and Assumptions

For this project which the Interconnection Customer has elected Option to Build the Transmission Owner Attachment and Direct Connection facilities, a proposed nineteen (24) month schedule is estimated to complete the engineering, construction and the associated Non-direct Connection activities, from the later of the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting or upon TO's receipt of IC's locational data and design parameters for the deadend structure(s) for final tie-in connections. 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 or January through March) will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

24 month Schedule

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

FE will need to conduct an environmental survey for the loop and proposed interconnect substation. If permits are necessary to complete the project, approximately 6-12 months will be needed to draft and receive agency approvals.

Attachment #1: Protection Study

PROTECTION REQUIREMENTS

SHORT CIRCUIT DATA for a fault at the proposed location of the connection of AD2-062 SS on the existing Roxbury - Grand Point 138 kV line (Symmetrical Values Only)

Initial conditions (percent on 100 MVA base)

138 kV

Z1 = 1.130 + j 5.869%

Z0 = 2.575 + j 10.874%

3 phase fault – 7000A

Single line to ground fault – 5422A 3I0

Note: These fault values do not include the AD2-062 Generator or GSU step up transformer as being modeled in the calculations.

Impedances are given on a 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.

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

The attached relay sketch provides details of relay requirements for AD2-062 Generation interconnection substation (AD2-062 Substation) and is considered part of the Facilities Study Report.

RELAY AND COMMUNICATION EQUIPMENT SCOPE

At AD2-062 SS:

138 kV Line Exit to Roxbury

Install the following:
Three single-phase dual winding capacitor voltage transformers, dual ratio = 1200/700/1
ADSS fiber to Roxbury and all related splice boxes, patch panels, and other hardware

The protective relaying for the 138 kV line to Roxbury shall contain the following:
SEL-411L relay for the primary line protection, which shall utilize a line differential scheme
SEL-411L relay for the backup line protection, which shall utilize a DCB scheme, and also reclose the B-1 breaker for faults on the Roxbury 138 kV line
SEL-501 relay for Bkr B-1 breaker failure
LOR relay for Bkr B-1 breaker failure tripping
SEL-2411, for anti-islanding receive from Roxbury
SATEC digital multimeter

138 kV Line Exit to Grand Point

Install the following:
Three single-phase dual winding capacitor voltage transformers, dual ratio = 1200/700/1 (carrier facilities are only required on phase Z, but may be included with all three CVTs)
2000A wide band line trap (phase Z only)
Wide band line tuner (phase Z only)

The protective relaying for the 138 kV line to Grand Point shall contain the following:
SEL-421 relay for the primary line protection, which shall utilize a DCB scheme
SEL-411L relay for the backup line protection, which shall utilize a step distance scheme, and also reclose the B-1 breaker for faults on the Grand Point 138 kV line
SEL-501 relay for Bkr B-3 breaker failure
LOR relay for Bkr B-3 breaker failure tripping
UPLC for DCB blocking carrier
RFL-9780 Rx, for anti-islanding receive from Grand Point
SATEC digital multimeter
RFL Hybrid chassis with one skewed hybrid
PowerComm PCM5350

Metering requirements: Inter-company metering will be required on the Greene/Grand Point line exit. The existing Greene – Roxbury 138 kV line is a tie line between Penelec and West Penn Power.

138 kV Line Exit to Generator – Customer SS

Install the following:

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

The protective relaying for the 138 kV line to the generator shall contain the following:
SEL-411L relay for the primary line protection, which shall utilize a line differential scheme with step distance backup
SEL-411L relay for the backup line protection, which shall utilize a line differential scheme with step distance backup
SEL-501 relay for Bkr B-2 breaker failure
LOR relay for Bkr B-2 breaker failure tripping
LOR relay for generation station breaker failure tripping (operate from transfer trip receive)
SATEC digital multimeter
SD relay ("27L") for line potential monitoring (blocks all closing of Bkrs B-2 and B-3 if line from generator is hot)

