ISO-New England

Synchrophasor Infrastructure and Data Utilization in the ISO New England Transmission Region

Scope of Work

ISO-New England (ISO-NE) and seven of its transmission owners have installed phasor measurement units (PMUs) and phasor data concentrators (PDCs) across the six states in the New England control area. These devices, in conjunction with a set of new applications, have the potential to improve the reliability of the transmission grid and to prevent the spread of local disturbances to neighboring regions through enhanced monitoring capabilities and increased situational awareness. ISO-NE is exploring a long-term plan for operations where advanced transmission management software will assist in determining real-time grid stability margins. ISO-NE has already used this technology to increase power system engineers' visibility into bulk power system conditions in near-real time and enabled the potential for earlier detection of disturbances that could result in instabilities or cascading outages. Access to more granular grid state information has allowed ISO-NE power system engineers to improve power system models and analytical techniques, enhancing the overall reliability of the ISO-NE system.

Objectives

The goal of the project was to improve grid reliability and resilience while enabling more efficient use of grid resources. With the newly implemented synchrophasor technology and applications, power systems engineers have enhanced visibility and situational awareness, facilitating earlier detection of potential disturbances as well as information sharing with nearby regional control centers.

At-A-Glance

Recipient: ISO-New England

States: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

NERC Region: Northeast Power Coordinating Council

Total Project Cost: $13,894,847

Total Federal Share: $5,955,740

Transmission Owners: Bangor-Hydro, Central Maine Power, Northeast Utilities, National Grid, NSTAR, United Illuminating, and VELCO

Project Type: Electric Transmission Systems

Equipment

- Synchrophasor Communications Network
- Phasor Measurement Units at 40 Substations
- Phasor Data Concentrators at 8 Locations

Advanced Applications

- Angle and Frequency Monitoring
- Post-Mortem Analysis
- Voltage Stability Monitoring
- Disturbance Detection

Key Benefits

- Improved Avoidance of Cascading Power Outages
- Increased Electric Service Reliability and Power Quality

Deployed Smart Grid Technologies

- **Phasor measurement units and phasor data concentrators:** The project deployed PMUs at 40 substations and PDCs at 8 locations. PMUs allow synchronized real-time measurements of multiple remote measurement points on the grid, recording grid conditions with great accuracy and offering operators near-real-time insight into grid stability or stress. Synchrophasor technology can be used for real-time operations and off-line engineering analyses to improve grid reliability and efficiency and lower operating costs. PDCs were deployed at each transmission owner's facility to collect the data provided through the PMUs.
- **Communications infrastructure:** The project included deployment of systems to gather data from PMUs and deliver it to PDCs at the transmission owners' facilities and to the regional PDC at ISO-NE. Each transmission owner provided and implemented the communications link from PMUs to their PDCs, while ISO-NE provided the communication links between the transmission owners' PDCs to the regional PDC and implemented encryption for the overall data network links.

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- **Advanced transmission applications:** The synchrophasor system generates, processes, and presents grid state data that enable true wide-area monitoring and visualization of the state of the transmission system. New applications that have been developed and/or deployed include:
    - **PhasorPoint,** used by operation engineers for post event analysis, model validation and oscillation modal analysis. This is being deployed for both offline and online analysis, and is currently in production at the ISO-NE (not in control room).
    - **ROSE**. The main purpose of ROSE is using PMU and State Estimation data for on-line calculation and visualization of the current operating point and its proximity to the steady-state stability boundary. ROSE also identifies minimal optimal corrective actions. ROSE is being deployed for both offline and online analysis, and is currently in production at the ISO-NE (not in control room) used by engineers for study and event analysis.
    - **Data Quality Monitoring System (DQMS)** monitors PMU data validity and health on-line, providing statistics and alerting the support staff when data quality issues arise. DQMS was an in-house development for online monitoring, and is currently in production at the ISO-NE used by IT support staff.
    - **PNNL's Frequency Response Tool** is being evaluated to assess Balancing Authority and generator's primary frequency response to specific power system events using PMU and SCADA data.
    - **Alstom's PhasorAnalytics** for off-line event analysis and tuning PhasorPoint parameters.

