

***PJM Generator Interconnection Request
Queue #X2-053
Amsterdam (Apex Sanitary Landfill) 12.47kV
Feasibility Study***

**674119
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Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, 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 impact study is performed.

The Feasibility 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.

X2-053 Amsterdam (Apex Sanitary Landfill) 12.47kV Feasibility/Impact Study Report

Option #1 – Connection to the Amsterdam Germano-Annapolis (01) 12.47kV Circuit

Request

The Interconnection Customer (“Customer” or "IC") has requested a feasibility study for the interconnection of 6.4 MW of synchronous generation through the PJM Interconnection (“Transmission Provider”), with the American Electric Power (AEP) Distribution System. The relatively large size of this Distributed Generation (DG) Customer on this Distribution feeder requires that an AEP impact study be performed. The AEP guide titled Customer Guide for the Interconnection of Distributed Resources to the American Electric Power Distribution System is referred to throughout this document and the DG Customer will receive a copy of this with this impact study document.

Disclaimer

The contents of this study apply only to the equipment as described in the Kupper Engineering Inc., provided drawings, one-line diagrams, equipment specifications and email correspondence to supplement the original information as disseminated in the “Generation Interconnection Feasibility Study Agreement” between the IC and PJM Interconnection LLC. All modeling is based on the Customer equipment connected at the Point of Common Coupling as described below.

Point of Common Coupling

The Point of Common Coupling (PCC) between AEP and the Customer was studied at AEP pole 40810087000066 on the APEX Sanitary Landfill property at or very near to latitude 40.4304132°, longitude -80.9066660°, and south of Amsterdam, Ohio. All modeling is based on the Customer equipment connected through assumed lengths of Customer overhead conductor and underground cable to the PCC.

Modeling and Assumptions

AEP Distribution System

The AEP distribution feeder that will provide electric service to the DG Customer is a radially configured three-phase, multi-grounded neutral, four wire, wye system. The nominal primary voltage of this feeder is 12.47 kV line-to-line, 7.2 kV line-to-ground. Nominal frequency is 60 hertz. This feeder is known as the Germano-Annapolis (01) circuit, and originates at company-owned facilities at Amsterdam Station (5044).

Another feeder is connected to the bus at Amsterdam Station, the Amsterdam-Bergholtz 12 kV circuit. Both bus connected feeders tie to the transmission system through a 69/12 kV, 7.5/9.375 MVA transformer.

The overhead wires at the Point of Common Coupling will be 3 – 556 kcmil Aluminum (AL) phase wires with a #4/0 Aluminum Alloy (AA) neutral wire.

IC Connected Electrical DG Equipment

The major electro-mechanical equipment connected by the DG Customer at or beyond the PCC will include:

Main Disconnect Switch – Three-phase aerial disconnect switch.

Primary Breaker and Relay – Vacuum Breaker, 15 kV class, 1200 Amp, 95 kV BIL metal clad circuit breaker, 350 MVA, 125 V DC Charge, Close, Trip, (Provided with neutral bus). Schweitzer 351-S7 Relay.

Transformer – 6.0/7.5 MVA, OA/FA, 55°C Rise, 150 kV BIL Rating, 12.47/7.2 kV Grounded Wye Primary, 4.16/2.4 kV Grounded Wye Secondary, 3Ø, 7% Impedance.

Synchronous Generators – (4) Caterpillar 6 pole, Permanent Magnet Generators with 3520 Methane Gas Engine Prime Movers, 1200 RPM, 4160 V, 246.6 FLA, three-phase, Y connected with 6 ohm grounding resistor, 60 Hz, 1600 kW at ± 0.9 power factor, 96.1% efficiency. The Customer has indicated that this equipment will be operated at or very near to unity power factor.

Generator Breakers and Relays – Vacuum Breaker, 5 kV, 1200 Amp. Bassler Electric BE1-GPS100 Generator Protection Management System Relay.

Ancillary Load and Transformer – 500 kVA @ 0.85 pf lag, 480 V. Connected to a 4.16 kV bus through a 750/840 kVA Transformer, 55°/65° C Rise, 4.16 – .480Y/.277 kV Delta / Grounded Wye, 5.75% Impedance. Specific ancillary load motor data was not provided. The effects of starting and operating the motor(s) will need to be evaluated prior to permitting interconnection of this equipment to the AEP system.

