Generation Interconnection

Combined Feasibility / Impact Study Report

for

Queue Project AE1-039

WEST STREET (ORCHARD HILLS) 12.47 KV

0.8 MW Capacity / 0.8 MW Energy

August, 2019

General

The Interconnection Customer (IC), has proposed a 0.8 MW (0.8 MW Capacity) uprate to the existing Methane generating facility located in Berrien, Watervliet, Michigan. The installed facilities will have a capability of 4.0 MW (3.8 MW Capacity). Note that this project is an increase to the Interconnection Customer's X1-042 project, which will share the same property and connection point. Please refer to Figure 1 for a SLD of AE1-039

Queue Number	**AE1-039**
Project Name	WEST STREET (ORCHARD HILLS) 12.47 KV
Interconnection Customer	Energy Developments Watervliet, LLC
State	Michigan
County	Berrien
Transmission Owner	AEP
MFO	4.0
MWE	0.8
MWC	0.8
Fuel	Methane
Basecase Study Year	2022

Point of Interconnection

AE1-039 is an uprate to the X1-042 queue position.

Cost Summary

The AE1-039 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$0
Direct Connection Network Upgrade	$0
Non Direct Connection Network Upgrades	$0
Total Costs	$0

In addition, the AE1-039 project may be responsible for a contribution to the following costs

Description	Total Cost
System Upgrades	$0

Cost allocations for these upgrades will be provided in the System Impact Study Report.

Transmission Owner Scope of Work

Attachment Facilities

The AE1-039 project will utilize the existing facilities constructed for the X1-042 project, however American Electric Power Distribution Planning has completed a Distribution Impact Study (DIS) for the EDL Energy "Watervliet" Interconnection Request associated with PJM project AE1-039 connecting an additional 800 kW (A.C.) generator, for a total system capacity of 4,000 kW AC to Watervliet Substation in Watervliet, MI.

Below is listed a summary of the requirements and cost estimates identified by distribution planning as associated with the details of this interconnection.

- The generating facility must install power factor and current limiting equipment and operate within parameters outlined in the "Electrical Description and Operations Manual - Energy Developments, Orchard Hill landfill, Watervliet, MI Original plant construction: 2010, Generator #3 addition: 2019. Issued June 6, 2019"
- There is no cost to improve AEP facilities if the above stated equipment and operating conditions are enacted.
- If the above equipment and operating conditions cannot be enacted and maintained, a high speed transfer trip scheme would need to be constructed, including installation of a three phase 139 kV bus potential transformer, a transfer trip relay, and a fiber option line for communication.
- In the event of the need for AEP to construct a high speed transfer trip scheme, the estimated cost to upgrade would be $600,000

A copy of the "AE1-039 Watervliet Electrical System Operations Guide, issued June 26, 2019, and Distribution Impact Study are included in this Combined Study Report as Appendix 1 and 2 respectively.

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
	$0
	$0
Total Direct Connection Facility Costs	$0

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
	$0
	$0
	$0
Total Non-Direct Connection Facility Costs	$0

Revenue Metering and SCADA Requirements

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.

AEP Requirements

The existing metering is sufficient.

Network Impacts

The Queue Project AE1-039 was evaluated as a 0.8 MW (Capacity 0.8 MW) uprate to the X1-042 queue position which is injection at the West St. 138kV substation in the AEP area. Project AE1-039 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AE1-039 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Load Flow

