Generation Interconnection Facility Study Report

For

PJM Generation Interconnection Request Queue Position AC1-085

"Stuart-Clinton 345 kV" 400 MW Energy, 152 MW Capacity

November 2018

General

Hecate Energy Highland, LLC, the Interconnection Customer (IC), has proposed a solar generating facility located in Hillsboro, Ohio. The installed facilities will have a total capability of **400 MW** with **152 MW** of this output being recognized by PJM as capacity. The proposed Commercial Operation Date for this project is **December 31, 2021**.

Point of Interconnection

AC1-085 will interconnect with the Dayton Power & Light Company (DP&L) transmission system via a new 345 kV three breaker ring bus substation that will tap the Stuart-Clinton 345 kV line. The Point of Interconnection (POI) will be the takeoff structure leaving the new DP&L 345kV ring bus substation fence (refer to one line diagram in **Attachment 1)**.

Cost Summary

The **AC1-085** project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 0
Direct Connection Network Upgrades (Dayton)	$ 5,037,026
Non Direct Connection Network Upgrades (Dayton)	$ 1,404,179
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades[1] (AEP)	$ 66,055
Total Costs	**$ 6,507,260**

[1] Note: Stuart Unit 1 deactivated on 9/30/2017 and the remaining Stuart and Killen generating units deactivated on 6/1/2018. These units are contributing to the flows on the Adkins – Beatty 345 kV line in this AC1analysis per the PJM Tariff to retain their capacity rights on the system. The rights for Stuart Unit 1 were terminated as of 9/30/2018. If no other queue positions claim the rights of the remaining Stuart and Killen generating units by 6/1/2019, the rights for these plants will also expire. If this occurs, no constraints, based on the generation dispatch in this study, will exist on the Adkins – Beatty 345 kV line and no upgrades will be required to be built on the Adkins – Beatty 345 kV line. The status of whether anyone claims the rights of the old Stuart and Killen generating units will be monitored and tracked to determine if construction of the network upgrades identified in this Facilities Study are still needed.

A. Transmission Owner Facilities Study Summary

1. Description of Project

Hecate Energy Highland, LLC, the Interconnection Customer (IC), has proposed a solar generating facility located in Hillsboro, Ohio. The installed facilities will have a total capability of **400 MW** with **152 MW** of this output being recognized by PJM as capacity. The proposed Commercial Operation Date for this project is **December 31, 2021**.

Point of Interconnection (POI)

AC1-085 will interconnect with the Dayton Power & Light Company transmission system via a new 345 kV three breaker ring bus substation that will tap the Stuart-Clinton 345 kV line. The Point of Interconnection (POI) will be the takeoff structure leaving the new DP&L 345kV ring bus substation fence (refer to one line diagram in **Attachment 1)**.

2. Amendments to the Original System Impact Study Results

The AC1-085 System Impact Study was revised on October 3, 2018 to incorporate the following changes[1]:

1. Stuart Unit 1 deactivated on 9/30/2017 and their Capacity Interconnection Rights terminated as of 9/30/2018. With their rights terminated, a retool of the System Impact Study was required. Analysis results were updated and it was determined that AC1-166 was the first to cause the need for network upgrade n5933. AC1-085 will only be responsible for their cost allocation of $66,055 towards this upgrade. This upgrade is not required for AC1-085 to be in-service.
2. Ownership of the Adkins-Beatty 345 kV line changed in June 2018 to be fully owned by American Electric Power (AEP). With this change, the responsibility for completing network upgrade n5933 is now with AEP.
3. Network upgrade n5136 for Replacing the Beatty Line Riser Section on the Adkins-Beatty 345 kV line to achieve SN/SE ratings of 1414/1414 MVA was removed as it is no longer needed. With the retirement of Stuart Unit 1, the overload of the emergency rating of the Adkins-Beatty 345 kV line is eliminated.
4. Cost allocation for a sag study of the Adkins-Beatty 345 kV line (under n5457) has been removed. With the retirement of Stuart Unit 1, the overload of the emergency rating of the Adkins-Beatty 345 kV line is eliminated.