Overhead Conductor and Underground Cable – Assumed lengths and impedances of overhead conductors and underground cables depicted on the Customer provided Electrical Single Line Diagram, Sheet E4.01, were modeled with similar known impedances of AEP conductors and cables. There is a tentative future concept for additional generation to be installed at this site, but the effects of the additional generation were not to be included in this study specifically.

System Analysis

Cyme Distribution Network Analysis (CYMDIST) software, version 5.02, revision 4 was utilized to model the DG effects on the following:

1. System Voltage Levels
2. System Load Flows
3. System Fault Levels and Overcurrent Protection

AEP Voltage, Fault Values and Thévenin Impedances

The following are the AEP voltages, symmetrical fault values and Thévenin sequence impedances calculated at the PCC without the DG Customer connected, assuming AEP's overhead line has been reconducted with 556 AL phase wires and a 4/0 neutral wire:

- PCC Peak Average Steady State Voltage: 124.4 volts or 1.037 per unit volts
- Fault Current: LLL = 2055 amps, LG = 1690 amps
- Positive and Negative Sequence Impedances: $Z_+ = Z_- = 0.5802 + j 3.4550$ ohms at 12.47 kV \pm 5%.
- Zero Sequence Impedance: $Z_0 = 1.4470 + j 6.2530$ ohms at 12.47/7.2 kV \pm 5%.

System Load Flow

Under steady state conditions and the existing circuit configuration, the circuit models indicate that the synchronous generators would need to operate at -0.985 lagging power factor (pf) to not adversely affect the AEP distribution System. The peak internal ancillary demand for this DG Customer is 500 kW and total output of the aggregate DG sources is 6.4 MW. The net real power that will flow into the AEP system is approximately 6 MW. The relative large size of the Customer's total output will back feed the 69/12 kV station transformer at Amsterdam Station and supply energy into AEP's transmission system continuously.

Currently, AEP's distribution system is operated and configured such that the DG Customer cannot operate the synchronous generators at any power factor other than -0.985 lagging pf. Deviation from this power factor will cause adverse conditions on the AEP system. To extend the range of operation for this Customer from -0.985 pf lagging and permit maximum power flow, AEP will need to construct approximately two miles of new line and reconductor another mile of line with 556 AL phase wires and a 4/0 neutral wire.

System Voltage Levels

AEP is obligated to provide and maintain voltage levels to all distribution customers within the acceptable limits of 120 volts \pm 5% (114 volts to 126 volts). Under steady

state conditions and the existing circuit configuration, the circuit models indicate that operating the synchronous generators at -0.985 pf would produce a voltage of 126 volts or 1.05 per unit volts at the PCC. The DG Customer intends to operate the units at or near unity power factor. However, as the unit's pf approaches unity, unacceptable voltages in excess of 126 volts are seen at the PCC.

Currently, AEP's distribution system is operated and configured such that the Customer cannot operate the synchronous generators at unity pf without producing adverse voltages on the AEP system. To extend the range of operation for this Customer from -0.985 pf lagging and correct the adverse voltages caused by this Customer, AEP will need to set the controls of the station bus regulators for Co-generation mode and lower the station bus midpoint voltage to 122 volts when power will be in reverse flow through the station transformer.

Maximum Available Fault Current

The addition of this DG Customer equipment will not subject the AEP overcurrent protection devices to excessive fault currents. It will not be necessary to upgrade the AEP distribution system overcurrent protection equipment for the additional fault current contribution from the Customer resources. However, a detailed study will need to be performed on both of the distribution feeders at Amsterdam Station. AEP will install a three phase electronic recloser to mitigate the exposure of this Customer from downstream faults. The station breaker will have sequence coordination with the electronic recloser to assure service continuity for the DG.

Anti-Islanding

The PCC is within the zone of protection of the AEP Distribution station breaker. The first reclose interval for the Amsterdam Station – Amsterdam-Bergholtz 12 kV Circuit is 3 seconds. IEEE 1547-2003 establishes criteria for anti-islanding protection which is required for the installation of DG resources. The station breaker reclose interval exceeds the 2 second unintentional islanding criteria as established in IEEE 1547-2003 thus permitting the DG to trip off line prior to the first AEP Distribution breaker reclose.

