Generator Interconnection Request

System Impact Study Report

For: [redacted]

Lee Combined Cycle Plant

Service Location: Anderson, South Carolina

Total Output: 776 MW

In-Service Date: 1/6/2016

Prepared By: Orvane Piper

Date: 9/19/2012

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1.0 Introduction

Following are the results of the Generation System Impact Study for the installation of 776 MW of generating capacity in Anderson County, South Carolina. This site is located near Lee Steam Station and has an estimated Commercial Operation Date of January 6, 2016.

2.0 Study Assumptions and Methodology

The power flow cases used in the study were developed from the Duke internal year 2016 summer peak case. This case contains the planned generation additions at Lee Combined Cycle Plant. The results of Duke's annual screening were used as a baseline to identify the impact of the new generation. To determine the thermal impact on Duke's transmission system, the new generation was modeled with the existing coal generation at Lee Steam Station, units 1-3, retired. The economic generation dispatch was also changed by adding the new generation and forcing it on prior to the dispatch of the remaining Duke Balancing Authority Area units. The impacts of changes in the Generator Interconnection Queue were evaluated by creating models with previously queued generators removed. The study cases were re-dispatched, solved and saved for use.

The NRIS thermal study uses the results of Duke Energy Delivery's annual internal screening as a baseline to determine the impact of new generation. The annual internal screening identifies violations of the Duke Energy Power Transmission System Planning Guidelines and this information is used to develop the transmission asset expansion plan. The annual screening provides branch loading for postulated transmission line or transformer contingencies under various generation dispatches. The thermal study results following the inclusion of the new generation were obtained by the same methods, and are therefore comparable to the annual screening. The results are compared to identify significant impacts to the Duke transmission system.

Stability studies are performed using an MMWG dynamics model that has been updated with the appropriate generator and equipment parameters for the new units. The SERC dynamically reduced 2016 summer peak case was used for this study. The case was modified to turn off some units to offset the new generation. Several transmission system improvements were identified for the addition of these units during the power flow portion of the interconnection request and were added to the dynamics case. NERC Category B, Category C, and Category D faults were evaluated.

Fault studies are performed by modeling the new generator and previously queued generation ahead of the new generator in the interconnection queue. Any significant changes in fault duty resulting from the new generator's installation are identified. Various faults are placed on the system and their impact versus equipment rating is evaluated.

Reactive Capability is evaluated by modeling a facility's generators and step-up transformers (GSU's) at various taps and system voltage conditions. The reactive capability of the facility can be affected by many factors including generator capability limits, excitation limits, and bus voltage limits. The evaluation determines whether sufficient reactive support will be available at the Connection Point.

3.0 Thermal Study Results

3.1 NRIS Evaluation

The following network upgrades were identified as being attributable to the studied generating facility:

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Upgrade Oakvale 100 kV Lines (Shady Grove-Oakvale)	B-477 ACSR	B-954 ACSR	4.09	$5.8M	36
2. Upgrade Tiger 100 kV Lines (Tiger-Lelia Tap)	266 ACSR	556 ACSR	5.27	$6.7M	36
3. Upgrade Union 100 kV Lines (O'Neal Retail-Pebble Creek Retail)	2/0 Cu	556 ACSR	3.03	$3.9M	36
CUSTOMER TOTAL COST ESTIMATE				$16.4M	36

WITH QUEUED PROJECT 40639-01 (958 MW combined cycle facility in Cleveland County, NC):

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Upgrade Clinchfield 100 kV Lines (Cliffside-Pink Harrill)	336 ACSR	954 ACSR	4.72	$6.4M	36
2. Upgrade Gardner 100 kV Lines (Peacock-McAdenville)	795 ACSR	B-795 ACSR	7.82	$10.9M	36
CUSTOMER TOTAL COST ESTIMATE				$17.3M	36

WITH QUEUED PROJECT 40633-01 (358 MW combustion turbine facility in Cleveland County, NC):

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Upgrade Gardner 100 kV Lines (Peacock-McAdenville)	795 ACSR	B-795 ACSR	7.82	$10.9M	36
CUSTOMER TOTAL COST ESTIMATE				$10.9M	36

WITH QUEUED PROJECT 40577-01 (2,344 MW nuclear facility in Cherokee County, SC):

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Reactor on McGuire 500/230 kV Transformer	N/A	1%	N/A	$1.4M*	36
2. Upgrade Beaver 100 kV Lines (Cherokee-Gaffney)	336 ACSR	954 ACSR	.48	$.7M	36
3. Upgrade Beaver 100 kV Lines (Pacolet-Colonial Tap)	336 ACSR	954 ACSR	9.41	$.9M**	36
4. Upgrade Oakvale 100 kV Lines (Shady Grove-Oakvale)	B-477 ACSR	B-954 ACSR	4.09	$5.8M	36
5. Upgrade Tiger 100 kV Lines (Tiger-Lelia Tap)	266 ACSR	556 ACSR	5.27	$6.7M	36
6. Upgrade Union 100 kV Lines (O'Neal Retail-Pebble Creek Retail)	2/0 Cu	556 ACSR	3.03	$3.9M	36
CUSTOMER TOTAL COST ESTIMATE				$19.4M	36

*Note: This upgrade has been previously identified with queue ID 40577-01. The shown cost reflects a 4 year acceleration of the project.

