PJM Generator Interconnection

Y1-060 Earleys 115 kV

7.5 MW Capacity / 15 MW Energy

Feasibility Study Report

July 2012
DMS #708824v1

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, §36.2 and §110, as well as the Feasibility Study Agreement between Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company.

Preface

The intent of this Feasibility Study is to determine a plan, with preliminary cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by IC. As a requirement for interconnection, IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM and the underlying system. All facilities required for interconnection of a generation interconnection project must be designed to meet ITO technical specifications.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. IC is responsible for its right of way, real estate, and construction permit issues.

General

The queue project Y1-060 was studied as a 15 MW (7.5 MW Capacity) solar injection at Earleys 115 kV substation in to the ITO area. IC provided engineering support to request Capacity above the class average of 38% of the total energy for solar. Project Y1-060 was evaluated for compliance with reliability criteria for summer peak conditions in 2015. Potential network impacts were as follows:

Network Impacts:

Impactful Contingencies

(The following contingencies resulted in overloads identified below)

None.

Generator Deliverability

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

None.

Multiple Facility Contingency

(Double Circuit Tower Line Contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)

None.

Contribution to Previously Identified Overloads

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have % allocation of cost responsibility which will be calculated and reported for the Impact Study.)

None.

Short Circuit

(Report Overdutied breakers here)

There is no impact to breaker interrupting capabilities.

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

To be determined at System Impact or Facilities Study.

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

To be determined at System Impact or Facilities Study.

Delivery of Energy Portion of Interconnection Request

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. Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

None.

ITO Analysis

ITO agrees with the results of this report.

Distribution Company Analysis

IC requested a Facility Study of a 15 MW interconnection for its proposed Aulander, NC facility onto ITO 34.5 kV distribution System. IC has requested that any modifications to existing facilities and any facilities built new to accommodate the 15 MW interconnection requests be constructed for a potential final build out capacity of 15 MW. The requested site has ITO's existing 34.5 kV Earleys Substation Circuit source.

Distribution Facilities and Location:

Earleys Substation, located on NC-11/NC-42 between Joe Holloman Road and NC-11 Business/NC-350 in Aulander, NC, is a 115/34.5 kV substation. It currently houses two 34.5 kV circuits and has room to expand. Dominion proposes installing a new breaker to accommodate IC's 15 MW interconnection. Even though the solar capacity factor reduces the capacity amount, the full 20 MW was used for this study onto the distribution network. The IC's interconnection is to be located approximately 4000 ft away from the substation. The smallest conductor in the main line to the interconnection is proposed to be 477 AAC which is capable of handling 36 MVA of load.

Non Direct Connect Local Upgrades

Modifications are required to existing Earleys Substation to accommodate proposed interconnection. Modifications inside the substation will include:

1. Relocation of Capacitor Banks to make room for a new breaker and getaway $28,989.

Direct Connect Local Upgrades

A new distribution bus structure will be added to accommodate the new breaker. The total estimate of the new distribution bus structure will be $22,516.

New Facilities Required:

The new facilities required to provide the interconnection will include:

1. Installation of transfer trip protection equipment in Earleys Substation.
2. Installation of transfer trip protection equipment at Carolina Substation
3. Installation of transfer trip protection on IC generator breaker.
4. Installation of approximately 2200 feet of a three phase overhead line and fourteen (14) poles.
5. Installation of approximately 400 feet of 1000 MCM Bulk Feeder.
6. Installation of new Breaker.
7. Installation of three phase overhead line tension disconnects at two separate pole locations.
8. Installation of pole mounted bi-directional metering.

The Facilities Study estimated cost for the installation of new facilities to provide the interconnection is $780,597.40. The grand total for modification and new facilities to provide interconnection is $832,102.42.

In addition to the ITO facilities indicated above, to provide a transfer trip circuit protection scheme, the IC will be responsible for providing and maintaining communication lines between the IC's main generator breaker and the ITO's Earleys Substation. The IC will also be responsible for providing and maintaining telephone lines to the ITO's metering equipment at the Point of Interconnection. The IC provided 34.5 kV 3-phase circuit will interconnect overhead at the Point of Interconnection which will be the load side terminals of the ITO provided pole mounted bi-directional meter. It will be the IC's responsibility to obtain any required right-of-way between the ITO's existing facilities and the Point of Interconnection.

The estimated time for engineering, material acquisition and construction of this interconnection is approximately 8 months. Detailed engineering, costs, material lead times and construction time requirements will be determined as part of the System Impact Study.