System Protection

The DG Customer responsibilities include providing adequate protection to AEP facilities due to events arising from the operation of the Distributed Resource under all AEP distribution system operating conditions. Details of the Customer's protective devices relay settings will need to be coordinated with AEP's overcurrent protection devices prior to paralleling with the AEP Distribution System. The Customer is responsible for the protection of their own facility under all AEP distribution system operating conditions whether the DG is connected to the AEP system or not, including but not limited to:

1. Abnormal voltage or frequency
2. Loss of a single phase of supply
3. Equipment failure
4. Distribution system faults
5. Lightning

6. Excessive harmonic voltages
7. Excessive negative sequence voltages
8. Separation from supply
9. Loss of synchronization

This study does not cover self-protection of the Distributed Resource or all operating requirements for the Distributed Resource. AEP's review and authorization for parallel operation shall not be construed as confirming or endorsing the Customer's interconnection design, or as warranting the Distributed Resource and interconnection systems' safety, durability or reliability. AEP shall not, by reason of such review or lack of review, be responsible for the strength, adequacy or capacity of such equipment.

IEEE 1547-2003, Standard for Interconnecting Distributed Resources with Electric Power Systems is the basis for the interconnection Technical Requirements and applies to all Distributed Resources technologies.

The interconnection system hardware and software used by a DG to meet the technical requirements do not have to be located at the PCC. However, the technical requirements shall be met at the PCC. For additional information on interconnection technical requirements please refer to the AEP Customer Guide for the Interconnection of Distributed Resources to the American Electric Power Distribution System.

Metering

The DG Customer interconnection with the AEP system will be metered by establishing a 12.47 kV primary metering location at the PCC. The Customer has requested and will be provided pulse information from the meter.

Communication

An AEP communication system will be installed to remotely monitor load and other quantities in real time as metered at the PCC for operation and planning purposes.

Summary

This impact study is limited to the equipment as described in the Kupper Engineering Inc, provided drawings, one-line diagrams, equipment specifications and email correspondence to supplement the original information as disseminated in the “Generation Interconnection Feasibility Study Agreement” between the IC and PJM Interconnection LLC.

The cost of any damage resulting from a system condition caused by the installation and/or operation of the DG Customer will be borne by the owner of the DG facility.

Abnormal distribution system events will be addressed on an individual basis through the AEP system operator. Corrective action shall be based on the judgment of the AEP system operator. Possible corrective action can include but is not limited to DG isolation from the distribution system.

This review has been limited to items which may affect the AEP system or to suggestions which may improve operations. The DG Customer must take all necessary steps to assure compliance with all laws, ordinances, building codes and other applicable regulations. Approval of this connection by AEP, when granted, is not an endorsement of a particular design nor does it assure fitness to accomplish an intended function.

Any additional AEP work to mitigate power quality issues not foreseen by this study but associated with the interconnection of the DG will be at the sole cost and expense of the Customer.

AEP System Improvements for Interconnection

The proposed DG interconnection will require the following improvements to AEP facilities:

1. Construct 2 miles of three-phase overhead line with 556 AL phase wires and a 4/0 AA neutral wire. The maximum capacity of this section of line will be 15.7 MVA.
2. Reconductor 1 mile of three phase overhead line with 556 AL phase wires and a 4/0 AA neutral wire. The maximum capacity of this section of line will be 15.7 MVA.
3. Replace two transmission structures to accommodate the new distribution wires.
4. Install a three-phase electronically controlled recloser.
5. Install a three-phase primary meter at the PCC.
6. Install a communication system to tie the AEP primary metering into the AEP remote data monitoring system.
7. Re-coordinate both circuits at Amsterdam Station, incorporate the new three phase recloser (Item 4) and coordinate with Customer’s 12 kV breaker.
8. Reconfigure the Amsterdam Station bus regulators for Co-generation operation.

Additional DG Customer Requirements for Interconnection

The DG Customer must meet all the requirements in the AEP Customer Guide for the Interconnection of Distributed Resources to the American Electric Power Distribution System. Additionally, the Customer must meet the following requirements:

A. The Customer indicates a 7.5 MVA grounded-wye primary / grounded-wye secondary and 750 kVA delta primary / grounded-wye secondary will be installed. Use of delta connected transformers will require additional provisions of the AEP Energy Distribution Guideline for Primary Metering Installations to be implemented by the Customer. This includes, but is not limited to, loss of phase protection to be incorporated into the Customer's 12.47 kV breaker to assure disconnection from the AEP system in the event that an AEP phase wire would lose continuity with the AEP system.

