Generation Interconnection Facilities Study Report

For

PJM Generation Interconnection Request Queue Positions AA2-119

Glen Falls 138 kV

November 2017

Queue #AA2-119 Glen Falls 138 kV
Facilities Study Report

Description of the Project

ESC Harrison County Power, LLC (hereinafter referred to as "Interconnection Customer") has proposed the connection of 550 MW from a Combined Cycle Steam Gas generation with 100% (550 MW) capacity to the Glen Falls 138 kV substation. The new generator will be located off Salvage Street, Clarksburg, Harrison County, WV and approximately 1.5 miles southeast of the Glen Falls 138 kV Substation (Ref: Figure 3).

The generation facility will be located near Clarksburg, WV, within the Monongahela Power Company ("Mon Power") service territory, and the power would be injected into the Mon Power 138 kV transmission system at a new 138 kV line terminal at the existing Glen Falls substation (interconnection substation). Mon Power is a subsidiary of FirstEnergy (hereinafter referred to as "Transmission Owner").

The project includes network upgrades/system reinforcements at Glen Falls substation, Oak Mound substation, and along the Glen Falls-Oak Mound 138 kV line also located in Mon Power service territory, a FirstEnergy Company, as an Affected Transmission Owner also hereinafter referred to as "Transmission Owner".

Amendments to the System Impact Study Data / Results

- Interconnection Customer confirmed the Point of Interconnection (POI) at Glen Falls substation as the 138kV West Bus, after evaluation of an alternative interconnection on the 138 kV East Bus. Retool Study was not required by either PJM or FirstEnergy.
- The West Bus POI affected line route for Interconnection Customer's 138 kV generator lead line, requiring underground 138 kV construction for the last 600 feet into Glen Falls substation.
- System Reinforcement projects for terminal upgrades at Glen Falls [n4852] and Oak Mound [n4853] substations had originally been identified as affected, but have since been removed once the Glen Falls-Oak Mound wave trap ratings were applied. Both terminal projects were found to meet or exceed ratings required for AA2-119.
- If AA2-119 goes in-service before the network upgrades are completed, an Interim Deliverability Study will be required to assess if there will be any reduced deliverability during that interim period.

Schedule

Interconnection Customer's requested Commercial Operation Date for the generation facility is June 1, 2020. Transmission Owner's proposed schedule does not match the Interconnection Customer's requested Milestone Schedule. A Project Kickoff meeting must occur by November 1, 2017 to meet Transmission Owner's Assumed Milestone Schedule listed below.

Interconnection Customer's Requested Milestone Schedule:

06/01/2019	Initial Back-feed through Project Substation Date
06/01/2020	Project Commercial Operation Date

Transmission Owner's Assumed Milestone Schedule:

11/01/2019	Initial Back-feed through Project Substation Date
06/01/2020	Project Commercial Operation

Direct Connection and Non-Direct Connection Schedule: To meet the Back-feed Date, a proposed twenty-four (24)-month schedule is estimated, from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting, to complete the engineering, construction and associated activities, as detailed in the "Direct Connection" and "Non-Direct Connection" sections below.

System Reinforcements Schedule: A proposed twenty-four (24)-month schedule (assumed March 2018 start) is estimated to complete the engineering, construction and associated activities, as detailed in the "System Reinforcements and Network Upgrades" section below, assuming an Interconnection Construction Service Agreement has been fully-executed, and a Construction Kick-Off Meeting has occurred.

Transmission Owner plans to have the System Reinforcements completed by June 2020. If Commercial Operation is planned prior to the Baseline reinforcement being completely built, PJM will need to assess if there will be any reduced deliverability during that interim period. If Interconnection Customer requests, and it's determined that the Baseline reinforcement can be expedited, Interconnection Customer would be responsible for any additional costs.

Scope of Interconnection Customer's Work

Direct Connection Facilities

Interconnection Customer will construct facilities, including the generation step-up (GSU) transformer station, approximately 1.5-2.0 miles of 138 kV generator lead line and connect to a new 138 kV line terminal at Transmission Owner-owned, Glen Falls 138 kV substation.

Point of Interconnection (POI): The POI will be located within existing Glen Falls Substation, where the Interconnection Customer's proposed underground termination structure, as designated by Mon Power, on the new Mon Power-owned 138 kV west bus terminal in a proposed expanded area of the Glen Falls 138 kV yard. (Ref: Figure 1)

Interconnection Customer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of each GSU transformer with revenue metering equipment, and a main breaker between the collector bus and the incoming line disconnect switch.

The direct connection facilities include substation yard expansion and new line terminal equipment on Transmission Owner's side of the point of interconnection. This typically includes operational metering, dead-end structure, a three-phase, gang-operated disconnect switch, and breaker. These facilities are considered radial equipment from the terminal to the point of interconnection.

Project Scope

It is proposed that the AA2-119 project be connected via expansion of the existing 138 kV west bus at Glen Falls substation, which will include a fence/yard expansion for a new 138 kV line terminal, disconnect switch, and 138 kV breaker. The Interconnection Customer's underground, transmission lead line shall terminate on a riser structure, designed, owned, and maintained by the Interconnection Customer within the Mon Power fenceline. Interconnection Customer is responsible for constructing all facilities on its side of the POI, as shown in the attached one-line diagram. (Ref: Figure 1)

Description of Facilities Work:

Direct Connection

Facilities Work to be constructed by Interconnection Customer:

1. **Generator Lead Line (approximately 2.0 miles from POI to Project Site, line route dependent) – Interconnection Customer owned**

   Assumptions / Notes:

