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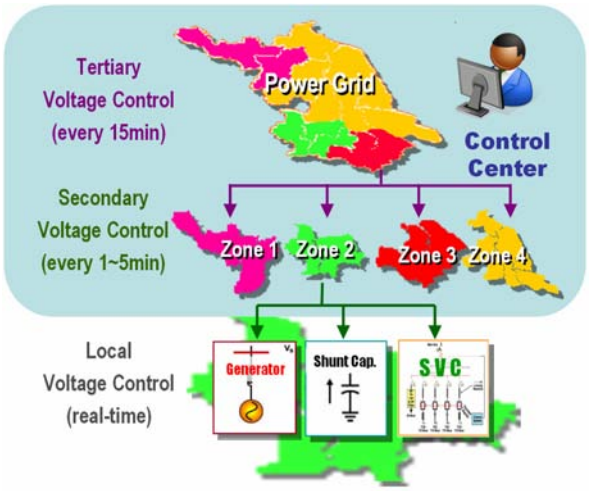
pjm

Transmission Efficiency Initiative: Host Demonstration Project

Hierarchical, Dynamic Voltage Control to Improve Transmission System and Utilization



Hierarchical, dynamic voltage control

- Demonstrate system-wide, coordinated voltage control
- Implement secondary voltage regulation in PJM's transmission system
- Significantly increase voltage stability and system reliability
- Reduce losses by minimizing loop currents and keeping a low voltage profile

Project Scope

As part of EPRI's Transmission Efficiency Initiative, PJM is evaluating a possible demonstration of a hierarchical, dynamic voltage control technology. The voltage control scheme will be intended to systematically and optimally coordinate local voltage regulators and control devices to both improve voltage stability and reduce transmission losses.

Technology Description

North American grid operators control transmission voltages and reactive powers mainly in a decentralized fashion at the power plant or substation level. In the control center, system operators might manually dispatch the reactive powers of generating units, schedule the high-side voltages of power plants, switch the banks of shunt capacitors or reactors, and change the voltage setpoints of on-load tap-changer and flexible ac transmission system controllers.

However, it is difficult for system operators to optimally coordinate the control actions at the system level under ever-changing operating conditions. Without system-wide coordination and optimization, massive MVAR flows might frequently occur to maintain voltage stability of weak areas using remote reactive power sources. As a result, transmission losses will increase. Even worse, system utilization might decrease in the attempt to avoid possible voltage collapse

Practices and studies in Europe and China have shown that application of hierarchical, dynamic voltage control allows a reduction of 1% to 6% in overall transmission losses. A recent evaluation study on the PJM system shows that the technology can help to reduce transmission losses by around 1.1%, which indicates an annual energy saving greater than 100 million kWh and an annual cost saving greater than US$10 million for PJM. A rough estimation for typical independent system operators and regional transmission organizations in the United States shows that annual cost savings could be US$5 million to US$20 million if the technology is adopted.

A typical hierarchical, dynamic voltage control strategy realizes system-wide coordination and optimization through two-level voltage regulators above local voltage control devices (local voltage control devices installed at power plants or substations):

- Secondary (regional) voltage regulators, coordinating setpoints of the control devices within each voltage control zone, aimed at improving voltage quality and reliability
- Tertiary (system-wide) voltage regulators, providing optimal voltage references at the pilot buses located in all voltage control zones by solving optimal reactive power flow to minimize the overall transmission loss.

The tertiary and secondary voltage regulators can both be installed at the grid control center or can be installed at the grid control center and sub-grid control centers for voltage control zones, respectively.

Expected Benefits

Practices of hierarchical voltage control in Europe and China have shown that the following benefits might be realized through the application of hierarchical, dynamic voltage control technology:

- Increased overall utilization of the transmission system by improving voltage stability
- Better utilization of reactive power sources
- Reduced transmission losses
- Reduced CO_2 emissions as a consequence of better system utilization and lower losses

Approach for Measurement and Verification

A key objective of EPRI's Transmission Efficiency Initiative is to verify and validate the "actual" benefits realized by the application of the technology using a consistent measurement and verification (M&V) methodology that will be developed as part of EPRI's transmission efficiency research portfolio.

The detailed methodology of M&V will be developed during the course of the project using the following general approach:

- Demand, energy, and CO_2 savings.
- Line load and losses will be measured and compared over a one-year period and compared to the calculations. This will lead to an industry-accepted methodology for projecting savings from advanced conductor projects.
- System utilization improvement will be assessed by considering generation dispatch, congestion costs, and other metrics that will be defined.

Project Schedule

The expected project tasks are the following:

- EPRI will work with PJM to test and document the benefits of a hierarchical dynamic voltage control strategy that can meet the voltage control requirements. The interfaces with supervisory control and data acquisition and energy management systems as well as the operator interface will also be assessed and defined as needed.
- EPRI will work with PJM vendors to assess the performance of system-wide hierarchical, dynamic voltage control strategy and associated algorithms. EPRI will apply the demonstration and loss reduction verification protocol developed as part of the initiative to document the impact that changes in operations can have on loss reduction and utilization improvements.
- PJM might also evaluate the feasibility of a closed-loop implementation of the strategy.
- EPRI will conduct M&V to assess the benefits achieved.

The deliverables of this project will include a technical report with the functional and interface specifications of the system-wide hierarchical, dynamic voltage control strategy, as well as the software package for the hierarchical, dynamic voltage control implementation.

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