Generator Interconnection Request

System Impact Study Report

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2x1 Combined Cycle Plant

Service Location: Anderson County

Total Output: 776 MW

Commercial Operation Date: 6/1/2016

In-Service Date (if given): 9/1/2015

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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, SC. This site is located near Lee Steam Station and has an estimated Commercial Operation Date of 6/1/2016. This study evaluates Network Resource Interconnection Service (NRIS).

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 at a new interconnection station on the same site with the existing Lee Steam Station. Construction of the new interconnection station will involve modification of two existing circuits. 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 Transmission Planning'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 Energy 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. Interconnection cost [1]	N/A	N/A	N/A	$10.5 M	30
2. Convert Greenbriar to Switching Station	N/A	N/A	N/A	$3 M	24
3. Upgrade Duncan 100 kV Lines (Inman – Campton Retail)	266 ACSR	556 ACSR	2.1	$2.9 M	24
4. Upgrade Greenbriar 100 kV (Shady Grove – Moonville Retail)	477 ACSR	B-477 ACSR	3.48	$5.8 M	24
5. Upgrade Oakvale 100 kV Lines (Shady Grove – Oakvale)	B-477 ACSR	B-954 ACSR	4.09	$6.8 M	18
6. Upgrade Tiger 100 kV Lines (Tiger – Walden Tap)	266 ACSR	556 ACSR	8.28	$11.2 M	30
7. Upgrade Union 100 kV Lines (O'Neal Retail – Pebble Creek Retail)	2/0 Cu	556 ACSR	3.03	$4.1 M	18
THERMAL NRIS CUSTOMER COST ESTIMATE				$44.3 M	30

The two higher queued projects below did not affect the identified upgrades.

- Queued project 40633-01 (355 MW combustion turbine facility in Cleveland County, NC):
- Queued project 40639-01 (937 MW combined cycle facility in Cleveland County, NC)

4.0 Fault Duty Study Results

The following breakers will need to be replaced:

1. At East Greenville Tie the following 100 kV breaker: Sevier Wh

[1] The interconnection cost includes the new 100 kV switching station and associated facilities (bus lines, relocation of lines, Lee Steam Station modifications).

2. At Lee Steam Station the following seven 100 kV breakers: Bank 3A HT Red & Yellow, Central Bl & Wh, Lee Bl & Wh, Piedmont Wh, Rabon Bl
3. At Lee Combined Cycle the following two 100 kV breakers: Broadway Wh, Toxaway Wh
4. At Shady Grove the following four 100 kV breakers: Greenbriar Bl & Wh, Oakvale Bl & Wh

Total estimated cost for breaker replacements: $1.7 M

5.0 Stability Study Results

Two NERC Category C5 faults, thirteen D2 faults, and two D7 faults were initially unstable. The C5 and D7 faults all included instantaneous reclosing on one or more lines. When instantaneous reclosing was disabled, all of these faults became stable. Eliminating or delaying reclosing is recommended for all 100 kV transmission lines at Lee.

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 Steam and CC 100 kV switchyards, a line breaker failure results in loss of about half the branches at that switchyard. 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 3 cycles. 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 under the assumption that two of the three existing units are retired 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.

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