   - Interconnection Customer will coordinate design, alignment, and construction with Mon Power on the proposed 138 kV underground riser structure, underground conduit and 138 kV cable installation, and underground vaults and mechanicals within the Mon Power-owned Glen Falls substation.
   - Outside of the Mon Power-owned substation fenceline, the Interconnection Customer will coordinate design and alignment of proposed underground and overhead 138 kV Lead Line with the Mon Power review of any clearance, right-of-way overlap, or right-of-way encroachment issues with existing Mon Power owned 138 kV facilities.
   - Interconnection Customer will coordinate design and construction of proposed 138 kV Lead Line with the Transmission Owner on any transmission line crossings or adjacent corridors for review of proper conductor clearances to Mon Power-owned facilities (i.e. 23 kV and 138 kV). For these areas, the Interconnection Customer shall provide Mon Power with proposed transmission plan & profile drawings prior to construction and as-built drawings, confirmed by as-built survey data post-construction.
   - Based upon the preliminary Generator lead line route, the Interconnection Customer's 138 kV lead line must cross beneath (not over) the Mon Power-owned Glen Falls-Rider/Glen Falls-Barnett's Run DCST 138 kV line. If the Mon Power must raise any existing structures, additional costs will be incurred by the Interconnection Customer.

- Transmission Owner preference would be to keep adjacent Interconnection Customer right-of-way beyond 100 feet from existing Mon Power centerline. As a minimum, Interconnection Customer facilities should not encroach within 100 feet of Mon Power centerline at blowout conditions. If Interconnection Customers's line design does not comply with this requirement Mon Power would need to review this area as a special exception.
- Additional costs will be incurred by the Interconnection Customer, if final alignment of the underground or overhead 138 kV Lead Line causes more encroachments, changes, or modifications to any existing Mon Power facilities, other than the two (2) Mon Power structures (Tower #1 and #87) already part of the proposed 138 kV underground alignment.

Facilities Work to be constructed by Transmission Owner:

1. **Glen Falls Substation – Expand substation and install new 138 Line Terminal [PJM Network Upgrades n4851]**

   Transmission Owner will design, furnish and install the following at Glen Falls substation for the new 138 kV line terminal:

   - One (1) 138 kV, 3000A, 63 kA SF6 Breaker
   - Three (3) 138 kV, 2000 ampere, three-pole, manually-operated, group disconnect switches for breakers and line terminal
   - Three (3) surge arresters for application on a 138 kV system
   - Three (3) 138 kV capacitor voltage transformers (CVT's) for relaying
   - 138 kV bus and conductor with associated structures
   - Grade and extend fence and ground grid approx. 50' x 280', includes additional storm water management measures as part of the site grading plan
   - Control Building 16' x 16' expansion to accommodate and new TO relaying and controls per the Protection Requirements (Ref: Attachment "A").
   - Foundations for the equipment listed above.
   - Add monitoring points to existing SCADA RTU
   - Substation fencing, cable trench & conduit system, ground grid and yard stone.
   - EXCEPTION, Interconnection Customer to own, design, install, and maintain one (1) 138 kV underground line (riser) termination structure, conduit, and all associated cables and associated underground mechanicals within Mon Power-owned substation

Non-Direct Connection

1. **Glen Falls Substation – Relocate two (2) 138 kV Transmission Structures to accommodate Interconnection Customer-owned, underground lead line placement**

   Transmission Owner will remove and relocate two (2) 138 kV transmission structures adjacent to Glen Falls substation to accommodate Interconnection Customer proposed 138 kV underground alignment.

This study assumes that the new 138 kV line structures will be located within the existing Transmission Owner 138 kV line right-of-way (Ref: Figure 1). The estimated costs shown in this study are typical for this type of steel structure design, under typical geo-technical soil/rock conditions.

Assumptions:

General Description of Scope of Work

Transmission Owner will perform the following work on 138 kV line structures, located within one (1) span of Glen Falls substation:

- **Glen Falls-McAlpin 138 kV Line (Tower #87)** - Remove single circuit, steel tower #87 and relocate with a vertical, single circuit, deadend, steel pole structure, includes new foundation.
- **Glen Falls-Waldo Run/Glen Falls-Fairview 138kV lines (Tower #1**) - Remove double circuit, steel tower #1 and relocate with two (2) independent, vertical, single circuit, tangent, steel pole structures, includes new foundations.

General Assumptions:

1. In order to meet the TO assumed Backfeed Date of **11/01/2019**, the exact location of the underground 138 kV lead line will be required from Interconnection Customer no later than **02/01/2018**. Delays in provision of substation site details will affect the schedule.
2. Tower #1 costs have been included assuming relocation required; however, if final route of Interconnection Customer's underground 138 kV lead line changes AND upon request by Interconnection Customer, Transmission Owner engineering will re-evaluate the need for Tower #1 relocation cost requirement.
3. Schedule is based on no outage issues, right-of-way, or siting/permitting issues.

Engineering Assumptions:

1. Both 138 kV structure relocations assume that conductor for the 138 kV lines shall match the existing lines.
2. Construction and cost estimate includes removal of two (2) existing steel lattice towers.
3. Install three (3) steel monopole deadend structures with associated 138 kV line hardware and concrete foundations for the transmission lines. Steel pole material cost based on conceptual design weights, and current contract steel pole pricing.
4. Foundation values assumed 'normal' soil plus rock. It was assumed that rock would be encountered at 6 ft. below the ground surface. Note that the depth to rock and quality of rock can greatly impact the foundation costs associated with the steel pole structures. While a 10% estimate was requested, without soil borings, it will be difficult to say with certainty that this estimate will be within 10% of the actual installed costs.
5. Conductor tensions will be low enough that existing deadend structures (within the substation) will not require reinforcement.
6. Construction access roads to the new 138 kV structures will be provided and permitted by the Interconnection Customer as part of the overall site plan for underground lead line installation to avoid construction interference and conflicts.
7. No forestry or vegetation clearing work is anticipated on this area of the site.