Generation Deliverability

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

None

Multiple Facility Contingency

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

None

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

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

System Reinforcements

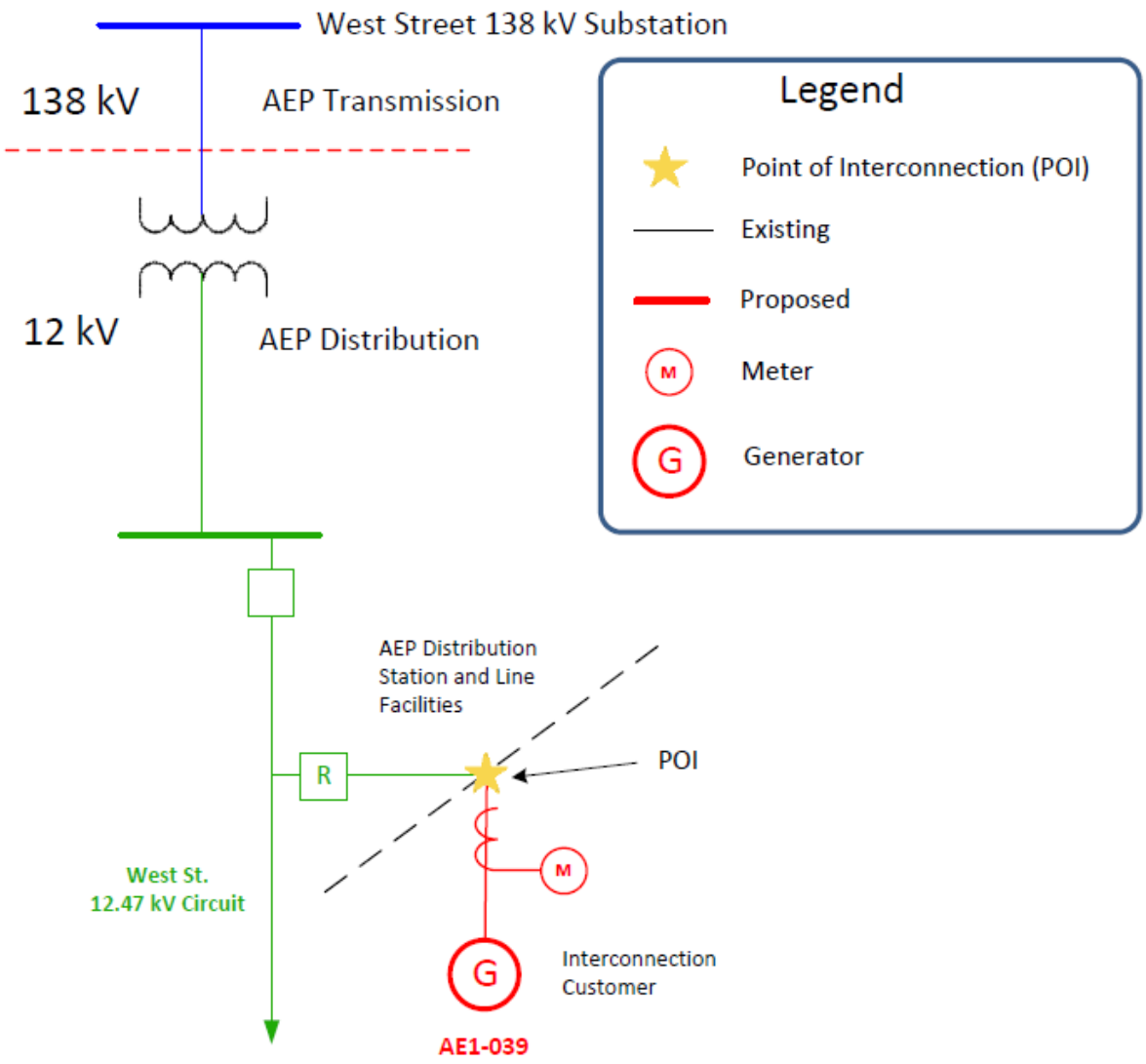
None

Short Circuit

The following Breakers are overduty

None

Single line Diagram



The point of interconnection is at AEP's distribution primary meter facility on the Interconnection Customer's premise.

Figure 1

Appendix 1 - Distribution System Impact Study

Request

Energy Developments Watervliet LLC (EDL) has requested an interconnection application for a synchronous methane gas generator capable of 800 kW total maximum power output. This is an addition to the existing 2-1600kW synchronous methane gas generators operating since 2012 at the site near the Orchard Hills Sanitary Landfill in Watervliet, Michigan. Energy Developments Watervliet LLC will install an 800kW/1000kVA generator with the intention of starting operations in July, 2019. These generators are planned to export power to the Indiana and Michigan Power Co. (I&M) 12kV utility grid.

The DG system will generate electricity by burning methane gas from the landfill. Energy Developments Watervliet LLC has indicated they will not serve any of the Orchard Hills Landfill site load from the DG system. Therefore, the maximum output of the DG system to the utility grid is 4.0MW/5000kVA.

Energy Developments Watervliet LLC intends to operate the generators 24 hours a day, seven days per week. The only anticipated down time for generation is planned maintenance of a couple days per year.

Disclaimer

The results of this Distribution System Impact Study apply only to the system described in the attached Distributed Generation Interconnection Request. All Modeling is based on a DG system location at 3563 Hennessey Rd, Watervliet MI 49098, interconnection pole BE0146000518.

This review is limited to equipment affecting the AEP system operations. The customer must take all necessary steps to assure compliance with all laws, ordinances, and building codes and other applicable regulations. AEP granting approval of the requested connection is not an endorsement of a particular design nor does it assure fitness of the DG to accomplish an intended function.

The customer is expected to understand and comply with IEEE 1547 concerning the DG installation and its requirements for interconnection with the utility grid.

Modeling and Assumptions

It is assumed the customer has received a copy of the Customer Guide To The Interconnection of Distributed Resources To The American Electric Power (AEP) Distribution System document to guide them through the application.

The DG system is assumed to be equipped with appropriate voltage regulation. As previously stated, the DG system will be operated in parallel with the AEP distribution System and Energy Developments Watervliet LLC intends to export power to the utility grid.

Energy Developments Watervliet LLC is currently served from the 138/12kV West St Station through the Ryno Rd feeder. The Ryno Rd feeder is a radial configuration; three phase multi-grounded four wire, wye system. The primary voltage is nominally 12.47kV line to line, and 7.2kV line to ground.

The DG system will add a single Caterpillar 3516 generator rated 4160 Volts, 800kW/1000kVA, 80% power factor to the existing two Caterpillar 3520 generators each rated 4160 volts, 1600kW/2000kVA, 80% power factor, 277.6 full load amps, driven by a methane gas burning engine. The DG system will contribute up to a maximum of 4.0kW/5000kVA at 80% power factor when operating. The Caterpillar output voltage of 4160 volts will be stepped up to 12.47kV through a 5000 kVA, 12.47/4.16 kV pad mount transformer. The Energy Developments Watervliet LLC facilities will be protected by a 1200 amp, 4160 Volt breaker with a Schweitzer SEL351 control. The AEP service will connect to Energy Developments Watervliet LLC DG system through the existing 12 kV primary metered point of common coupling (PCC) to a 3 phase, 600 amp, pole mounted disconnect switch.

