PJM Generator Interconnection

X1-067 Plymouth 34.5 kV

0 MW Capacity / 20 MW Energy

Feasibility Study Report

July 2011
DMS #656468v1

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 project X1-067 was studied as a(n) 20.0 MW (0.0 MW of which was Capacity) injection into ITO system at the Plymouth 34.5 kV substation. Project X1-067 was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

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.

Energy Portion of Interconnection Request

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. 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 analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

No problems identified.

ITO Analyses

IC has requested a Feasibility Study of a 20 MW interconnection for its proposed Plymouth, 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 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 Plymouth Substation circuit 335 source.

Distribution Facilities and Location

Plymouth Substation, located on Rankin Lane off of highway 64/ North Carolina route 32, in Plymouth, NC, is a two transformer 115/34.5 kV substation. It currently houses two 34.5 kV circuits (62335 and 62340). Even though the solar capacity factor reduces the capacity amount, the full 20 MW was used for this study onto the distribution network. IC point of interconnection is to be located approximately 17,250 ft. (3.3 miles) away from the substation.

Modifications Required:

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

1. Replace substation fuses with circuit switcher.
2. Reconductor approximately 17250 feet of a three phase overhead line with 477 Al. conductor.
3. Replace approximately 20 - three phase poles.
4. Replace 2 hydraulic reclosers with 2 - electronic reclosers with transfer trip capability.

The total estimated cost of substation modification work is $1,144,970.

New Facilities Required:

The new facilities required to provide the interconnection will include:

1. Installation of transfer trip protection on the circuit 335 breaker in Plymouth Substation.
2. Installation of transfer trip protection on IC generator breaker.

3. Installation of transfer trip protection on reclosers.
4. Installation of three phase overhead load break switch.
5. 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 $150,000. The grand total for modification or existing and new facilities to provide interconnection is $1,294,970.

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 Plymouth 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 eight months. Detailed engineering, costs, material lead times and construction time requirements will be determined as part of the System Impact Study.

Technical Requirements

ITO reviewed the 20 MW Solar Farm (PJM Queue X1-067) request for installation of parallel generation (20 MW) units located at Pine St. & Wilson St., Plymouth, North Carolina 27962. The IC desires to export power into the ITO source. This is an inverter based interconnection which consists of twenty (20) 1 MVA rated transformers rated 34.5 kV – 480 V (delta - wye-ground), with four (4) 260 kW inverters per

transformer. The resulting protection requirements are based on the following information:

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

- IC generation facility will be paralleled with the ITO system by the following connection:

  - IC will be connected to Plymouth substation circuit 335 via up-line breaker 33532, up-line recloser 335R4, and up-line recloser 335R19.

  - Plymouth circuit 335 breaker has reclosing time at 10 seconds and 45 seconds after the first trip. 335R4 has reclosing times at 20 seconds and 55 seconds after the first trip. 335R19 has reclosing times at 2 seconds and 4 seconds after the first trip.

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

  - Plymouth Circuit 335 (33532) has a typical "light" loading of 2.51 MVA.
  - Recloser 335R4 has a typical “light” loading of 1.79 MVA.
  - Recloser 335R19 has a typical “light” loading of 1.31 MVA.

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

- IC will be contracting to export power into the ITO distribution system.

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

ITO Transmission Line	Minimum Ratio
CB 33532	0.100
335R4	0.072
335R19	0.053

The minimum ratios applicable for this installation would normally require the IC to have the Direct Pilot Wire Tripping (or Transfer Trip) function installed from the utility protection zones or devices: CB 33532, 335R4, 335R19 (which will need to be replaced with an electronic unit), and substation transformer/bus #1 to the generation site's lockout (interconnection or main breaker). Such direct tripping functions should sectionalize the IC generation for any opening of the respective devices. 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 IC generator from an out-of-step reclosure of the ITO source.

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

- Line 64 - Winfall to Trowbridge light load is about 20,000 kW
- The minimum ratio with respect to the IC generation is 1.0

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

The closing conditions for the IC interconnection, or main breaker (IC relays monitoring all three phases of the incoming line [all three "hot"] to establish a "hot" condition) shall be limited to no more than hot line-dead bus (generator) or hot line-hot bus (generator) under supervision of the IC synchronization system.

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

Function		Set Point	Duration To Disconnection (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. ITO requests that information documenting the selected 260 kW 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 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 ITO 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 ITO 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 facility and will be obtained at the IC'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.

In order to proceed, evidence of certification to UL1741 will be required.