8. Line phasing will match existing substation line terminal phasing.
9. Cost estimates assume no significant geo-tech matting required for access to the relocated transmission structures during construction.

Siting Assumptions:

1. Interconnection Customer to provide all access rights, easements, ROW and permits, including local zoning and land use permits, for the transmission structure placement.
2. Assumes a Letter of Notification (LON) is required for filing with the West Virginia PSC for approval prior to construction. The WV Code 24-2-11a exempts lines that are ordinary extensions of an existing system in the usual course of business. However, the Transmission Owner must prepare a written notification to be sent to the Director of Engineering of the PSC Staff so that the department is aware of the work and respond to public requests for information.
3. Assume no significant ecological impacts on Transmission Owner-owned property. Transmission Owner is assuming that it will have no significant field or office ecological work or review.
4. Schedule assumes no property owner, governmental, or municipal opposition to the overall AA2-119 project.

Right-of-Way Assumptions:

1. Interconnection Customer shall work with the Transmission Owner to record survey metes and bounds of Interconnection Customer facilities located on Transmission Owner property.
2. Right-of-Way costs included are associated with review of documentation transferring rights to Transmission Owner.

Forestry/Vegetation Management Assumptions:

1. Construction and cost estimate assumes no additional vegetation clearing will be required.
2. Interconnection Customer to provide all clearing on Transmission Owner-owned property which supports installation of underground 138 kV lead line or relocation of transmission line structures.
3. Seasonal vegetation removal may be constrained due to T&E's (10/1 - 3/31) for native bat habitat. This should be included and verified as part of Interconnection Customer's environmental studies for development of the site.
4. Soil Erosion and Sedimentation Control measures, road grading, post construction rehabilitation and stabilization to be performed by Interconnection Customer.

Total Estimated Costs of Transmission Owner Facilities for Direct and Non-Direct Connection:

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in 2017 dollars. The taxes are a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged dependending upon whether this project meets the eligibility requirements of IRS Notice 88-129.

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
PJM Network Upgrade Number: N4851. **Glen Falls Substation** - Grade and extend fence and ground grid approx. 50' x 180'. Extend 138 kV bus and install 138 kV SF6 breaker, bus/line disconnects, foundations, control cable and associated facilities, incudes 16' x 16' expansion of concrete control building. **Note: Estimate DOES NOT include property acquisition necessary for substation expansion, provided by Interconnection Customer.**	$2,029,000	$243,000	$1,786,000
Total Direct Connection (DC) Costs	**$2,029,000**	**$243,000**	**$1,786,000**

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
PJM Network Upgrade Number: N5905 **Glen Falls-McAlpin 138 kV Line** – Replace Tower #87 w/ one (1) steel pole, single circuit, dead-end structure	$338,900	$40,600	$298,300
PJM Network Upgrade Number: N5906 **Glen Falls-Waldo Run/Glen Falls - Fairview** 138kV lines – Replace Tower #1 w/ two (2) steel pole, single circuit, tangent structures	$401,200	$48,100	$353,100
Total Non-Direct Connection (NDC) Costs	**$740,100**	**$88,700**	**$651,400**

Total DC & NDC Costs	**$2,769,100**	**$331,700**	**$2,437,400**

Schedule:

A proposed twenty-four (24)-month Direct Connection and Non-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 will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

24-month Schedule (assume Nov 2017 start)

Activity	Start Month	End Month
Preliminary Engineering	1	2
Permits & Real Estate	2	8
Detailed Engineering	2	10
Equipment Procurement - Delivery	11	12
Below Grade Construction	10	14
Above Grade Construction	14	24
Seasonal System Outage Constraints – Limited AG work (Jun-Aug 2019)	20	22
Testing & Commissioning	22	24

System Reinforcements:

Per the AA2-119 System Impact Study report, Transmission Owner will perform the following System Reinforcement and Network Upgrades:

1. **Oak Mound Substation – No longer required**
   [PJM Network Upgrades n**4852**]

   No limiting elements. Currently meets minimum rating requirements. No further work is required.

2. **Glen Falls Substation – No longer required**
   [PJM Network Upgrades n**4853**]

   No limiting elements. Currently meets minimum rating requirements. No further work is required.

3. **Glen Falls Substation**
   [PJM Network Upgrades n**4854**]

   - **Scope:** Replace five (5) 138 kV breakers with 63 kA, 3000 A units. Install 3 new foundations, 4 switches, cable trench, control cable and all associated facilities. The following overdutied breakers to be replaced: Buckhannon 50, Barnetts Run 406, Oak Mound 4, No. 1 & No. 4 transformers, and 138 kV Bus-tie breaker.

Cost Estimate:

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Glen Falls SS - Replace five (5) existing 138 kV breakers with 63 kA, 3000 A units. Install 3 new foundations, 4 switches, cable trench, control cable and all associated facilities. **PJM Network Upgrades:** **N4854.1** - Replace Buckhannon 50 **N4854.2** - Replace Barnetts Run 406 **N4854.3** - Oak Mound 4 **N4854.4** - No.1 & No.4 Transformer **N4854.5** - 138 kV Bus-tie	$2,436,400	$521,100	$1,915,300

Schedule:

A proposed twenty-three (23) month System Reinforcements schedule (assumed February 2018 start) is estimated to complete the engineering, construction and the associated activities, assuming an Interconnection Construction Service Agreement has been fully-executed, and a Construction Kick-Off Meeting has occurred.

This schedule assumes that no more than one (1) 138 kV line terminal can be de-energized at a time at Glenn Falls substation and that sequential/seasonal (off-peak) outages will occur beginning September 2018 through November 2019 to replace all five (5) 138 kV breakers and upgrade wiring, relays/controls as necessary. Breaker replacement work will be sequenced and coordinated with new 138 kV terminal work at Glen Falls substation.

