Midwest Independent Transmission System Operator

Midwest ISO Synchrophasor Deployment Project

Scope of Work

For this project, the Midwest Independent Transmission System Operator (Midwest ISO) deployed synchrophasor technology throughout its service footprint. The project deployed phasor measurement units (PMUs), phasor data concentrators, and advanced transmission software applications. This technology has increased grid operators' visibility into bulk power system conditions in near-real time, enabled earlier detection of conditions that could result in grid instability or outages, and facilitated information sharing with neighboring regional control areas.

Objectives

Midwest ISO's primary objective was to leverage synchophasor technology to optimize the dispatch and operation of power plants while improving the reliability of the bulk transmission system. Newly developed advanced transmission applications use data collected from the PMUs to enable increased real-time situational awareness as well as improved after-the-fact event analysis. This technology has provided an expanded view of the system, facilitated cost reductions, and optimized generator operation.

Deployed Smart Grid Technologies

- **Communications infrastructure:** Midwest ISO and its member transmission owners (TO) leveraged the existing communications infrastructure to support PMU data collection and transfer.
- **Wide-area monitoring, visualization, and control system:** The new synchrophasor system provides a more expansive view of the bulk transmission grid while revealing dynamic operating details. These improvements have helped optimize the dispatch of power generation while improving system reliability.
- **Advanced transmission applications:** The new applications for the synchrophasor system include the following:
  - **Wide-area situational awareness** allows Midwest ISO previously unavailable visibility into the regional bulk transmission system. This has enabled better response to adverse changes in system conditions.
  - **Oscillation monitoring** allows grid operators and engineers to monitor the grid for power system frequency oscillations that could destabilize the system.

At-A-Glance

Recipient: Midwest Independent Transmission System Operator

States: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Montana, North Dakota, Ohio, Pennsylvania, South Dakota, and Wisconsin

NERC Regions: Midwest Reliability Organization, ReliabilityFirst Corporation, SERC Reliability Corporation, and Western Electricity Coordinating Council

Total Project Cost: $33,157,191

Total Federal Share: $16,578,596

Transmission Owners: Ameren, American Transmission Co., Duke Energy, Great Rivers Energy, Hoosier Energy, Indianapolis Power & Light Co., Manitoba Hydro, MidAmerican Energy, Minnesota Power, Montana Dakota Utilities, Northern Indiana Public Service, Ottertail Power, Vectren TSO, Western Area Power Administration, XCEL Energy

Project Type: Electric Transmission Systems

Equipment

- 260 Phasor Measurement Units
- 40 Phasor Data Concentrators

Advanced Transmission Applications

- Wide-Area Situational Awareness
- Oscillation Monitoring
- Event Detection
- State Estimation Integration

Key Benefits

- Reduced Congestion Cost
- Reduced Ancillary Service Cost
- Optimized Generator Operation
- Increased Ability to Prevent Large-Scale Cascading Outages

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.

  - **Event detection** automatically notifies grid operators of real-time conditions that may affect grid stability.
  - **State estimation integration** improves accuracy of power systems models for planning and operations.

Benefits Realized

- **Data sharing for after-the-fact analysis:**
  - 16 TOs send data to MISO
  - 3 reliability coordinators (RCs) send data to MISO (PJM, Tennessee Valley Authority, New York ISO)
  - 16 TOs receive application outputs resulting from processing real-time phasor data
  - 2 TOs receive data from MISO (ATC, MHEB)
  - 3 RCs receive data from MISO (PJM, TVA, NYISO)
- **Implemented several phasor data solutions:**
  - PhasorPoint™ in the control room
  - In-house visualization software, eRTD
  - After-the-fact analysis tools
  - Phasor data store with ready access to real-time and historical data
- **Reliability improvements:**
  - Angle pair alarm that corresponds to unusual system conditions (several generation outages in a large load area), heightened operator awareness

Additional reliability improvements will be realized in the future as quantifiable data and analysis continues to grow and improve.

Lessons Learned

- **Phasor data storage:**
  - MISO initially maintained all data and maximized storage space.
    - Solution: MISO has begun to archive data and implemented data down-sampling for historical phasor data storage.
    - Result: MISO is finalizing its phasor data storage strategy.
- **Operator usage:**
  - Given the status of the development of synchrophasor technology, operator acceptance and adoption of technology is an ongoing challenge.
    - Solution: MISO will continue training, sharing successes and installations.
    - Result: It will be several years before results can be measured, so operator confidence will take equally long to mature.

Future Plans

- Midwest ISO's three-year vision includes (1) integration of synchrophasor data into operational toolsets and (2) routine operator use of PMU data to support real-time decision making.
- Midwest ISO will continue to collaborate with members to:
  - Support the current Synchrophasor Working Group.
  - Encourage members to install PMUs at key TSAT™/VSAT™ (Transient Security Assessment Tool /Voltage Security Assessment Tool) locations.

- Request PMU-enabled relays at substations with preselected beneficial locations.
- Have TOs explore bus-to-bus monitoring of phase angles with added PMU locations.
- Request additional PMU measurements for bus-to-bus phase angle monitoring at key locations.

- **Year 1 Plan**
  - Integrate PMU data in our state estimator with energy management system (EMS) upgrade.
  - Finalize the phasor data storage strategy.
  - Evaluate data quality from PMU data.
  - Evaluate the advantage of adding time-aligned data to the state estimator.
  - Evaluate alternative visualization concepts.
  - Implement down-sampling for historical phasor data storage.
  - Update the annual technical training plan to include annual tool and data usage.
- **Year 2 Plan**
  - Evaluate state estimator confidence factors with time-aligned PMU phase angles and line flow measurements.
  - Implement an operator cycle training schedule, which is part of the annual technical training plan.
- **Year 3 Plan**
  - Investigate a time-aligned area control error (ACE), time-aligned frequency measurements at multiple locations, and time- aligned tie line data measurements at all tie lines.
  - Investigate a time-aligned state assessment solution that can solve more quickly and accurately than the current state estimator.

Contact Information

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