

Generation Interconnection Feasibility Study Report Queue Position W1-131

The Interconnection Customer (IC), has proposed a 5 MWE (1.9 MWC) solar powered generating facility consisting of ground mounted fixed panel solar arrays to be located in Worcester County, Maryland. PJM studied W1-131 as a 5 MW injection into the Delmarva Power and Light (DPL) system at the Kenney 25kV substation. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Point of Interconnection

W1-131 will interconnect to the Delmarva Power and Light distribution system at the Kenney 69/25kV substation.

Summary of Required DPL System Enhancements/Changes

- Establish a dedicated 25kV circuit out of Kenney substation to serve the proposed generator installation. The new feeder will be protected by a front line SEL-451 and backup SEL-551.
- Install a fiber optic bi-directional transfer trip channel (two fibers) between Kenney and the generator site, the transfer trip channel will use SEL mirrored bit protocol. Transfer trip will be sent from Kenney to the site to trip the generation. The status of the generator breaker will be sent from the site to Kenney substation.
- Install a new ALR at the point of interconnection (the installation of this new ALR is dependent on Distribution Planning's decision as to whether to apply the proposed draft DR design criteria).
- Install a circuit breaker on the high side of the transformer at Kenney.
- Install a three phase 69kV potential transformer on the Kenney 69kV bus position, and provide overcurrent and differential protection for the Kenney transformer via a new SEL-487E and SEL-451 relay. The SEL-451 will be used to provide overvoltage protection for the DPL 69kV equipment, due to the potential for backfeeding through the ungrounded high side winding on the distribution transformer.
 - The phase directional over current elements must be set to see all phase faults on the Piney Grove-Wattsville 69kV Line.
 - The OV/UV voltage protection must be set based on IEEE 1547, Table 1 requirements.
 - The OF/UF frequency protection must be set based on IEEE 1547, Table 2 requirements.
 - The preceding protection must operate before automatic reclosing takes place on the Piney Grove-Wattsville 69kV line. The first automatic reclose time is 3 Seconds from the Piney Grove end.

Direct Connection (Attachment Facilities) Work Summary

- Add a new feeder bay to the T1 25kV bus. It will be a new steel box structure similar to designs used at other stations. The new bay will include a 25kV, 1200A breaker with

disconnect switches and all associated foundations, bus, grounding, conduit, etc. A 3-phase PT will be installed on the 25kV bus.

- The protection for the new feeder will be SEL451/SEL551 package
- T1 will be replaced with a new 69-25kV, 37MVA unit with LTC. Its foundation and oil containment would also be replaced along with its disconnect switches (69kV and 25kV) and main 25kV breaker.
- New T1 will be protected by SEL387E/SEL451 package
- A set of 3-phase CVT's will be installed on the T1 69kV bus position
- Old T1 will be removed along with its foundation / oil containment
- Adequate space for new equipment exists in the control house at the time of this project
- No major ground grid upgrades are required beyond small additions associated strictly with the addition of the new equipment in the station

DPL Work Scope and Costs

The scope of work and estimated costs for the direct connection facilities is as follows:

1. Kenney 69/25kV substation
 - a. Install an express feeder (including one circuit breaker with disconnect switches and foundation, one one-bay box structure with foundations, 69 kV CVTs on the 25 kV bus with structure and foundation, change out of the 25 kV bus overcurrent relay with a new SEL451, one new feeder control panel with SEL 451 and SEL551 relays and all bus work, conduit, control cable, and grounding for above items as needed). Install a new 69/25 kV transformer to replace the existing 7.5 MVA transformer T1 (including new foundation and oil containment, removal of old foundation and new transformer protection panel). The estimated cost to perform this work is **\$2,330,000**.
 - b. Perform the distribution line work for the feeder (install approximately 3 miles of 1000 kcmil UG cable). The estimated cost to perform this work is **\$1,000,000**.
 - c. Install utility grade metering on the new feeder. The estimated cost to perform this work is **\$40,000**.
 - d. Install SCADA to Control Center for the new feeder. The estimated cost to perform this work is **\$20,000**.
 - e. Perform upgrades to the 69kV bus as necessary. The estimates cost to perform this work is **\$200,000**.

The estimated cost to perform the work at the **Kenney** substation is **\$3,570,000**.

2. Perform Dynamic Study. The estimated cost to perform this work is **\$30,000**.
3. Perform system protection planning, transfer trip, and other engineering work. The estimated cost to perform this work is **\$30,000**.

The total estimated cost to perform this work is **\$3,650,000** and will take an estimated **6 – 12 months** to complete after receipt of a fully executed Interconnection Service Agreement (ISA) and Interconnection Construction Service Agreement (CSA).

Note: the above cost does not include the Contribution in Aid of Construction (CIAC) tax.

Interconnection Customer Scope of Direct Connection Work

The Interconnection Customer (IC) assumes full responsibility for design and construction of all facilities associated with the W1-131 generating station. Site preparation including grading and an access road, as necessary, is assumed to be by the IC.

Metering

The IC will be required to install metering and telemetry equipment to provide revenue metering and real-time telemetry data to PJM. The requirements for this equipment are listed in Appendix 2, Section 8 of Attachment O to the PJM Tariff, as well as PJM Manuals 01 and 14D. Protective relaying and metering design and installation must comply with Delmarva Power and Light's Applicable Standards.