23-month Schedule (assume Feb 2018 start)

Activity	Start Month	End Month
Preliminary Engineering	1	2
Permits (if required)	2	5
Detailed Engineering	2	8
Equipment Procurement - Delivery	8	10
2018 Summer Peak – No Outages	5	7
Ph1 - Replace two (2) 138kV Breakers	8	12
Ph1 - Testing and Commissioning	10	12
Ph2 - Replace two (2) 138kV Breakers	13	17
Ph2 - Testing and Commissioning	15	17
2019 Summer Peak – No Outages	18	20
Ph3 - Replace one (1) 138kV Breaker	21	23
Ph3 - Testing & Commissioning	22	23

4. Glen Falls-Oak Mound 138 kV - Reconductor from Glen Falls Substation to Str #13, 2.5 miles with 954 ACSR conductor
[PJM Network Upgrade **n4855**]

- **Scope:** Increase the line rating on a portion of the Glen Falls-Oak Mound 138kV line by upgrading the conductor. The 336.4 kcmil ACSR will need to be upgraded to a minimum conductor size of 795 kcmil ACSR. For estimate purposes, it is assumed that 954 kcmil ACSR will be used to match the existing 954 kcmil ACSR conductor existing from Str #13 to Oak Mound SS. The section from structure #13 to Oak Mound Sub will require no additional work since the existing 954 ACSR conductor meets the rating requirements. The existing structures are lattice towers with a horizontal circuit configuration.

Cost Estimate:

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Glen Falls-Oak Mound 138 kV Line - Reconductor from Glen Falls SS to Str #13, 2.5 miles with 954 ACSR conductor on existing mix of steel lattice & wood-pole structures **[N4855]**	$3,027,500	$362,500	$2,665,000

Engineering Assumptions:

- Reconductor 2.5 miles of single circuit 138 kV with 954 kcmil ACSR conductor. All insulator assemblies assumed to be replaced. Line consists of (5) deadend/strain towers, (7) tangent towers, and (1) guyed wood 3-pole deadend.
- Based upon previous work in the area, the towers on the Glen Falls-Oak Mound portion to be reconductored are the same towers as on the Glen Falls-Waldo Run circuit, therefore it is assumed the towers can be reinforced to support the 954 ACSR conductor. Towers assumed to have been previously modeled for the Glen Falls-Waldo Run reconductor. If tower models do not exist or cannot be located, additional engineering hours will be required. Per reinforcement drawings from prior designs, each tower is assumed to required approximately 450 lbs of additional steel member reinforcement.
- Structure #13 is a guyed wood 3-pole structure and assumed to be replaced with a new guyed wood 3-pole structure for the reconductor.
- The new 954 ACSR conductor will be installed on existing towers and poles, at a tension of 12,000 lbs (same as Glen Falls-Waldo Run design tension) and was modelled using LIDAR data with a clearance report was generated. The PLS-CADD analysis resulted in (3) spans that indicated potential ground clearance issues in spans 3-4, 10-11, and 12-13. To mitigate the issues, a wood H-frame is assumed to be installed mid-span between structures #3 and #4 and an additional wood H-frame is assumed to be installed approximately 150' east of tower #11. The issue between structure #12 and #13 is assumed to be mitigated by replacing structure #13 with a taller structure. Depending on review of existing right-of-way easements and more detailed engineering analysis, tower replacement may be required to mitigate additional clearances, which would result in further cost adjustments to the project.
- Estimate includes 1.6 miles of gravel access roads and/or matting will be required and 1.2 miles are assumed to be available via existing private access roads with property owner permission. Access road costs could be higher due to difficult mountainous terrain.

Siting and Right-of-Way Assumptions:

- A Letter of Notification (LON) will be required for filing with the West Virginia PSC for approval prior to construction. Schedule provides WV PSC four (4) months to review and approve. The WV Code 24-2-11a exempts lines that are ordinary extensions of an existing system in the usual course of business. However, the Transmission Owner must prepare a written notification to be sent to the Director of Engineering of the PSC Staff so that the department is aware of the work and respond to public requests for information.
- All work occurs within an existing transmission line right-of-way; however, additional rights from property owners may be required for installation of two (2) new mid-span structures.
- All work will occur within existing FirstEnergy right-of-way. Some off-ROW access will likely be required from adjacent property owners. These additional costs are NOT included as part of the estimate.
- Schedule assumes no property owner, governmental, or municipal opposition to the overall AA2-119 project.

Environmental Assumptions:

- Minor ecological and social impacts.
- Environmental studies will be required to develop E&S Control Plans and required measures installed along sections of access road and individual structure construction sites. Costs include development and submittal of E&S Plan, periodic monitoring of E&S measures including post construction removal and rehabilitation.

Forestry/Vegetation Management Assumptions:

- Additional vegetation clearing may be required for access road installation and within existing right-of-way where additional conductor clearance is required.
- No special conditions for vegetation clearing. Vegetation removal may be constrained due to seasonal restrictions due to T&E's (10/1 - 3/31) for native bat habitat. This should be included and verified as part of project environmental studies.