The Energy Developments Watervliet LLC owned 5000 kVA, 12.47/4.16kV step up transformer will be configured Gnd Wye-Gnd Wye and has an impedance of Z=6.0%. This transformer will be connected to the PCC by no more than 100 feet of two conductors per phase of 500MCM Cu.

Analysis

The system conditions of concern are:

1. Generator location.

2. Generator fault contribution.

3. Generator effect on system steady state voltage at peak load.

4. Generator effect on system steady state voltage at light load.

5. Generator effect on power flow for the West St Transformer during light load conditions.

DG Location

The Energy Developments Watervliet LLC facility is modeled near AEP pole BE0146000518 on the West St-Ryno Rd distribution circuit. This is approximately 9350 feet east of the West St station.

DG Fault Contribution

1. Analysis of DG system effects during bolted fault conditions (Available fault current in amps).

Base case. West Street-Ryno Rd circuit; No DG system connected.

Case 1. West Street-Ryno Rd circuit; DG system connected steady state analysis.

Case 2. West Street-Ryno Rd circuit; DG system connected subtransient analysis.

Location: West Street station

Case	LLL fault current	LG fault current
Base case	5942 A	6016 A
Case 1	5954 A	6690 A
Case 2	5942A	6016A

The circuit analysis indicates a steady state 11.2% increase in LG fault current the West Street station.

Location: Energy Developments Watervliet LLC (PCC)

Case	LLL fault current	LG fault current
Base case	3225 A	2448 A
Case 1	3148 A	3876 A
Case 2	4228 A	4328 A

The circuit analysis shows a 31% increase in LLL fault current, and a 58% increase in steady state and 77% increase in subtransient LG fault current at I&M facilities at the PCC.

Location: Ryno Rd down line of circuit tap to DG connection.

Case	LLL fault current	LG fault current
Base case	3492 A	2705 A
Case 1	3504 A	4035 A
Case 2	4561 A	4429 A

The circuit analysis shows a 30% increase in LLL fault current and a 63% increase in LG subtransient fault current at I&M facilities at the PCC.

Bolted fault current analysis does show an increase in available fault currents but not to a level that exceeds interrupting ratings on system protection devices.

Analysis of DG system effects during single phase fault conditions (Available fault current in amps). All faults are on A phase and have a 10 ohm resistance applied.

Base case: West Street-Ryno Rd circuit; No DG system connected.

Case 1. West Street-Ryno Rd circuit; DG system connected subtransient analysis.

LG 10 Ohm fault current, fault location on Hennessey Rd between Ryno Rd and Granger PCC:

Case	West Street Station	Hennessey Rd tap	Granger PCC
Base Case	711 A	689 A	685 A
Case 1.	711 A	685 A	677 A
Result	No change	-4 A (-0.5%)	-8 A (-1%)

LG 10 Ohm fault current, fault location on Hennessey Rd north of Ryno Rd:

Case	West Street Station	Hennessey Rd tap	Ryno Rd upline of tap to Granger PCC

Base Case	711 A	658 A	660 A
Case 1.	711 A	685 A	686 A
Result	No change	27 A (4%)	26 A (4%)

Shunt fault current analysis does show a slight decrease in available fault current at the three phase tap to the Energy Developments Watervliet LLC .

There is no required change to the sectionalizing settings or equipment on the West Street- Ryno Rd circuit due to the additional 800kW generation from Energy Developments Watervliet LLC.

Voltage Regulation

Generator effect on system steady state voltage at peak load

The generator output has negligible effect on utility voltage at peak demand load when operated at unity power factor. When the generator power factor gets to +98% lagging or -92% leading it causes the AEP distribution system to exceed voltage limits.

- Therefore, it is recommended to the customer to operate within these power factor limits. Energy Developments Watervliet LLC has agreed to this condition and sent an attachment with the operating procedure to achieve this power factor limit.

Generator effect on system steady state voltage at light load

Light load conditions are assumed to be one third of peak demand. The generator output has negligible effect on utility voltage at light demand load when operated at unity power factor. When the generator power factor gets to +90% lagging or -95% leading, it causes the AEP distribution system to exceed voltage limits. As in the peak load condition, the operating procedure to limit the power factor range will address this condition.

Generator effect on power flow for the West Street Transformer during light load

During fall and spring months, the transformer at West Street Station is lightly loaded.

The generated power of the Energy Developments Watervliet LLC DG system could be more than the load on the 12 kV bus, thus resulting in a back flow of power through the 12 kV bus regulators and the transformer.

- No additional system work will be required from this additional generation application. In 2012, the CL-5A controls on the 3-833 KVA West St station bus regulators were reprogrammed for Co-generation regulation.

- The addition of the 800kW generator will cause conductor overload over 195 amps on the 4-2AA conductor from the customer interconnection point back to Hennessey Rd. This condition occurs when the generator power factor gets to -91% leading.
- Therefore, it is recommended to the customer to operate within these power factor limits. The voltage regulation power factor limit will achieve this power factor limit.