Metering and telemetering requirements for Delmarva Power and Light Company:

Primary Metering

A new revenue quality meter will be installed at the Point of Interconnection. This will be the official measurement of net bidirectional megawatt hours (MWH) and megavar hours (MVARH) exchanged between the Delmarva System and the Interconnection Customer. Interconnection Customer will be required to provide a phone line within close proximity (approximately three feet) of the revenue meter to enable Delmarva to remotely interrogate the meter. Metering will conform to Delmarva's Applicable Standard "Technical Considerations Covering Parallel Operations of Customer Owned Generation of One Megawatt or Greater and Interconnected with the Conectiv Power Delivery System" on the PJM website. The Delmarva work scope will include providing, installing and owning the meter.

Islandizing Protection

Background

In the event of source circuit loss, the generators must not continue to operate in an island condition with other Delmarva Power load. In addition, the generators must be disconnected before any reclose is made on the DPL source circuit. Local protection at the generator site must detect islanding and disconnect the generators. Frequency and voltage sensing is generally used to detect islanding in addition to being used for fault detection and to prevent abnormal generator operation outside allowable ranges. Trip values and operating times for voltage and frequency protection are outlined in IEEE Standard 1547, 2005, *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*. The generator protection must sense these quantities at the 25kV Point of Interconnection (POI) and disconnect the generators within the values and operating times defined in IEEE 1547.

To utilize frequency and voltage protection to detect islanding, the voltage and/or frequency must decline to the required setting range and within the necessary clearing time. For this to occur, a certain amount of generation to load mismatch is required. The IEEE 1547 Standard (Section 4.4, "Islanding" & "Footnote 12") require that the generator capacity be less than one third of the

minimum load in the local electric power system. This criteria was used to evaluate the generator isolation cases detailed below.

Trip of the 25kV Source Transformer

It has not yet been determined which 25kV bus (T1 or T2) the new dedicated circuit for this interconnection will be fed from. However, the tripping of either transformer will result in the proposed generator being isolated with the total loads of that transformer. Delmarva Distribution Planning provided the following load data for these feeders.

Feeder	Peak Load
T1	5 MVA
T2	7.9 MVA

T1

$$0.9(5) = 4.5 \text{ MW @ } 0.9 \text{ PF}$$

$$4.5/5 = 0.9/1 \text{ Load to Generation Ratio at Peak Load}$$

System Operations normally considers minimum load to be approximately 40% of peak load.

$$0.4(4.5) = 1.8 \text{ MW}$$

$$1.8/5.0 = .36/1 \text{ Load to Generation Ratio at Estimated Minimum Load}$$

T2

$$0.9(7.9) = 7.11 \text{ MW @ } 0.9 \text{ PF}$$

$$7.11/5 = 1.42/1 \text{ Load to Generation Ratio at Peak Load}$$

System Operations normally considers minimum load to be approximately 40% of peak load.

$$0.4(7.11) = 2.84 \text{ MW}$$

$$2.84/5 = 0.57/1 \text{ Load to Generation Ratio at Estimated Minimum Load}$$

Based on the preceding minimum loading, operation of the local voltage and frequency relaying at the generator site is inadequate at any loading, and cannot insure detection of all islanding cases. Therefore, transfer trip is required between Kenney substation and the generator. The SEL-451 front line multi-function microprocessor relay protecting the new dedicated circuit to this interconnection will interface with the transfer trip channel to provide this functionality.

Trip of the 6712 or 6729 Lines

Since the proposed generator will have sufficient capacity to exceed the maximum expected loading on its associated 25kV bus, a backfeed through the 69/25kV transformer is expected. Therefore a trip of either line will also require transfer trip to be sent to the generator as well. This backfeed will also require the installation of three single phase potential transformers on the Kenney 69kV bus, and the addition of an SEL-451. This is required to provide overvoltage protection, since there will be a backfeed through the 69/25kV transformer’s high side ungrounded winding.

Feeder Circuit Fault Detection

The generator must automatically and immediately disconnect in the event of fault conditions on the DPL source circuit. The IEEE 1547 document (Section 4.1.2, “Integration with Area EPS

Grounding” and Section 4.2.1 “Area EPS Faults”) requires that interconnected generators disconnect for utility source circuit faults and not cause over voltages.

Transmission Network Impacts

Potential transmission network impacts are as follows:

Generator Deliverability

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

None

Multiple Facility Contingency

*(Double Circuit Tower Line, Line with Failed 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

Short Circuit

None

Stability Analysis

Not required due to project size.

Dynamic Analysis

A time-based dynamic study will be completed during the System Impact Study phase of W1-131.

AC injection into the grid must follow a ramp up rate that does not negatively affect the distribution system. An inverter capable of dynamic VAR output with Droop and Time Delay settings will be required. Further study will be required to review the impact to the grid under all output scenarios and grid load profiles. The proposed project will be reviewed for protection and coordination issues and any other required upgrades will be identified in future studies.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. “Network Impacts,” initially caused by the addition of this project’s generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project.

None

Potential Congestion due to Local Energy Deliverability

(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:

These are not required reliability upgrades.

None