Schedule:

24-month Schedule (assume Feb 2018 start)

Activity	Start Month	End Month
Preliminary Engineering	1	4
Siting & LON filing	4	8
Detailed Engineering	5	9
Equipment Procurement - Delivery	9	10
Access Road Construction & Vegetation Clearing	9	13
Steel Tower Reinforcement	12	16
2019 Summer Peak – No Outages	18	20
Install new wood pole structures, and install, tension & sag new conductor	21	23
Commission & Test Line	23	24

Total Estimated Costs of Transmission Owner Facilities:

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Total DC & NDC Costs	$2,769,100	$331,700	$2,437,400
Total System Reinforcements and Network Upgrade Costs: n4854, and n4855	$5,463,900	$883,600	$4,580,300
TOTAL Costs (ALL Categories)	**$8,233,000**	**$1,215,300**	**$7,017,700**

Generation Connection Requirements

The proposed interconnection facilities must be designed in accordance with the Transmission Owner's *Requirements for Transmission Connected Facilities* and *Wholesale Generation Interconnection (WGI) Manual* 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. FirstEnergy 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. FirstEnergy will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when needed.*

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	Generator's Terminals[1]
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[2]	Generator's Terminals

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

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

Design Requirements

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

Design Criteria

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

General Design Requirements

- System phasing (counter clockwise) A-B-C
- 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

[1] For projects that entered PJM's New Service Queue prior to May 1, 2015, the power factor requirement will be measured at the Point of Interconnection.
[2] For projects that entered PJM's New Service Queue prior to May 1, 2015, the power factor requirement is 1.0 (unity) to 0.95 lagging.

- 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: 3000 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: 52-1/2”
- 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”

Metering, SCADA and Communications

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

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 telephone service in the Transmission Owner interconnection substation.

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

Communications for transmission line protection between the new interconnection substation, and Interconnection Customer's generation (collector) substation, will be via fiber optics (see "Fiber Optic Communication Channels" section below).

Fiber Optic Communication Channels

Interconnection Customer will design, provide, install, own and maintain a fiber-optic communications cable between the new interconnection substation, and Interconnection Customer's generation (collector) substation. Two (2) fiber-optic channels are required for protection schemes to obtain high-speed tripping capability for any fault within the zone of protection. These channels may reside in the same cable, provided that this line does not require completely redundant protection for system stability reasons. 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 provide a demark location outside of Glen Falls substation for termination of Interconnection Customer -owned OPGW or ADSS fiber and will make the fiber-optic cable termination connections and provide for Transmission Owner fiber cable(s) to the existing control house. Interconnection Customer is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber-optic cable(s).

Environmental, Real Estate and Permitting Issues

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

- Environmental permitting, Real Estate acquisition, and West Virginia Public Service Commission (PSC) notification durations vary, some up to six (6) months after preliminary engineering is completed to provide the required information.
- Prior to agreement by Interconnection Customer to purchase the property parcels adjacent to Glen Falls substation, a Phase 1 Environmental Assessment should be conducted on each parcel to avoid assumption of environmental liabilities by Interconnection Customer or Transmission Owner. If Interconnection Customer chooses to transfer substation property in fee, the Interconnection Customer must complete a Phase II environmental assessment of the subdivided parcels and provide that to Transmission Owner prior to start of construction. Remediation of any hazardous substance discovered during the Phase II study must be remediated to meet WV Site Remediation Standards before the parcel is transferred to the Transmission Owner.
- Interconnection Customer to provide all access and property rights, easements, ROW and permits necessary to complete the Project to the satisfaction of Transmission Owner. Environmental permitting in and around Glen Falls substation shall encompass all federal, state and local requirements, consultations and agency coordination. Confirmation of meeting all permitting requirements shall be provided to Transmission Owner, prior to start of construction. Following construction and energization, confirmation of permit closeout shall be provided to the satisfaction of Transmission Owner, prior to transfer of ownership. If any

of these elements are not included in the final agreement between Transmission Owner and Interconnection Customer, twelve (12)-to-eighteen (18) months may be added to the Project schedule to closeout all necessary permits.

- Transmission Owner is not responsible for any environmental clean-up or remediation of any pre-existing contamination or hazardous materials found on the adjacent parcels to Glen Falls substation expansion for interconnection.
- Interconnection Customer is responsible for project site plan approval (if required), subdivision plan (if required), and relative environmental permits and other necessary approvals to Transmission Owner before Transmission Owner begins construction on Glen Falls substation expansion.
- Interconnection Customer is required to install an access road and provide unimpeded access for Transmission Owner at all times for tower relocation.
- Interconnection Customer is responsible for all property acquisition (including easements/rights-of-way) for transmission, distribution and communication facilities needed for the generator interconnection.
- If Interconnection Customer owns the adjacent project property, in fee title, Transmission Owner will require a fee property transfer for the interconnection substation expansion area which may require subdivision approval, together with permanent access rights in and around the substation, as well as a perpetual easement for any transmission lines to the substation. Interconnection Customer is responsible for all costs, including but not limited to subdivision, associated with the property transfer.
- All property rights for adjacent parcels to Glen Falls substation and any Interconnection Customer -owned 138 kV transmission lines must be surveyed and metes and bounds descriptions prepared for incorporation into Transmission Owner's document forms, for transfer of title.
- Project assumes that both Transmission Owner 138 kV transmission tower relocations and rebuild of 2.5 miles of Glen Falls-Oak Mound 138 kV line will require a Letter of Notification (LON), submitted to the WV PSC for approval.

General Assumptions/Qualifiers

The accomplishment of the work on the Transmission Owner system to support the estimated costs and proposed schedule is dependent on the following:

- Obtaining the necessary line outages. Transmission line outages are typically not granted from June to September and are discouraged during extreme winter conditions.
- No equipment delivery, environmental, permitting, regulatory or real estate delays.
- No extreme weather.
- No force majeure.
- Estimates assume no significant rock encountered during construction, and suitable soil conditions exist to accommodate a standard ground-grid and foundation installation.
- It is assumed that the new interconnection will be located on the western-side of Glen Falls substation and the Interconnection Customer's 138 kV underground lead line will not otherwise interfere with Transmission Owner transmission lines and relocated structures.
- All work occurs within an existing transmission line right-of-way or on Interconnection Customer's property with access to all existing structures possible via that property and the right-of-way following established access routes that do not cross wetlands or streams.