B. It is requested that the Customer's grounded-wye primary / grounded-wye secondary connected type transformers be of a five-limb Core Form design or a Shell Form design.

C. The Customer shall terminate its overhead line on the AEP primary metering structure utilizing the dead-ends provided by AEP. AEP must be notified well in advance to ensure that proper material is on hand. The metering structure will be designed for the maximum AEP line tension along with an adequate margin of safety. AEP maximum design tension is 3,000 lbs. per phase conductor and 3,000 lbs. for the neutral conductor (NESC medium loading conditions). The Customer shall contact AEP Ohio Project Design to insure the installation location for the primary metering structure meets the needs of both parties.

D. AEP requires that the Customer install a group-operated load break disconnecting device located on their last structure. In this case the Customer has indicated the use of a three phase aerial disconnect. The disconnect device must be group operated. The disconnecting device must be accessible to AEP personnel, must be suitable for use by AEP personnel at all times and must be suitable for use by AEP as a protective tagging location. The disconnecting device shall have a visible open gap when in the open position and be capable of being locked in the open position. Each disconnecting device must have a ground grid designed in accordance with specifications to be provided by AEP. Operation must be restricted to AEP personnel and properly trained operators designated by the interconnection customer. The disconnecting device must comply with the applicable current ANSI Standard from the C37 series of standards that specifies the requirements for circuit breakers, reclosers and interrupting switches.

E. The Customer is required to install an overcurrent protective device on the load side of their GOAB. This would meet the requirement in the Energy Distribution Guideline for Primary Metering Installations that the Customer install a protective device within one span of the terminating structure. This device will isolate faults from there to the Customer-owned 12kV equipment. The Customer shall contact AEP Ohio Project Design to coordinate the device or other 12 kV protective equipment with AEP protective settings.

F. The Customer's protective relays must be utilized to detect line-to-ground faults. The Customer shall provide adequate protection to comply with IEEE Standard 1547 to clear their generation

source for all types of faults on the AEP system including any breaker failure event. Adequate protection requires that all fault types are cleared before equipment damage occurs to AEP facilities. If the Customer fails to provide adequate protection for faults on the AEP system, then the Customer will pay all costs associated with AEP facility damages.

G. For any event where AEP Transmission and Distribution source breakers trip and isolate the Customer's facilities, the Customer shall ensure that their generation equipment is disconnected from AEP facilities in accordance with requirements established in IEEE Standard 1547 prior to automatic reclosure by AEP. Automatic reclosing out-of-phase with the Customer's aggregate generation equipment may cause damage to the Customer's equipment. The Customer is solely responsible for the protection of their equipment from automatic reclosing by AEP.

H. All synchronization of the Customer's aggregate generation with AEP must be done by the Customer's relaying and equipment.

I. The specific ancillary load motor data was not provided. The effects of starting and operating the motor(s) will need to be evaluated prior to permitting interconnection of this equipment to the AEP system.

J. During the planned paralleling or disconnection of the DG Customer's unit(s) from the AEP Distribution system, it should be noted that the ramping up or ramping down of the unit(s) real power output will need to be performed incrementally to allow the station bus regulators to step adjust to the changing voltage conditions. The regulators may also require additional response time to transition from the normal mode of operation to the cogeneration mode to accommodate the reverse power flow into AEP's system.

K. The Customer has indicated that they will operate the units at unity power factor. AEP's distribution system has been designed to accommodate a small variance from unity pf. The Customer must ensure that it does not allow the units to produce vars (leading) or absorb vars (lagging) to the extent that it would drive voltage at the PCC outside of the 114-126 volt limit for all system loading conditions. This shall be verified as part of the required testing described in the next item.

L. The documentation submitted by the Customer does not explicitly state that the installation meets IEEE 1547 interconnection guidelines. Ohio Administrative Code requires installations up to 20 MW in size meet IEEE 1547. Therefore:

- The DG Customer must conduct testing according to the procedures of IEEE Standard 1547.1-2005 to verify compliance with the requirements of IEEE Standard 1547-2003.
- Prior to any IEEE 1547.1 specified testing, the DG Customer must supply to AEP proposed testing procedures.
- Prior to any IEEE 1547.1 specified testing, the DG Customer must supply to AEP a 3rd party to conduct the testing.

