DISCUSSION OF [redacted] (Customer) GENERATION SYSTEM IMPACT STUDY RESULTS FOR THE PROPOSED GENERATING FACILITY AT DAN RIVER STEAM STATION (100 KV CONNECTION). TOTAL SUMMER PEAK OUTPUT IS EXPECTED TO BE 727.0 MW

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**A. Study Assumptions and Methodology**

The original request was for operating a combined cycle plant along with existing units Dan River 3 and combustion turbines 4 – 6 for a total of 847 MW at Dan River Steam Station in 2012. As a result of a meeting between Duke Energy Power Delivery and the customer on August 5, 2009, the original interconnection request has been modified to evaluate the addition of a combined cycle plant at Dan River while repowering Dan River unit 3 from a coal fired unit to a biomass unit with a rating of 106 MW. The other two existing coal units at Dan River (units 1 and 2) and all three combustion turbines (units 4 – 6) are assumed to be retired.

The power flow cases used in the study were developed from the Duke internal year 2012 summer peak case. The results of Duke's annual screening were used as a baseline to identify the impact of the new generation. All cases were modified to include 621 MW of additional generation at Dan River Steam Station with 106 MW from the existing fossil generation operating as a biomass unit. To determine the thermal impact on Duke's transmission system, the new generation was modeled with a double-circuit, direct connection to the 100 kV bus at Dan River Steam Station and some modifications were made to the Dan River Steam Station bus configuration. The economic generation dispatch was also changed by adding the new generation and forcing it on prior to the dispatch of the remaining Duke Control Area units. The worst case generation contingency for the new combined cycle station is the loss of one combustion turbine and half the output of the steam turbine. The study cases were re-dispatched, solved and saved for use.

The thermal study uses the results of Duke Power Delivery's annual internal screening as a baseline to determine the impact of the new generation. The annual internal screening identifies violations of the Duke Energy 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 Dan River units. The SERC dynamically reduced 2011 summer model was used for this study. Although the commercial operation date is in 2012, the 2011 case is readily available and there are no significant changes to the system that would invalidate the results. With the addition of the combined cycle facility, the plan is to retire the existing Dan River units 1 and 2 and to reduce unit 3 to 106 MW. The case was modified to remove these units and turn off some combustion turbine units to offset the new generation. Several transmission system improvements were identified during the previous power flow studies for the addition of these units, so the appropriate upgrades 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 Dan River 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.

**B. Thermal Study Results**

Due to transmission system needs identified during Duke's annual screening, the customer is not responsible for upgrade 1. The need for upgrade 2 is primarily driven by a decrease in load at Motley Tie. Because this loss of load resulted in the Mayo Lines (Dan River to Madison) requiring upgrade, Duke Energy Power Delivery is responsible for the upgrade. The following network upgrades were identified:

| Facility Name/ Upgrade | Existing Size/Type | Proposed Size/Type | Mileage | Estimated Cost |
|---|---|---|---|---|
| 1. Haw River 100 kV lines (Sadler to Glen Raven) Rebuild | 336 ACSR | B954 ACSR | 21.64 | $19.5M |
| 2. Mayo 100 kV lines (Dan River to Madison) | 477 ACSR | B477 ACSR | 16.24 | $14.6M |
| 3. Elon 100 kV lines (Reidsville Tap to Glen Raven) Rebuild | 336 ACSR | B954 ACSR | 18.68 | $16.8M |
| 4. Elon 100 kV lines (Sadler to Reidsville Tap) | B336 ACSR | B954 ACSR | 2.92 | $2.6M |
| 5. Alamance 100 kV lines (Burlington to Mebane) | 795 ACSR | B795 ACSR | 4.61 | $4M |
| TOTAL COST ESTIMATE | | | | $57.5M |
| CUSTOMER TOTAL COST ESTIMATE | | | | $23.4M |

**C. Fault Duty Study Results**

1. Dan River - 100 kV 43 ika Mayo Bl line Breaker is OD @ 45.0 kA
2. Dan River - 100 kV 44 ika Motley Bl line Breaker is OD @ 45.2 kA

Total estimated cost for 100 kV breaker replacements: $240K

**D. Stability Study Results**

The proposed 621 MW combined cycle units with 106 MW of existing fossil generation connected to the existing Dan River 100 kV switchyard are transiently stable for all contingencies tested.

Since the units will be connected via a fold-in of the Motley lines, it is possible for the generator to become isolated with a comparatively small load. Therefore, out of step protection is recommended and possibly some additional protection logic may be preferable to address this potential system configuration.

While the bus tie breaker itself did not prove to be a stability problem, it is a single failure at the proposed station and at the existing station that can shutdown the generators.

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 and optionally placed in service. If problems arise in the future, then the facility can quickly implement a PSS solution.

Addition of the proposed 621 MW combined cycle facility with the existing fossil generation operating at 106 MW does not present stability concerns. Based on this analysis, with the assumed protective relay systems, the units will not negatively impact the overall reliability of the interconnected transmission system.

**E. Reactive Capability Study Results**

With the customer's proposed 727 MW 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 Dan River indicates adequate reactive support exists in the region. Should future studies show the need for additional support, Duke Energy integrated resource planning will evaluate solutions and make appropriate changes to the system.

**Study completed by _____**
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