- Interconnection Customer will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- Interconnection Customer will support and/or obtain all necessary permits work in and round Glen Falls substation and expansion.
- Interconnection Customer will develop all necessary access roads for project sites in and around Glen Falls substation.
- Interconnection Customer will conduct all necessary wetlands and waterways studies and permits for 138 kV generator lead line.
- Interconnection Customer will conduct all necessary historical and archaeological studies for 138 kV generator lead line.

Since Interconnection Customer interconnect termination occurs within Glen Falls substation, the Interconnection Customer must utilize an approved Transmission Owner A/E & Construction Contractor. A listing of Transmission Owner Approved Vendors and Contractors is located at the following PJM site:

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

Transmission Owner will act in an oversight capacity reviewing all design information & site construction for the Interconnection Customer's 138 kV riser structure within Glen Falls. Interconnection Customer will coordinate with the Transmission Owner on engineering design and construction of the generator lead line. Transmission Owner will then coordinate all end-to-end testing between the Interconnection Substation and all remote terminal substations.

ATTACHMENTS

ATTACHMENT A
Queue Position AA2-119
Detailed Protection Requirements
(NOT to be used for Construction)

PROTECTION AND MEASUREMENTS EQUIPMENT SPECIFICATIONS

General Connection Requirements

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

SHORT CIRCUIT DATA for a fault at the proposed location of the connection of the AA2-119 generator at Glen Falls SS (Symmetrical Values Only)

INITIAL CONDITIONS (PERCENT ON 100 MVA BASE)

138kV
Z1 = 0.397+ j 2.450%
Z0 = 1.482+ j 5.205%

3-phase fault – 16,863A
Single line to ground fault – 12,228A

Note: These fault values do not include the AA2-119 Generator or GSU step up transformer as being modeled in the calculations.

Impedances are given on a 100 MVA and 138kV 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 FirstEnergy's "Requirements for Transmission Connected Facilities" document.

The relay sketch (Ref: Figure 1A) provides details of relay requirements for AA2-119 Generation substation and is considered part of the Facilities Study Report.

PROTECTION REQUIREMENTS FOR THE 138kV INTERCONNECTION LINE

The zone of protection for this scheme consists of the transmission line between the CTs supplying the relays at Glen Falls Substation and the CTS on the high side circuit breaker at the Generator Substation. Two fiber optic channels are required for these schemes to obtain high-speed tripping capability for any fault within the zone of protection. These channels may reside

in the same cable provided that this line does not require completely redundant protection for system stability reasons. The breaker at Glen Falls Substation will only close into this line if it is dead. All synchronizing is to be performed at the Generator Substation. No automatic reclosing will be applied. Further requirements are set forth in FirstEnergy's "Requirements for Transmission Connected Facilities" document.

Glen Falls Substation 138kV Line Exit to AA2-119 wind generator substation

Install the following:

- one single-phase dual winding capacitor voltage transformer, dual ratio = 1200/700/1 (carrier facilities are not required) on phase A
- Fiber Optic Ground Wire (OPGW) fiber optic communication channels to the customer substation for protective relaying

The switchboard panel for the purpose of protecting the 138kV line to the wind 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 breaker failure
- LOR relay for wind farm breaker failure tripping (operate from transfer trip receive)
- SATEC digital multimeter
- Breaker control switch
- SD relay ("27L") for line potential monitoring (blocks all closing if line from wind generator is hot)
- All other related switches, fuses, and related hardware

Generation Substation Protection Requirements for 138kV line to Glen Falls Substation

It is the responsibility of the Interconnection Customer and/or Generator Owner 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 FirstEnergy supply
- Synchronizing generation
- Synchronizing facilities between independent transmission system and FirstEnergy
- Transmission System

The Interconnection Customer, as generator owner, is required 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 138kV portion of the generator 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 generator 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 Glen Falls Substation.