  These applications provide the following capabilities:
    - **Angle and frequency monitoring and voltage stability monitoring** provides improved situational awareness about grid conditions and power flows across New England. This enables ISO-NE to detect and analyze oscillations, low voltage conditions, inaccuracies in planning/operations models, and conditions that can result in grid instability and outages.
    - **Post-mortem analysis.** ISO-NE pwer system engineers are better able to analyze disturbances and large-scale system events after they have occurred, in order to understand their causes and improve future system models and operations procedures.
    - **Disturbance and event detection** notifies grid operators of real-time conditions that may affect grid stability.
    - **Validation of power system dynamic models** to improve predictions of system behavior.

Benefits Realized

ISO-NE power system engineers continue to explore the new technology and are starting to see benefits such as:

- The ability to monitor power system dynamics. ROSE alarms in real time when system operating point is close to the N-1/N-2 secure operational region reflecting voltage stability, voltage violation and thermal overload. In addition, ROSE also provides recommendations on corrective actions if there is low margin or violations. In the future, this will be important to improve the system reliability in terms of both monitoring and taking actions.
- Fast and accurate post-event analysis. PMU data across all New England are automatically synchronized and easily visualized. ISO-NE engineers are now able to analyze two or three events each week, and are able to perform system wide model validation which was not possible in the past. Without synchrophasor data, this was a tedious and slow process, and we analyzed only one or two events each year.
- Validation of power system dynamic models. ISO-NE has been actively using PhasorPoint and the on-line Transient Stability Analysis Tool (TSAT) for dynamic model validations. This has provided a much improved HVDC model in the on-line TSAT program. Another benefit is the verification of a nuclear unit model during a local oscillation caused by

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a line trip and reclosing. PhasorPoint also identified two large oscillation modes that were never predicted by previous engineering simulations and is working with power plant owners to diagnose the causes.

- Computation and monitoring of security boundary and operational margins using state estimator and PMU data enables ISO-NE to more accurately set and re-evaluate operating limits and reserve requirments.
- The new synchrophasor deployment will facilitate future information sharing with neighboring regional control areas.
- ISO-NE has been sharing historical PMU data with:
  - University of Tennessee and Rensselaer Polytechnic Institute for research purposes;
  - EPRI to test and validate Measurement Based Voltage Stability Assessment (MBVSA) tool;
  - Alstom to test and validate the Linear State Estimator (LSE); and to perform oscillation source study and long term baselining;
  - Washington State University to research using the cloud as a PMU collaboration platform and data repository;
  - EPG and PNNL for Eastern Interconnection angle baselining study.

Lessons Learned

As ISO-NE reflects back on the execution of the SIDU project, several lessons learned come to mind:

- Greater technical engagement with transmission owner staff earlier in the project would have been more effective in getting the entire project team, both ISO-NE and transmission owners, aligned on project goals.A rigorous PMU data validation on the part of ISO New England and the transmission owners was able to resolve issues earlier in the project when resolution was least costly.
- Enhanced focus on formal training plans for engineers at both ISO-NE and transmission owners helps in promoting the project's benefits to a wider audience.
- Establishment of more detailed requirements and standards for project PMU implementations might have eliminated some technical issues that appeared as the project was being implemented.

Future Plans

ISO-NE continues to better understand the benefits that can be obtained, with the objective of moving the synchrophasor technology from engineering to real-time operations. Several ideas have emerged for future initiatives:

- A streamlined process of model validation using PMU, supervisory control and data acquisition (SCADA), and digital fault recorder (DFR) data
- Streaming real time synchrophasor data to and from PJM and/or NY-ISO, to provide ISO-NE and the other areas the ability to prototype wide area monitoring displays and tools.
- Explore using EIDSN for future PMU data exchange after it goes live in June 2015
- Improved state estimation:
  - Feasibility demonstration of PMU-only state estimation for a 345 kV network
  - Evaluation of hybrid PMU/SCADA state estimation
- Long-term baseline and oscillation source study to improve state estimation and generator models, resulting in more accurate load flow simulations and diagnosing the cause 0.12 Hz, 100 MW peak-to-peak oscillation discovered using synchrophasor data
- Utilizing cloud-based hosting as a collaboration platform and reporitory for PMU data
- Further enhancement of the in-house developed DQMS to increase its monitoring effectiveness

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