Generator Interconnection Impact Study Report

Scotland County, NC
75.0 MW Solar Farm
Queue #380

September 13, 2017
Duke Energy Progress
Transmission Department

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1 PURPOSE

The purpose of this Impact study is to assess the impacts of the generator interconnection requests on the reliability of the Duke Energy Progress (DEP) transmission system with respect to power flow, power factor, stability, and short circuit. Estimates of the cost and time required to interconnect the generation as well as to resolve the impacts as determined in this analysis are also included. The DEP internal system analysis consists of an evaluation of the internal DEP transmission system utilizing documented transmission planning criteria. The requests are described in Table 1 below.

Table 1: Interconnection Requests

DEP Generator Interconnection Queue No.	MW	Requested In-Service Date	County	Interconnection Facility
380	75.0	10/2/2017	Scotland County, NC	Bennettsville Sw. Sta.-Laurinburg 230 kV Line

2 ASSUMPTIONS

The following Impact Study results are from the DEP internal power-flow models that reflect specific conditions of the DEP system at points in time consistent with the generator interconnection requests being evaluated. The cases include the most recent information for load, generation, transmission, interchange, and other pertinent data necessary for analysis. Future years may include transmission, generation, and interchange modifications that are not budgeted and for which no firm commitments have been made. Further, DEP retains the right to make modifications to modeling cases as needed if additional information is available or if specific scenarios necessitate changes. For the systems surrounding DEP, data is based on the ERAG MMWG model. The suitability of the model for use by others is the sole responsibility of the user. Prior queued generator interconnection requests were considered in this analysis.

The results of this analysis are based on Interconnection Customer's queue requests including generation equipment data provided. <u>If the facility technical data or interconnection points to the transmission system change, the results of this analysis may need to be reevaluated</u>.

This study was based on the following assumptions:

- CUSTOMER would construct, own and operate the electrical infrastructure that would connect their generation to DEP's facilities, including any step up transformers and lines from the generators, but excluding the circuit breaker in the new breaker station where applicable.

3 RESULTS

3.1 Power-flow Analysis Results

Facilities that may require upgrade within the first three to five years following the in-service date are identified. Based on projected load growth on the DEP transmission system, facilities of concern are those with post-contingency loadings of 95% or greater of their thermal rating and low voltage of 92% and below, for the requested in-service year or the in-service year of a higher queued request. The identification of these facilities is crucial due to the construction lead times necessary for certain system upgrades. This process will ensure that appropriate focus is given to these problem areas to investigate whether construction of upgrade projects is achievable to accommodate the requested interconnection service.

All queue requests, as well as nearby existing and prior-queued generation, were modeled and assumed to be operating at full output.

Contingency analysis study results show that interconnection of these generation facilities **DOES** result in potential thermal overloads on the DEP system. The following facilities will need to be upgraded to accommodate the proposed generation:

Table 2: Network Upgrades

Facility	Sections	Length (mi)	Upgrade	Cost Estimate ($M)	Time To Complete (years)
Erwin - Fayetteville East 230kV line	All	23	Reconductor to 6-1590 ACSR	40.8	4
Fayetteville - Fayetteville DuPont SS 115kV line	Hope Mills Ch. St. – Roslin Solar	3	Reconductor to 3-1590 ACSR	4.5	3
Cape Fear - West End 230kV line	West End – Center Ch. – Sanford Garden St – Sanford US1	26	Reconductor to 6-1590 ACSR	52.0	4
Cape Fear - West End 230kV line	Sanford Deep River Tap Point – Sanford Horner Blvd.	4.4	Upgrade to full conductor rating	2.2	2
Erwin - Fayetteville 115kV line	Fay Slocomb Tap – Beard - Wade	9	Reconductor to 3-1590 ACSR	13.5	3
Rockingham – West End 230kV Line	Eden Solar Sw. St. - West End	7.7	Upgrade to full conductor rating	3.4	2
Total				**116.4**	**4**

These results are dependent on assumptions regarding prior-queued interconnection requests. If any prior-queued requests drop out of the queue, these results may change.

3.2 Stability Analysis Results

A stability analysis was performed to determine the impact of the proposed generation additions on the DEP transmission system and other nearby generation. All queue requests, as well as nearby existing and prior-queued generation, were modeled and assumed to be operating at full output. The proposed solar farm was modeled considering the specific layout and number of inverters (30 SMA SC2500-EV, 75.0 MVA). The model included a single lumped equivalent generator (to represent the inverters) with inverter transformer (5.75%Z at 2500 kVA x 30) and collector impedance. The interconnection to the DEP transmission system was via a single substation transformer (10%Z at 45/60/75 MVA), based on data provided by the Customer.

A representative set of faults was simulated to determine if there would be any adverse impact to the transmission system as a result of the proposed generation. The ability of the solar farm to ride through the voltage depressions resulting from the faults was also verified, based on the model parameters provided by the Customer. The stability evaluation **did NOT** identify any stability related problems. All generators stayed on-line and stable for all simulated faults. If the Customer data changes from that provided, these results will need to be reevaluated.