AD2-062 will only close into this line of it is dead. All synchronizing is to be performed at the Generator Substation. No automatic reclosing will be applied.
Additional items

GPS Clock, Arbiter 1094B, with antenna, 50 feet of cable, and antenna mounting kit
SCADA and annunciator, details to be determined by Real Time Operations
SEL RATC for remote access to SEL protective relays
Test switches, fuses, and terminal blocks as deemed necessary
At Roxbury SS:

Remove line trap and tuner
Install ADSS from AD2-062 and all necessary splices boxes, patch panels, and hardware
Add SEL-2411 for the anti-islanding scheme
At Grand Point SS:

Add frequency for new anti-islanding transmitter
Change frequency for existing DCB scheme if necessary
Re-tune traps and tuners as necessary
Add RFL-9780 Tx/Rx as a transmitter for the anti-islanding scheme
Add PowerComm PCM5350
Add balanced hybrid
At Greene SS:

Replace RFL-9785 with a UPLC carrier transceiver

Generation Substation Protection Requirements for 138 kV line to AD2-062 SS

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

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

The generator owner (GO) is to design their protective system to clear any faults within their zones of protection with one or more of their local breakers. Each zone of protection covering the 138 kV portion of the GO system (including the GSU(s)) is to be protected by two fully independent relay schemes that each provides high speed fault protection. The terminal breaker at the GO end of the direct connection line is to be included in one of these zones of protection. Two SEL-411L relays shall be used for protection of the interconnect line, to match the companion relays at AD2-062 Substation.

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

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

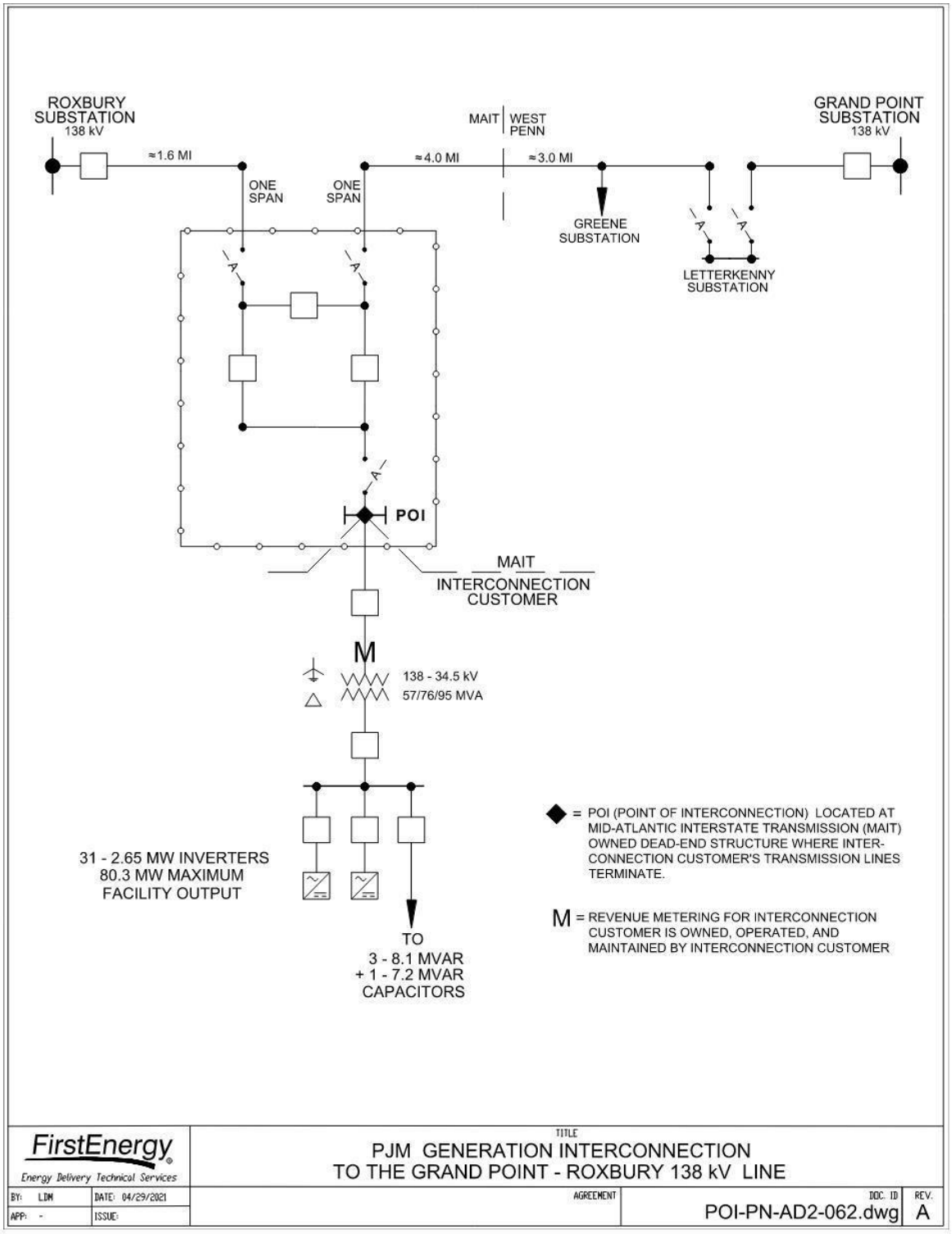
Operational metering is also required for this generation connection. These requirements are also outlined in FirstEnergy's "Requirements for Transmission Connected Facilities" document. These requirements are in addition to any metering required by PJM.

