Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AB1-169

“Stuart 345 kV”
1150 MW Energy, 1100 MW Capacity

April 2018

General

Invenergy Thermal Development LLC, the Interconnection Customer (IC), has proposed a natural gas generating facility located in Mason, Kentucky. The installed facilities will have a total capability of **1150 MW** with **1100 MW** of this output being recognized by PJM as Capacity. The IC expects to be in commercial operation by **June 30, 2023.**

Point of Interconnection

AB1-169 will interconnect with the Dayton Power & Light Company (DP&L) transmission system via a new 345 kV bay position at the Stuart 345 kV Substation. The Point of Interconnection (POI) will be the takeoff structure leaving Stuart Substation (refer to one line diagram in **Attachment 1)**. DP&L will make the final connections to the takeoff structure inside the substation.

Cost Summary

The **AB1-169** project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrades	$ 5,756,130
Non Direct Connection Network Upgrades	$ 0
Allocation for New System Upgrades	$ 37,200
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 5,793,330**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Invenergy Thermal Development LLC, the Interconnection Customer (IC), has proposed a natural gas generating facility located in Mason, Kentucky. The installed facilities will have a total capability of **1150 MW** with **1100 MW** of this output being recognized by PJM as Capacity. The IC expects to be in commercial operation by **June 30, 2023.**

Point of Interconnection (POI)

AB1-169 will interconnect with the DP&L transmission system via a new 345 kV bay position at the Stuart 345 kV Substation. The Point of Interconnection (POI) will be the takeoff structure leaving Stuart Substation (refer to one line diagram in **Attachment 1)**.

2. Amendments to the Original System Impact Study Results

The original AB1-169 System Impact Study report was revised on June 20, 2017 to include the final Stability analysis results. No additional system reinforcements have been identified as being required from the original System Impact Study issued in February 2017. Issues were not identified in the revised report but in real-time operations it is possible that multiple facility outages outside of the scope of the study could cause curtailments of generation in this region.

The June version of the AB1-169 System Impact Study report was revised on October 31, 2017 to add a note to the "*New System Reinforcements*" section on Page 9 regarding how the Stuart and Killen pending generation retirements would affect the Adkins-Beatty 345 kV line overload. No analysis results have been changed from System Impact Study report issued in June 2017.

3. Interconnection Customer's Submitted Milestone Schedule

The IC's proposed Commercial Operation Date (COD) for the generation facility is June 30, 2023. In order to meet the backfeed date, a proposed **18 month** schedule is estimated to complete engineering, construction, and associated activities from the date of a fully executed Interconnection Construction Service Agreement.

4. Scope of Customer's Work

IC will install a 1150 MW natural gas facility located in **Mason, Kentucky**. The IC will construct and own facilities including the natural gas generator facilities, four (4) generation step up (GSU) transformers, four (4) 25 kV breakers with associated relay/protection/controls, one (1) 345 kV breaker, one (1) generation 345 kV bus, and 345 kV line up to the Point of Interconnection (POI). The POI will be located at the takeoff structure inside Stuart Substation as shown on the one-line diagram in **Attachment 1**.

The IC shall coordinate with DP&L on the establishment of dedicated communication circuits for SCADA monitoring to the DP&L Transmission System Control Center. Additionally, the IC will be responsible for paying all expenses to meet the DP&L Protection Requirements outlined in Attachment 4.

The proposed attachment of the IC's project to Stuart 345 kV Substation will be made by a tap connection between two 345kV circuit breakers inside Stuart Substation. The IC will construct a 345 kV line extension from the POI to their project substation. The IC will be responsible for acquiring all rights-of-way, easements, properties, vegetation clearing, environmental and municipal permits that may be required to construct all attachment facilities, up to the POI shown in the one-line diagram in **Attachment 1**.

Reference the TO's Generation Connection Requirements in **Attachment 3**.

