PJM Generator Interconnection

W3-050 Kelford 34.5 kV

7.6 MW Capacity / 20 MW Energy

Feasibility Study Report

January 2011
DMS #628923v1

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, §36.2, 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

Queue W3-050 is an IC 20 MW energy (7.6 MW Capacity) solar park generation request. W3-050 will be located in Kelford, NC in the Dominion area. The requested in-service date is December 31, 2012. The project was studied with its primary interconnection point at Kelford 115 kV substation. Project W3-050 was evaluated for compliance with reliability criteria for summer peak conditions in 2014.

Network Impacts:

Generator Deliverability

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

No problems identified.

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)

No problems identified.

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.)

No problems identified.

Contribution to Previously Identified System Reinforcements

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

None.

Short Circuit

(Report Overdutied breakers here)

No problems identified.

ITO Analyses

IC has requested a Feasibility Study of a 20 MW interconnection for its proposed Kelford, NC facility onto ITO 34.5 kV distribution system. IC requested that any modifications to existing facilities and any facilities built new to accommodate the 20 MW interconnection requests be constructed for a potential final build out capacity of 20 MW. The requested site has ITO's existing 34.5 kV Kelford Substation Circuit 380 source.

Distribution Facilities and Location

Kelford Substation, located on NC-308 (Governors Rd.) just north of Piney Woods Rd. in Kelford, NC, is a 115/34.5 kV substation. It is the source of one 34.5 kV circuit (67 380). Even though the solar Capacity factor reduces the Capacity amount, the full 20 MW was used for this study onto the distribution network. There are two options available for IC's interconnection. The first Point of Interconnection (POI) is to be located approximately 6000 ft away from the substation; tapped off of Governors Rd., and the second is to be located approximately 1250 ft away; closest point to substation.

Non-Direct Connection Local Upgrades for Both Options

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

1. Installation of Circuit Switcher for both Points of Interconnection ($125,000).

The total estimated cost of Substation modification work is $125,000.

Attachment Facilities and Direct Connection Upgrades

Primary Option

The new facilities required to provide the interconnection will include:

1. Installation of transfer trip protection on the Circuit 380 breaker in Kelford Substation.
2. Installation of transfer trip protection on IC generator breaker.
3. Installation of approximately 2000 feet of a three phase overhead line and 9 - three phase poles (depending on the location of interconnection).
4. Installation of ABB Electronic Recloser.

5. Installation of three phase overhead load break switch.
6. Installation of pole mounted bi-directional metering.

The Feasibility Study estimated cost for the installation of new facilities to provide the interconnection, at this location, is $245,005.00. The Grand Total for Modification and New Facilities to provide interconnection is $370,005.

Secondary Option

The new facilities required to provide the interconnection will include:

1. Installation of transfer trip protection on the Circuit 380 breaker in Kelford Substation.
2. Installation of transfer trip protection on IC generator breaker.
3. Installation of approximately 250 feet of a three phase overhead line, 3- three phase poles, and 2 - three phase terminal poles depending on the location of interconnection.
4. Installation of approximately 1000 feet of 1000 MCM Bulk Feeder.
5. Installation of ABB Electronic Recloser.
6. Installation of three phase overhead load break switch.
7. Installation of pole mounted bi-directional metering.

The Feasibility Study estimated cost for the installation of new facilities to provide the interconnection, at this location, is $260,667.00. The Grand Total for Modification and New Facilities to provide interconnection is $385,667.

Other Technical Requirements Applicable to Both Options

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 Kelford Substation. The IC will also be

responsible for providing and maintaining telephone lines to the ITO's metering equipment at the POI. The IC provided 34.5 kV 3-phase circuit will interconnect overhead at the POI which will be the load side terminals of ITO provided pole mounted bi-directional meter. It will be IC's responsibility to obtain any required right-of-way between ITO's existing facilities and the POI.

ITO reviewed the 20 MW Solar Farm (PJM Queue W3-050) request for installation of parallel generation units (20 MW) located at 3725 Governors Road, Kelford, North Carolina 27847. IC 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 MW inverters per transformer and ten (10) 2 MVA rated transformers rated 34.5/19.9 kV – 800/462 V (wye-ground - wye-ground). The resulting protection requirements are based on the following information:

- No more than 20 MW of total generation will be in parallel with the DNCP system at any one time.

- IC generation facility will be paralleled with the DNCP system by the following connections:

  1. IC will be connected to Kelford Substation to Circuit 380 via up-line breaker 38022.

  2. Kelford Circuit 380 breaker has reclosing time at 10 seconds and 45 seconds after the first trip.

- The load data for the pertinent sectionalizing devices are as follows:

  1. Kelford Circuit 380 (38022) has a typical "light" loading of 5 MVA.

  2. Kelford Transformer Number 1has a typical "light" loading of 5 MVA.

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

- IC 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*
CB 38022	0.25
Transformer No. 1	0.25

The minimum ratios applicable for this installation would normally require IC to have the Direct Pilot Wire Tripping (or Transfer Trip) function installed from the utility device CB 38022 and substation transformer #1 to the generation site's lockout (main breaker). Such direct tripping functions should sectionalize the IC 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 IC 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 IC generation equipment from an out-of-step reclosure of the utility source.

A review of the Transmission Line 126 light loading provided the following information:

- Line 126 typical "light" loading is approximately 7.9 MVA

- The minimum ratio with respect to the customer generation is 0.4

Such line loading and associated ratio indicates a 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	

Some inverter models have the option of customizing some of their protective or tripping settings such as the over-current or ground protection. If this is the case, for IC selected inverters, ITO 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 IC 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 IC 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 IC 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.

Once the actual inverters for use with this project have been determined, we request that specific manufacturer/model information be provided for our review.

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.