Generator Step-Up Transformer Requirements

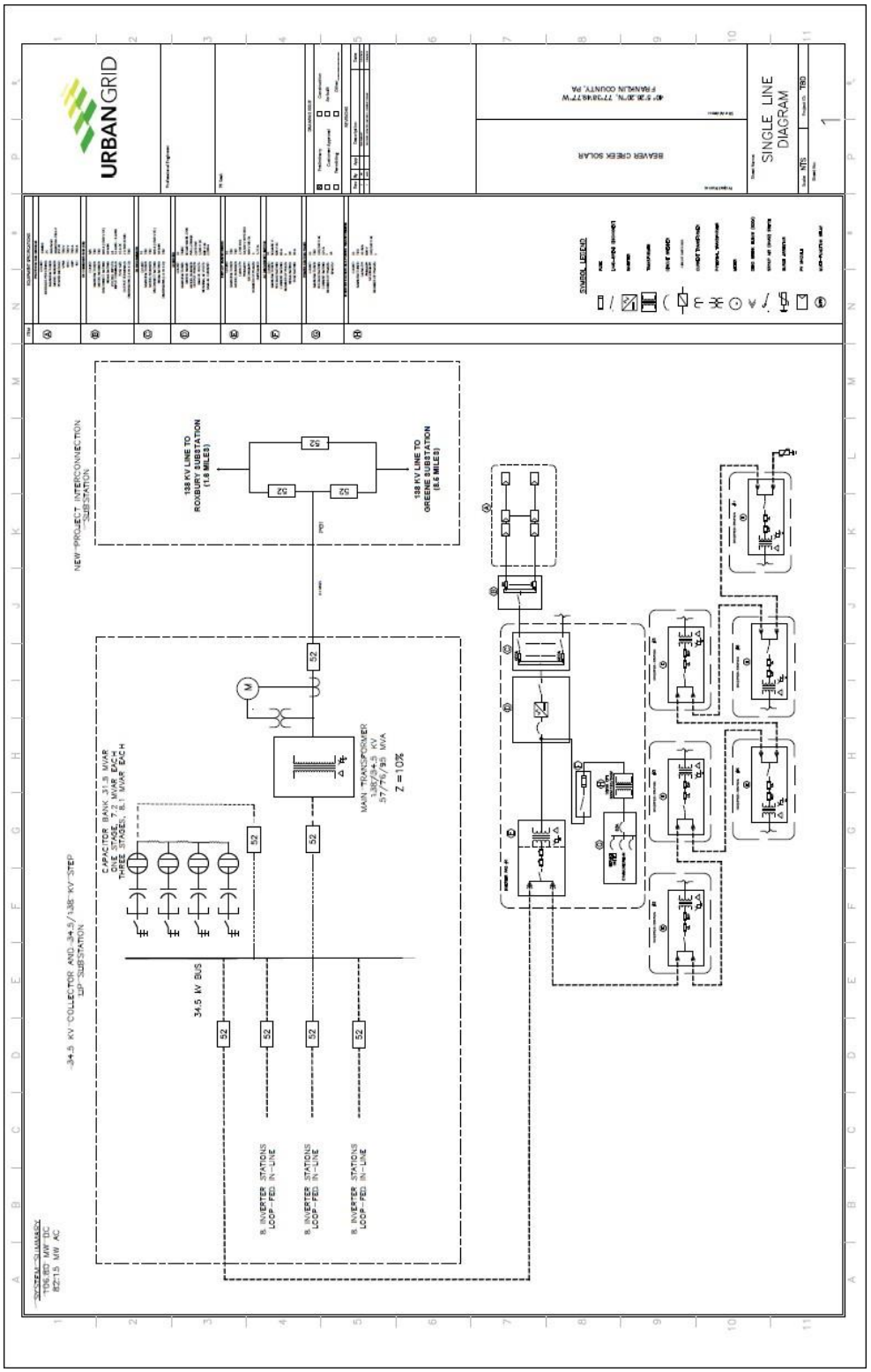
As per section 14.2.6 of the First Energy Requirements for Transmission Connected Facilities document, because this area of the system is effectively grounded, the transformer shall have a wye grounded winding on the high (transmission system) side and have a delta connected winding on the low side.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