The AC1-085 System Impact Study was revised on September 18, 2018 to incorporate the following changes:

1. American Electric Power (AEP) Planning Criteria has been revised. Emergency ratings are now used evaluating single contingencies to 345 kV and above facilities. Retools of the AC1

[1] Stuart Unit 1 deactivated on 9/30/2017 and their Capacity Interconnection Rights terminated as of 9/30/2018. With their rights terminated, a retool of the analysis identified that Network Upgrades n5136 and n5457 were no longer required.

System Impact Studies were required to determine how this would affect cost responsibility for queue projects.

2. System Impact Study results have changed as the AB1-169 project is no longer the first to cause the need for the Beatty Road Line Riser section upgrade (Network Upgrade n5136). The cost responsibility has moved to the AC1 queue and this project now has cost allocation for n5136.
3. System Impact Study results have changed and this project now has a cost allocation towards a sag study for the Adkins-Beatty 345 kV line (Network Upgrade n5457).
4. Attachment Facilities and Direct/Non-Direct Connection costs updated as Facilities Study estimates have been received.

3. Interconnection Customer's Submitted Milestone Schedule

The IC's proposed Commercial Operation Date (COD) for the generation facility is December 31, 2021. A **24** month schedule has been developed for DP&L 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 400 MW solar generating facility located in Hillsboro, Ohio. The IC will construct and own facilities including the solar generator facilities, two (2) 345/34.5 kV 150/200/266 MVA generation step up (GSU) transformers, bi-directional revenue metering, two (2) 345 kV circuit breakers with associated relay/protection/controls, one (1) 345 kV generation bus, and one (1) 345 kV generator lead line from the generation substation to the Point of Interconnection at the new 345 kV AC1-085 interconnection switchyard. The POI will be located at DP&L takeoff structure inside the new 345 kV ring bus substation, shown on the one-line diagram in **Attachment 1**.

IC shall coordinate with Dayton the establishment of dedicated communication circuits for SCADA monitoring to the Dayton Transmission System Control Center. Additionally, IC will be responsible for paying all expenses to meet the Dayton Protection Requirements due to direct connections and other upgrades required by this project.

The proposed attachment of the IC's project to the Stuart-Clinton 345kV line will be made by a via new 345 kV three breaker ring bus substation where one position will be dedicated to the Clinton 345kV line, one position dedicated to the Stuart 345kV line, and one position dedicated to the AC1-085 generator. The IC will construct a 345 kV line extension from its project substation up to the POI which will be the takeoff structure leaving the new 345 kV three breaker ring bus substation as shown in **Attachment 1**. IC will be responsible for acquiring all rights-of-way, easements, properties, vegetation clearing, environmental, state siting approvals, and local permits that may be required to construct all attachment facilities, up to the POI shown in the one-line diagram in **Attachment 1**. Also, the IC will provide the land at no cost to Dayton for the construction of the new 345 kV three breaker ring bus substation.

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

5. Description of Facilities Included in the Facilities Study

Attachment Facilities –

- **Generator Lead Line (IC) -** 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 –

- **AC1-085 Switchyard (Dayton)** - The substation direct connection work for this project includes the engineering, procurement, and construction of a new greenfield 345 kV three breaker ring bus substation.
- **AC1-085 Switchyard Equipment (Dayton)** - Dayton will install three (3) 345 kV circuit breakers with associated disconnect switches, line relaying, communication, control building, substation structures and foundations, station power, civil site work, interconnection metering, and other supporting substation equipment required to accommodate the interconnection of the AC1-085 generator and tap the existing Stuart-Clinton 345 kV line.

PJM Network Upgrade Number n5896

Non-Direct Connection Network Upgrades –

- **Stuart-Clinton 345 kV Transmission Tie-in (Dayton) -** Dayton will need to install two (2) new steel dead-end structures to allow for the 345kV transmission line to be looped in and out of the new 345 kV three breaker ring bus substation. This work will require engineering, construction, new foundations, new conductor and the necessary transmission hardware required to facilitate the interconnection of the new 345 kV substation off the Stuart-Clinton 345 kV line.