- AEP must approve the test procedures and the 3rd party before testing may begin.
- The 3rd party shall provide certification that the DG Customer installation meets IEEE 1547. Documentation and results of the testing must be provided to AEP before final approval is granted for interconnection.
- Upon AEP verification that all testing shows the DG Customer is in compliance with IEEE 1547, the Customer may connect and begin parallel operation with AEP distribution facilities.

Cost to the DG Customer

The conceptual estimate for the cost of AEP improvements previously described is **\$514,500**.

Federal Gross-Up Tax, at the applicable rate, must be added to the total cost of the improvements.

It is estimated that the process for AEP to design and construct these improvements will take approximately 6 to 12 months from the time an agreement is reached between AEP and the DG Customer to proceed. However, the uncertainty of right of way acquisition could lengthen this time.

Network Impacts

The Queue Project #X2-053 was studied as a(n) 6.4MW(Capacity 6.4MW) injection as a tap between Amsterdam-Millers 69kV station in the AEP area. Project #X2-053 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Generator Deliverability

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

No problems identified

Multiple Facility Contingency

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

No problems identified

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

No problems identified

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.)

No violations identified.

New System Reinforcements

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None

Option #2 – Connection to the 69kV System

General

The IC proposes to install PJM Project #X2-053, a 6.4 MW (6.4 MW capacity) methane generating facility. The point of interconnection evaluated is a new 69 kV 3-Breaker Ring Bus station connected to the East Amsterdam – Miller 69 kV circuit (Figure 2) or via a single breaker interconnection at the Amsterdam 69 kV station (Figure 3). The IC will be required to construct a 2.3 mile 69 kV line to connect to the Amsterdam 69 kV station. The location of the wind generating facility is in Amsterdam, Ohio.

The proposed in service date is January 31, 2013.

Attachment Facilities

The secondary point of interconnection evaluated is a new 69 kV 3-Breaker Ring Bus station connected to the East Amsterdam – Miller 69 kV circuit (Figure 2) or via a single breaker interconnection at the Amsterdam 69 kV station (Figure 3). The single breaker connection at the Amsterdam 69 kV station will need to be reviewed by PNC in the Impact Study. The IC will be required to construct a 2.3 mile 69 kV line to connect to Amsterdam 69 kV station. The interconnection cost for a new 69 kV 3-Breaker Ring Bus is **\$2,100,000**. The interconnection

cost for a single 69 kV breaker is **\$350,000**. Protection schemes will need to be modified and 69 kV metering will need to be installed.

It is understood that the IC will be responsible for all costs associated with connecting their 6.4 MW generation to either the Amsterdam 69 kV station or to the East Amsterdam – Miller 69 kV circuit. Note that the X2-053 station facilities and any facilities outside the new station were not included in the cost estimates. These are assumed to be PPL’s responsibility. The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately 18 months after obtaining the authorization to construct the facilities as outlined above.

AEP Local etwork Impacts

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet single contingency performance criteria in accordance with the AEP FERC Form 715. Therefore, this criterion was used to assess the impact of the proposed facility on the AEP System. The project was studied as a 6.4 MW (6.4 MW capacity) generating facility consistent with the interconnection application. Project #X2-053 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Normal System (2015 Summer Conditions Capacity Level)

None

Single Contingency (2015 Summer Conditions Capacity Level)

None

Multiple Contingency (2015 Summer Conditions Capacity Level)

None

Contribution to Previously Identified Overloads (2015 Summer Conditions Capacity Level)

None

Normal System (2015 Summer Conditions Full Output)

None

Single Contingency (2015 Summer Conditions Full Output)

None

Multiple Contingency (2015 Summer Conditions Full Output)

None

Contribution to Previously Identified Overloads (2015 Summer Conditions Full Output)

None

Short Circuit Analysis

None

Stability Analysis

Not required

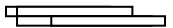
Additional Limitations of Concern

None

Local/Network Upgrades

None

Network Impacts



The Queue Project #X2-053 was studied as a(n) 6.4MW(Capacity 6.4MW) injection as a tap between Amsterdam-Millers 69kV station in the AEP area. Project #X2-053 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Generator Deliverability

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

No problems identified

Multiple Facility Contingency

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

No problems identified

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

No problems identified

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.)

No violations identified.

New System Reinforcements

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None

New In-Line 3-Breaker Ring Bus Connection

X2-053

Figure 2: New 3-Breaker Ring Bus Point of Interconnection

Figure 3: Connecting at Amsterdam 69 kV Station