5. Description of Facilities Included in the Facilities Study

Attachment Facilities –

- The Interconnection Customer will construct the attachment lines from its generating facility into the proposed Point of Interconnection as depicted on the one line diagram in **Attachment 1.**

Direct Connection Network/Local Upgrades –

Stuart 345 kV Switchyard Upgrades (Dayton)

- The substation direct connection work for this project consists of the construction of a new 345 kV circuit breaker bay at Stuart Substation. In order to accommodate this addition to the Stuart Substation, the substation will require expansion. This work includes the procurement and installation of two (2) new 345 kV circuit breakers along with the associated switches and relaying.

- To accommodate the direct connection work, Stuart Substation will require the addition of the following equipment:

    - 345 kV Disconnect Switches
    - 345 kV Line and Transfer Trip Relays
    - 345 kV Gas Circuit Breakers
    - 345 kV Metering Equipment
    - 345 kV Instrument Transformers
    - 345 kV Bus Bay Structures
    - 345 kV Insulators
    - 345 kV Lightning Arrestors
    - Physical Site Expansion including Grading
    - Foundational Work for New Equipment

- The 345 kV generator lead line constructed by the developer will be terminated at a designated takeoff structure within the Stuart Substation as directed by DP&L.

The PJM Network Upgrade Number for this work is **n5211**.

Non-Direct Connection Network Upgrades –

None.

New System Upgrades -

Adkins-Beatty 345 kV line Upgrade (AEP)

- Adkins-Beatty 345 kV Line: Replace the Beatty Road Line Riser section (substation conductor 2-1024.5 ACAR) to raise AEP-end line ratings to SN/SE 1414/1414 MVA.

The PJM Network Upgrade Number for this work is **n5136**.

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

The AB1-169 project will be responsible for the following costs:

Description	NUN	Cost (without tax)
Attachment Facilities	N/A	$ 0
Direct Connection Network Upgrades		$ 5,756,130
Stuart 345 kV Bay installation (Dayton)	n5211	
Non Direct Connection Network Upgrades	N/A	
Allocation for New System Upgrades		
Adkins-Beatty 345 kV line upgrade (AEP)	n5136	$ 37,200
Contribution for Previously Identified Upgrades	N/A	$ 0
Total Costs		**$ 5,793,330**

The costs given in this report show the estimates without state or federal tax. This tax may or may not be charged based on whether or not this project meets the eligibility requirements of IRS Notice 88-129. The IC will be responsible for the actual cost of all implementing all work identified in the table above.

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

A proposed **18 month** Direct Connection schedule is estimated to complete engineering, construction and the associated activities listed above from the date of a fully executed Interconnection Construction Service Agreement. This schedule assumes that all issues covered

by the "Environmental, Real Estate and Permitting Issues" and "General Assumptions/Qualifiers" sections of this document are resolved, and outages occur as planned.

Construction will not begin and is predicated upon (a.) all applicable environmental and municipal permits obtained, and (b.) all line and equipment outages secured through DP&L Transmission System Operations, AEP Transmission Operations (where necessary), and PJM.

AEP anticipates completing the new Network Upgrades in parallel with the Direct Connection schedule. However, timing of this work is subject to approval of facility outage requests by AEP, Dayton and PJM Transmission Operations, and that system conditions allow outages to occur as scheduled.

Activity Schedule	Start Month	End Month
Preliminary Engineering	1	4
Detailed Engineering	5	8
Equipment Procurement – Delivery	9	12
Above Grade Construction	13	16
Testing & Commissioning	17	18

Back-up Service Agreement

The execution of a back-up retail service agreement with Dayton or the local Load Serving Entity will be necessary if the IC desires to receive transmission service for load serving purposes from the AB1-169 interconnection point or a backup distribution service.

General Assumptions/Qualifiers

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

- Obtaining the necessary transmission line/equipment outages. Transmission outages are typically not granted from June to September and are discouraged during extreme winter conditions. PJM, AEP, and Dayton TSO requires 6 to 12-month notice for greater than 5-day and 30-day outages respectively.
- IC provides design plan for generator lead line.
- No transmission line work required to relocate existing facilities to accommodate the interconnection customer line route to Stuart Substation.

- Relocation of existing transmission circuits surrounding Stuart Substation could lead to project delays and increased costs. The interconnection customer did not have detailed line routes to determine if transmission line relocation work will be necessary.
- All equipment can be procured and delivered on-time.
- No environmental problems with the proposed substation site expansion.
- No delays in the power siting process for expansion of the substation.
- No extreme weather.
- No force majeure.

