

***Generation Interconnection  
Facility Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position Y3-092***

***Erie West 345kV***

**August 2019**

## Preface

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

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

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

## Cost Summary

The Y3-092 project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
Attachment Facilities	\$ 617,720
Direct Connection Network Upgrades	\$ 0
Non Direct Connection Network Upgrades	\$ 4,113,280
Allocation for New System Upgrades	\$ 0
Contribution for Previously Identified Upgrades	\$ 0
<b>Total Costs</b>	<b>\$ 4,731,000</b>

## **A. Transmission Owner Facilities Study Summary**

### **1. Description of Project**

ITC Lake Erie Connector LLC, the Interconnection Customer (referred to as the “IC” or “Developer”), has proposed a Merchant Transmission line to connect Ontario IESO’s transmission system to Mid-Atlantic Interstate Transmission’s (or “MAIT”) transmission system, in Erie County, PA. The installed facilities will have a capability of +/- 1000MW- with the entire 1000 MW of this injection capability being recognized by PJM as Firm Transmission Injection Rights, 500MW of the withdrawal capability being recognized as of Firm Transmission Withdrawal Rights (“TWR”) and the remaining 500 MW of withdrawal capability being recognized as non-firm TWR. The proposed in-service date for this project is March 31, 2024. **This study does not imply a “MAIT commitment to this in-service date.**

Y3-092 will interconnect with the MAIT transmission system at the Erie West 345kV substation.

The merchant transmission line facility will interconnect with **Mid Atlantic Interstate Transmission, LLC (“MAIT”)** a FirstEnergy Company (FE) hereinafter referred to as "Transmission Owner" (TO), at a new 345 kV line terminal in the Erie West 345 kV Substation.

### **2. Amendments to the System Impact Study data or System Impact Study Results**

None

### **3. Interconnection Customer’s Submitted Milestone Schedule**

Developer’s requested Commercial Operation Date (COD) for the generation facility is **March 31, 2024**. Transmission Owner’s proposed schedule does match the Developer’s requested Milestone Schedule. A Project Kickoff meeting must occur by March 31, 2022 to meet Transmission Owner’s Assumed Milestone Schedule listed below.

#### **Developer’s Requested Milestone Schedule:**

03/31/2024 Initial Back-feed through Project Substation Date  
03/31/2024 Project Commercial Operation Date

#### **Transmission Owner’s Assumed Milestone Schedule:**

03/31/2024 Initial Back-feed through Project Substation Date  
03/31/2024 Project Commercial Operation Date

**Direct Connection Schedule:** In order to meet the Back-feed date, a 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” section below.

This assumes that sufficient engineering details are available to evaluate the scope of work.

### 24-month Schedule (assume March 2022 start)

Activity	Start Month	End Month
Preliminary Engineering	1	3
Siting, Permits & Real Estate	1	12
Detailed Engineering	4	12
Equipment Delivery	13	14
Below Grade Construction – Substation	15	18
Above Grade Construction – Substation	19	23
Testing & Commissioning	24	24

**System Reinforcements Schedule:** A proposed twenty (24) month schedule (assumed March 2022 start) is estimated to complete the engineering, construction and associated activities, as detailed in the “System Reinforcements” section below, assuming an Interconnection Construction Service Agreement has been fully-executed, and a Construction Kick-Off Meeting has occurred. It is assumed these system reinforcements are able to be constructed within the same time frame as the interconnection substation.

## **4. Scope of Customer’s Work**

### **Direct Connection Facilities**

Developer will construct facilities, including the interconnection transformer; and 345 kV lead line and connect to the new 345 kV line exit terminal at Erie West Substation.

**Point of Interconnection (POI):** The POI will be located within the new breaker string in the 345 kV yard at Erie West Substation where Developer-owned 345 kV underground line conductor will terminate on the insulators on the dead-end structure and will be defined as the POI. (see Figure 1)

Developer is required to own, install, and maintain a fully-rated, fault-interrupting circuit breaker on the high-side of the interconnection transformer with revenue metering equipment between the collector bus and the incoming generator lead line.

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

### **Project Scope**

The Y3-092 project will be interconnected via a 345 kV lead line to a new 345 kV line exit position in the Erie West 345 kV substation. The Developer’s substation will be built approximately 0.4 miles from the Erie West 345 Substation. Developer is responsible for

constructing all the facilities on its side of the POI, as shown in the attached single-line diagram (see Figure 2).

The Transmission Owner is responsible for the design, procurement, and construction of the new 345 kV line exit terminal at Erie West Substation.

Facilities Work to be constructed by Developer:

- Construct transmission lead line approximately 0.5-mile interconnection to Y3-092 from the new terminal (POI) at the Erie West 345 kV substation.