Operating Restrictions

ITO has reviewed the 15 MW Solar Farm (PJM Queue W1-057) request for installation of parallel Generation (15 MW) units located at 265 Joe Holloman Road, Aulander, North Carolina 27805. The Interconnection Customer desires to export power into the Dominion North Carolina Power (DNCP) utility source and site generation power. This is typically an inverter based interconnection which consists of two (2) 1 MVA and nine (9) 2 MVA rated transformers rated 34.5 kV – 480 V (delta - wye-ground). The customer is planning the installation of a line switch between their Main Breaker and Dominion facilities. The resulting protection requirements are based on the following information:

- No more than 15 MW of total generation will be in parallel with the DNCP system at any one time.

- The customer's generation facility will be paralleled with the DNCP system by the following connections:

- The Customer will be connected to Earleys substation new circuit breaker dedicated to the generation and located adjacent to 30262.

- Earleys new breaker has reclosing time at 10 seconds and 45 seconds after the first trip.

- Customer parallel operation will not be limited to any particular time or utility circuit-loading condition.

- The customer will be contracting with PJM to export power into the DNCP distribution system.

Based on the minimum loads given for the utility sectionalizing devices, the following minimum "Local Load to Customer Generation Capacity" ratios will apply for this installation:

Utility Device	*Minimum Ratio*
New CB	0.00

The minimum ratios applicable for this installation would normally require the customer to have the **Direct Pilot Wire Tripping** (or Transfer Trip) function installed from the utility device new CB and Substation Transformer #1 to the generation site's lockout (main breaker). Such direct tripping functions should sectionalize the customer generation for any opening of the respective device. The direct trip control feature is meant to ensure that a "prolonged" (or "permanent") islanding condition (with the customer generation supplying utility load in the absence of the utility source) will not be set-up. In addition, the direct tripping function would aid in protecting the customer generator from an out-of-step reclosure of the utility source.

A review of the Transmission Line Light load provided the following information:

- Carolina Line 54 to Earleys light load is about 15,500 kW or 19.4 MVA
- The minimum ratio with respect to the customer generation is 0.77

Such line loading and associated ratio shows a possible risk of Islanding and therefore will require the addition of Line Transfer Trip.

Moreover, additional functions are required at the customer main breaker relays in order to provide adequate backup protection. Those functions and their general set point are listed in the following table:

Function		**Set Point**	Duration to Generation Cleared (seconds)	
			Preferred	Maximum
27	Undervoltage	90% of nominal operating voltage	Less than 2.0	2.0
59	Overvoltage	106 to 110% of nominal operating voltage	Less than 2.0	2.0
81U	Underfrequency	59.0 to 59.5 Hz	Less than 2.0	2.0
81O	Overfrequency	60.5 to 61.0 Hz	Less than 2.0	2.0
51	Phase Time-delay Overcurrent	Set for minimum, with adequate load allowance	Maintain proper coordination	
51N	Ground Time-delay Overcurrent	Set for minimum, with adequate imbalance allowance	Maintain proper coordination	

The inverters specified in this interconnection request have **not yet been proven** to comply with the UL-1741 standard. We request that information documenting the selected 1000 kW Sun Power inverters are UL certified be provided once that information becomes available.

Some inverter models have the option of customizing some of their protective or tripping settings such as the Overcurrent or Ground protection. If this is the case, for your selected inverters, we will also need to know that in advance so that appropriate setting ranges can be established for application to the inverters in a timely manner.

Harmonics (voltage and current) if not controlled can be a source of problems on the DNCP network. Though it is definitive that small scale PV systems (i.e. about 10 kW or less) have little to no significant Harmonics effects on the system provided their associated converter meet the IEEE standard 519 (Guideline for Harmonic Control and Reactive Compensation of Static Power Converter), the impacts of

larger scale PV systems is far less certain. It is a general consensus that a concentration of small sources of harmonic distortion - as little as they could be - can have a significant effect on the overall utility network's power quality as the effect of harmonics are cumulative thus making it imperative not to ignore the Harmonics in this particular 20 MW interconnection request.

In Summary, **Power Quality baseline readings** will be required at the point of common coupling (PCC) before and after the interconnection is completed in order to monitor the Harmonic effects of the Generation unit and will be obtained at the customer's expense. Also, if there is evidence that the Total Harmonic Distortion (THD) is greater than or equal to 5% harmonic distortion for any single harmonic is greater than or equal to 3%, the customer would be required to add a filtering system to its installation to meet the requirements of IEEE 519.

Since the application of Pilot Wire Tripping is provided at customer expense and have associated engineering, equipment acquisition and installation lead-time, we would need to work out all of those details to coordinate with your planned installation.

Finally, a request for model information and evidence of certification of the 1000 kW inverters to the UL1741 standard for use with Distributed Energy Resources was submitted to the customer and has not yet been satisfied. In order to proceed with a ISA, ICSA, hard evidence of certification to UL1741 will be required.