**Note: This upgrade has been previously identified with queue ID 40577-01. The shown cost reflects a 2 year acceleration of the project.

WITH QUEUED PROJECTS 40577-01 (2,344 MW nuclear facility in Cherokee County, SC) and 40639-01 (958 MW combined cycle facility in Cleveland County, NC):

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Upgrade Clinchfield 100 kV Lines (Cliffside-Pink Harrill)	336 ACSR	954 ACSR	4.72	$6.4M	36
2. Upgrade Gardner 100 kV Lines (Peacock-McAdenville)	795 ACSR	B-795 ACSR	7.82	$3.3M*	36
CUSTOMER TOTAL COST ESTIMATE				$9.7 M	36

*Note: This upgrade has been previously identified with queue ID 40577-01. The shown cost reflects a 5 year acceleration of the project.

WITH QUEUED PROJECTS 40577-01 (2,344 MW nuclear facility in Cherokee County, SC) and 40633-01 (358 MW combustion turbine facility in Cleveland County, NC):

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Upgrade Gardner 100 kV Lines (Peacock-McAdenville)	795 ACSR	B-795 ACSR	7.82	$2M*	36
CUSTOMER TOTAL COST ESTIMATE				$2M	36

*Note: This upgrade has been previously identified with queue ID 40577-01. The shown cost reflects a 3 year acceleration of the project.

3.2 ERIS Evaluation

The Customer did not request the facility to be studied under the terms of ERIS service.

4.0 Fault Duty Study Results

The following breakers will need to be replaced:

1. At Lee Steam Station the following seven 100 kV breakers: Broadway Wh, Central Bl & Wh, Lee Bl & Wh, Piedmont Wh, Toxaway Wh
2. At Shady Grove Tie the following four 100 kV breakers: Greenbriar Bl & Wh, Oakvale Bl & Wh

Total estimated cost for breaker replacements: $2.68MM

If the project with queue ID 40577-01 is built, these additional breakers will need to be replaced:

1. At Lee Steam Station the following 100 kV breaker: Rabon Bl

Total estimated cost for breaker replacements: $2.8MM

5.0 Stability Study Results

One NERC Category B2 fault, eight C3 faults, two C5 faults, thirteen D2 faults, and two D7 faults were initially unstable. The B2, C3, C5, and D7 faults all included instantaneous reclosing on one or more lines. When instantaneous reclosing was disabled, all of these faults became stable except for D7-01. D7-01 is a common right-of-way fault near Shady Grove including the Lee, Piedmont, and Oakvale double-circuit 100 kV lines. Disabling instantaneous reclosing at Shady Grove does not help Lee generator stability.

All D2 faults were unstable. These involve a three-phase fault on a 100 kV line near Lee, with the Lee breaker failing to open. For the double-bus, single-breaker design of Lee 100 kV station, a line breaker failure results in loss of about half the branches at Lee. The assumed breaker failure clearing time is 18 cycles, including the 12 cycle intentional delay. This intentional delay would have to be reduced to as low as 1.5 cycles for breakers connected to the Yellow bus and 5.5 cycles for breakers connected to the Red bus. This difference between the Red and Yellow buses is because the new steam turbine generator, ST9, is more susceptible to instability than the combustion turbines, probably due to ST9's lower inertia and higher generator and transformer impedances. ST9 is connected to the Red bus, so it is tripped anyway for Red bus clearing.

However, ST9 needs to stay on-line and stable for Yellow bus clearing. If these reduced breaker failure delays are not feasible, any reduction would improve the chances for stability, for example if the fault were farther out on the line or if the fault had non-zero impedance.

NERC does not require stability for Category D faults because of their low probability of occurrence. As such, no solutions are required for the unstable Category D faults.

Because loss of synchronism on Lee CC units was seen for some faults in this study, the installation and operation of the out-of-step protection is recommended to minimize the possibility of generator damage during the loss of synchronism condition.

The manufacturer proposed power system stabilizers (PSS) were not studied because there was sufficient damping without them. However, a PSS should be purchased along with each exciter. If problems arise in the future, then the facility can quickly implement a PSS solution.

The addition of the proposed 776 MW to the Lee Steam Station does present some stability concerns. However, with the solutions outlined in this report, the Customer's proposed 776 MW generating facility will not negatively impact the overall reliability of the generators or the interconnected transmission system.

6.0 Reactive Capability Study Results

With the proposed generating facility, the level of reactive support supplied by the units has been determined to be acceptable at this time. Evaluation of MVAR flow and voltages in the vicinity of Lee Steam Station indicates adequate reactive support exists in the region.

Study completed by: _____

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