#### **Assumptions / Notes:**

- Developer will coordinate design and alignment of proposed Y3-092, 345 kV transmission lead line with the Transmission Owner for review of any clearance, right-of-way or right-of-way encroachment issues with TO owned facilities.
- Developer will coordinate design and construction of proposed Y3-092 345 kV Lead Line. For these areas, the Developer shall provide TO with proposed transmission plan & profile 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 345 kV line. As a minimum, Developer facilities should not encroach within 100 feet of TO centerline at blowout conditions if any portion were to be constructed overhead. If Developer's line design does not comply with this requirement TO would need to review this area as a special exception.
- Developer shall maintain adequate clearances for its 345 kV lead line from Transmission Owner's electric lines and structures. Developer shall submit final engineering design of its attachment line to Transmission Owner for approval prior to proceeding with the construction of the attachment line.
- For additional details, 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>
- Additional costs will be incurred by the Developer, if final alignment of Y3-092 345 kV lead line causes encroachments, changes, or modifications to any existing or relocated TO facilities.
- Developer is responsible to obtain and maintain all associated Rights-of-Way (ROW), Easements, and Permits for its 345 kV lead line between the new Y3-092 generation interconnection substation and Transmission Owner's designated substation dead-end structure at Erie West substation.

## 5. Description of Facilities Included in the Facilities Study

### Attachment Facilities

- Erie West Substation – Install termination structure, disconnect switch, foundations, etc. from the customer Point Of Interconnection to the point where it attaches to the new breaker string at Erie West 345 kV (PJM Network Upgrade Number #N6105)

### Non-Direct Connection Facilities

- Erie West Substation - Expand 345 kV bus and install two new 345 kV breakers for new line exit (PJM Network Upgrade Number #N4321)
- Removal of reactor at Erie East Substation on S. Ripley 230 kV line. Increase size of the 230-kV capacitor to the original nameplate of 79.4 MVAR. (PJM Network Upgrade Number #N5825)

## 6. Total Costs of Transmission Owner Facilities included in Facilities Study

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in 2018 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 based on whether this project meets the eligibility requirements of IRS Notice 88-129.

Description	Total (w/ Tax)	Tax (if applicable)	Total Cost
Erie West Substation – Install termination structure, disconnect switch, foundations, etc. from the customer Point Of Interconnection to the point where it attaches to the new breaker string at Erie West 345 kV (PJM Network Upgrade Number #N6105)	\$ 744,160	\$ 126,440	\$617,720
<b>Total Attachment Facility Costs</b>	<b>\$ 744,160</b>	<b>\$ 126,440</b>	<b>\$617,720</b>
Erie West Substation - Expand 345 kV bus and install two new 345 kV breakers for new line exit (PJM Network Upgrade Number #N4321)	\$ 4,837,040	\$ 821,860	\$ 4,015,180
Removal of reactor at Erie East Substation on S. Ripley 230 kV line. Increase size of the 230-kV capacitor to the original nameplate of 79.4 MVAR. (PJM Network Upgrade Number #N5825)	\$ 118,200	\$ 20,100	\$ 98,100
<b>Total Non-Direct Connect Costs</b>	<b>\$ 4,955,240</b>	<b>\$ 841,960</b>	<b>\$ 4,113,280</b>
<b>Total Costs</b>	<b>\$ 5,699,400</b>	<b>\$ 968,400</b>	<b>\$ 4,731,000</b>

**7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:**

A proposed **twenty-four (24) 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 “Engineering, Siting, Right-of-Way and Environmental Issues” sections 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 March 2022 start)**

Activity	Start Month	End Month
Preliminary Engineering	1	3
Siting, Permits & Real Estate	1	12
Detailed Engineering	4	12
Equipment Delivery	13	14
Below Grade Construction – Substation	15	18
Above Grade Construction – Substation	19	23
Testing & Commissioning	24	24

**New System Reinforcements and Network Upgrades**

As a result of a Phase Angle Regulator (“PAR”) being installed in the National Grid service territory to resolve post-contingency issues, the series reactor at Erie East 230 kV substation will need to be removed from service. When the reactor is removed, the size of the 230-kV capacitor will be returned to the original nameplate size of 79.4 MVAR

**Cost Estimate:**

- See previous table

**Schedule:**

**7-month Schedule**

Activity	Start Month	End Month
Preliminary Engineering	1	2
Detailed Engineering	3	4
Mobilization and Site Preparation	5	6
Above Grade Construction – Substation	6	6
Testing & Commissioning	7	7

Note: It is assumed that this work can be performed during the same outage timeframe as the PAR installation in the National Grid territory is occurring so that only one outage of the line is required.

## **B. Transmission Owner Facilities Study Results**

### **1. Transmission Lines – New**

None

### **2. Transmission Line – Upgrades**

None

### **3. New Substation/Switchyard Facilities**

None.

### **4. Upgrades to Substation / Switchyard Facilities**

#### **Attachment Facilities**

##### **Erie West 345 kV Substation**

PJM Network Upgrade Number #N6105

Transmission Owner will design, furnish and construct the termination structure, disconnect switch, foundations, etc. from the customer Point Of Interconnection to the point where it attaches to the new breaker string at Erie West 345 kV

- One (1) 345 kV, 3000 ampere, three-pole, motor-operated, disconnect switch
- One (1) 345 kV transmission line termination structure
- Foundations for the equipment listed above.

#### **Non-Direct Connection Facilities**

##### **Erie West 345 kV Substation**

PJM Network Upgrade Number #N4321

Transmission Owner will design, furnish and construct the new 345 kV line terminal for the Developer as part of the expansion of the Erie West 345 kV substation, including the following:

- Extend both 345 kV bus sections
- Two (2) 345 kV, 3000 ampere, 63 kA interrupting power circuit breakers
- Four (4) 345 kV, 3000 ampere, three-pole, manually-operated, group disconnect switches
- Six (6) capacitor voltage transformers for relaying
- Transmission Owner relaying and controls per the Protection Requirements (provided as Attachment “A”).
- SCADA RTU/Communications circuit – Contact Transmission Owner for specifics
- Foundations for the equipment listed above.
- Substation fencing, cable trench & conduit system, ground grid and stoning as required.
- Compliance with Transmission Owner security standards.



