



## **TOT 7 Transfer Path Voltage Stability (Reactive Power Margin) Study**

**Last Revised: September 2, 2010**

### **A. Purpose and Need**

This purpose of this study is to determine if the TOT 7<sup>1</sup> transfer capability or the TOT7 system operating limits are limited in the target operating season by voltage stability (Reactive Power Margin or V-Q) issues rather than line thermal limits or substation equipment limitations. If there are limitations to TOT 7 due to voltage stability that are more limiting than the thermal capability of the substation equipment ratings, those limits will be determined. Only Category B disturbances will be evaluated for this voltage stability study. Real Power Margins (P-V) for the Foothills load-serving area will not be determined in this study.

### **B. Study Area**

The study area for the transient stability study is the Foothills area consisting of the transmission system in Colorado bounded by the Colorado/Wyoming border in the north, the Valmont and Henry Lake substations in the south, Estes Park in the west, and Greeley in the east.

### **C. Study Cases**

The voltage stability studies will be based on the WECC approved "10hs3bp.sav" base case, as reviewed and updated for the WECC Rocky Mountain Region 2010 summer Operating Transfer Capability studies.

Load levels reflect 2010 heavy summer peak system conditions. This case will be modified by PRPA to represent two different operating scenarios of interest as part of the thermal TOT 7 path limit studies:

1. 2010 summer peak load in the Foothills area with CBT generation at 0 MW and TOT 7 stressed to its thermal limit (north to south), and
2. 2010 summer off-peak load in the Foothills area and CBT generation at 180 MW with TOT 7 stressed to the 890 MW transfer rating of the transfer path.

These cases will be used as a starting point for the TOT 7 voltage stability studies

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<sup>1</sup> The TOT 7 transfer path consists of three transmission lines – the Ault-Windsor-FSV 230 kV line (metered at Ault), the Weld-FSV 230 kV line (metered at Weld), and the Longs Peak-FSV 230 kV line (metered at FSV). The TOT 7 transfer path allows power deliveries to central Colorado load centers from the north. The TOT 7 transfer path is operated by Public Service Company of Colorado (PSCo) and jointly owned by PSCo and the Platte River Power Authority (PRPA). Thermal limits have been developed by PRPA for the 2010 summer season.

#### **D. Voltage Stability Study (Reactive Power Margin) Methodology**

1. For the TOT7 transfer path study, create the 105% transfer flow base case. The TOT3 transfer path that is near the northern boundary of the receiving region (Foothills) and the TOT7 transfer path that near the southern end of the receiving region (Foothills) will be monitored. Voltage stability analysis for system intact conditions will be performed for the two extreme operating scenarios described in Part C “Study Cases” above.
2. Post-transient power flows will be conducted with post-contingency cases developed for each of the most severe contingencies for the cases with 100% transfer path flow and for the cases with 105% transfer path flow.
3. The sub-set of the most critical buses (three to five) for each of the selected contingencies studied will be created. These may include buses with the lowest voltage or the highest voltage deviation. It should be noted that the buses electrically close to the outage may not be the ones that would be closest to the voltage collapse point.
4. A fictitious synchronous condenser will be applied at each critical bus identified earlier; one at a time. The power flow case (either a standard or post-transient power flow solution can be used) will be solved. The bus voltage (V) and the reactive output of the condenser (Q) will be recorded.
5. The condenser scheduled output voltage will be reduced in small steps (< 0.01 p.u.). The condenser’s output (or scheduled voltage) will be varied until sufficient points to identify the voltage collapse point have been collected.
6. The “Reactive Power Margin” is defined as the value of the condenser output at the voltage collapse point on the V-Q curve where  $dQ/dV=0$ . The change in the reactive power margin between the two different load levels (100% and 105%) for the same Category B contingency and at the same bus is the Reactive Power Margin Requirement at that bus for that Category B contingency<sup>2</sup>.

#### **E. Schedule**

The TOT 7 Voltage Stability Study will begin following receipt of the two load flow base cases. The goal is to complete the voltage stability study and report before December 2010. A more detailed study of the Foothills area load-serving area that will include a Real Power Margin analysis (P-V) will be completed in the Spring of 2011.

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<sup>2</sup> For Category C contingencies, the change in the Reactive Power Margin between the two different transfer levels (100% and 102.5%) for the same Category C contingency and at the same bus is defined as the Reactive Power Margin Requirement at that bus for that Category C contingency. Category C outages are double contingencies (i.e., breaker failures, common tower disturbances, etc). The most reactive deficient bus must have adequate reactive power margin for the worst single contingency to satisfy the conditions for n-1 outages, whichever is worse. The Reactive Power Margin Requirements at each bus will be determined as a study history over several years is developed.