Second Revised

Generation Interconnection

Impact Study Report

for

Queue Project AE2-282

EAST FAYETTE 138 KV

43.9 MW Capacity / 67 MW Energy

February 2022

Revision 2

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1 Introduction

This System Impact Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 205, as well as the System Impact Study Agreement between Arche Energy Project, LLC, the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is American Transmission Systems Inc. (ATSI).

2 Preface

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

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or 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.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

3 Revision from March 2, 2020 Report

The AE2-282 System Impact Study report has been updated to reflect retooled load flow and stability analysis. The physical connection costs have not been modified in this revision. Final scope, cost and schedule for the physical interconnection will be provided in the Facilities Study Report.

- **Load Flow:** Retooled analysis shows that no network upgrades required for this project.
- **Stability Analysis:** Analysis results show there are no stability issues.
- **Reactive Power Assessment:** There are no reactive power deficiencies.

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- **Affected Systems:** Updated to reflect no impacts.

4 Revision from February 25, 2020 Report

The report has been updated to remove an upgrade (*n6185 – Build new 138 kV Line from Black River to Astor*) from the "**System Reinforcements**" table in **Section 16**. The customer does not have cost allocation for the overload of the Lorain to Admiral 138 kV facility per PJM Cost Allocation Rules.

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5 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Fulton County, Ohio. The installed facilities will have a total capability of 67 MW with 43.9 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is September 1, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AE2-282
Project Name	EAST FAYETTE 138 KV
Interconnection Customer	Arche Energy Project, LLC
State	Ohio
County	Fulton
Transmission Owner	ATSI
MFO	67
MWE	67
MWC	43.9
Fuel	Solar
Basecase Study Year	2022

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6 Point of Interconnection

The interconnection of the AE2-282 project at the Point of Interconnection (POI) will be accomplished by installing a new 138 kV breaker at the FirstEnergy East Fayette 138 kV substation and connecting the East Fayette 138 kV ring bus substation and the new line exit to the POI. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection line tap and the associated Attachment Facilities.

Attachment 1 shows a one-line diagram of the proposed primary Direct Connection facilities for the AE2-282 generation project to connect to the FirstEnergy ("FE") transmission system. Attachment 2 provides the proposed location for the point of interconnection. IC will be responsible for constructing all the facilities on its side of the POI, including the Attachment Facilities which connect the generator to the FE transmission system's Direct Connection facilities.

7 Cost Summary

The AE2-282 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$291,000
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$1,259,700
System Upgrades	$0
Total Costs	**$1,550,700**

The costs provided above exclude the Contribution in Aid of Construction ("CIAC") Federal Income Tax Gross Up charge. If, at a future date, it is determined that the CIAC Federal Income Tax Gross Up charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

Note: PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. The allocation of costs for a network upgrade will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not closed less than 5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

Note: PJM Open Access Transmission Tariff (OATT) section 217.3A outline cost allocation rules. The rules are further clarified in PJM Manual 14A Attachment B. The allocation of costs for a network upgrade will start with the first Queue project to cause the need for the upgrade. Later queue projects will receive cost allocation contingent on their contribution to the violation and are allocated to the queues that have not closed less than

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5 years following the execution of the first Interconnection Service Agreement which identifies the need for this upgrade.

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8 Transmission Owner Scope of Work

The interconnection of the project at the POI will be accomplished by installing a new 138 kV breaker at the FE East Fayette 138 kV substation and connecting the East Fayette 138 kV ring bus substation and the new line exit to the Primary POI. The IC will be responsible for acquiring all easements, properties, and permits that may be required to construct both the new interconnection line tap and the associated Attachment Facilities.

Attachment 1 shows a one-line diagram of the proposed primary Direct Connection facilities for the AE2-282 generation project to connect to the FE transmission system. Attachment 2 provides the proposed location for the point of interconnection. IC will be responsible for constructing all the facilities on its side of the POI, including the Attachment Facilities which connect the generator to the FE transmission system's Direct Connection facilities.