B. Transmission Owner Facilities Study Results

1. Transmission Lines – New

None.

2. Transmission Line – Upgrades

Adkins-Beatty 345 kV line Upgrade (AEP)
PJM Network Upgrade n5136

Replace the Beatty Road Line Riser section (substation conductor 2-1024.5 ACAR) to raise AEP-end line ratings to SN/SE 1414/1414 MVA.

3. New Substation/Switchyard Facilities

None.

4. Upgrades to Substation / Switchyard Facilities

Stuart Switchyard New 345 kV Bay (Dayton)
PJM Network Upgrade n5211

Construct a new 345 kV breaker bay with two new 345 kV circuit breakers at the Stuart Substation. DP&L will install the associated disconnect switches, line relaying, interconnection metering, and complete the necessary site work to accommodate the interconnection of the AB1-169 generator.

5. Metering & Communications

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 Sections 24.1 and 24.2.

IC will be responsible for designing, furnishing and installing Supervisory Control and Data Acquisition (SCADA) RTU equipment in its generation substation, and for obtaining the telecommunication circuits and data transfer from the RTU to the Transmission Owner Data Center.

Transmission Owner (Dayton Power and Light) Requirements

The Interconnection Customer will be required to comply with all Dayton Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the Dayton Power & Light Co. "Requirements for the Connection of Facilities to the Dayton Power & Light Co. Transmission System" document located at the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-dayton/dayton-facilities-connection-requirements.ashx

The metering point for this interconnection will be located at the Stuart 345 kV substation as shown in **Attachment 1**.

6. Environmental, Real Estate and Permitting Issues

This project will be subject to Ohio Power Siting Board review and approval since it involves an expansion of a transmission substation.

Permits required by the interconnection customer are not considered in this report.

7. Information Required for Interconnection Service Agreement

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

Description	Direct Labor	Direct Material	Indirect Labor	Indirect Materials
Dayton Work				
Stuart Substation expansion to accommodate new 345 kV breaker bay (n5211)	$2,590,330	$2,014,600	$575,600	$575,600
AEP Work				
Adkins-Beatty 345 kV line: Beatty Road Line Riser section upgrade (n5136)	$25,800	$3,000	$7,700	$700
Total	**$2,616,130**	**$2,017,600**	**$583,300**	**$576,300**

Schedule:

A proposed **18 month** Direct Connection schedule is estimated to complete engineering, construction and the associated activities listed above from the date of a fully executed Interconnection Construction Service Agreement. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" and "General Assumptions/Qualifiers" sections of this document are resolved, and outages occur as planned.

Construction will not begin and is predicated upon (a.) all applicable environmental and municipal permits obtained, and (b.) all line and equipment outages secured through DP&L Transmission System Operations, AEP Transmission Operations (where necessary), and PJM.

AEP anticipates completing the New Network Upgrades in parallel with the Direct Connection schedule. However, timing of this work is subject to approval of facility outage requests by AEP, Dayton and PJM Transmission Operations, and that system conditions allow outages to occur as scheduled.

