PJM Interconnection

PJM Synchrophasor Technology Deployment Project

Scope of Work

PJM Interconnection (PJM) and 12 of its member transmission owners deployed synchrophasor measurement devices in 85 high-voltage substations and implemented a robust data collection network to provide the necessary information technology infrastructure and wide-area monitoring and coverage necessary to support further use of advanced transmission applications. The project successfully deployed phasor measurement units (PMUs), phasor data concentrators, communications systems, and advanced transmission software applications.

Objectives

The project improves electric system reliability, wide-area observability, and event detection and analysis. PJM was successful in installing technology designed to increase grid operators' visibility of bulk power system conditions in near-real time, enable earlier detection of problems that threaten grid stability or cause outages, and facilitate information-sharing with neighboring control areas. The access to better system operating information now allows PJM engineers to improve power system models and analysis tools for better reliability and operating efficiency.

Deployed Smart Grid Technologies

- **Communications infrastructure:** The new synchrophasor network enables communication between the PMUs and phasor data concentrators of each transmission owner in the PJM region and the PJM control center. The new network uses redundant infrastructure through multiple telecommunications providers and network devices to ensure reliable data delivery.
- **Wide-area monitoring and visualization systems:** These systems provide a more expansive view of the bulk transmission system and reveal dynamic operating details that were previously unavailable.
- **Advanced transmission applications:** PJM implemented advanced transmission applications to harness and leverage the data being captured by the PMUs. Power system engineers and grid operators have accessed these applications to assist in the analysis and understanding of the bulk power grid.
  - **Disturbance analysis** provides engineers and operators with the ability to visualize historical data trends, obtain temporal and spatial information about the disturbance, and assess the impact on system reliability and the root cause of the disturbance.
  - **Angle and frequency monitoring** enables engineers and operators access to detailed information regarding grid conditions and power flow.

At-A-Glance

Recipient: PJM Interconnection, LLC

States: DE, IL, IN, KY, MD, MI, NJ, OH, PA, TN, VA, WV, and Washington, DC

NERC Region: ReliabilityFirst Corporation and SERC Reliability Corporation

Total Project Cost: $27,399,719

Total Federal Share: $13,688,509

Project Type: Electric Transmission Systems

Equipment Installed

- 301 Phasor Measurement Units
- 85 Transmission Substations with PMUs Deployed
- 21 Phasor Data Concentrators (transmission owner-level)
- 2 Super Data Concentrators (PJM)
- Synchrophasor Communications Network

Advanced Applications

- Wide-Area Monitoring System (Visualization):
  - Angle and Frequency Monitoring
  - Oscillation Detection and Analysis
- Disturbance Analysis

Key Benefits

- Increased Electric Service Reliability
- Optimized Generator Operation

Note: The dollars presented within the project description are approved project budget amounts. Actual figures will not be available until after the official close of the project.

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- **Oscillation monitoring** allows PJM grid operators and engineers to observe power system disturbances and oscillations and recognize the impact of these conditions on the grid's reliability.

- **Cyber security implementation:** A robust cyber security plan was developed and implemented to ensure secure communications and operation of the PMU network.

Benefits Realized

PJM now has a robust PMU infrastructure—over 300 PMUs—across the regional transmission organization. Synchrophasor data have provided PJM staff with the opportunity to evaluate the impact of system events at sub-second level and to refine system modeling based upon actual system performance measurements.

- Post-mortem analysis was implemented in 2012. Disturbance analysis provides operators with the ability to visualize historical data trends, obtain temporal and spatial information about the disturbance, and assess the impact on system reliability and the root cause of the disturbance. Most past outage investigations did not acquire any dynamic data. By analyzing the synchrophasor data associated with disturbances, PJM has been able to determine oscillation frequency signatures. These signatures enable PJM to better detect events before they cause interruptions.
- Synchrophasor data also enabled PJM to find generation models that were not accurate and to update them.
- PJM implemented angle and frequency monitoring in 2012. This capability provides PJM grid operators and engineers with detailed information about grid conditions and power flow. The visualization capability of the PJM wide-area monitoring provides the ability to determine typical phase angles and to compare those to real-time phase angles. Increased grid operators' visibility of bulk power system conditions in near-real time enables earlier detection of problems that threaten grid stability or cause outages. PJM's wide-area monitoring also gives the operators real-time visibility of system stress conditions on an interim basis until legacy network applications can perform N-1 contingency analysis.
- Dominion Virginia Power has used the synchrophasor data to detect a failing voltage transformer and to identify un-damped oscillations at one of its power plants.

Lessons Learned

Installation of a synchrophasor system is only the first step in being able to fully realize the benefits of the new technology. Advanced application design, development, and deployment are necessary steps towards providing operators with actionable insights and procedures to be utilized in the control room.

- PJM set up a Phasor Data Quality Task Force stakeholder group that meets quarterly. The task force has increased awareness of the importance and value of the PMU data and provided PJM members a pool of experience upon which to resolve issues and work toward common goals.
- Proving the value provided by the data is critical to ensuring acceptance and adoption of the data.
- Not all PMUs are created equal. Some of the transmission owner's vendors are still performing firmware updates and resolving issues to achieve the established data quality goals.
- Depending on how the PMU data are being used within operations, those data have the potential to impact the PMU owners in terms of evaluation and readiness of critical infrastructure protection (CIP) assets.

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Future Plans

PJM and its member transmission owners plan to continue to develop improved monitoring and visualization applications to fully leverage the new grid state data that are available. More robust modeling and simulation for real-time contingency analysis also will provide better decision-making support to grid operators.

- PJM plans to incorporate synchrophasor-based wide-area monitoring into the control room via the reliability engineer desk.
- Power Plant Parameter Derivation, developed by EPRI, is a generator, exciter, and turbine-governor model validation tool that uses PMU data. Implementation of the Power Plant Parameter Derivation tool is awaiting PMU data from new generator locations of 100 MW or greater in 2016.
- PJM plans to implement a linear state estimator using data directly from PMUs to assist with improving data quality and potentially for incorporation into PJM's non-linear state estimator and other applications.
- PJM will use PMU data in 2015 to calculate frequency bias. The PMUs will provide a benefit thanks to the time-synchronized nature of the data and their usefulness for post-event analysis.
- PJM has implemented a PMU technology training schedule for system operators.
- Additional areas in which PJM plans to expand use of synchrophasor technology include:
  - Improving data quality and availability and validation and event analysis.
  - Adding a phase angle display in PJM's control room.
  - Using synchrophasor data to feed PJM's intelligent event processor.
  - Integrating synchrophasor technology with operations.
  - Expanding data sharing with neighboring reliability coordinators.

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