System Protection

The customer responsibilities include providing adequate protection to AEP facilities due to events arising from the operation of the DG under all AEP distribution system operating conditions. The customer is responsible for protecting their own facility under all AEP distribution system operating conditions whether the DG is connected to AEP facilities 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

Ground Current Sources – Protective relays must be utilized to detect line-to-groundfaults. Energy Developments Watervliet LLC shall provide adequate protection to comply with IEEE 1547 to clear generation source for all types of faults on the AEP system including any breaker failure events. Adequate protection requires that all fault types are cleared before equipment damage occurs to AEP facilities. If Energy Developments Watervliet LLC fails to provide adequate protection for faults on the AEP system, then Energy Developments Watervliet LLC will pay all costs associated with AEP facility damage.

Automatic Reclosing – Automatic high speed reclosing is applied to the transmission circuit serving West Street Station (18 cycles or .3 seconds). When the AEP source breakers trip and isolate Energy Developments Watervliet LLC 's facilities, Energy Developments Watervliet LLC shall ensure that their generation equipment is disconnected from AEP facilities in accordance with requirements established in IEEE 1547 prior to automatic reclosure by AEP. Automatic reclosing out-of-phase with Energy Developments Watervliet LLC's generation equipment may cause damage to Energy Developments Watervliet LLC's equipment. Energy Developments Watervliet LLC is solely responsible for the protection of their equipment from automatic reclosing by AEP.

- AEP will continue to require communication to the customer site in order to monitor connection status, real power output, reactive power output and voltage as stated in section 4.1.6 of IEEE-1547.
- If the customer is unable to detect AEP's automatic high speed reclosing a transfer trip signal can be sent to their protection system. This will require installation of a three phase 138kV bus potential transformer, a transfer trip relay, and a fiber optic line for communication path.

Summary

Facilities

The proposed interconnection will not require any improvements to AEP facilities with the attached customer operating procedure limiting power factor and current levels.

Additional system improvement options:

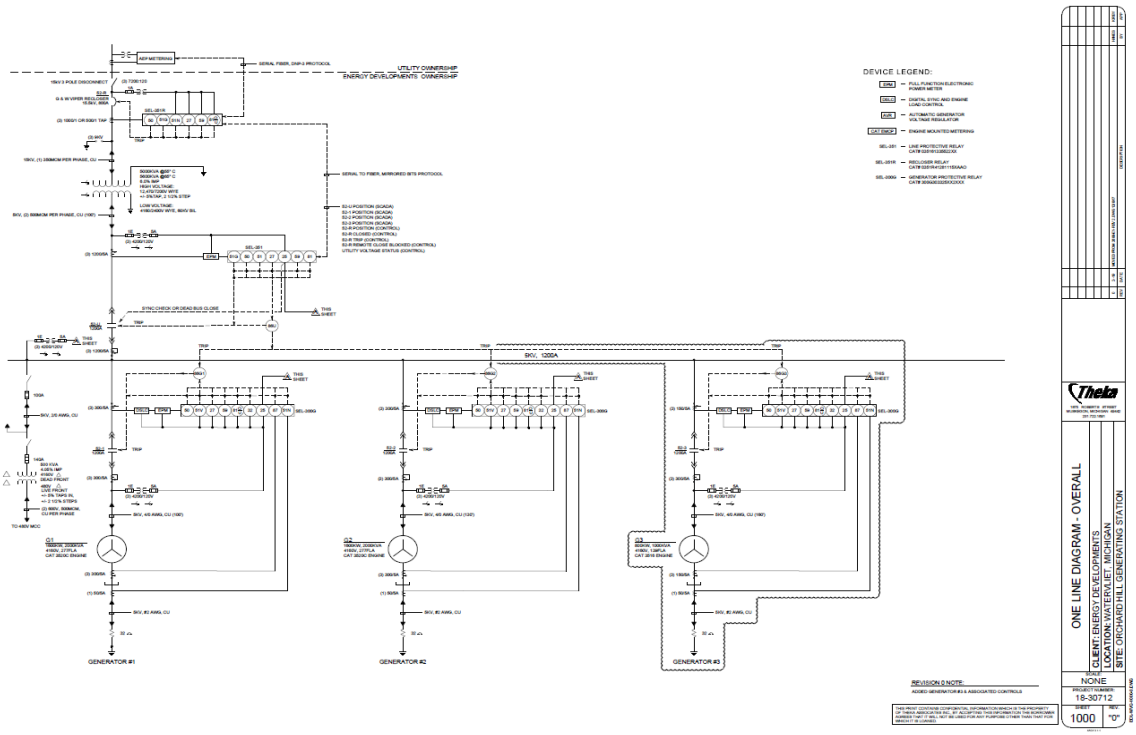
- If the customer selects the high speed transfer trip option the cost estimate is $600,000.