Activity Schedule	Start Month	End Month
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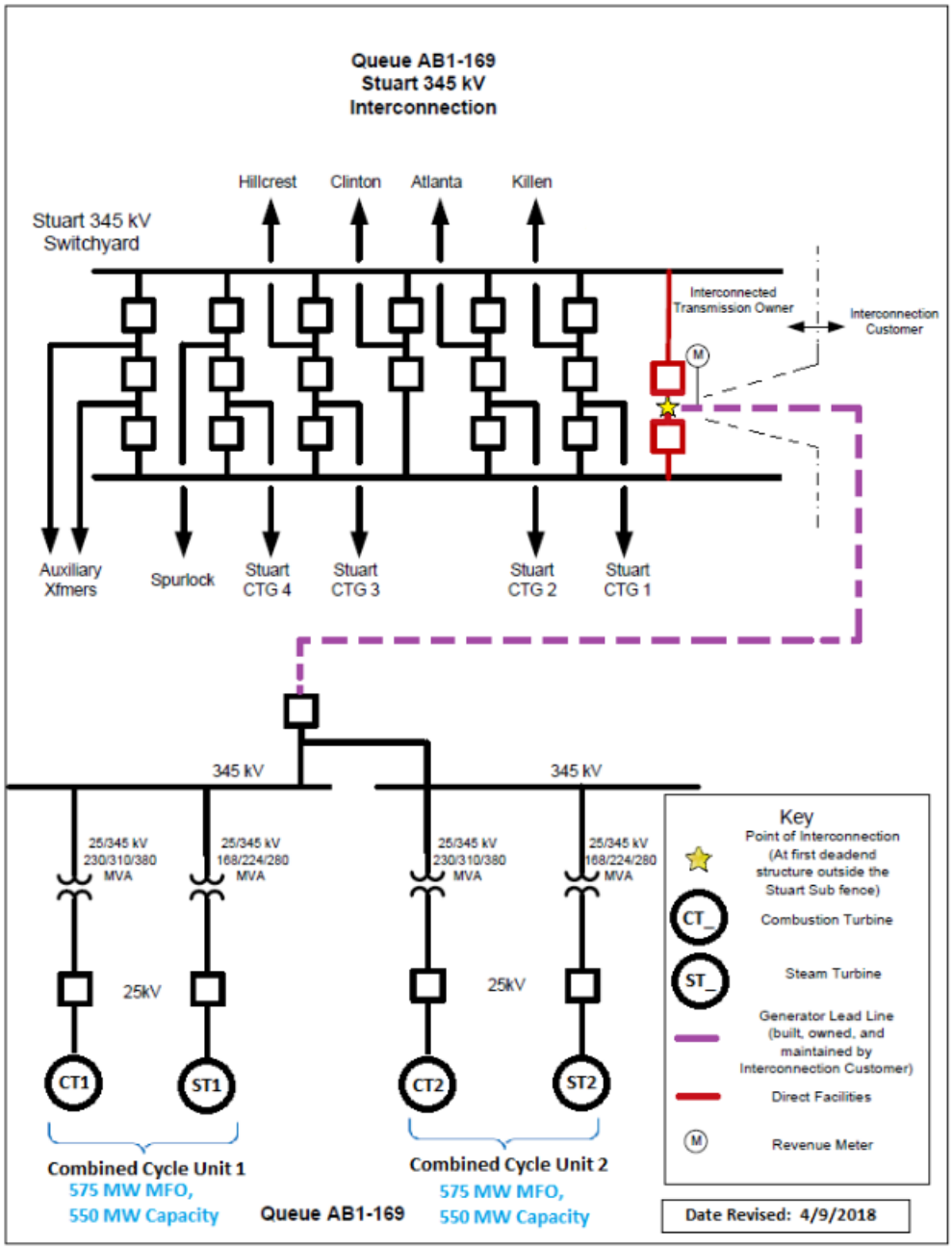
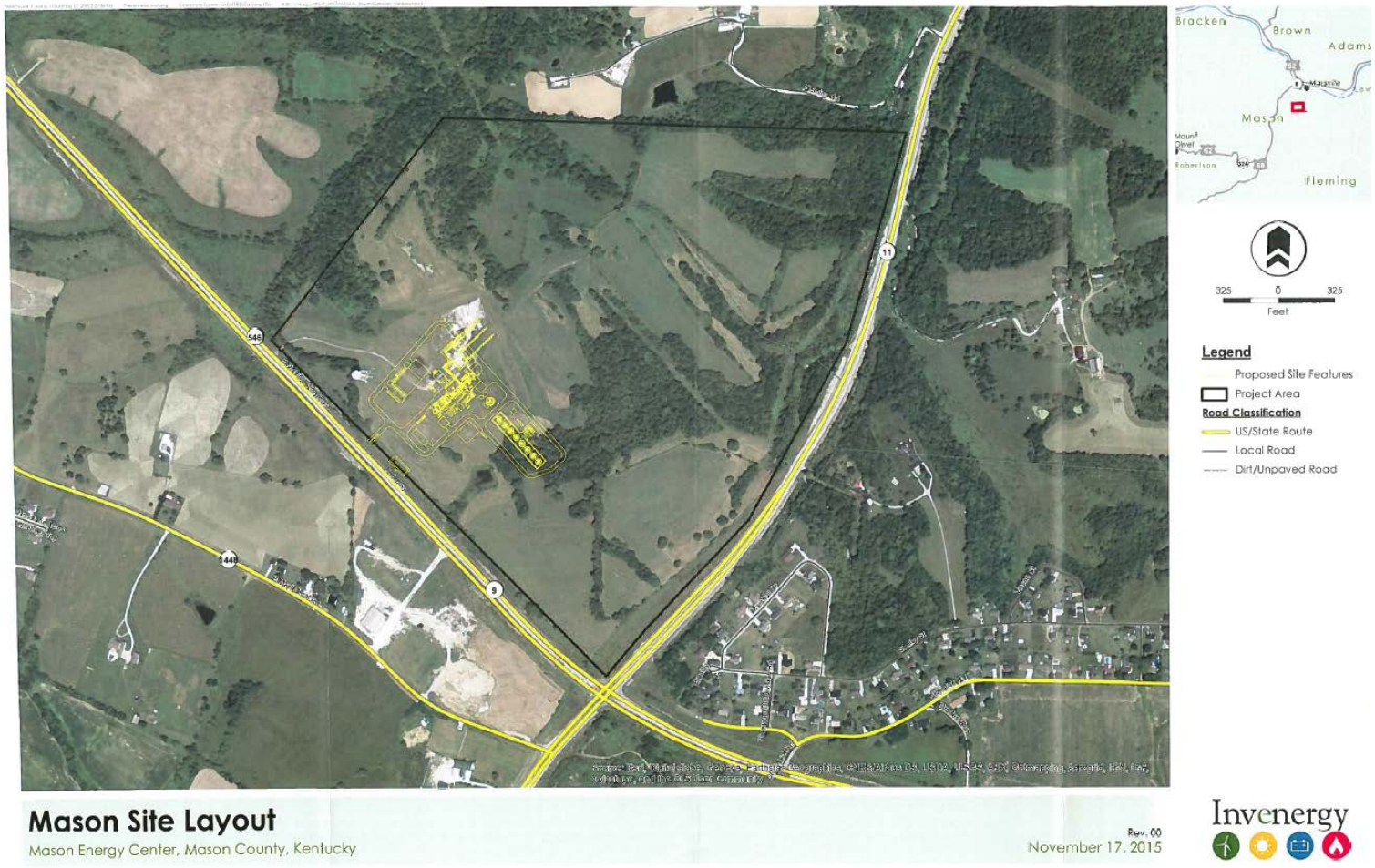
Attachment 1. PJM Queue #AB1-169