9 Attachment Facilities

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Install line exit take-off structure, foundations, disconnect switch and associated equipment at ring bus substation	$291,000
Total Attachment Facility Costs	**$291,000**

10 Direct Connection Cost Estimate

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
	$0
Total Direct Connection Facility Costs	$0

11 Non-Direct Connection Cost Estimate

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Install one new 138 kV breaker for the line exit of AE2-282. at East Fayette substation	$1,259,700
Total Non-Direct Connection Facility Costs	**$1,259,700**

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12 Schedule

Based on the scope of work for the Attachment Facilities and the Direct and Non-Direct Connection facilities, it is expected to take a minimum of **15 months** after the signing of an Interconnection Construction Service Agreement to complete the installation. This includes the requirement for the IC to make a preliminary payment that compensates FE for the first three months of the engineering design work that is related to the construction of the interconnection substation. This assumes that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined Direct Connection and network upgrades, and that all transmission system outages will be allowed when requested.

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

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13 Transmission Owner Analysis

13.1 Power Flow Analysis

FE performed an analysis of its underlying transmission <100 kV system. The AE2-282 project did not contribute to any overloads on the FE transmission <100 kV system.

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14 Interconnection Customer Requirements

14.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. Preliminary protection requirements will be provided as part of the Facilities Study. Detailed protection requirements will be provided once the project enters the construction phase.

Regarding the Secondary POI, the IC has requested a non-standard GSU transformer winding configuration. This transformer is in violation of section 14.2.6 of FE's "Requirements for Transmission Connected Facilities" document and will not be accepted. The GSU transformer must have a grounded wye connection on the high (utility) side and a delta connection on the low (generator) side.

14.2 Compliance Issues and Interconnection Customer Requirements

The proposed Customer Facilities must be designed in accordance with FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated 138 kV circuit breaker to protect the AE2-282 generator lead line. A single circuit breaker must be used to protect this line; if the project has several GSU transformers, the individual GSU transformer breakers cannot be used to protect this line.

2. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the FE Transmission System Control Center.

4. Compliance with the FE and PJM generator power factor and voltage control requirements.

5. The execution of a back-up service agreement to serve the customer load supplied from the AE2-282 generation project metering point when the units are out-of-service. This assumes the intent of the IC is to net the generation with the load.

The IC will also be required to meet all PJM, ReliabilityFirst, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to

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comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the FE system.

14.3 Power Factor Requirements

The IC shall design its solar Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the FE transmission system.

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15 Revenue Metering and SCADA Requirements

15.1 PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 8 of Attachment O.

15.1.1 Meteorological Data Reporting Requirement

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

15.2 ATSI Requirements

The IC will be required to comply with all FE revenue metering requirements for generation interconnection customers which can be found in FE's "Requirements for Transmission Connected Facilities" document located at: http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

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16 Network Impacts

The Queue Project AE2-282 was evaluated as a 67.0 MW (Capacity 43.9 MW) injection at the East Fayette 138 kV substation in the ATSI area. Project AE2-282 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE2-282 was studied with a commercial probability of 100%. Potential network impacts were as follows:

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Summer Peak Load Flow

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16.1 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

16.2 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

16.3 Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

16.4 Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

None

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17 System Reinforcements

None

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18 Flow Gate Details

The following indices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact. It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

None

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Affected Systems

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19 Affected Systems

19.1 NYISO

None

19.2 MISO

None

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Short Circuit

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20 Short Circuit

The following Breakers are overdutied:

None.

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Stability

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21 Stability Analysis and Reactive Power Requirement

Generator Interconnection Request AE2-282 is for a 67 MW Maximum Facility Output (MFO) solar generating facility, which consists of 21 Power Electronics FS3430M solar inverters. Project AE2-282 is connected to the American Transmission Systems Inc. (ATSI) zone in First Energy (FE) transmission system by installing a new 138 kV breaker at the East Fayette 138 kV substation. This solar generating facility will connect into the East Fayette Substation via a 1.38 miles 138 kV transmission line. The Point of Interconnection (POI) will be where the Interconnection Customer gen-tie line attaches to the line terminal dead-end structure. The AE2-282 solar generating facility will be located in Fulton County, Ohio.

This report describes a dynamic simulation analysis of AE2-282 as part of the overall system impact study. The load flow scenario for the analysis was based on the RTEP 2022 peak load case, modified to include applicable queue projects. AE2-282 has been dispatched online at maximum power output, with approximately unity power factor at the high side of GSU, 1.01 pu scheduled voltage at the generator terminal and 1.01 pu voltage at the POI bus.