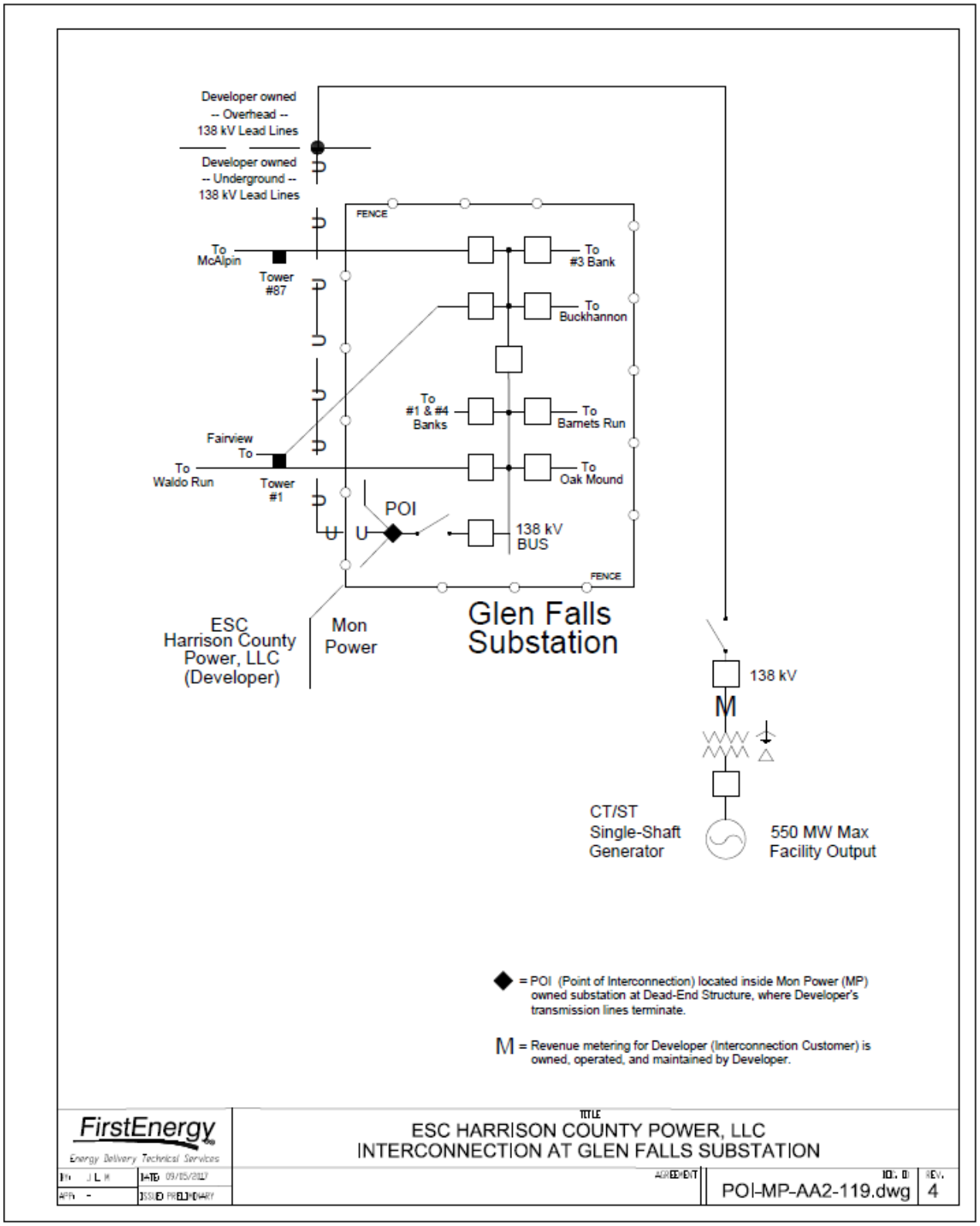
The customer is solely responsible for protecting its own equipment in such a manner that electrical faults or other disturbances on the FirstEnergy system do not damage its equipment.

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.

FIGURE 1
Queue Position AA2-119
Planning One-Line Diagram*



* Note: Diagram does not represent a physical layout. Not to be used for construction.