System improvements required on the Energy Developments Watervliet LLC DG system:

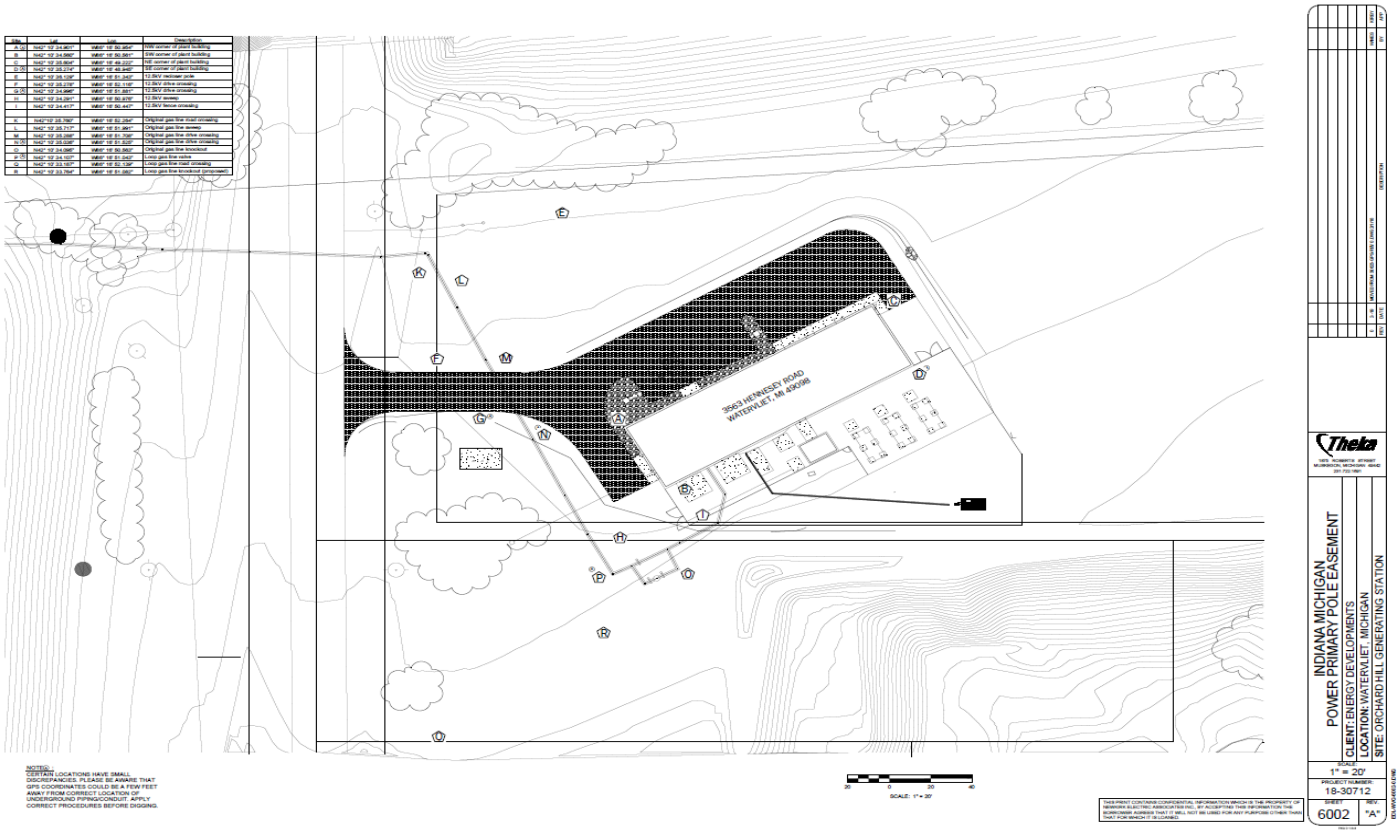
- Energy Developments Watervliet LLC to install power factor and current limit settings as detail in the attached operation procedure addition.

Attachment 1

Energy Developments Watervliet LLC DG system one line:

