Colstrip 500 kV Power Transfer Capabilities Studied

Overview

The transmission owners of the Colstrip 500 kV Transmission System and the Bonneville Power Administration wanted to evaluate the ability of their existing 500 kV transmission assets to support additional power transfers from Montana to the Pacific Northwest. This study was initiated in anticipation of significant new generator interconnection requests and transmission requests. One benefit of this study was the identification of the level of power transfers that could be supported from existing facilities prior to the need to study, permit, design and construct new transmission. Siemens PTI conducted this study in 2009.

The participants in this study were NorthWestern Energy (Butte, MT); PacifiCorp (Portland, OR); Avista Corporation (Spokane, WA); Portland General Electric Company (Portland, OR); Puget Sound Energy (Bellevue, WA) and the Bonneville Power Administration (Portland, OR).

The goals of the study were to determine the following:

• What transmission upgrades to the existing 500 kV infrastructure are necessary to allow increased power transfers injected in Montana and offloaded in central Washington?
• What is the incremental increase in transfer capability for discrete investment levels in infrastructure upgrades?
• What is the ultimate capability of the existing 500 kV infrastructure?

The study participants identified three locations for possible injections of power to the existing system: Colstrip, Broadview, and Townsend. Further, the participants specified that two generation technologies were of interest: wind and thermal. In combination with three seasonal scenarios representing two unique flow patterns and three types of technical assessments, a total of 36 unique evaluations were performed. The basic study system is shown below:
Voltage Collapse Evaluation

The first evaluation completed was a PV voltage collapse evaluation. This analysis established a distinct upper limit. Although more limiting constraints in subsequent analyses are possible, exceeding the voltage collapse limit would have required major system improvements, and this helped to bound the stability assessments that followed.

The PV functionality of PSS®E is ideally suited for this evaluation, because it evaluates a range of injection levels, and runs contingencies at each internal level of the scaling process of the analysis.

The principal information garnered from the voltage collapse evaluation was whether the thermal capability of the conductor and bus work was greater than or less than the voltage collapse limits. Naturally, the hope was that the voltage collapse limit was at a higher flow level than the thermal capabilities of the major infrastructure, leaving open the possibility that the full thermal capability of the conductor and bus could be used to support power transfers.

Steady-State Contingency Evaluation

Although both the PV and contingency evaluation are both fundamentally steady-state evaluations, these reveal slightly different system characteristics. Whereas the PV analysis identified a maximum steady-state capability, the contingency evaluation provided insight into generally less severe criteria violations that also needed to be mitigated, such as high or low voltage levels or overloads.

The PV and dynamic stability analyses focused efforts on identifying ultimate system capability, based on taking a few severe contingencies to their points of failure, regardless of any equipment overloads or underlying low voltage concerns that may occur during the process of stressing the system to its voltage collapse or dynamic limits. The contingency analysis did not change the system’s stress level, but included a comprehensive set of contingencies at the limits established by the PV or dynamic studies.

The added value, therefore, of performing the steady-state contingency analyses was that a clearer picture emerged of the equipment upgrades and supplemental voltage support devices needed during less severe contingency conditions. This, in turn, resulted in better cost estimates. The steady-state contingency analysis was the mechanism by which the need for an augmenting Static VAR Compensator for some injections and some flow patterns was determined.
Dynamic Stability
The final type of evaluation performed was dynamic stability. The intent of this study was to determine if the injection points and flow pattern scenarios were limited by stability concerns. The study system relies heavily on established remedial actions to assure dynamic stability, and additional transfers did not reduce this reliance, particularly during double circuit contingencies of the 500 kV system. The study system includes double circuit 500 kV towers, thereby requiring double circuit contingency evaluations.

Cost Estimates
After completing all technical analyses, Siemens PTI developed rough order-of-magnitude cost estimates to incrementally increase transfer capability on the study system. Basic unit costs were utilized, thereby making the cost estimates suitable for comparison purposes only. A key factor in developing the cost estimates was Siemens PTI’s knowledge and experience with Thyristor-Controlled Series Capacitors (TCSC).

Siemens PTI was able to develop some preliminary design parameters, and develop cost estimates from the preliminary design. Complimenting the series capacitor cost estimates was rough order-of-magnitude cost estimates of various other infrastructure upgrades.

Siemens PTI takes pride in providing independent consulting advice to clients, rejecting all forms of favoritism. In this study, however, our association with Siemens as an equipment manufacturer, and Siemens PTI’s knowledge of leading-edge power electronics, provided valuable insight in forging the preliminary cost estimates.

Conclusion
Given today’s asset limitations and ever-increasing need for power transfer, studies like this provide important information regarding current and future transmission system capability. Through this study, the Consultants at Siemens PTI provided preliminary insight into the challenges and upgrade magnitudes necessary to support additional power transfers on the 500 kV system from Colstrip in the east to eastern Washington in the west.