Attachment #2: One-Line Diagrams

First Energy One-Line

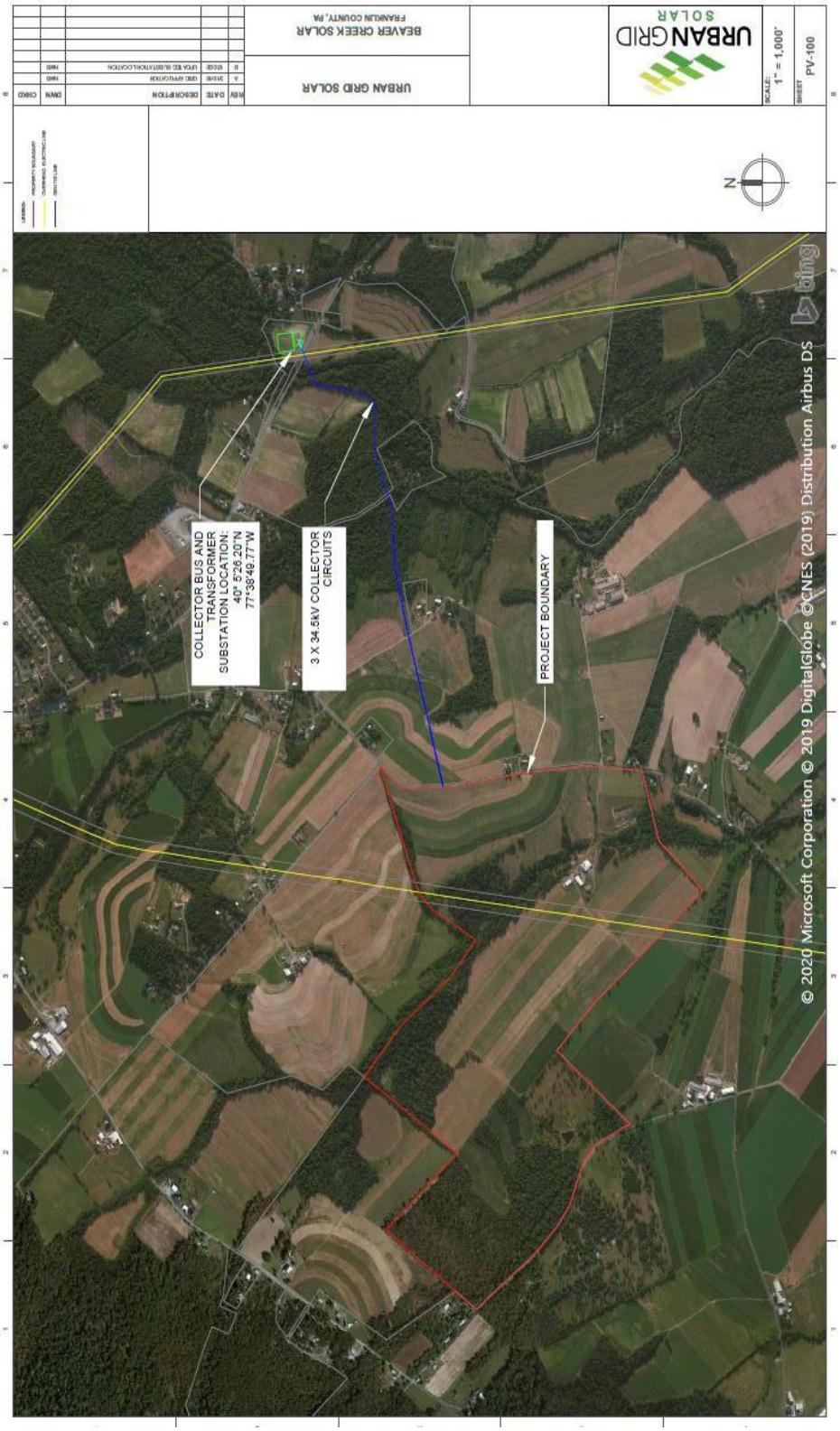


IC One Line
Not Approved for Construction



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 /	Size	Power Factor Requirement	Measurement Location
Wind or Non-Synchronous	New	All	0.95 leading to 0.95lagging	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).

Design Requirements

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

Transmission Design Requirements

Design Criteria

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

General Design Requirements

• System phasing (counter clockwise)	X-Y-Z
• System frequency:	60 hertz
• Elevation, AMSL:	Less than 1000 meters
• Isokeraunic level:	40
• Maximum ambient temperature:	40 degrees C
• Minimum ambient temperature:	-40 degrees C
• Maximum conductor operating temperature:	Contact Transmission Owner
• Wind Loading (round shapes):	Per ASCE 7-98, per Fig. 6-1 depending on location
• Ice loading – Substations (no wind):	25 mm
• Seismic zone:	Per ASCE 7-98, per Fig. 9.4.1.1(a) and (b). Equipment qualification per IEEE 693-97

Voltage and Current Ratings

• Nominal phase-to-phase:	138 kV
• Maximum phase-to-phase:	145 kV
• Basic impulse level (BIL):	650 kV
• Maximum continuous current carrying capacity:	2000 A
• Design fault current:	40 kA
• Single Contingency (breaker failure) clearing time:	60 cycles

Clearances and Spacing

• Recommended rigid bus center-to-center phase spacing:	96"
• Minimum phase-to-phase, metal-to-metal distance:	63"
• Recommended phase-to-ground:	52.5"
• Minimum phase-to-ground:	50"

- Low bus height above top of foundations (match existing): 16’-0”
- High bus height above top of foundations (match existing): 24’-0”
- Minimum vertical clearance from live parts to grade: 12’-2”
- Minimum horizontal clearance from live parts: 6’-8”
- Minimum conductor clearance above roads in switchyard: 25’-0”
- Minimum bottom of insulator to top of foundation: 8’-6”