One Line Diagram



Attachment 2. PJM Queue #AB1-169
Site Plan Drawing



Attachment 3. PJM Queue #AB1-169

Dayton Generation Connection Requirements

The Dayton Power and Light Company (DP&L) has prepared this Facilities Connection Requirements document to ensure compliance with North American Electric Reliability Council (NERC) Reliability Standards and applicable Regional Reliability Organization, sub regional, Power Pool, and individual Transmission Owner planning criteria and facility connection requirements in compliance to NERC Standard FAC-001-2. These connection requirements apply to all generation facilities, transmission facilities, and end-users connecting to the DP&L transmission system. Detailed information outlining DP&L interconnection requirements can be reviewed utilizing the following link:

http://www.pjm.com/~/media/planning/plan-standards/private-dayton/dayton-facilities-connection-requirements.ashx

Attachment 4. PJM Queue #AB1-169

System Relay and Protection Requirements

The Interconnection Customer will be required to comply with all Dayton System Relay and Protection Requirements. The System Relay and Protection Requirements may be found within the Dayton Power & Light Co. "Requirements for the Connection of Facilities to the Dayton Power & Light Co. Transmission System" document located at the following link:

Specifically reference the "System Relay and Protection Requirements" section which can be found on pages 7-9.

http://www.pjm.com/-/media/planning/plan-standards/private-dayton/dayton-facilities-connection-requirements.ashx?la=en

System Protection and Coordination.