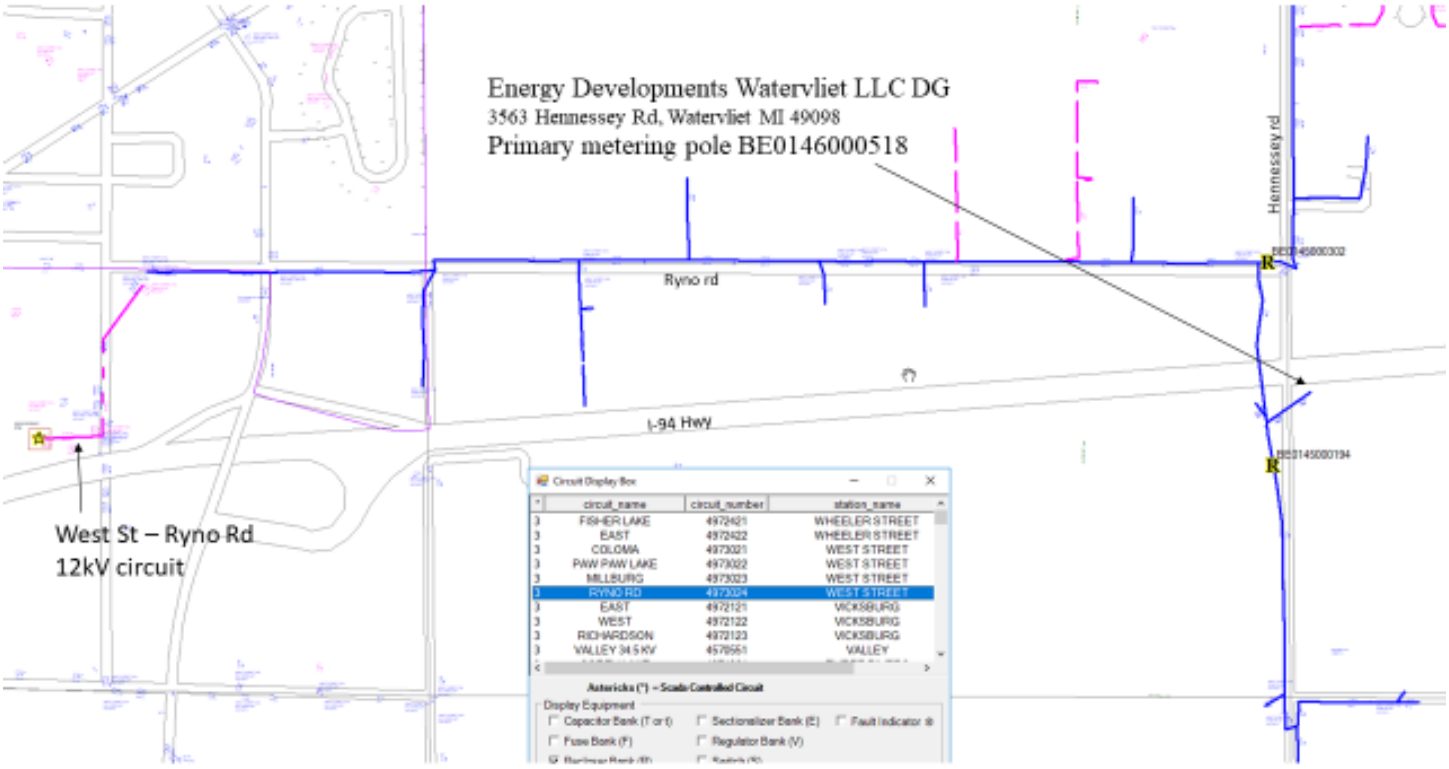


Energy Developments Watervliet LLC DG system Location plan:



Attachment 2:

AEP system diagram:



Appendix 2

Electrical Description and Operations Manual

Energy Developments, Orchard Hill landfill, Watervliet, MI Original plant construction: 2010, Generator #3 addition: 2019
Issued June 6, 2019

System description:
A 12,470V distribution feeder supplies service to this generation facility via overhead line at the northern property line at 3563 Hennessy Road, Watervliet, MI. The AEP ownership changes at the first pole that contains metering transformers. The site visible disconnect is the next pole with load breaking three pole gang disconnect, ground level operated. The last pole contains a G&W Viper recloser controlled by a SEL-351R controller that communicates to AEP via DNP protocol and inside the generation facility via SEL mirrored bits via fiber optic connection.

The G&W recloser protects a sub-surface 15kV rated cable connected to a 5000kVA @ 55deg C rated transformer (5600kVA @ 65 deg C). The 12,470V wye to 4,160V wye transformer feeds indoor switchgear protected by a SEL-351 relay. The 5kV switchgear has a fused house power disconnect feeding a 500kVA @ 55deg C transformer that powers a 480V motor control center. The 500kVA transformer is 4160V delta : 480V delta connected.

The 5kV switchgear has one 1200A main breaker (protected by SEL-351), one fused house power disconnect, and three 1200A generator circuit breakers each protected by a SEL-300G relay. Generator #1 and #2 are CAT 3520, 1600kW, 0.8pf, 4160V, 277amp. Generator #3 currently is a CAT 3516, 800kW, 0.8pf, 4160V, 139amp. Generator 3 is designed to be replaced with a CAT 3520 in the future as landfill gas supply increases.

Protection description:
The SEL-351R provides primary system protection from voltage and frequency issues on the AEP system as well as over current protection of the main generator step-up transformer.

The SEL-351 located in the 5kV switchgear provides similar voltage and frequency protection as the SEL-351R and over current protection of the 5kV switchgear bus. Additional protection was required with the addition of Generator #3 in 2019.

The addition of Generator #3 is pushing the limits of the current AEP distribution system construction. The line conductors are limited in capacity as well as the possible reactive power capability of the facility would cause overvoltage issues on the nearby system. EDL agreed to more strict parameters of operation that would take Generator #3 offline (only) by using the SEL- 351 relay in the switchgear. Line overloading was addressed by limiting current out of the Watervliet facility to 195 amps at 12,470V for 30 seconds. These settings were converted to 4160V and applied to the SEL-351 relay. System voltage management was addressed by limiting reactive power (VARs) of the facility to 500kVAR exported from the plant to 2000kVAR imported to the plant for 30 seconds. Both considerations for operation were accepted by AEP.

Each generator is protected by a SEL-300G generator relay. These relays protect the individual generator with volts/hz, sync check, under voltage, over voltage, loss of excitation, reverse power, voltage restraint overcurrent, frequency, and current differential elements. Each generator relay trips that individual generator from the system.