Assumptions / Notes:

- In order to meet the requested Backfeed Date of **03/31/2024**, the exact underground 345 kV line from the Developer's interconnection substation site is required from Developer no later than **03/31/2022** (i.e. minimum **twenty-four** (24) months lead-time from Backfeed Date). Delays in provision of line route details will affect the schedule.

**Y3-092 Substation location**

The HVDC converter station is to be located at the following:

Approximately 0.3 miles east of Erie West 345 kV Substation on Parcel ID: 04-005-010.0-004.00

This study assumes that the interconnection new converter substation which will convert the HVDC to 345 kV will be located a short distance (0.3 miles) from Erie West Substation. The Developer is proposing to construct an underground 345 kV line from their substation to the new line terminal to be constructed at Erie West Substation.

Note: An outage of the substation is unlikely to be granted from May 1 to October 1. Therefore, the engineering and construction for the project must be completed in a timely manner in order to meet the requested Backfeed Date. An outage of each 345 kV bus is required for this project. The schedule is based on no issues with siting/permitting, right-of-way acquisition, or outage requirements.

**Assumptions:**

**Engineering Assumptions:**

- Access will be provided through the substation area and substation access roads.
- No forestry work is anticipated.
- It is assumed that no existing structures will need to be removed.

**Siting Assumptions:**

- An application to the Pennsylvania Public Utilities Commission. One of the issues in determining what will be needed is property acquisition. It is expected that Developer will acquire all of the necessary property and easements for their portion of the project.
- The estimate assumes PaPUC approval. If a full siting application is required, significant external legal involvement and environmental studies will be required which would greatly increase costs and schedule (not included herein).
- It is expected that the Erosion & Sedimentation Control Plan for the substation work will be the responsibility of the Transmission Owner.
- In PA, assume that project will receive local municipal approval with no public or municipal opposition.
- Schedule assumes no property owner, governmental, or municipal opposition to the overall Y3-092 project.

**Right-of-Way Assumptions:**

- Right-of-way is required from Developer only. If additional property is required, the Developer will acquire it and the property will be transferred to Transmission Owner at no cost.
- Right-of-way acquisition must occur prior to Pa PUC review of the submittal.
- Title completed by Developer and provided to Transmission Owner upon request.

### **Environmental Assumptions**

- Environmental permits from PA will be required.
- Environmental studies will be required to develop E&S Control Plans and required measures. Costs include development and submittal of E&S Plan, periodic monitoring of E&S measures including post construction removal and rehabilitation.

### **Non-Direct Connection Facilities**

#### **Erie East 345 kV Substation**

PJM Network Upgrade Number #N5825

- Removal of reactor at Erie East Substation on S. Ripley 230 kV line. Increase size of the 230-kV capacitor to the original nameplate of 79.4 MVAR.

As a result of a Phase Angle Regulator (“PAR”) being installed in the National Grid service territory to resolve post-contingency issues, the series reactor at Erie East 230 kV substation will need to be removed from service. When the reactor is removed, the size of the 230-kV capacitor will be returned to the original nameplate size of 79.4 MVAR

## **5. Metering & Communications**

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

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](http://www.firstenergycorp.com/feconnect)

[www.pjm.com/planning/design-engineering/to-tech-standards.aspx](http://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 Developer to PJM. Transmission Owner will work with PJM and Developer to ensure the generation data provided to PJM meets Transmission Owner's requirements.

Communications for transmission line protection between the Developer's new **interconnection/converter** substation, and Transmission Owner's Erie West substation, will be via fiber optics (see "Fiber Optic Communication Channels" section below).

### **Fiber Optic Communication Channels**

Developer will design, provide, install, own and maintain a fiber-optic communications cable between the Erie West 345 kV substation, and Developer's interconnection/converter 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. These channels may not reside in the same cable or path. 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 Developer will make the fiber-optic cable termination connections for its cable(s) at the interconnection/converter substation control house.

Transmission Owner will make the fiber termination connections for its cable(s) at the Erie West 345 kV substation control house. Developer is responsible for obtaining and maintaining all associated Rights-of-Way (ROW), Easements, and Permits for its fiber cable.

## **6. Environmental, Real Estate and Permitting Issues**

### **Environmental, Real Estate and Permitting Issues**

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

- Environmental permitting, Real Estate acquisition, and Pennsylvania Public Utilities Commission (PaPUC) notifications vary, some up to twelve (12) months after preliminary engineering is completed to secure the required approvals.
- Developer is responsible for all property acquisition (including easements/rights-of-way (ROW)) for transmission, distribution and communication facilities needed for the generator interconnection.