Generation facilities, transmission facilities, and end-user facilities connecting to the DP&L transmission system are responsible for determining that the proper protective equipment meet all applicable standards, is properly installed and coordinates with DP&L relaying. Protective relaying systems and associated communications systems for all facility interconnections shall be planned, designed, constructed, and maintained in accordance with applicable NERC, RF, and PJM standards. Utility grade protective relays and fault clearing systems are to be utilized on the interconnected power system. Utility grade relays are defined as follows:

- Meet ANSI/IEEE Standard C37.90, Relays and Relay Systems Associated with Electric Power Apparatus.
- Have relay test facilities to allow testing without unwiring or disassembling the relay.
- Have appropriate test plugs/switches for testing the operation of the relay.
- Have targets to indicate relay operation.

The Applicant must take responsibility for providing adequate system protection to its facilities and to DP&L facilities under any transmission operating condition, whether or not their facilities are in operation. Conditions may include but are not limited to:

Single phasing of supply

System faults.

Equipment failures.

Abnormal voltage or frequency.

Lightning and switching surges.

Excessive harmonic voltages and/or currents.

Excessive negative sequence voltages

Separation from DP&L.

Synchronizing of generation to the DP&L system.

DP&L reserves the right to specify functional specifications and relay settings deemed necessary to avoid safety hazards or to prevent any disturbance, impairment or interference with DP&L's ability to serve other customers. The criteria for these functional specifications and settings will be based on existing DP&L protection practices. DP&L reserves the right to specify the type and manufacturer for these protective relays to ensure compatibility with existing relays. DP&L will make the specific recommendations and requirements for protection based on the individual substation location, voltage and configuration.

For generation facilities, the relay protection system may be part of a self-contained generation control package. Additional relay protection may be required if testing or operational problems are encountered with this self-contained generation control package. DP&L shall review the interface protection and/or the self-contained protection schemes included with the generation before the unit will be permitted to connect to the DP&L system. The following relay functions are required by the Applicant for protection of the DP&L system. Use of the transfer trip receiver is conditional as set forth below.

Relay	**Purpose**
Frequency	To detect under and over frequency operation and separate the customer's parallel generation.
Under/over voltage	To detect under and over voltage operation and cause separation of the customer's parallel generation.
Transfer Trip Receiver	To receive a trip signal from a DP&L transfer trip transmitter and separate the customer's parallel generation.
Ground Detector	To detect a ground fault on the DP&L or customer system and separate the customer's parallel generation.

Directional Power	To detect a reverse power flow condition and separate the customer's parallel generation.

The purpose of these relays is to detect the Generation Owner's energizing of a DP&L circuit that has been isolated from the DP&L system, by circuit breaker or other disconnect device operations or detect the generation operating at an abnormal voltage or frequency, or to detect a fault or abnormal condition on the DP&L system requiring the Generation Owner to separate their generation from the DP&L system. Output contacts of these relays shall directly energize the trip coil(s) of the generation breaker or an intermediate auxiliary tripping relay that directly energizes the breaker trip coil(s). The relaying system shall have a power source independent from the ac system or immune to ac system loss or disturbances (e.g., dc battery and charger) to assure proper operation of the protection scheme. Loss of this source shall cause removal of the generation from the DP&L system.

DP&L will specify settings for the generation's DP&L-required relays to ensure coordination between the generation protective equipment and the DP&L system relays. It is the Generation Owner's responsibility to determine that their internal protective equipment coordinates with the required DP&L protective equipment and is adequate to meet all applicable standards. DP&L reserves the right to modify relay settings when deemed necessary.

A transfer trip relaying system (or other not specified above) must be installed at the Generation Owner's expense if DP&L determines it is necessary to protect the Transmission System. The transfer trip relaying system shall consist of all transfer trip transmitters located at DP&L facilities, transfer trip receivers at the Generation Facility and the communication channels between the DP&L location(s) and the Generation Facility.

Also, the Interconnection Customer should be familiar with the PJM Protection System Standards which can be found at the link below.

(http://www.pjm.com/-/media/documents/manuals/m07.ashx