AE2-282 was tested for compliance with NERC, PJM, Transmission Owner, and other applicable criteria. 48 contingencies were studied, each with a 20 second simulation time period (with 1.0 second initial run prior to any events). Studied faults included:

a) Steady state operation (Category P0);

b) Three phase faults with normal clearing time on the intact network (Category P1);

c) Single phase to ground faults with delayed clearing due to a stuck breaker (Category P4);

d) Single phase faults placed at 80% of the line with delayed (Zone 2) clearing at line end remote from the fault due to primary communications/relay failure (Category P5);

For all 48 fault contingencies tested on the 2022 peak load case:

a) AE2-282 was able to ride through the faults (except for faults where protective action trips a generator(s)).

b) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

Please note that a 1.12 MW fictitious load (“FL”) shall be added to the high voltage side of GSU to ensure the MFO at the POI does not exceed the requested MFO.

The queue project, AE2-282, with planned compensation meets both the 0.95 lagging and 0.95 leading power factor requirement at the high side of facility main transformer.

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Light Load

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22 Light Load Analysis

Light Load analysis not required for solar projects.

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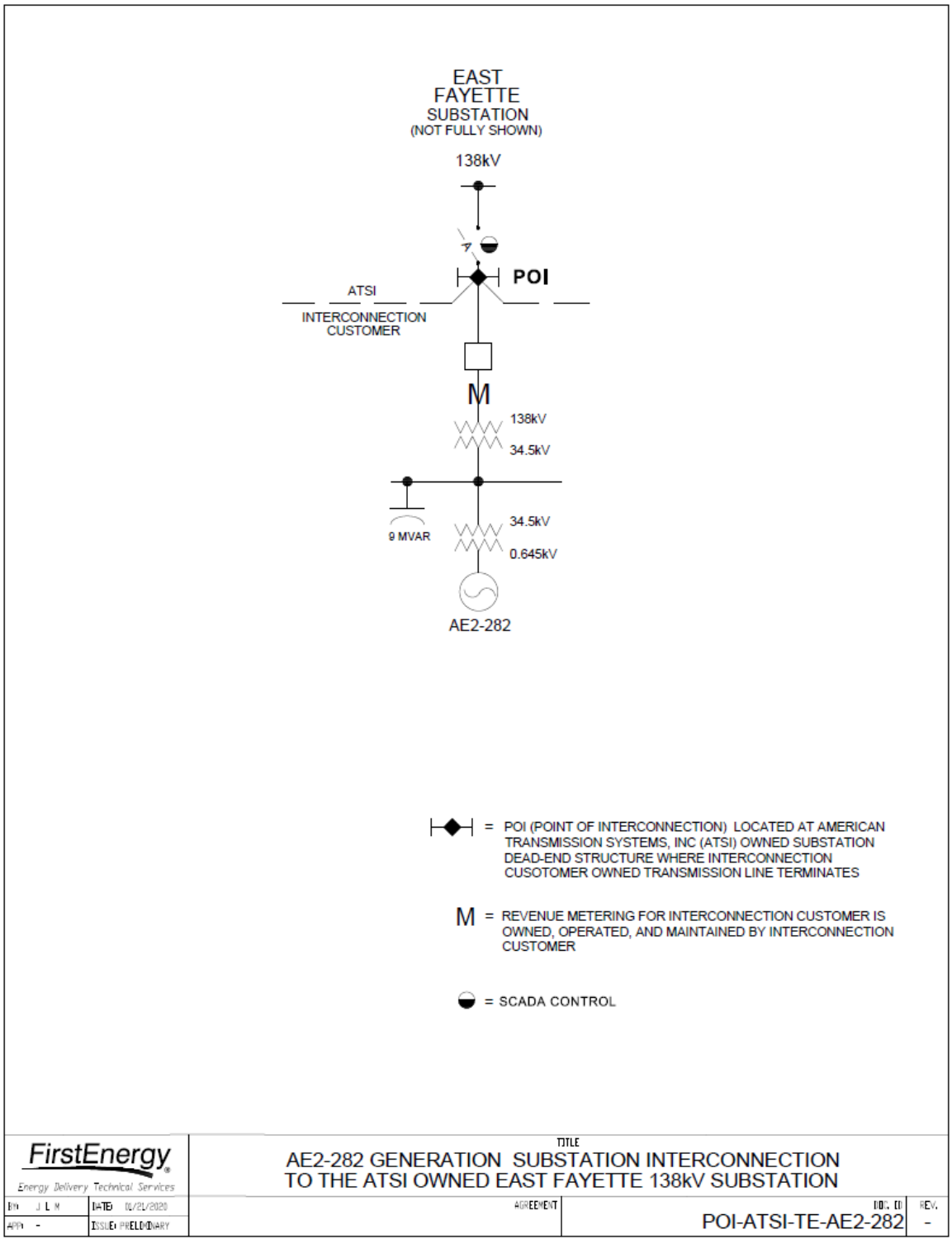
23 Attachment 1 – One Line