PJM Network Upgrade Number n5692

- **Clinton Substation (Dayton)**: Upgrade Stuart 345 kV line relaying.

PJM Network Upgrade Number n5897

- **Stuart Substation (Dayton)**: Upgrade Clinton 345 kV line relaying.

PJM Network Upgrade Number n5898

- **Adkins-Beatty 345 kV Line (AEP) -** Replace a full takeoff structure and upgrade the Beatty conductor leaving Adkins Substation. SN/SE ratings of Adkins-Beatty 345 kV line after reinforcement are 1339 MVA/1556 MVA, respectively.

PJM Network Upgrade Number n5933

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

The AC1-085 project will be responsible for the following costs:

Description	NUN	Cost (without tax)
Attachment Facilities	N/A	$ 0
Direct Connection Network Upgrades		
New 345 kV Three Breaker Ring Bus (Dayton)	n5896	$ 5,037,026
Non Direct Connection Network Upgrades		
Stuart-Clinton 345 kV Transmission Line Work (Dayton)	n5692	$ 1,294,179
Clinton Substation: Upgrade Stuart 345 kV line relaying. (Dayton)	n5697	$ 100,000
Stuart Substation: Upgrade Clinton 345 kV line relaying. (Dayton)	n5898	$ 10,000
Allocation for New System Upgrades		
	N/A	$ 0
Contribution for Previously Identified Upgrades		
Adkins-Beatty 345 kV Line: Replace full takeoff structure and upgrade Beatty line conductor leaving Adkins Substation. (AEP)	n5933	$ 66,055[2]
Total Costs		**$ 6,507,260**

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 **twenty four (24)-month** schedule for Dayton's direct and non-direct transmission and network upgrade work is estimated to complete engineering, construction and the associated activities listed above from the date of a fully executed Interconnection Construction Service Agreement and Construction Kickoff call. This schedule assumes that all issues covered by the

[2] AC1-085 shares cost allocation for network upgrade n5933 with other projects in the AC1 queue. AC1-166 is the first to cause the need for this upgrade. AC1-085 only has cost allocation and does not need this reinforcement to be completed in order to be in-service.

"Environmental, Real Estate and Permitting Issues" section of this document are resolved, and outages occur as planned.

Construction cannot begin and is predicated upon (a.) all applicable environmental, power siting, and local permits obtained, and (b.) all line and equipment outages secured through Dayton Transmission System Operations and PJM.

Activity Schedule	Start Month	End Month
Preliminary Engineering	1	4
Detailed Engineering	4	12
Equipment Procurement – Delivery	12	15
Above Grade Construction	15	22
Testing & Commissioning	22	24

Back-up Service Agreement

The execution of a back-up retail service agreement with the TO will be necessary to serve the customer load supplied from the AC1-085 interconnection point when the units are out-of-service. This assumes the intent of the IC is to net the generation with the load.

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 and Dayton TSO requires 6 to 12-month notice for greater than 5-day and 30-day outages respectively.
- IC provides land for new 345 kV three breaker ring bus substation.
- IC provides location and orientation of their attachment facilities.
- No extreme weather.
- No force majeure.

B. Transmission Owner Facilities Study Results

1. Transmission Lines – New

- **Generator Lead Line (IC)** - 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**.

- **Stuart-Clinton 345 kV Transmission Tie-in (Dayton)** - Dayton will need to install two (2) new steel dead-end structures to allow for the 345kV transmission line to be looped in and out of the new 345 kV three breaker ring bus substation. This work will require engineering, construction, new foundations, new conductor and the necessary transmission hardware required to facilitate the interconnection of the new 345 kV substation off the Stuart-Clinton 345 kV line.

*PJM Network Upgrade Number **n5692***

2. Transmission Line – Upgrades

- **Adkins-Beatty 345 kV Line (AEP)**[2]- Replace a full takeoff structure and upgrade the Beatty conductor leaving Adkins Substation. SN/SE ratings of Adkins-Beatty 345 kV line after reinforcement are 1339 MVA/1556 MVA, respectively.