### **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:

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. There are times in May and September, depending upon system conditions, where outages are limited or not granted.
- 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 point will be located on the southern-side of the transmission corridor (see “Figure 2”) and the loop will avoid crossing other Transmission Owner transmission lines.
- All work occurs within an existing transmission line right-of-way or on Developer’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.
- Right-of-way is required from Developer only. The project is entirely on Developer's property.
- Developer will develop, and secure regulatory approval for, all necessary Erosion and Sediment Control (E&SC) plans and National Pollutant Discharge Elimination System (NPDES) permits.
- Developer will obtain all necessary permits.
- Developer will develop all necessary access roads for project sites.
- Developer will conduct all necessary wetlands and waterways studies and permits.
- Developer will conduct all necessary historical and archaeological studies.
- The 345 kV connection between the substations will be via an underground 345 kV transmission line.
- Developer shall maintain adequate clearances for its 345 kV generation attachment line from Transmission Owner’s electric lines and structures. Developer shall submit final engineering design of its generation attachment line to Transmission Owner for approval prior to proceeding with the construction of the attachment line.
- For additional details, 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>
- In order to meet the requested Backfeed Date of **03/31/2024**, the location of the route for the 345 kV underground line is required from Developer **no later than 03/31/2022** (i.e. minimum **twenty-four (24)** months lead-time from Backfeed Date). Delays in provision of line route details will affect the schedule.
- Developer is responsible to make all arrangements for electric distribution service (if required) for its generation station. No costs or schedule included herein.
- 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](http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx)
- The IC shall complete all additional studies as established by Transmission Owner and PJM to determine impacts caused by Y3-092, define specifications of the project, verify

performance of the combined DC and AC system, and also establish impacts related to the interconnection.

## **7. Information Required for Interconnection Service Agreement**

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in 2018 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 based on whether this project meets the eligibility requirements of IRS Notice 88-129.

<b>Description</b>	<b>Direct Labor</b>	<b>Direct Material</b>	<b>Indirect Labor</b>	<b>Indirect Materials</b>
<b>Attachment Facilities</b>				
Erie West Substation – Install termination structure, disconnect switch, foundations, etc. from the customer Point Of Interconnection to the point where it attaches to the new breaker string at Erie West 345 kV (PJM Network Upgrade Number #N6105)	\$ 370,632	\$ 123,544	\$ 92,658	\$ 30,886
<b>Non-Direct Connection Facilities</b>				
Erie West Substation - Expand 345 kV bus and install two new 345 kV breakers for new line exit (PJM Network Upgrade Number #N4321)	\$ 2,409,108	\$ 803,036	\$ 602,277	\$ 200,759
Removal of reactor at Erie East Substation on S. Ripley 230 kV line. Increase size of the 230-kV capacitor to the original nameplate of 79.4 MVAR. (PJM Network Upgrade Number #N5825)	\$ 58,860	\$ 19,620	\$ 14,715	\$ 4,905
<b>Total</b>	<b>\$ 2,838,600</b>	<b>\$ 946,200</b>	<b>\$ 709,650</b>	<b>\$ 236,550</b>

**Direct Connection Schedule:** In order to meet the Back-feed date, a 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” section below.

This assumes that sufficient engineering details are available to evaluate the scope of work.

**24-month Schedule (assume March 2022 start)**

Activity	Start Month	End Month
Preliminary Engineering	1	3
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Testing & Commissioning	24	24

**System Reinforcements Schedule:** A proposed twenty (24) month schedule (assumed March 2022 start) is estimated to complete the engineering, construction and associated activities, as detailed in the “System Reinforcements” section below, assuming an Interconnection Construction Service Agreement has been fully-executed, and a Construction Kick-Off Meeting has occurred. It is assumed these system reinforcements are able to be constructed within the same time frame as the interconnection substation.

## Attachment 1. 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](http://www.firstenergycorp.com/feconnect)

[www.pjm.com/planning/design-engineering/to-tech-standards.aspx](http://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.*

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 <sup>1</sup>
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

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<sup>1</sup> 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.

Wind or Non-Synchronous	Increase	All	0.95 leading to 0.95 lagging <sup>2</sup>	Generator's Terminals
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*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**

Developer is responsible for specifying appropriate equipment and facilities such that the equipment is compatible with Transmission Owner's Transmission System. Developer 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. Developer 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) 1-2-3
- System frequency: 60 hertz
- Elevation, AMSL: 2254 feet
- 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

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<sup>2</sup> 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.



### **Voltage and Current Ratings**

- Nominal phase-to-phase: 345 kV
- Maximum phase-to-phase: 362 kV
- Basic impulse level (BIL): 1300 kV
- Maximum continuous current carrying capacity: 3000 A
- Design fault current: 63 kA
- Single Contingency (breaker failure) clearing time: 30 cycles

### **Clearances and Spacing**

- Recommended rigid bus center-to-center phase spacing: 174"
- Minimum phase-to-phase, metal-to-metal distance: 119"
- Recommended phase-to-ground: 106"
- Minimum phase-to-ground: 104"
- Low bus height above top of foundations (match existing): 20'-0"
- High bus height above top of foundations (match existing): 34'-0"
- Minimum vertical clearance from live parts to grade: 17'-2"
- Minimum horizontal clearance from live parts: 11'-8"
- Minimum conductor clearance above roads in switchyard: 30'-0"
- Minimum bottom of insulator to top of foundation: 8'-6"

## **Attachment 2. Detailed Protection Requirements**

### **Short Circuit Analysis**

#### **Short Circuit Values (Existing Conditions)**

Fault values for the Erie West 345 kV Bus (Y3-092 Interconnection location):

Three phase = 11525 A

Single line to ground = 10507 A

Z1= 0.00128 + j0.01446 p.u.

