TIP 51: Response-Based Voltage Stability Controls

Context

BPA's transmission system is typically voltage stability limited. Traditionally, severe outages and grid disturbances threaten system voltage stability. Today, BPA must additionally manage generation patterns that are more volatile due to the integration of large amounts of wind power that provides less voltage control capabilities, and changing load characteristics such as more air-conditioning and electronic loads. These and other factors conspire to increase instability on the grid. This project looks at a portfolio of operational and control solutions to maintain and increase voltage stability within prescribed limits.

Description

This project assesses voltage stability risks and researches methods to improve the voltage stability and controls in the Pacific Northwest power system. The project started with a nation-wide panel of leading voltage stability experts scoping the existing and emerging voltage stability risks and framing specific research areas. Currently, the project has three main focus areas: (i) dynamic voltage stability risks due to changing characteristics of electrical loads, (ii) voltage stability controls to enable reliable integration of wind integration, and (iii) using synchronized wide-area measurements for situational awareness and controls, including the development of the BPA synchrophasor applications lab. The project is supported by BPA capital investment in synchrophasor technology.

The project will develop a comprehensive "defense" in depth control strategy to increase voltage stability across BPA's transmission system and addresses the following issues:

- *Operator:* What tools do operators need to have better awareness of voltage stability risks?
- *Grid Level*: What coordinated voltage controls are needed to optimize voltage stability and to deal effectively with fast wind ramps?
- *Supply Side*: What voltage controls do we need from wind generators?
- *End-Use:* How is end-use behavior in dynamic stability studies modeled? What are the risks of load-induced voltage instability in the Pacific Northwest?
- What are the risks of a local voltage collapse cascading into a WECC area-wide outage?
- What is the appropriate regulatory framework to evaluate load-induced voltage instability risks and make capital investments to mitigate risk?

Why It Matters

Capacity on the BPA transmission system is mostly voltage stability limited. There is a strong desire to increase the transmission capacity at the lowest cost to ratepayers. At the same time, the Agency faces very signficant reliability challenges due to:

- Greater variety and variability of generation patterns with reduced time for operational decision making
- Changing voltage control characteristics and renewable generation capabilities
- Changing load composition in Pacific Northwest.

A combination of situational awareness tools and response-based controls are needed to optimize voltage stability while meeting emerging reliability challenges.

Goals and Objectives

The objective of the project is to develop a comprehensive "defense" in depth control strategy to optimize voltage stability across the BPA transmission system. The project encompasses multiple issues:

• *Operational tools:* Evaluate operational tools for better situational awareness of voltage stability risks.

• *Grid Level:* Develop response-based voltage stability scheme. Develop a framework for coordinated voltage control.

• *End-Use:* Develop appropriate models to study the phenomenon of load-induced voltage instability.

• *Risk & Investment:* Assess reliability risks, support the development of the regulatory framework for capital investment (NERC/WECC reliability standards drive transmission capital investment and operating limits).

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Project Start Date: October 1, 2007

Project End Date: September 30, 2015

Key Results/Conclusions

A combination of model-based stability assessment, measurement-based tools and response-based Remedial Action Schemes (RAS) are needed to address voltage stability limits.

Operational tools:
Several measurement-based tools have been researched and are currently in the prototype phase.

Response-based RAS:
Wide-area control system (WACS) is under development. WACS will be deployed under the synchrophasor capital program. California-Oregon Intertie reactive coordination studies are in progress.

Wind power plant voltage controls:
Voltage control requirements are developed. Secondary voltage control studies are planned.

Load-Induced voltage instability
Load models are developed by WECC. BPA did significant amount of equipment testing, model development and data preparation. Studies indicate that the Portland metro may be at risk of voltage instability due to air-conditioner stalling. Project supports development of appropriate reliability metrics and regulatory framework with huge impact on capital investment needs. Studies are completed for Portland metro area.

Analysis tools:
Tools for analysis of wind-power-plant voltage controls are deployed by BPA Transmission Planning, wind power plant performance control issues have been identified and corrected.

Time-sequence power flow:
Time-sequence powerflow capabilities in Power World and PSLF; also, time sequence for studying the impact of wind ramp events on system voltage stability.

Funding

Total Project Cost:	$2,817,997
BPA Share:	$2,817,997
External Share:	None
BPA FY2014 Budget:	$250,000

Participating Organizations

Western Electricity Coordinating Council (WECC)
US Dept. of Energy (DOE)
North American Synchro-Phasor Initiative (NASPI)
Lawrence Livermore National Laboratory (LBNL)
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