Generation Interconnection Feasibility Study Report Queue Position W2-002

The Interconnection Customer (IC) has proposed a 20 MWE (7.6 MWC) solar powered generating facility consisting of ground mounted fixed panel solar photovoltaic arrays. The project is to be located in Kennedyville, Kent County, Maryland. PJM studied W2-002 as a 20MW injection into the Delmarva Power and Light (DPL) system at the Lynch substation and at a tap of the Lynch-Kennedyville 69kV circuit. The project was evaluated for compliance with reliability criteria for summer peak conditions in 2014. The planned in-service date, as stated in the Attachment N, is December 1, 2011.

Point(s) of Interconnection

The Interconnection Customer requested two (2) Points of Interconnection (POI) be evaluated for the W2-002 project. The Primary POI is a distribution interconnection at the DPL Lynch 25kV substation. The Secondary POI is a transmission interconnection at a tap of the Lynch-Kennedyville 69kV circuit.

Primary Option

W2-002 will connect to the Delmarva Power and Light distribution system at the Lynch 25kV substation via two new lines as follows:

10 MWs of generation to the existing T1 at Lynch Substation; 10 MWs of generation to a new transformer at the Lynch Substation.

Direct Connection Requirements

Summary of DPL System Enhancements/Changes Needed

- Establish two dedicated 25kV circuits out of Lynch substation to serve the proposed generator installation. One circuit will connect to the existing transformer, and one on the new transformer. The new feeders will each be protected by a front line SEL-451 and backup SEL-551.
- Install the following upgrades to accommodate the new transformer and circuits: four 69kV breakers, two 25kV mains, one 25kV bus tie, two 25kV feeder breakers, and two 25kV bus breakers.
- Install a fiber optic bi-directional transfer trip channel (two fibers) between Lynch and the generator site, the transfer trip channel will use SEL mirrored bit protocol. Transfer trip will be sent from Lynch to the site to trip the generation. The status of the generator breaker will be sent from the site to Lynch substation.
- Install a new Automatic Line Recloser (ALR) at each point of interconnection (the installation of two new ALRs is dependent on Distribution Planning's decision as to whether to apply the proposed draft DR design criteria).

- Install a three phase 69kV potential transformer on the Lynch 69kV bus position, and provide overcurrent and differential protection for the new Lynch 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 6727 terminal at Church.

Transmission Owner Scope of Direct Connection Work

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

1. Establish two (2) new 25 kV feeders with PAC overhead conductor from the Lynch Substation to the Customer Facility – approximately 2.44 miles.
2. A utility operated recloser will be required on the customer taps that will have proper relaying and communication.
3. Utility grade primary metering will be required.
4. SCADA point addition to Control Center will be required.
5. Perform Dynamic Study.
6. Protection, Planning, and other engineering departments will do further studies and design work.

The estimated cost to perform this work is as follows:

Estimated Costs For			
Lynch Substation T1			
PAC Express Feeder	2.44	Miles	$976,000
New Feeder Terminal (Included in Substation Cost Below)			
Recloser w/ Relaying and Communications			$50,000
Utility Grade Metering			$20,000
SCADA Work			$10,000
Dynamic Study			$30,000
Various Departments Work ($15,000 10 MW or less, $20,000 if over 10 MW)			$15,000
Approximate Total Cost			$1,101,000

Estimated Costs For			
Lynch Substation New Transformer			
New Transformer, Feeder Terminals, Breakers, Bus Tie			$5,200,000
PAC Express Feeder	2.44	Miles	$976,000
Recloser w/ Relaying and Communications			$50,000
Utility Grade Metering			$20,000
SCADA Work			$10,000
Dynamic Study			$30,000
Various Departments Work ($15,000 10 MW or less, $20,000 if over 10 MW)			$15,000
Approximate Total Cost			$6,301,000

Total Estimated Costs	
Lynch Substation, Both Transformers and Feeders	
Approximate Sub Total	$7,402,000
Approximate Sub Total with 18% Overhead	$8,734,000
Approximate Sub Total with 15% contingency	$10,044,000

The estimated time to complete this work is **12 months** 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 W2-002 generating station. Site preparation including grading and an access road, as necessary, is assumed to be by the IC.

Inverter Requirements and Capabilities

The inverter at the Customer Facility should have the following capabilities:

- Voltage flicker reduction through dynamic VAR response
- Ramp rate control
- SCADA communications
- Curtailment or other mitigation ability if high voltage were to occur
- Low voltage and system disturbance ride through
- Ability to receive and respond to a transfer trip or SCADA signal

The inverter shall operate in accordance with the IEEE 1547 series of standards that have been approved. While inverters should be capable of voltage stabilization thru dynamic VAR response and capable of low voltage and system disturbance ride through, neither of these capabilities shall be implemented until such time that the IEEE 1547 series of standards are revised and approved to include standards for these capabilities. At such time as these revised standards become available, the PV owner/operator shall cooperate with ACE to implement these capabilities with settings acceptable to Pepco Holdings, Inc. (ACE, DPL, and Pepco). Until such time, the inverters shall operate with a fixed power factor schedule as supplied by PHI.

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.

Trip of the 25kV Source Transformer

This installation will be connected in two 10MW blocks. One block will be connected on an express circuit to a transformer with existing DPL load, and the other will be connected to a new 69/25kV transformer at the station. In both cases there is either inadequate load or no load that would be isolated with the generation to ensure it trips due to voltage and/or frequency decay.

Therefore, transfer trip is required between Lynch substation and the generator. The SEL-451 front line multi-function microprocessor relay protecting each circuit to this interconnection will interface with the transfer trip channel to provide this functionality.

Trip of the 6727 Line

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 the 69kV line will require transfer trip to be sent to the generator. This backfeed will also require the installation of three single phase potential transformers on the Lynch 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.

Metering Equipment

Metering and telemetering requirements for PJM:
The Interconnection Customer will be required to install the equipment necessary to provide revenue metering (KWH and KVARH hourly data sent once per day) and telemetry for the Interconnection Customer's generating resource in compliance with PJM Manuals M-01 and M-14B, and the Tariff.

Metering and telemetering requirements for Delmarva Power and Light Company:
Primary Metering
A new revenue quality meter will be installed at each 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.

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 contingencies at **Full** energy output. Stuck Breaker and Bus Fault contingencies will be applied during the System Impact Study.*

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

Not required.

Dynamic Analysis

A time-based dynamic study will be completed during the System Impact Study/Facilities Study phase of W2-002.

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

Secondary Option

The Secondary POI is a transmission interconnection at a tap of the Lynch-Kennedyville 69kV circuit.

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 contingencies at **Full** energy output. Stuck Breaker and Bus Fault contingencies will be applied during the System Impact Study.*

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

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