Z0= 0.00402 + j0.01832 p.u.

#### **Short Circuit Values (Including Y3-092 and 345 kV line from Erie West to Leroy Center)**

Fault values for the Erie West 345 kV Bus (Y3-092 Interconnection location):

Three phase = 13051 A

Single line to ground = 17407 A

Z1= 0.00276 + j0.01252 p.u.

Z0= 0.00023 + j0.00316 p.u.

Impedances are given on 100 MVA and 345 kV bases. Fault values including the Y3-092 project and 345 kV line from Erie West to Leroy Center are from the PJM Aspen System Impact short circuit case that includes Y3-092. The faults provided are bolted, symmetrical values for normal system conditions with a flat 1.0 p.u. voltage profile. Future increases in fault currents are possible and it is the customer's responsibility to upgrade their equipment and/or protective equipment coordination when necessary.

### **General Connection Requirements**

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

**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.**

### **Erie West Substation - Y3-092 345 kV Interconnection Requirements**

The attached relay sketch provides detail on the installation of the new Y3-092 345 kV interconnection at Erie West Substation. Two new 362kV rated, 3000A continuous, 50kA interrupting, nominal 345 kV breakers are required to create a new breaker string and Y3-092 interconnection tie line exit at the south end of the existing 345kV facilities, between the 345 kV No 1 and No 2 buses at Erie West Substation. The 345 kV breakers will be equipped with four sets (12 total) 2000:5 A multi-ratio C800 relay accuracy CTs with a thermal rating factor of 2.0, and one set (3 total) 1500:5 A, single-ratio 0.3B1.8 meter accuracy CTs with a thermal factor of 2.0, for interconnection tie line operational metering. One set of (3) CVTs, one per phase, are required for installation on the Y3-092 line exit. The CVTs shall have dual secondary windings with each winding capable of being connected at either a 3000:1 or an 1800:1 ratio.

### **Y3-092 345 kV Interconnection Tie Line Protection**

The zone of protection for this scheme consists of the protected interconnection tie line between the CTs supplying the relays at Erie West Substation and the CTs on the high side circuit breaker at the HVDC substation. The Y3-092 interconnection tie line primary protection shall be an SEL-411L current differential scheme communicating over a dedicated fiber-optic channel via a direct, relay to relay fiber cable, with direct tripping, non-pilot step distance and directional ground overcurrent elements. The Y3-092 interconnection tie line backup protection shall be an SEL-411L current differential scheme utilizing a second dedicated fiber-optic channel over a direct, relay-to-relay fiber cable, with direct tripping, non-pilot, step distance and directional ground overcurrent elements. Direct Transfer Trip (DTT) for breaker failure to trip will also utilize both SEL-411L relays and their respective fiber optic communication channels between Erie West Substation and the Y3-092 HVDC Substation. Redundancy for primary and backup line protection schemes is required including independent DC supply on separate breakers from a DC panelboard, separate tripping paths energizing separate trip coils in the breakers, independent current transformers, and independent voltage transformers or independent secondary windings of the same voltage transformer for primary and backup relaying. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes, the primary and backup relay fiber optic communication channels must be in separately routed cable paths. The developer may propose additional schemes or relays to protect his facility such as DTT transmitters/receivers, etc. FirstEnergy must review and agree to any additional protection. No automatic reclosing will be applied at the Erie West Substation for faults on the 345kV interconnection tie line.