3.3 Power Factor Requirements

DEP's Large Generator Interconnection Procedure (LGIP) requires the proposed generation to be capable of delivering the requested MW to the Point of Interconnection (POI) **at a 0.95 lagging power factor**. For analysis of the power factor requirement, the Customer-supplied data regarding inverter capabilities, collector field configuration, impedances and line charging, and transformer impedances were used. The results of the analysis indicate that the proposed solar plant design, without capacitors, **does not meet** the 0.95 lagging power factor requirement at the POI for the requested MW delivery level. If no capacitors are included in the plant design, Table 2 below summarizes the approved MW at the POI, along with the MVAR capability at the POI required to meet the 0.95 lagging power factor requirement at the POI. If capacitors are included in the design, Table 4 below summarizes the approved MW at the POI, along with the MVAR capability at the POI and the capacitor size required to meet the 0.95 lagging power factor requirement at the POI. The Customer must notify Duke Energy which option they choose before the Facility Study can be performed.

Table 3: MW Approved and MVAR Capability Required at the POI to Meet Power Factor Requirements – *Reduce MW Option*

DEP Generator Interconnection Queue No.	MW Requested	MW Approved	MVAR Capability Required
380	75.0	**64.4**	21.2

Table 4: MW Approved and MVAR Capability Required at the POI to Meet Power Factor Requirements – *Add Capacitor Option*

DEP Generator Interconnection Queue No.	MW Requested	MW Approved	MVAR Capability Required	Capacitor MVAR Required
380	75.0	**69.9**	23.0	15.8

3.4 Short Circuit Analysis Results

A short circuit analysis was performed to assess the impact of the proposed generation addition on transmission system equipment capabilities. The analysis indicates that no short circuit equipment capabilities will be exceeded as result from the proposed generation additions and associated transmission upgrades.

The results of the short circuit study are based on Customer provided generation equipment data and location. Also, the prudent use of engineering assumptions and typical values for some data were used. If the units' technical data or interconnection points to the transmission system changes, the results of this analysis may need to be reevaluated.

3.5 Harmonics Assessment

There is potential interaction of harmonic current injections from the Customer's proposed generation and certain capacitor banks on the DEP system. Testing may be necessary after the actual in-service date of this generation and the Customer will be responsible for mitigation of any detrimental impacts to the system.

3.6 Interconnection of Customer's Generation

The point of interconnection for Queue #380 is a new 230 kV breaker station connected to the Bennettsville Sw. Sta.-Laurinburg 230 kV Line near structure 60. The breaker station one-line is provided as Figure 1. The customer should verify that the MVA ratings of their connecting lines are sufficient to accommodate delivering the total MVA output to the point of interconnection at the required 0.95 power factor.

3.7 Estimate of Interconnection Cost

Q380

The estimate includes the assumption that DEP will acquire and use a portion of the property that the Customer will secure for the addition of the facility.

Tap Line

Description: DEP will tap the Bennettsville Sw. Sta.-Laurinburg 230 kV Line and Construct a short tap line to New Breaker Station adjacent to DEP ROW. Manual switches will be installed on each side of the Tap.

Estimated Cost: $950,000

New Breaker Station

Description: Construct new 1-230 kV breaker station at generation new connection point. Assumes a control building with cable trench, line trap, CCVTs, surge arrestors, power pot, 230 kV breaker with air break switches, metering PTs and CTs.

Estimated Cost: $2,200,000

Install Transfer Trip Scheme at New Breaker Station and Transmission Substations

Description: It will be necessary to separate this generation facility from the DEP system for faults on the Bennettsville Sw. Sta.-Laurinburg 230 kV Line. Install protection system and transfer trip for coordination between the above listed transmission line and proposed generation facility.

Estimated Cost: $300,000

Taxes

Description: NC utility tax of 7%

Estimated Cost: $241,500

Total Interconnection Cost Estimate: $3,691,500

4 SUMMARY

This Generator Interconnection Impact Study assesses the impact of interconnecting a new generation facility with a requested summer/winter rating of 75.0 MW. The approved MW injection is 64.4 MW without a capacitor or 69.9 MW with a 15.8 Mvar capacitor bank. Power flow analysis found multiple overloading issues requiring long lead time network upgrades. Stability and short circuit analyses found no issues. Interconnection upgrades to the DEP Transmission System are necessary to accommodate Q380.

DEP will require at least 48 months minimum after a firm written agreement to proceed is obtained from the customer.

The additional cost for telecommunications and metering can be estimated as a monthly charge of $3,000/month per interconnection.

Power-flow	$116,400,000
Stability	$0
Short Circuit	$0
Interconnection	$3,691,500
Total Estimate	$120,091,500

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APPENDIX I : FIGURES

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Figure 1-