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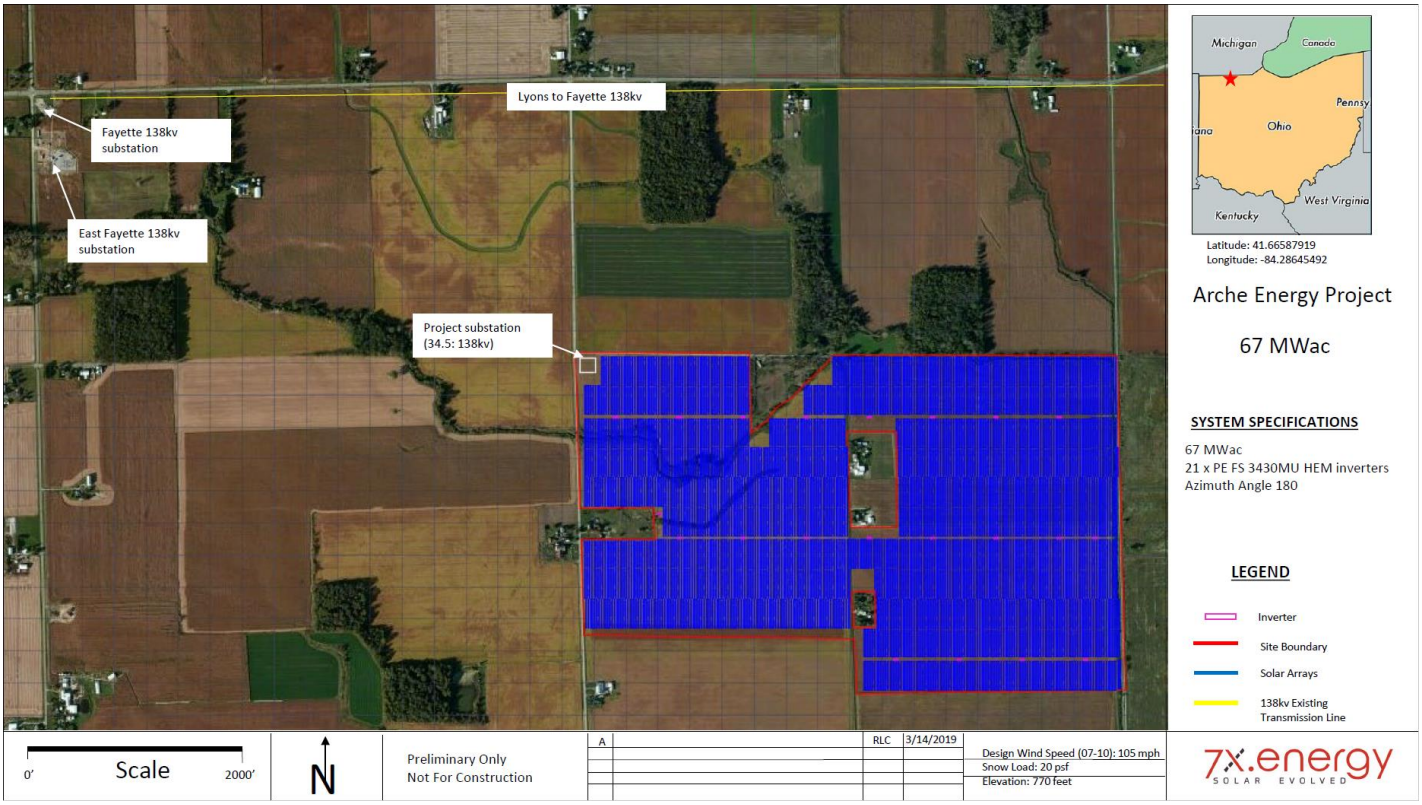
24 Attachment 2 – Project Location



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