### **Breaker Failure Relaying**

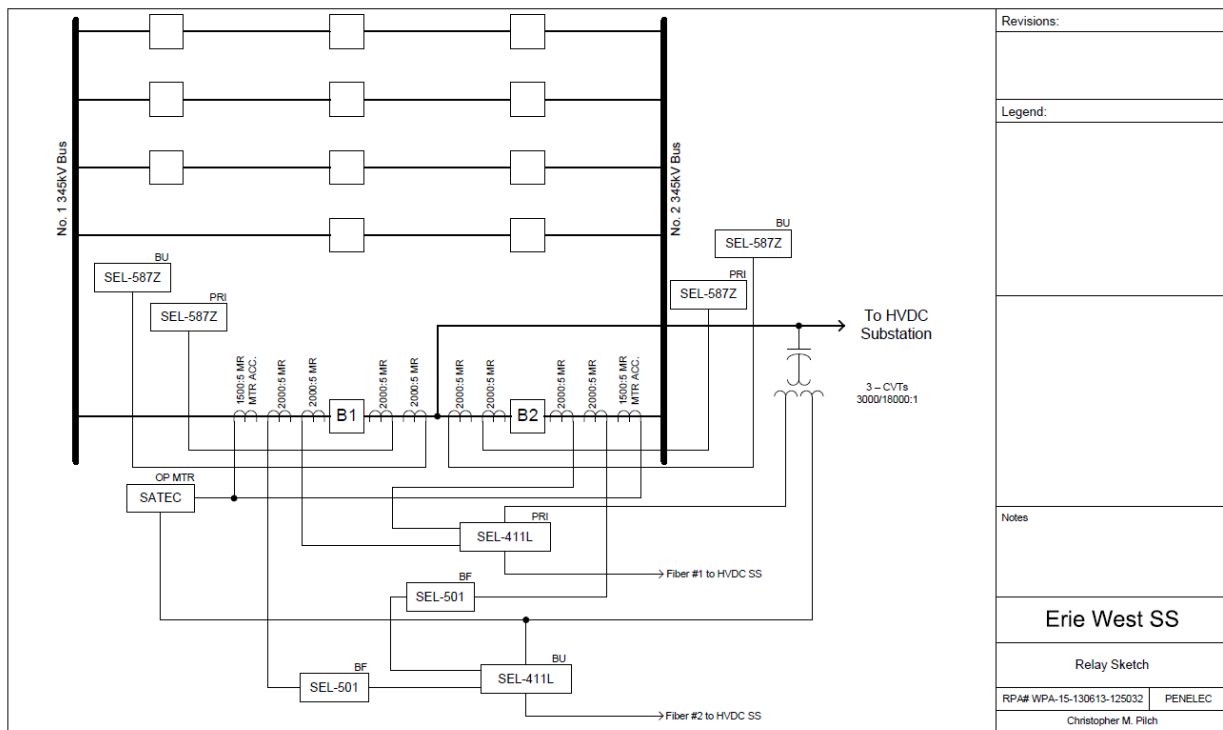
A breaker failure SEL-501 relay shall be utilized on each of the 345 kV circuit breakers on the Y3-092 interconnection tie line exit. The source for the breaker failure relay shall be CTs on either side of the 345 kV circuit breaker. Any protective trip of this breaker shall initiate the breaker failure to trip scheme. The re-trip feature of each SEL-501 breaker failure relay shall be utilized to re-trip the associated 345 kV circuit breaker. DC supplied to power the breaker

failure schemes shall be DC breakers independent from either the primary or backup relaying scheme DC. The 345 kV breaker failure scheme shall trip and block close each electrically adjacent breaker. Tripping shall be done via a hand-reset LOR lockout relay. Additionally, the breaker failure scheme will key direct transfer trip to the remote substation terminal.

### Operational Metering Requirements

Meter accuracy operational metering is required by PJM for the interconnect tie line and will be provided using a Satec meter, and meter accuracy CTs and CVTs at the interconnect tie line exit at Erie West.

### Erie West 234 kV relay sketch (for Protection Requirements)



## Y3-092 HVDC SUBSTATION PROTECTION REQUIREMENTS

It is the responsibility of the Interconnect 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 FE supply
- Synchronizing generation
- Synchronizing facilities between independent transmission system and FE
- Transmission System

The Interconnect Owner is to design their protective system to clear any faults within their zones of protection with one or more of their local circuit breakers. Each zone of protection covering the 345 kV portion of the interconnection system, including the transformer, is to be protected by two independent relay schemes that each provide high speed fault clearing. The terminal breaker at the interconnect end of the direct connection line is to be included in the 345 kV over-lapping zones of protection. The CTs used for the zones of protection covering the 345 kV portion of the system shall use C800 relay accuracy CTs and the CTs should not saturate for the maximum through-fault current that can be experienced by the relay system for the tap ratio in use. Each 345 kV breaker is to have breaker failure to trip protection. The transformer windings shall be wye grounded high side, with two secondary windings, one ungrounded or high impedance grounded wye and a delta tertiary. The low side high impedance grounded wye winding shall be designed such that no more than 400A ground current shall appear at the primary 345 kV line terminal for ground faults on the transformer secondary winding. The HVDC Substation shall not close into the interconnection tie line if it is dead, so that all synchronizing is performed at the HVDC Substation. All communications between Erie West and the HVDC Substation, including relay trip signals, shall utilize fiber optic communications paths so that no copper cables shall be run between these substations for the purpose of carrying currents, trip signals, or communications of any sort.

### **Erie West 345 kV Interconnection Tie Line Protection**

Two SEL-411L relays with separate fiber optic communication channels shall be used for the interconnection tie line protection to match the line relays schemes as described for Erie West Substation. Two fiber optic channels are required for these schemes to obtain high-speed tripping capability for any fault within the tie line zone of protection. Should additional PJM studies indicate that stability issues exist, therefore requiring dual high-speed tripping schemes for stability, the two fiber optic channels must be in separately routed paths. At least one of the two current differential protective relays shall also provide direct tripping non-pilot phase distance and ground time overcurrent protection to cover for a loss of communication. The use of any other relays for interconnection tie line protection will require written approval from FirstEnergy. The 345 kV interconnection tie line protection circuit breaker CTs shall be 2000:5 A MR C800 current transformers. A 345 kV three phase potential source (CVT or equivalent) is required for line terminal relaying.

### **Breaker Failure Relaying**

The interconnection tie line breaker on the high side of the HVDC Substation is to have breaker failure to trip protection. The breaker failure to trip protection must include current sensing Or'd with the breaker status to identify a closed breaker. The breaker failure to trip protection shall

trip all breakers electrically adjacent to the failed breaker at the HVDC Substation and shall send DTT utilizing the SEL-411L line protection relays through both fiber channels to the FirstEnergy Erie West Substation.