SEL-351R
Location: outdoor, pole mounted CT
ratio: 500:1
PT ratio: 60:1

Element Number	Description	Setting/delay	Primary pickup value
81D1P	**Under Frequency level 1**	**59.0Hz @ 60cy**	**59.0Hz**
81D2P	**Under Frequency level 2**	**57.0Hz @ 9.5cy**	**57.0Hz**
81D3P	**Over Frequency**	**60.5Hz @ 9.5cy**	**60.5Hz**
27P1P	**Under Voltage level 1**	**105.6V @ 120cy (SV1)**	**6336V**
27P2P	**Under Voltage level 2**	**60.0V @ 9.5cy (SV2)**	**3600V**
59P1P	**Over Voltage level 1**	**132.0V @ 60cy (SV3)**	**7920V**
59P2P	**Over Voltage level 2**	**144V @ 9.5cy (SV4)**	**8640V**
50P1P	**Phase Instant Overcurrent**	**3.70A @ 0 sec**	**1850A**
50G1P	**Residual Instant Overcurrent**	**0.10A @ 0 sec**	**50A**
51P1P	**Phase Time Overcurrent**	**0.58A / U4 curve / 5.0 dial / EM reset**	**250A**
51G1P	**Residual Time Overcurrent**	**0.10A / U4 curve / 3.50 dial / EM reset**	**50A**

Trip function: Open recloser
Trip elements: all in above table + local push button + remote trip bit via mirrored bits
Close function: local pushbutton + remote pushbutton provided remote control is not disabled
Communication via mirrored bits to SEL-351 in plant, DNP-3 to AEP for metering/status

SEL-351R Mirrored Bits transmit equations		
Bit	**Function**	**Description**
TMB1A	**52A- recloser position**	**Used to indicate recloser open/close inside plant**
TMB2A	**LT1- remote close block**	**Used to block closing recloser from plant, used in logic and display in plant**
TMB3A	**Frequency and Voltage elements not tripped**	**Used for indication in plant that utility voltage is restored and recloser may be closed to re-energize facility**
TMB4A	**Alarm**	**Used for indication in the plant of a SEL-351R relay problem.**

SEL-351R Display points on LCD at relay		
Display	**Function**	**Description**
Point 1	**recloser open or closed**	**IN101 logic, displays position in conjunction with lamp near open/close button**
Point 2	**Utility voltage OK / not OK**	**Voltage/Freq logic detection used to determine if OK to close recloser- also used as a lamp indicator in plant**
Point 3	**Under Volt trip**	**Reset with breaker close**
Point 4	**Over Volt trip**	**Reset with breaker close**
Point 5	**Over Freq trip**	**Reset with breaker close**
Point 6	**Under Freq trip**	**Reset with breaker close**
Point 7	**Over Current trip**	**Reset with breaker close**

SEL-351
Location: indoor, 5kV switchgear, utility breaker door
CT ratio: 240:1
PT ratio: 35:1

Element Number	Description	Setting/delay	Primary pickup value
81D1P	Under Frequency	58.0Hz @ 60cy	58.0Hz
81D2P	Over Frequency	61.0Hz @ 60cy	61.0Hz
27P1P	Under Voltage	59.0V @ 90cy (SV1)	2065V
59P1P	Over Voltage	75.0V @ 90cy (SV2)	2625V
50P1P	Phase Instant Overcurrent	30.0A @ 0 sec	7200A
*50P2P	Phase Overcurrent w/delay	2.438A @ 30 sec	585 A (195A @12.47kV)
51PP	Phase Time Overcurrent	3.5A / U4 curve / 10.0 dial / EM reset	840A
51G1P	Residual Time Overcurrent	0.5A / U4 curve / 3.0 dial / EM reset	120A
*3PWR1P	Reactive element leading	59.53 VA @ 30 sec	-500kVAR
*3PWR2P	Reactive element lagging	238.09 VA @ 30 sec	+2000kVAR

*Elements used to trip Gen #3 only per modified AEP operations agreement.

SEL-351 Input / Output assignment		
I/O	Function	Description
IN101	Main 5kV breaker position	Used in protection logic
IN102	Isolated mode	Allows operation of plant isolated from utility
IN103	Close recloser- remote	Recloser close via com to SEL-351R
IN104	Open recloser- remote	Recloser open via com to SEL-351R
IN105	Generator #1 breaker position	Transmit breaker status to AEP
IN106	Generator #2 breaker position	Transmit breaker status to AEP
IN201	Generator #3 breaker position	Transmit breaker status to AEP
IN202	Generator #4 breaker position	Future
ALARM	SEL-351 relay trouble	PLC indication of SEL-351 relay trouble
OUT101	Trip main 5kV breaker	Protection logic trip local breaker
OUT102	Trip 86U lockout relay	Protection logic trip local lockout relay
OUT103	Main 5kV breaker close permissive	Logic to allow main 5kV breaker close (sync, utility volts OK, dead bus, etc)
OUT104	Recloser closed	Panel lamp lit if recloser closed and com OK
OUT105	Recloser open	Panel lamp lit if recloser open and com OK
OUT106	Remote recloser close blocked	Panel lamp lit if remote close ability is blocked for recloser and com OK
OUT107	Utility voltage OK indicator	Panel lamp lit if utility voltage present and com OK
OUT201	DC voltage trouble	PLC indication of 48Vdc system trouble
OUT202	Mirrored Bits com trouble	PLC indication of SEL-351/351R com trouble
OUT203	SEL-351R trouble	PLC indication of SEL-351R relay trouble
OUT204	Trip Generator #3 only	AEP system parameters exceeded per interconnect agreement/system limitations

SEL-351 Mirrored Bits transmit equations		
Bit	**Function**	**Description**
TMB1A	**Main 5kV breaker position**	**Transmit breaker status to AEP**
TMB2A	**Generator #1 breaker position**	**Transmit breaker status to AEP**
TMB3A	**Generator #2 breaker position**	**Transmit breaker status to AEP**
TMB4A	**Generator #3 breaker position**	**Transmit breaker status to AEP**
TMB5A	**Generator #4 breaker position**	**Future**
TMB6A	**Close recloser- remote**	**Transmit recloser close command**
TMB7A	**Open recloser- remote**	**Transmit recloser open command**