*PJM Network Upgrade Number **n5933***

3. New Substation/Substation Facilities

- **AC1-085 Switchyard (Dayton)** - The substation direct connection work for this project includes the engineering, procurement, and construction of a new greenfield 345 kV three breaker ring bus substation.
- **AC1-085 Switchyard Equipment (Dayton)** - Dayton will install three (3) 345 kV circuit breakers with associated disconnect switches, line relaying, communication, control building, substation structures and foundations, station power, civil site work, interconnection metering, and other supporting substation equipment required to accommodate the interconnection of the AC1-085 generator and tap the existing Stuart-Clinton 345 kV line.

  *PJM Network Upgrade Number **n5896***

4. Upgrades to Substation / Substation Facilities

- **Clinton Substation (Dayton)**: Upgrade Stuart 345 kV line relaying.

*PJM Network Upgrade Number **n5897***

- **Stuart Substation (Dayton)**: Upgrade Clinton 345 kV line relaying.

*PJM Network Upgrade Number **n5898***

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) 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 new 345 kV three breaker ring bus substation tapping the Stuart-Clinton 345kV line. The meter will be located on the 345 kV line connected to the AC1-085 generator as shown in **Attachment 1**.

6. Environmental, Real Estate and Permitting Issues

IC will be responsible for acquiring all rights-of-way, easements, properties, vegetation clearing, environmental, state siting approvals, 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. The IC will

be responsible for the costs incurred to obtain the necessary environmental and other permits necessary to construct the non-direct and direct connect facilities.

7. Information Required for Interconnection Service Agreement

The following table summarizes the total estimated costs according to FERC criteria. The estimated costs are in **2018 dollars.** The taxes are a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether 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
Direct Connection Upgrades				
Stuart-Clinton 345kV 3 Breaker Ring Bus Substation (n5896)	$2,266,662	$1,762,958	$503,703	$503,703
Non-Direct Connection Upgrades				
Stuart-Clinton 345kV Line Tie-in Work (n5692)	$ 582,381	$ 452,962	$ 129,418	$ 129,418
Clinton Substation: Upgrade Stuart 345 kV line relaying. (n5897)	$ 75,000	$ -	$ 25,000	$ -
Stuart Substation: Upgrade Clinton 345 kV line relaying. (n5898)	$ 7,500	$ -	$ 2,500	$ -
Allocation for New System Upgrades				
	$ -	$ -	$ -	$ -
Contribution to Previously Identified Upgrades				
Adkins-Beatty 345 kV Line: Replace full takeoff structure and upgrade Beatty line conductor leaving Adkins Substation. (n5933)	$ 29,725	$ 23,118	$ 6,606	$ 6,606
Totals	$2,961,268	$2,239,038	$667,227	$639,727

Schedule:

The Interconnected Transmission Owner will complete design and construction of the facilities listed in Schedules C and I of this CSA within **24 months** from the later of the Effective Date of the CSA and the date that Interconnection customer notifies both PJM and the Interconnected Transmission Owner in writing that it has acquired all easements, properties, and permits necessary for the construction of Customer Interconnection Facilities.

Activity Schedule	Start Month	End Month
Preliminary Engineering	1	4
Detailed Engineering	4	12
Equipment Procurement – Delivery	12	15
Above Grade Construction	15	22
Testing & Commissioning	22	24