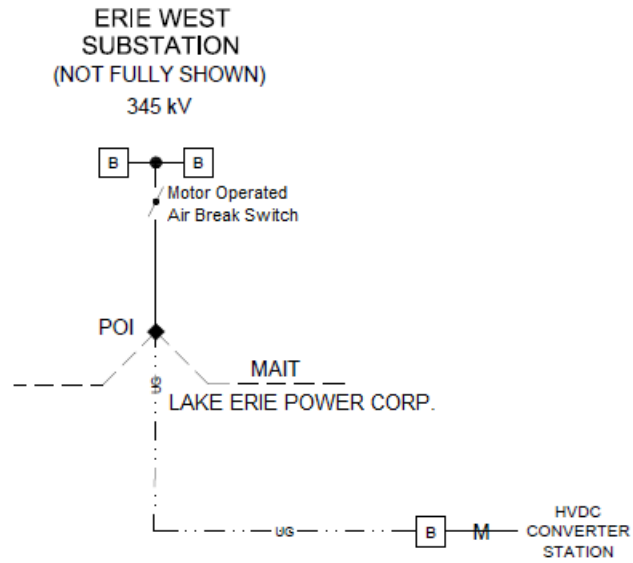
### **DC Power**

The relaying system shall have a reliable source of DC power independent from the AC system or immune to AC system disturbance or loss (for example - DC battery and charger) to assure proper operation of the protection scheme.

### **Approvals**

All relays, relay schemes and relay settings that include 345 kV voltages or currents, or trip any 345 kV circuit breakers shall require the review and approval of FirstEnergy. FirstEnergy will complete detailed relay coordination studies to identify off-site relay setting changes required due to this HVDC interconnection. This may result in additional individual relay replacements being required. The cost of these relay replacements will be borne by the developer.

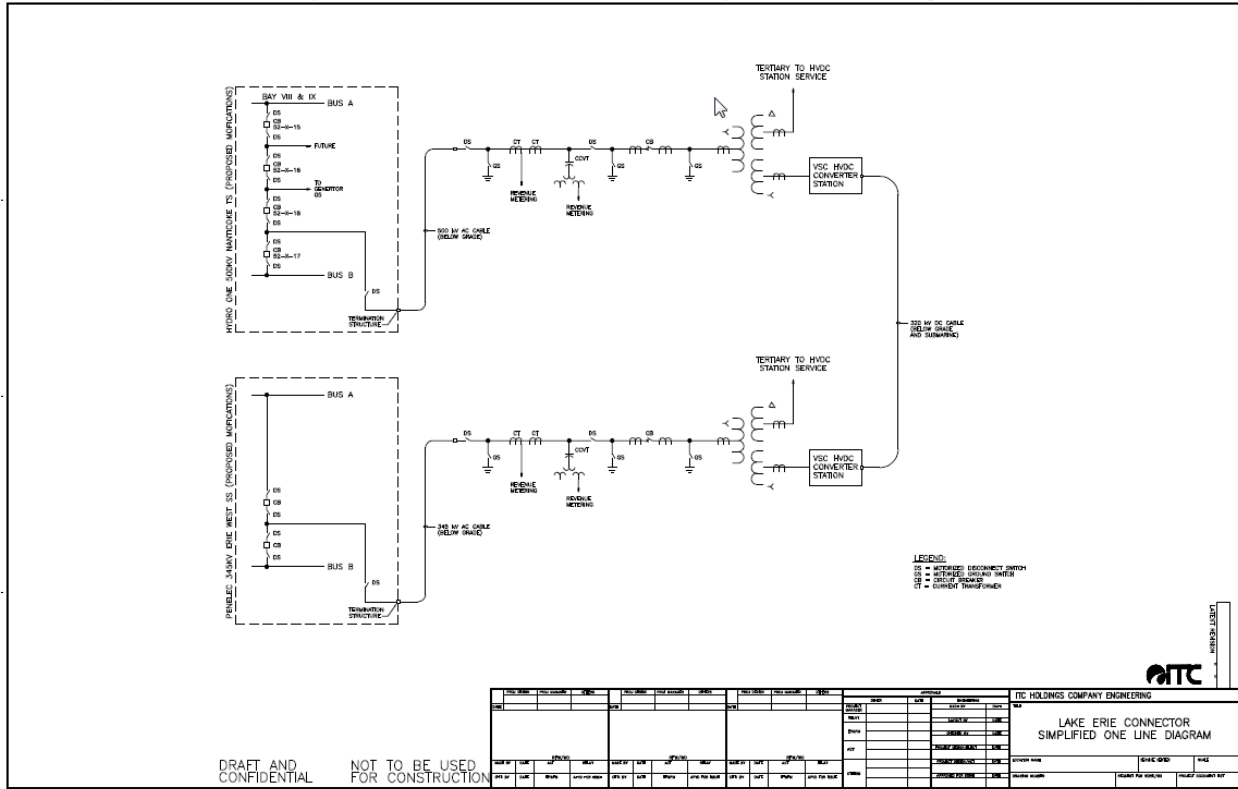
### Attachment 3. Single-Line Diagram Penelec



◆ = POINT OF INTERCONNECTION (POI) WILL BE LOCATED WITHIN THE ERIE WEST 345 KV SUBSTATION FENCE. THE POINT BETWEEN THE DEVELOPER-OWNED TERMINATORS ON THE 345 KV UNDERGROUND ATTACHMENT CABLE AND TRANSMISSION OWNER'S TERMINATION CONDUCTORS/STRUCTURE WILL BE DEFINED AS THE POINT OF INTERCONNECTION.