FIGURE 1A
Queue Position AA2-119
Relay Sketch*

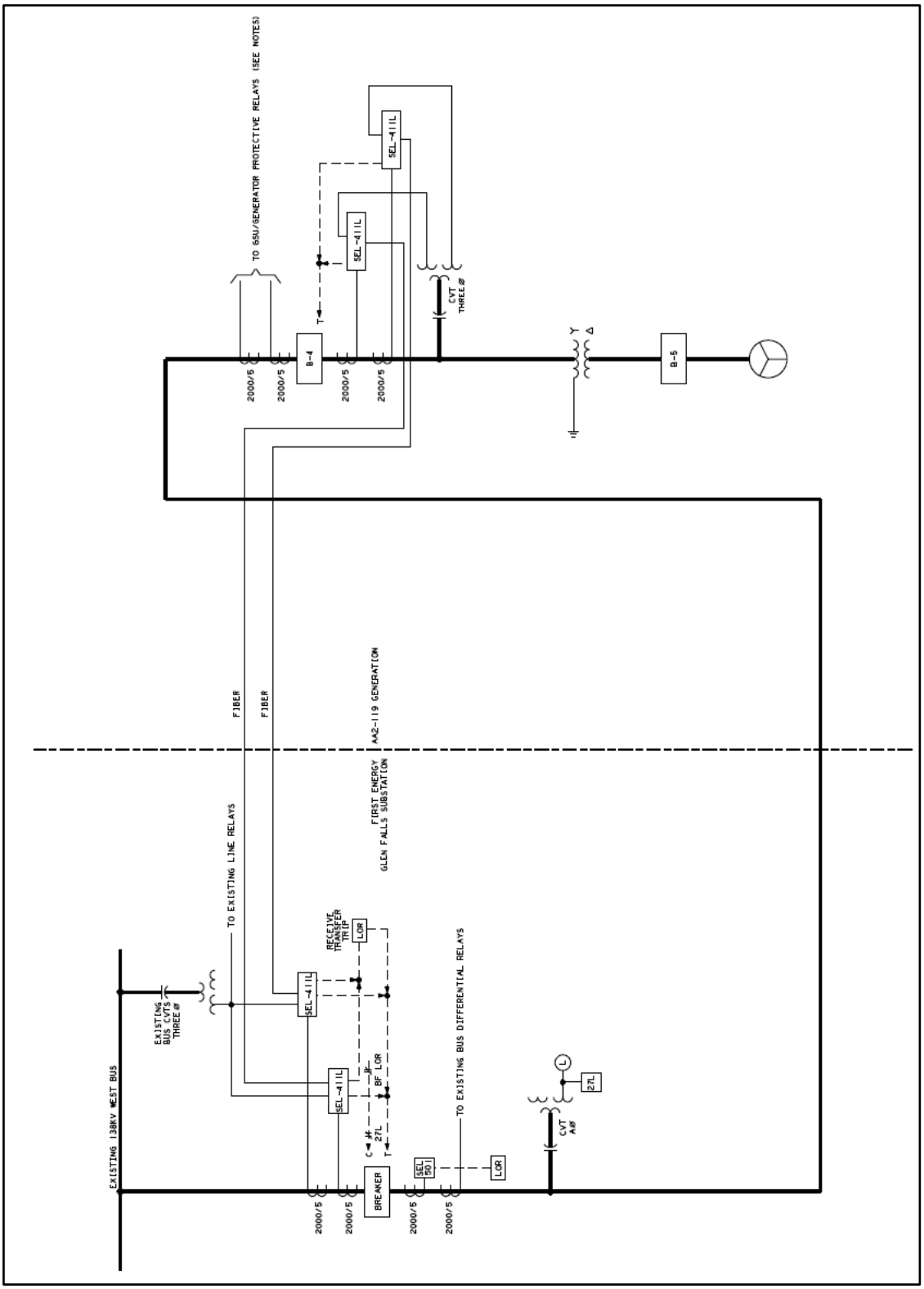
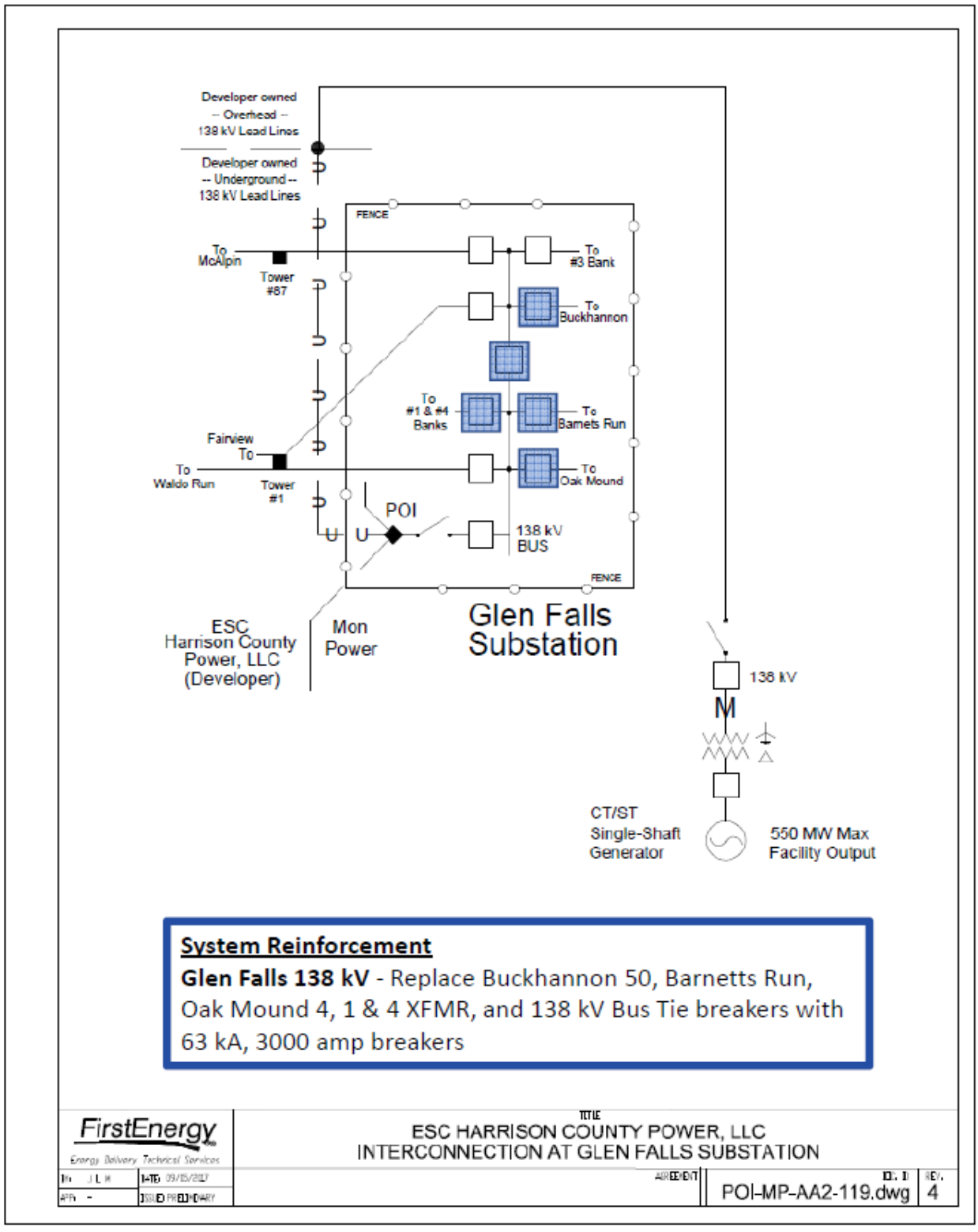


*Diagram does not represent a physical layout. Not to be used for construction.

Notes:
1. For simplification, only one (1) trip coil per breaker is shown.
2. Trips from breaker failure SEL-501 and LOR relays are not shown.
3. "BF LOR" shown in close block circuit may indicate multiple BF LOR relays.
4. Required GSU/Generator relaying is detailed in the *First Energy Requirements for Transmission Facilities* document.

FIGURE 2

Queue Position AA2-119
Glen Falls Substation – Overdutied Breakers Sketch*



* Note: Diagram does not represent a physical layout. Not to be used for construction.

FIGURE 3

Queue PositionAA2-119
Project Location

Notes:

- AA2-119 interconnection POI is located at a new 138 kV terminal at Glen Falls substation.
- AA2-119 Generation site is approximately 1.5 miles, southeast of Glen Falls substation.
- Interconnection Customer to secure private right-of-way and construct approximately 1.5-2.0 miles for the 138 kV generator lead line from proposed Generator site to Glen Falls Substation.
- Areas where 138 kV generator lead line will be adjacent to or cross Transmission Owner facilities will be subject to alignment/design review with Transmission Owner per Assumptions/Notes on Page 4, of AA2-119 Facility Study.