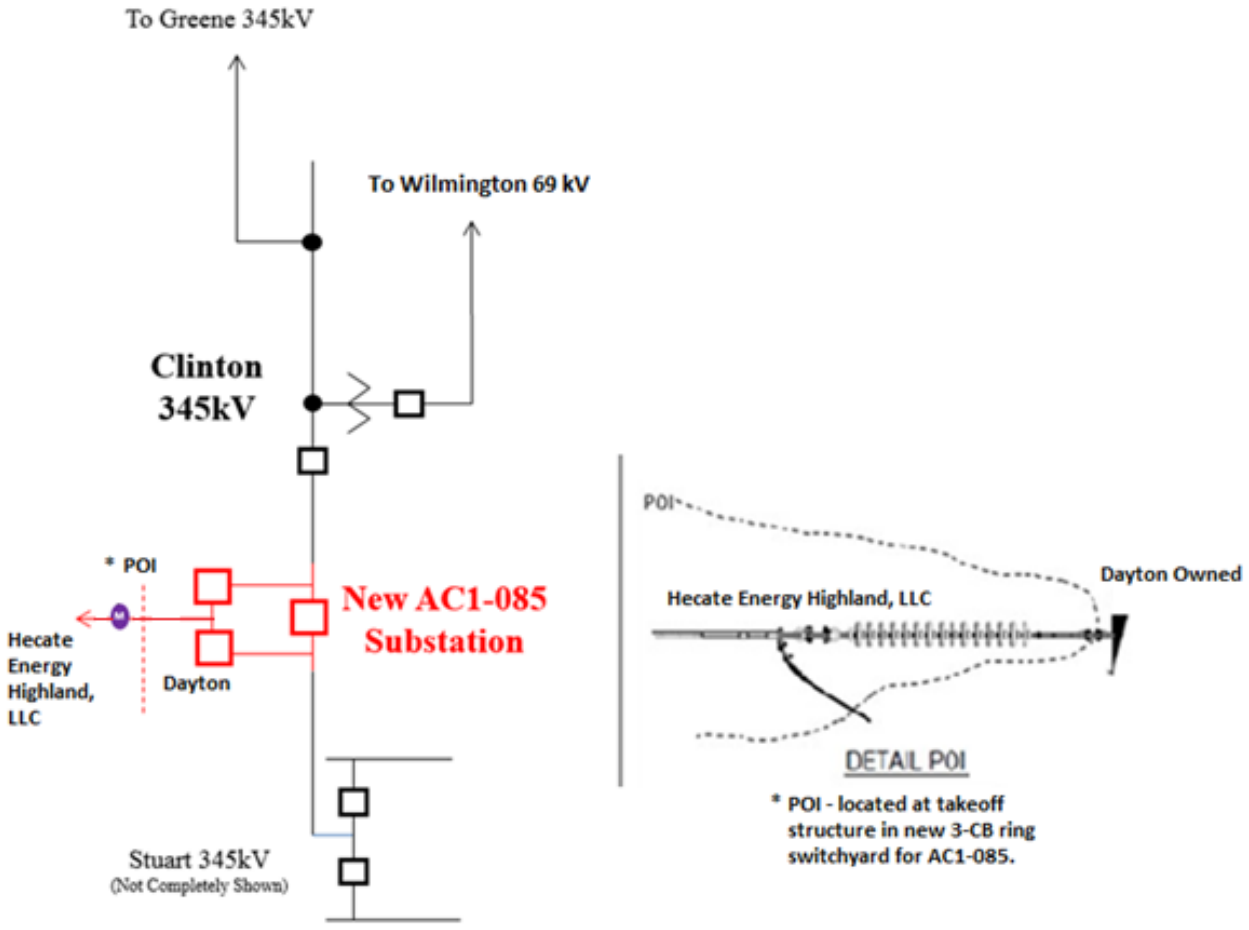
Month #1 corresponds to the first month after the later of the Effective Date of the CSA and the date that Interconnection Customer notifies both PJM and the Interconnected Transmission Owner in writing that it has acquired all easements, properties, and permits necessary for the construction of Customer Interconnection Facilities.

The Interconnection Customer shall complete all Customer Interconnection Facilities set forth in Schedules G and I of this CSA by **December 31, 2021**.

Timing of this work is subject to approval of facility outage requests by Dayton and PJM Transmission Operations, and that system conditions allow outages to occur as scheduled.

Attachment 1. PJM Queue #AC1-085

One Line Diagram



Attachment 2. PJM Queue #AC1-085
Site Plan Drawing

2.5 Miles East of Buford, Ohio

Attachment 3. PJM Queue #AC1-085

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 #AC1-085

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