M = REVENUE METERING

# Attachment 4. Single-Line Diagram Interconnection Customer

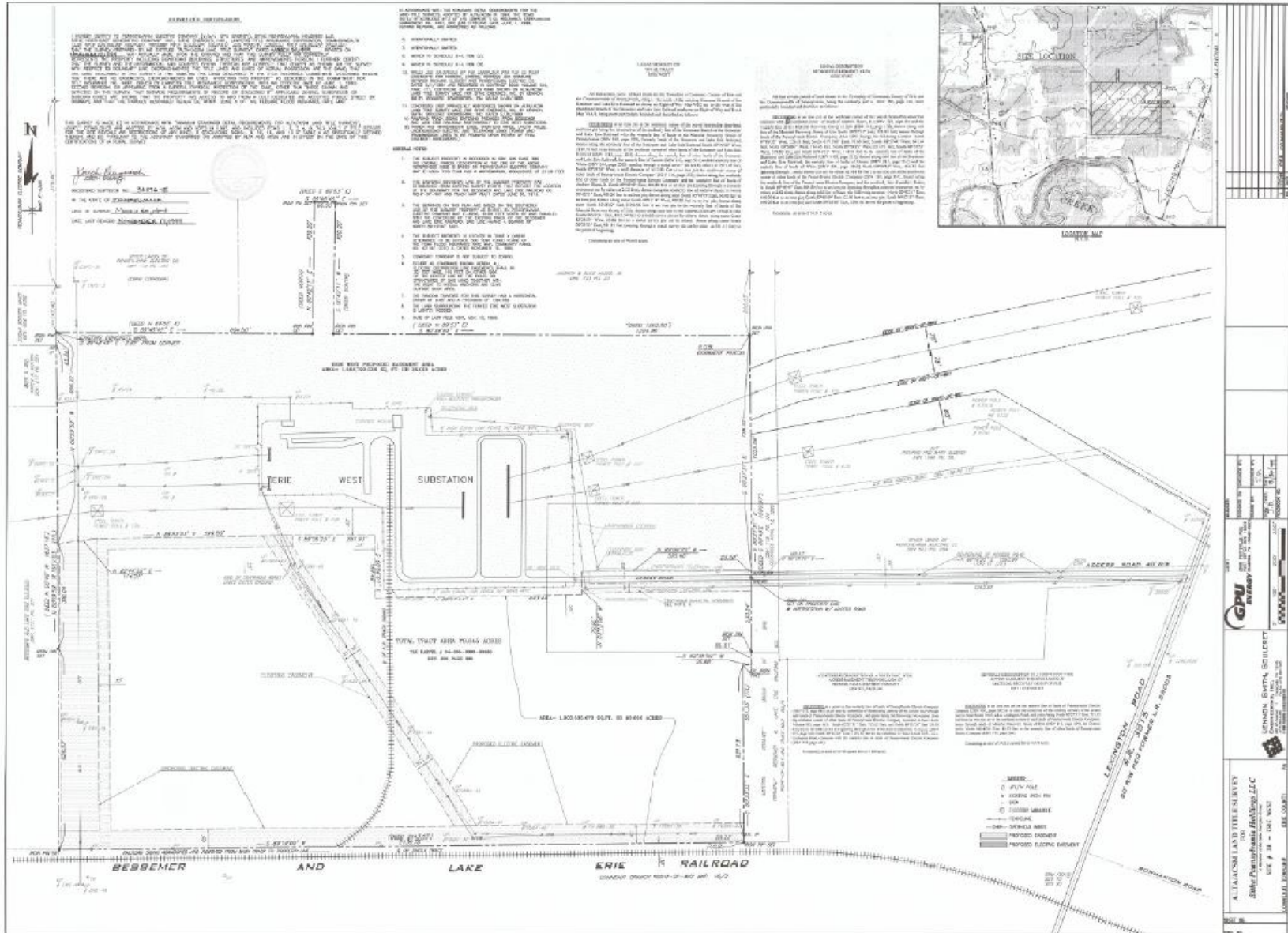




## Attachment 5. Project Location



# Attachment 6. Site Plan



# Attachment 7. Site Plan



**NOTES:**  
 1. TEMPORARY WIDE AREA CLEARANCE IS NOT IN CONFLICT WITH THE EXISTING OPTION CLEARANCE.

**LEGEND:**  
 [Symbol] RELAY  
 [Symbol] WIDE AREA CLEARANCE  
 [Symbol] EXISTING OPTION CLEARANCE  
 [Symbol] TEMPORARY WIDE AREA CLEARANCE

**ROUTE 114**  
 NOT TO SCALE

ISSUED FOR BID											
NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION	NO.	DATE	BY	DESCRIPTION



ITC HOLDINGS COMPANY ENGINEERING  
 L.V.E. I.E. CONNECTOR  
 U.S. UNDERGROUND  
 TRANSMISSION LINE ROUTE

**DRAFT AND CONFIDENTIAL**

**NOT TO BE USED FOR CONSTRUCTION**