System Impact Study Report

For: XXXXXXX ("Customer")

Queue #: 42795-01

Service Location: Lincoln County, NC

Total Output: additional 525 MW

In-Service Date: 10/1/2019

Commercial Operation Date: 10/1/2022

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Date: **7/19/2017**

1.0 Introduction

Following are the results of the Generation System Impact Study for the installation of an additional 525 MW of generating capacity in Lincoln County, NC. This site is located near Lincoln Combustion Turbine Station (Lincoln) and has an estimated Commercial Operation Date of 10/1/22. This study includes both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

2.0 Study Assumptions and Methodology

The power flow cases used in the study were developed from the Duke Energy Carolinas (DEC) internal year 2022 winter peak and 2023 summer peak cases. The results of DEC's annual screening were used as a baseline to identify the impact of the new generation. To determine the thermal impact on DEC's transmission system, the new generation was modeled as a new interconnection on the 230 kV bus at Lincoln. All cases were modified to include 525 MW of additional generation at the Customer's facility. The economic generation dispatch was changed by adding the new generation and forcing it on prior to the dispatch of the remaining DEC Balancing Authority Area units. The study cases were re-dispatched, solved and saved for use. The impacts of changes in the Generator Interconnection Queue were not evaluated, because it was determined that no earlier queued generators would have a significant impact on the study results.

The NRIS thermal study uses the results of DEC 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 DEC transmission system.

The ERIS thermal study utilizes a model that includes the new generation with relevant earlier queued generators and associated known upgrades. The new generation economically displaces DEC Balancing Authority Area units. Transmission capacity is available as long as no transmission element is overloaded under N-1 transmission conditions. The thermal evaluation will only consider the base case under N-1 transmission contingencies to determine the availability of transmission capacity. ERIS is service using transmission capacity on an "as available" basis; adverse generation dispatches that would make the transmission capacity unavailable are not identified. The study will also identify the maximum allowable output without requiring additional Network Upgrades at the time the study is performed.

Short circuit analysis is performed by modeling the new generator and any associated transmission upgrades. The impacts of changes in the Generator Interconnection Queue were not evaluated, because it was determined that no earlier queued generators would have a significant impact on the study results. Various faults are placed on the system and their impact versus equipment rating is evaluated. Any significant changes in short circuit current resulting from the new generator's installation are identified.

Stability studies are performed using a Multiregional Modeling Working Group dynamics model that has been updated with the appropriate generator and equipment parameters for the new unit. The SERC dynamically reduced 2023 summer peak case was used for this study. The case was modified to turn off

some existing generation to offset the new generation. The power flow portion of the interconnection request did not identify any transmission upgrades associated with the addition of the new generation that need to be added to the dynamics case. NERC TPL-001-4 Planning Events and Extreme Events were 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 based on the requirements set forth in DEC's Facilities Connection Requirements (FCR) for generators connected to the Transmission System. For more information on generator reactive requirements, reference the 'Generator Power Factor Requirements' document on the DEC OASIS site[1].

Any costs identified in the short circuit current, stability or reactive capability studies are necessary for both NRIS and ERIS service.

[1] http://www.oatioasis.com/DUK/DUKdocs/Generator_Interconnection_Information.html

3.0 Thermal Study Results

3.1 NRIS Evaluation

No earlier queued generators were deemed to have a material impact on the results of the study.

The following network upgrades were identified as being attributable to the Customer's generating facility:

Facility Name/Upgrade	Existing Size/Type	Proposed Size/Type	Mileage	Estimated Cost	Lead Time (months)
1. Interconnection Cost	[redacted]			$7.2 MM	36
2. Install Fixed Series Reactors On (3) 230/100 kV Transformers [2]	N/A	3%	N/A	$6 MM	18
TOTAL ESTIMATED COST FOR THERMAL UPGRADES				$13.2 MM	36

For NERC TPL-001-4 Category P6 or P7 Planning Events involving the loss of multiple circuits that terminate at Lincoln, the Customer may be directed to reduce the output of its facility.

Alternative solutions to mitigate the potential thermal issues caused by the P6 and P7 events described in the preceding paragraph would require either 1) rebuilding the 230 kV circuits that terminate at Lincoln or 2) building new transmission out of Lincoln. Cost estimates associated with either of these alternative solutions are not provided in this report.

3.2 ERIS Evaluation

Under the terms of ERIS service, the full output of the Customer's facility can be delivered at the time of the study without causing thermal upgrades. For ERIS service, the estimated cost and lead time for the upgrades associated with the interconnection facilities are identified in section 3.1.

4.0 Short Circuit Analysis Results

There are no breakers that need to be replaced as a result of the new generation.

[2] Responsibility for this upgrade is dependent upon determination of the final design of a local load project that will cause changes to the local transmission configuration. This proposed load project is independent of this generator interconnection request. Re-evaluation will be required in the future in order to determine whether this upgrade will be included in the Large Generator Interconnection Agreement.

5.0 Stability Study Results

Instability was not observed for any Planning Events in this study; however, instability was observed for some Extreme Events in this study involving a three-phase fault with delayed clearing due to relay failure. The instability was not caused by the proposed generation at the Customer's facility. NERC does not require stability for Extreme Events because of their low probability of occurrence. As such, no transmission improvements are required for Extreme Events.

Because instability was observed for some events in this study, it is recommended that the Customer's generators have out-of-step protection installed and operational.

Weakly damped generator oscillations were not observed in this study; however, it is recommended that a power system stabilizer (PSS) be purchased with each exciter. If problems arise in the future, then the Customer can quickly implement a PSS solution.

With the assumptions and models used in this study, the Customer's facility will not negatively impact the stability of the DEC transmission system. Any changes to assumptions or models may change these results.

6.0 Reactive Capability Study Results

Evaluation of MVAR flow and voltages in the vicinity of Lincoln indicates adequate reactive support exists in the region. The recommended tap setting at the high side of the GSU is 241.5 kV.

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