SEL-351 Display points on LCD at relay		
Display	**Function**	**Description**
Point 1	**Under Volt Trip**	**Reset with target reset button**
Point 2	**Over Volt Trip**	**Reset with target reset button**
Point 3	**Under Freq Trip**	**Reset with target reset button**
Point 4	**Over Freq Trip**	**Reset with target reset button**
Point 5	**Over Curr Trip**	**Reset with target reset button**
Point 6	**Ground Curr Trip**	**Reset with target reset button**
Point 7	**Fiber com OK/Fail**	**Mirrored Bits communication status**
Point 8	**Recloser closed**	**Status of line recloser via Mirrored Bits**
Point 9	**Recloser open**	**Status of line recloser via Mirrored Bits**
Point 10	**VAR trip Gen #3**	**Line parameters exceeded**
Point 11	**OC trip Gen #3**	**Line parameters exceeded**

SEL-300G (Gen 1,2,3)
Location: indoor, engine control panels
CT ratio, phase: 60:1 (3520) 30:1 (3516)
CT ratio, neutral: 10:1 (3520)
PT ratio: 35:1

Element Number	Description	Setting/delay (3520)	Primary pickup value
24D1P	**Volts/Hz level 1**	**105% @ 60.0 sec**	
24D2P1	**Volts/Hz level 2 PU one**	**110% @ 60.0 sec**	
24D2P2	**Volts/Hz level 2, PU two**	**115% @ 10.0 sec**	
25	**Sync check**	**63.5 V low, 73.9 V high, 2.0 V delta, -0.1 slip min, 0.15 slip max**	**2222.5V to 2586.5V sync range 48V delta**
27P1P	**Under Voltage phase-neutral**	**54.0V @ cy**	**1890V**
27PP1	**Under Voltage phase-phase**	**108V @ 1.0 sec (SV5)**	**3780V**
27PP2	**Under Voltage phase-phase**	**105V @ 1.0 sec (SV6)**	
59P1P	**Over Voltage phase-neutral**	**74.0V @ cy**	**2590V**
59PP1	**Over Voltage phase-phase**	**126V @ 1.0sec (SV1)**	**4410V**
32P1P	**Reverse power- level 1**	**-0.0800W @ 10 sec**	**168kW**
32P2P	**Reverse power- level 2**	**-0.20 @ 2.0 sec**	**420kW**
40	**Loss of excitation, zone 1**	**14.9 ohm diameter, -1.0 ohm offset, 0.05 sec delay**	

40	**Loss of excitation, zone 2**	**15.7 ohm diameter, -1.0 ohm offset, 0.50 sec delay**	
50P1P	**Phase Instant Overcurrent**	**50.0A @ 0.05 sec**	**3000A**
50H1P	**Differential instant Overcurrent**	**50.0A @ 0.05 sec**	**3000A**
51NP	**Neutral Time Overcurrent**	**0.50A / U4 curve / 3.0 dial / EM reset**	**5A**
51VP	**Voltage Restraint Time Overcurrent**	**5.0A / U4 curve / 6.0 dial / EM reset**	**300A**
81D1P	**Under Frequency**	**59.0Hz @ 1 sec (SV7)**	**59.0Hz**
81D2P	**Over Frequency**	**61.0Hz @ 1 sec (SV7)**	**61.0Hz**
87U	**Differential, unrestrained**	**10.0 x tap**	
87R	**Differential, restrained**	**0.30 x tap @ 25% slope**	

SEL-300G Input / Output assignment		
I/O	**Function**	**Description**
IN101	**Generator breaker position**	**Used in protection logic**
OUT101	**Trip generator breaker**	**Protection logic trip local breaker**
OUT102	**Trip 86G lockout relay**	**Protection logic trip local lockout relay**
OUT103	**PLC trip indication**	**Protection/indication to PLC**
OUT104	**PLC 48V battery alarm**	**Indication to PLC of high/low 48V DC battery system**
OUT105	**Sync check breaker close**	**Supervise DSLC controller for backup sync check of generator breaker**

SEL-300G Display points on LCD at relay		
Display	**Function**	**Description**
Point 1		**Not used at this time**
Point 2	**EM Reset Timing**	**Displays when any element is reset timing. Used when calibrating relays**
Point 3	**Over Volt Trip**	**Reset with target reset button or 20 seconds after breaker closes**
Point 4	**Under Volt Trip**	**Reset with target reset button or 20 seconds after breaker closes**
Point 5	**Reverse Power**	**Reset with target reset button or 20 seconds after breaker closes**
Point 6	**Volt per Hertz Trip**	**Reset with target reset button or 20 seconds after breaker closes**
Point 7	**Excitation Loss**	**Reset with target reset button or after breaker closes**
Point 8	**Overcurrent Trip**	**Reset with target reset button or after breaker closes**
Point 9	**Gen Differential**	**Reset with target reset button or after breaker closes**

Electrical system data obtained from AEP on 3/12/13 for use in arc flash study: LLL= 3682 amps, LG= 2832 amps
X/R ratio = 5.49
X Thevenin = 2.0200 ohms R
Thevenin = 0.3681 ohms